A Joint Report by the OECD Nuclear Energy Agency
and the International Atomic Energy Agency

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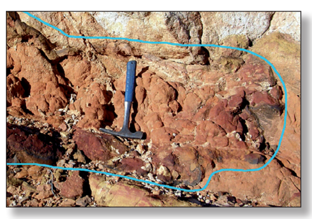
Uranium 2014: Resources, Production and Demand



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Uranium 2014:
Resources, Production and Demand

NEA No. 7209

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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NUCLEAR ENERGY AGENCY

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The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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Cover photos: Aerial photo of the Bruce Nuclear Generating Station near Kincardine, Ontario, Canada (Chuck Szmurlo); Paleao-Rollfront at Dead Tree Creek, Mt. Painter Gebiet, South Australia (Geomartin).

Preface

Since the mid-1960s, with the co-operation of their member countries and states, the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) have jointly prepared periodic updates (currently every two years) on world uranium resources, production and demand. These updates have been published by the OECD/NEA in what is commonly known as the "Red Book". This 25th edition of the Red Book reflects information current as of 1 January 2013.

This edition features a comprehensive assessment of uranium supply and demand in 2013 and projections of supply and demand to the year 2035. The basis of this assessment is a comparison of uranium resource estimates (according to categories of geological certainty and production cost) and mine production capability with anticipated uranium requirements arising from projected installed nuclear generating capacity. In cases where longer-term projections of installed nuclear capacity were not provided by national authorities, projected demand figures were developed with input from expert authorities. Current data on resources, exploration, production and uranium stocks are also presented, along with historical summaries of exploration and production as well as plans for future mine production. Available information on secondary sources of uranium is presented and the potential impact of secondary sources on the market is assessed. Individual country reports provide detailed information on recent developments in uranium exploration and production, updates on environmental activities, regulatory requirements and information on relevant national uranium policies.

This publication has been prepared on the basis of data obtained through questionnaires sent by the NEA to OECD member countries (19 countries responded and 1 country report was prepared by the Secretariat) and by the IAEA for those states that are not OECD member countries (17 countries responded and 8 country reports were prepared by the Secretariat). The opinions expressed in Chapters 1 and 2 do not necessarily reflect the position of the member countries or international organisations concerned. This report is published on the responsibility of the OECD Secretary-General.

Acknowledgements

The OECD/NEA, Paris, and the IAEA, Vienna, gratefully acknowledge the co-operation of those organisations (see Appendix 2) which replied to the questionnaire.

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Executive summary

In addition to updated resource figures, *Uranium 2014 – Resources, Production and Demand* presents the results of the most recent review of world uranium market fundamentals and offers a statistical profile of the world uranium industry as of 1 January 2013. It contains official data provided by 36 countries and 9 national reports prepared by the joint NEA-IAEA Secretariat on uranium exploration, resources, production and reactor-related requirements. Projections of nuclear generating capacity and reactor-related uranium requirements through 2035 are presented, as well as a discussion of long-term uranium supply and demand issues.

Resources[1]

Total identified uranium resources have increased by more than 7% since 2011, adding almost ten years of global reactor requirements to the existing resource base, but the majority of the increases occurred in resource categories with higher production costs.

Total identified resources (reasonably assured and inferred) as of 1 January 2013 amounted to 5 902 900 tonnes of uranium metal (tU) in the <USD 130/kgU (<USD 50/lb U_3O_8) category, an increase of 10.8% compared to 1 January 2011. In the highest cost category (<USD 260/kgU or <USD 100/lb U_3O_8) which was reintroduced in 2009, total identified resources amount to 7 635 200 tU, an increase of 7.6% compared to the total reported in 2011.

Although the total identified resources have increased overall, since 2011 there has been a significant reduction of 36% in the <USD 80/kgU (or <USD 30/lb U_3O_8) cost category, owing principally to increased mining costs. The lowest cost category (<USD 40/kgU or <USD 15/lb U_3O_8) changed little, owing mainly to successful exploration efforts in Kazakhstan. The majority of the increases are a result of re-evaluations of previously identified resources and additions to known deposits, particularly in Australia, Canada, the Czech Republic, Greenland, Kazakhstan, Peoples' Republic of China and South Africa. At the 2012 level of uranium requirements, identified resources are sufficient for over 120 years of supply for the global nuclear power fleet. Moreover, an additional 119 100 tU

1. Uranium resources are classified by a scheme (based on geological certainty and costs of production) developed to combine resource estimates from a number of different countries into harmonised global figures. **Identified resources** (which include *reasonably assured resources,* or *RAR,* and *inferred resources*) refer to uranium deposits delineated by sufficient direct measurement to conduct pre-feasibility and sometimes feasibility studies. For *RAR*, high confidence in estimates of grade and tonnage are generally compatible with mining decision-making standards. *Inferred resources* are not defined with such a high degree of confidence and generally require further direct measurement prior to making a decision to mine. **Undiscovered resources** (*prognosticated* and *speculative*) refer to resources that are expected to exist based on geological knowledge of previously discovered deposits and regional geological mapping. *Prognosticated resources* refer to those expected to exist in known uranium provinces, generally supported by some direct evidence. *Speculative resources* refer to those expected to exist in geological provinces that may host uranium deposits. Both *prognosticated* and *speculative resources* require significant amounts of exploration before their existence can be confirmed and grades and tonnages can be defined. For a more detailed description, see Appendix 3.

of resources have been identified by the Secretariat as resources reported by companies that are not yet included in national resource totals.

Total undiscovered resources (prognosticated resources and speculative resources) as of 1 January 2013 amounted to 7 697 700 tU, a significant decrease from the 10 429 100 tU reported in 2011, principally because the United States did not report data for this edition as previous estimates completed in 1980 need re-evaluation to determine their accuracy.

It is important to note that in some cases, including those of major producing countries with large identified resource inventories (e.g. Australia, Canada), estimates of undiscovered resources are either not reported or estimates have not been updated for several years.

The uranium resource figures presented in this volume are a snapshot of the situation as of 1 January 2013. Resource figures are dynamic and related to commodity prices. The overall increase in identified resources (including high cost resources) from 2011 to 2013 have added over eight years of global supply based on 2012 uranium requirements, despite less favourable market conditions. Nonetheless, as in the case of past periods of increased exploration activity, continued high levels of investment and associated exploration efforts have resulted in the identification of additional resources of economic interest.

Exploration

The increased resource base described above has been identified thanks to a 23% increase in uranium exploration and mine development expenditures between 2010 and 2012.

Worldwide exploration and mine development expenditures in 2012 totalled USD 1.92 billion, a 22% increase over updated 2010 figures (reduced from over USD 2 billion to USD 1.56 billion). Despite a decline in market prices over the past few years, prices for uranium since 2003 have been generally higher compared to the preceding two decades and have stimulated increased exploration in regions known to have good potential based on past work and grass roots exploration in new areas. Concerted efforts also continue to be made to expand the resource base and develop deposits for projected future supply requirements. Over 95% of exploration and development expenditures in 2012 were devoted to domestic activities.

From 2011 to 2013, domestic exploration and mine development expenditures decreased in some countries, partly due to the declining uranium price which slowed down many exploration and mine development projects, particularly in the junior uranium mining sector. In Canada, although overall expenditures decreased, exploration expenditures increased by 3.5% from 2011 to 2012. In contrast, Australia reported a significant decrease in exploration expenditures from 2011 to 2012. This decrease was offset by increased total expenditures from 2011 to 2012 in a number of countries including Brazil, China, Ethiopia, Iran, Kazakhstan, Poland, Spain, Tanzania, Turkey, the Ukraine, the United States and Zambia. Worldwide expenditures are expected to remain the same or increase slightly in 2013 despite declining expenditures expected in China, Poland and Tanzania. Exploration expenditures in 2013 are projected to increase significantly in Kazakhstan.

Non-domestic exploration and development expenditures, although reported only by China, France, Japan and the Russian Federation, decreased from USD 371 million in 2009 to less than USD 200 million from 2010 through 2012, but remained significantly above the USD 70 million reported in 2004. Non-domestic development expenses in China are projected to reach over USD 560 million in 2013 principally due to investment in the Husab mine in Namibia, pushing expected non-domestic exploration and development expenditures to a total of more than USD 650 million in 2013.

Production

Global uranium mine production between 2010 and 2012 increased by 7.6%, which is a lower rate of growth compared to the last reporting period, but increases were again mainly the result of rising production in Kazakhstan, currently the world's leading producer.

Overall, world uranium production increased only 0.2% from 54 653 tU in 2010 to 54 740 tU in 2011. However, production in 2012 increased by 7.4% from 2011 to 58 816 tU and is projected to increase to over 59 500 tU in 2013. This recent growth is principally the result of increased production in Kazakhstan, with smaller additions in Australia, Brazil, China, Malawi, Namibia, Niger, the Ukraine and the United States. Within OECD countries, production increased slightly from 16 982 tU in 2011 to 17 956 tU in 2012 and is expected to remain relatively stable in 2013.

From 2011 to 2013, uranium was produced in 21 different countries; one less than in 2010 (Bulgaria did not report mine remediation recovery for this edition and France, Germany and Hungary continue to recover minor amounts of uranium only as the result of remediation activities). Kazakhstan's growing production continued to 21 240 tU in 2012 (with 22 500 tU expected in 2013). Although the rate of increase has been reduced from previous years it remains the world's largest producer by a large margin. Production in Kazakhstan in 2012 totalled more than the combined production that same year in Canada and Australia, the second and third largest producers of uranium respectively.

In situ leaching (ISL, sometimes referred to as *in situ* recovery, or ISR) production continued to dominate uranium production accounting for 45% of world production in 2012, largely due to production increases in Kazakhstan and to other ISL projects in Australia, China, the Russian Federation, the United States and Uzbekistan. World uranium production by ISL is forecast to reach 47.5% of total production in 2013. In 2012, underground mining (26%), open-pit mining (20%) and co-product and by-product recovery from copper and gold operations (6%), heap leaching (2%) and other methods (1%) accounted for the remaining production shares.

Environmental and social aspects of uranium production

With uranium production poised to expand, in some cases to countries that have not previously hosted uranium mining, efforts are being made to develop operations similar to leading practice operations in more established uranium producing countries. These efforts aim to develop safe mining practices in communities well-informed of such activities and to continue to minimise environmental impacts.

Although the focus of this publication remains uranium resources, production and demand, environmental aspects of the uranium production cycle are gaining increasing importance and, as in the last few editions, updates on activities in this area are included in national reports in the current edition. With uranium production ready to expand, in some cases to countries hosting uranium production for the first time, the continued development of transparent, safe and well-regulated operations that minimise environmental impacts is crucial.

In January 2013, a number of agreements covering the Ranger Project Area were signed by the Australian government, Northern Land Council, the Mirarr traditional owners and the mine operator Energy Resources Australia. Such initiatives provide greater benefits to traditional owners, including intergenerational benefits, in this case through the establishment of the Kakadu West Arnhem Social Trust. Other key features include an agreed approach to increasing opportunities for local Aboriginal participation in business development, training and employment.

The Uranium Council (formerly the Uranium Industry Framework), established by the government in 2009 to develop a sustainable Australian uranium mining sector, initiated a project led by the Australian Radiation Protection and Nuclear Safety Agency on radiological protection of non-human biota and participated in the development and implementation of the Australian National Radiation Dose Register, a centralised database for the collection and long-term storage of radiation dose registers for uranium mine and mill workers.

In Botswana, A-Cap Resources established the Safety, Health, Radiation, Environment and Community Group aimed at informing, educating and involving local communities through meetings held on a regular basis. An environmental and social impact assessment study of the Letlhakane Project was submitted to the government of Botswana in 2011 and a detailed exploration programme was undertaken to identify sufficient water resources for the proposed Letlhakane Project.

In the Czech Republic, although environmental activities and actions attempting to resolve social issues arising from the closure of major mining activities were formally terminated in 2009, extensive environmental remediation projects and projects with a focus on associated social issues continue to be funded by the state budget and European Union (EU). These projects aim to develop alternative (mainly environmental) approaches to address social issues stemming from decreasing employment in uranium mining. This includes the development of projects and related environmental impact assessments, decommissioning activities, waste rock management, site rehabilitation and maintenance, water treatment and long-term monitoring.

Following the closure of all uranium mines in France in 2001, all facilities have been shut down, dismantled and the sites reclaimed. All sites (over 200), ranging from exploration camps to mines of various sizes, 8 mills and 17 tailings deposits (containing a total of 52 Mt of tailings) resulting from the production of over 80 000 tU, have been remediated. Monitoring continues at only the most affected sites and 14 water treatment plants have been installed to treat water at the remediated facilities.

In Kazakhstan, remediation of the west and central site of the Uvanas deposit has been completed and the second stage of remediation is being planned. Remediation of the Kanzhugan deposit is also scheduled to begin.

In Malawi, mine owner and operator Paladin Energy continues to fulfil its social development obligations under the terms of the Kayelekera mine development agreement. A programme to promote local involvement, economic growth and capacity building in communities is in progress and opportunities are being explored for the transfer of skills from Kayelekera's experienced workforce to local businesses. Additional projects include renovations to Karonga district hospital, the provision of medical equipment, implementation of a health awareness programme and the continuation of a weekly outpatient clinic.

Namibia continues to make progress in a number of environmental and social issues, building on the establishment of the Rössing Foundation in 1978. The foundation's activities focus on education, health care, environmental management and radiation safety in the uranium industry. Paladin Energy, owner and operator of the Langer Heinrich production centre, held numerous community meetings in 2011 and 2012 to update interested parties on mine development activities and to help identify an appropriate focus for the company's social development programme. One focus of site activities has been the reuse and recycling of water. With the development of the Husab mine, Swakop Uranium has also engaged in social responsibility programmes, including committing itself to local procurement, recruitment and employment, training, education and responsible environmental management practices. To this end, projects were initiated to address research needs identified in the company's environmental management plan, including groundwater monitoring. In January 2013, the Geological Survey of Namibia released the first annual report produced under the Strategic Environmental Management Plan (SEMP) developed in response to the Strategic Environmental Assessment on the cumulative effects of uranium mine development.

One of the key points of interest of SEMP is water. Since 2010, water has been supplied to the Erongo region from a coastal desalination plant built by AREVA.

In Niger, Somaïr and Cominak maintained their ISO 14001 certification for environmental management and AREVA continues to manage environmental issues with a focus on water. Methods to conserve and reduce water consumption have successfully reduced water use despite increased production. The mining companies manage two hospitals and technical support centres in Arlit and Akokan. First created to provide medical care for miners and their families, the centres are now largely open to the public free of charge. A medical centre to treat local residents at no cost was also recently opened at Imouraren.

In several other countries with closed uranium production facilities (Brazil, Hungary, Poland, Portugal, the Slovak Republic, Slovenia, Spain and the Ukraine), updates of remedial and monitoring activities are provided in the respective country reports.

Additional information on environmental aspects of uranium production may be found in the joint NEA-IAEA Uranium Group publications *Environmental Remediation of Uranium Production Facilities* (OECD, 2002) and *Environmental Activities in Uranium Mining and Milling* (OECD, 1999). The OECD/NEA has also recently released a report, *Managing Environmental and Health Impacts of Uranium Mining* (OECD, 2014), outlining significant improvements in these areas that have been undertaken since the early strategic period of uranium mining to the present day.

Uranium demand

Demand for uranium is expected to continue to rise for the foreseeable future

At the end of 2012, a total of 437 commercial nuclear reactors were connected to the grid with a net generating capacity of 372 GWe requiring some 61 980 tU, as measured by uranium acquisitions. Taking into account changes in policies announced in Belgium, France, Germany, Italy and Switzerland following the Fukushima Daiichi nuclear power plant accident, world nuclear capacity by the year 2035 is projected to grow to between about 400 GWe net in the low demand case and 680 GWe net in the high demand case, representing increases of 7% and 82% respectively. Accordingly, world annual reactor-related uranium requirements are projected to rise to between 72 000 tU and 122 000 tU by 2035. In addition to declining projections of nuclear generating capacity, uranium requirements have been reduced from 2011 on the assumption that tails assays at enrichment plants have been reduced, on average, from 0.30% to 0.25%.

Nuclear capacity projections vary considerably from region to region. The East Asia region is projected to experience the largest increase, which, by the year 2035, could result in the installation of between 57 GWe and 125 GWe of new capacity in the low and high cases respectively, representing increases of more than 65% and 150% over 2013 capacity. Nuclear capacity in non-EU member countries on the European continent is also projected to increase significantly, with additions of between 20 and 45 GWe of capacity projected by 2035 (increases of about 50% and 110% respectively). Other regions projected to experience significant nuclear capacity growth include the Middle East, Central and Southern Asia and South-East Asia, with more modest growth projected in Africa and the Central and South American regions. For North America, nuclear generating capacity in 2035 is projected to either decrease by almost 30% in the low case or increase by over 15% in the high case by 2035. In the European Union the outlook is similar, with nuclear capacity in 2035 either projected to decrease by 45% in the low case scenario or increase by 20% in the high case scenario.

These projections are subject to even greater uncertainty than usual due to the Fukushima Daiichi accident, since Japan has not yet determined the role that nuclear power will play in its future generation mix and China did not report official targets for nuclear power capacity beyond 2020 for this edition. Key factors influencing future nuclear energy capacity include projected baseload electricity demand, the economic competitiveness of nuclear power plants, as well as funding arrangements for such capital-intensive projects, the cost of fuel for other electricity generating technologies, non-proliferation concerns, proposed waste management strategies and public acceptance of nuclear energy, which is a particularly important factor in some countries after the Fukushima Daiichi accident. Concerns about longer-term security of fossil fuel supply and the extent to which nuclear energy is seen to be beneficial in meeting greenhouse gas reduction targets and enhancing security of energy supply could contribute to even greater projected growth in uranium demand.

Supply and demand relationship

The currently defined resource base is more than adequate to meet high case uranium demand through 2035, but doing so will depend upon timely investments given the typically long lead times required to turn resources into refined uranium ready for nuclear fuel production. Other concerns in mine development include geopolitical factors, technical challenges, increasing expectations of governments hosting uranium mining and other issues facing producers in specific cases.

In 2012, world uranium production (58 816 tU) provided about 95% of world reactor requirements (61 980 tU), with the remainder supplied by previously mined uranium (so-called secondary sources) including excess government and commercial inventories, low-enriched uranium (LEU) produced by blending down highly enriched uranium (HEU) from the dismantling of nuclear warheads, re-enrichment of depleted uranium tails (DU) and spent fuel reprocessing.

Uranium miners vigorously responded to the market signal of increased prices and projections of rapidly rising demand prior to the Fukushima Daiichi accident. However, the continued decline in market prices following the accident and lingering uncertainty about nuclear power development in some countries has at least temporarily reduced uranium requirements, further depressed prices and slowed the pace of mine development. Uranium miners have been hit harder by the Fukushima Daiichi accident than any other segment of the nuclear fuel cycle. The uranium market is currently well-supplied and projected primary uranium *production capabilities* including existing, committed, planned and prospective production centres would satisfy projected high case requirements through 2032 and low case requirements through 2035 if developments proceed as planned. Meeting high case demand requirements to 2035 would consume less than 40% of the total identified resource base. Nonetheless, significant investment and technical expertise will be required to bring these resources to the market, and producers will have to overcome a number of significant and at times unpredictable issues in bringing new production facilities on stream, including geopolitical factors, technical challenges and risks at some facilities, the potential development of ever more stringent regulatory requirements and the heightened expectations of governments hosting uranium mining. Sufficiently robust uranium market prices will be needed to support these activities, especially in light of the rising costs of production.

Although information on secondary sources is incomplete, the availability of these sources will at least temporarily decline somewhat after 2013 when the agreement between the United States and the Russian Federation to blend down HEU to LEU suitable for nuclear fuel comes to an end. Limited available information indicates that there remains a significant amount of previously mined uranium (including material held by the military), some of which could feasibly be brought to the market in the coming years. With the successful transition from gas diffusion to centrifuge enrichment now complete and capacity at least temporarily in excess of requirements following the Fukushima Daiichi accident, enrichment providers are well-positioned to reduce tails assays below contractual requirements and in this way create additional uranium supply. Moreover, interest in the re-enrichment of DU is growing, and if a commercially viable means of re-enriching DU is developed a considerable source of secondary supply could become available. Developments in laser enrichment have the potential to accelerate secondary supply from DU, although considerable progress remains to be made to be successful in this regard. In the longer term, alternative fuel cycles (e.g. thorium), if successfully developed and implemented, could have a significant impact on the uranium market, but it is far too early to say how cost-effective and widely implemented these proposed fuel cycles could be.

Although declining market prices have led to a delay in some mine development projects, other projects have advanced through regulatory and further stages of development. However, the overall timeframe for mine development should be reduced if market conditions warrant renewed development activity. The current global network of uranium mine facilities is, at the same time, relatively sparse, creating the potential for supply vulnerability should a key facility be put out of operation. Utilities have been building significant inventory over the last few years at reduced prices, which should help to protect them from such events.

Conclusions

Despite recent declines in electricity demand stemming from the global financial crisis in some developed countries, overall demand is expected to continue to grow in the next several decades to meet the needs of a growing population, particularly in developing countries. Since nuclear power plant operation produces competitively priced, baseload electricity that is essentially free of greenhouse gas emissions, and the deployment of nuclear power enhances security of energy supply, it is projected to remain an important component of energy supply. However, the Fukushima Daiichi accident has eroded public confidence in nuclear power in some countries and prospects for growth in nuclear generating capacity are in turn being reduced and subject to even greater uncertainty than usual. Additional safety measures required after reviews of all operating nuclear facilities have also driven operating costs upward. This, combined with the abundance of low-cost natural gas in North America and the risk-averse investment climate stemming from the global financial crisis, has reduced the competitiveness of nuclear power plants in liberalised electricity markets. Government and market policies that recognise the benefits of low-carbon electricity production and the security of energy supply provided by nuclear power plants could help alleviate these competitive pressures, but it is not yet clear when and how widely such measures can be adopted. Nuclear power nonetheless is projected to grow considerably in regulated electricity markets with increasing electricity demand and a growing need for clean air electricity generation.

Regardless of the role that nuclear energy ultimately plays in meeting future electricity demand, the uranium resource base described in this publication is more than adequate to meet projected requirements for the foreseeable future. The challenge is to continue developing safe and environmentally responsible mining operations to bring the required quantities of uranium to the market in a timely fashion.

Chapter 1. Uranium supply

This chapter summarises the current status of worldwide uranium resources, exploration and production.

Uranium resources

Identified conventional resources

Identified resources consist of ***reasonably assured resources*** (RAR) and ***inferred resources*** (IR) recoverable at a cost of less than USD 260/kgU (USD 100/lbU_3O_8). Relative changes in different resource and cost categories of identified resources between this edition and the 2011 edition of the "Red Book" are summarised in Table 1.1. The overall picture is one of resources shifting to higher cost categories and an increase in total identified resources, similar to the trend noted in previous recent editions. Resources recoverable at costs <USD 260/kgU increased by 538 600 tU (7.6%) to a total of 7 635 200 tU. This increase is equivalent to more than eight years of global supply at 2012 uranium requirements. The increases are the result of re-evaluations of known deposits and increased exploration efforts to extend the life-of-mine or expand production capacity at existing mining facilities. Resource increases in Australia, Canada, the Central African Republic, China, the Czech Republic, Greenland, India, Kazakhstan, Mongolia, the Russian Federation, the Slovak Republic, South Africa, Tanzania and Zambia were countered by reductions in other countries owing to re-evaluation and depletion by mining, mainly in Botswana, Namibia and Niger. The most significant changes in terms of an increased resource base were reported for the Czech Republic, Greenland and Mongolia.

Identified resources recoverable at costs of <USD 130/kgU (USD 50/lbU_3O_8) increased by 10.8% from 5 327 200 tU in 2011 to a total of 5 902 900 tU in 2013, as a result of shifting lower cost resources to higher cost categories in Australia, Namibia, the Russian Federation and South Africa as well as overall additions, through exploration and re-evaluation of resources, in a number of other countries.

The shift to higher cost categories resulted in a marked decline in the <USD 80/kgU (USD 30/lbU_3O_8) category, which dropped by 1 121 800 tU (36.4%) to 1 956 700 tU from 2011 to 2013. There was very little change in the lowest cost category (<USD 40/kgU or USD 15/lbU_3O_8) with only a 0.3% increase reported for a total of 682 900 tU. A notable exception to generally declining figures in this cost category in recent years is Kazakhstan, where exploration resulted in an 88% increase in low-cost identified resources (<USD 40/kgU) from 47 400 tU in 2011 to 89 300 tU in 2013. It should be noted however that resources in this lowest cost category are likely higher than reported, because some countries have indicated that detailed estimates are not available, or that the data are confidential.

Current estimates of identified resources, RAR and IR, on a country-by-country basis, are presented in Tables 1.2, 1.3 and 1.4, respectively. Table 1.5 summarises major changes in resources between 2011 and 2013 in selected countries.

Distribution of identified conventional resources by categories and cost ranges

Australia still dominates the world's uranium resources with 29% of the total identified resources (<USD 130/kgU) and 24% of identified resources in the highest cost category (<USD 260/kgU). Kazakhstan is a distant second with approximately 12% in both cost categories, with all of the other countries having less than a 10% share. Only 15 countries

around the world have more than a 1% share of the total world's identified resources available at costs <USD 130/kgU (Figure 1.1) and 16 countries in the high-cost category. The most significant changes between 2011 and 2013 are in the shift of the <USD 80 kg/U to higher cost categories and an overall increase in total identified resources in the <USD 260/kgU category (Table 1.2). The distribution of identified resources (RAR and IR) among the countries with major resources is shown in Figures 1.2 and 1.3.

RAR recoverable at costs <USD 40/kgU, the most economically attractive category, increased slightly by 13 500 tU (2.7%) mainly as a result of exploration near existing production centres in Canada, China and Kazakhstan. The most significant change in RAR was a decrease of 803 200 tU (39.9%) in the <USD 80/kgU category, reflecting a continued trend towards higher production costs. In the <USD 130/kgU and <USD 260/kgU categories there were modest increases of 7% and 4.8% respectively, which are mainly the result of the re-evaluation and transfer of lower cost resources to higher cost categories. The increases in the overall total RAR are mainly due to increases in Australia, Canada, China, the Czech Republic, India, Mongolia, the Russian Federation and South Africa with smaller contributions from the Central African Republic, Slovak Republic and Tanzania. Reductions in the highest cost category in Botswana, Kazakhstan, Namibia and Niger were due to technical and economic re-evaluation of deposits. France no longer reports uranium resources.

Lower cost inferred resources were reduced substantially with the <USD 40/kgU category decreasing by 6.1% and the <USD 80/kgU dropping by 30%. This resulted in increases in both the <USD 260/kgU and <USD 130/kgU categories of 12.1% and 17.8%, respectively. A significant increase in total inferred resources came from Greenland with the addition of 86 000 tU and the Czech Republic with 68 000 tU. A reclassification of prognosticated to inferred resources in Kazakhstan also contributed to the increased overall total. Decreased resource totals were registered in other countries, including Niger and the Russian Federation, with the latter upgrading inferred resources to RAR. Inferred resources comprise 40% of the identified resource total, a 2% increase over the last reporting period.

Table 1.1. Changes in identified resources 2011-2013

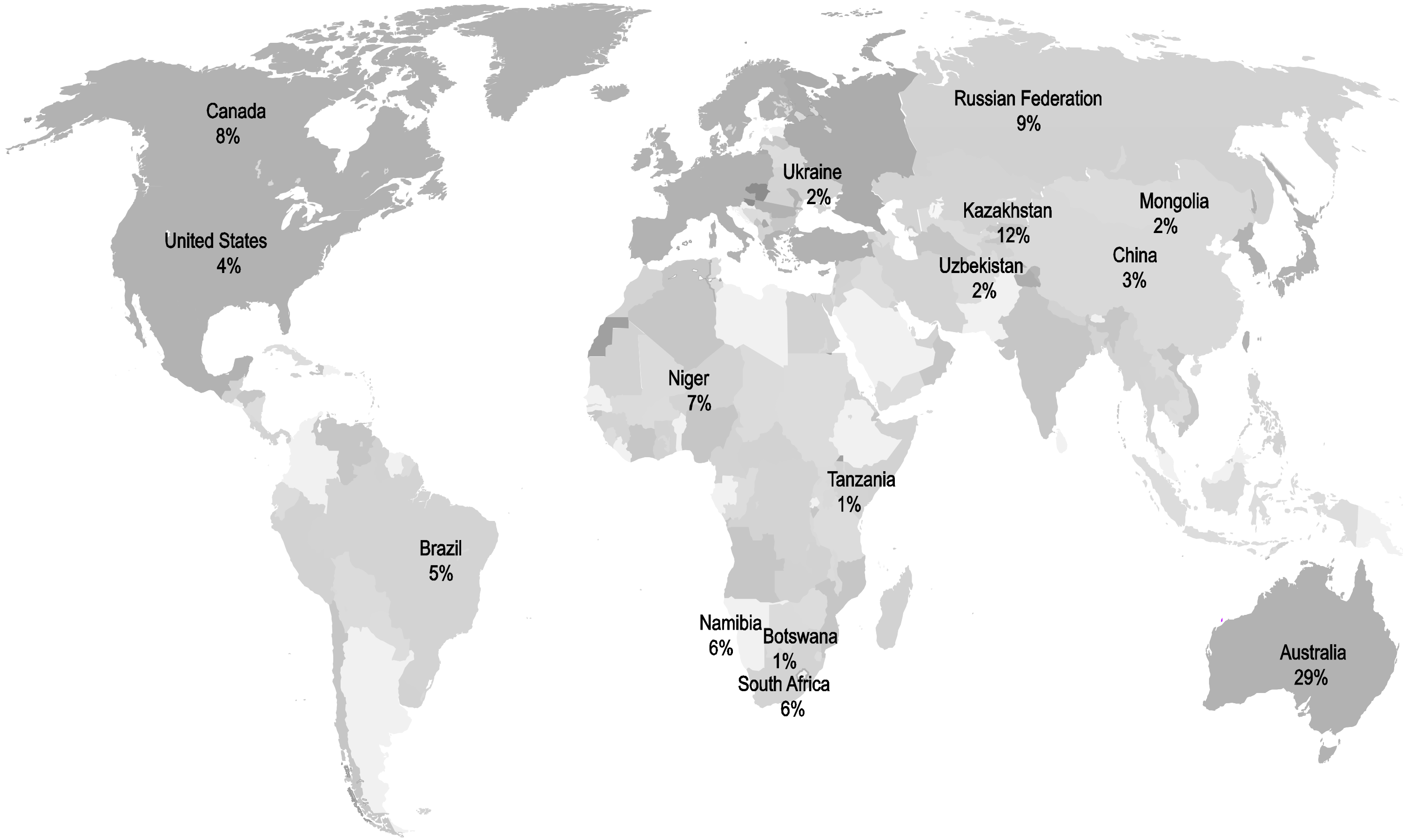
(1 000 tU)

Resource category	2011	2013	Change (1 000 tU)[a]	% change
Identified (total)				
<USD 260/kgU	7 096.6	7 635.2	538.6	7.6
<USD 130/kgU	5 327.2	5 902.9	575.7	10.8
<USD 80/kgU	3 078.5	1 956.7	1 121.8	-36.4
<USD 40/kgU[b]	680.9	682.9	2.0	0.3
RAR				
<USD 260/kgU	4 378.7	4 587.2	208.5	4.8
<USD 130/kgU	3 455.5	3 698.9	243.4	7.0
<USD 80/kgU	2 014.8	1 211.6	803.2	-39.9
<USD 40/kgU[b]	493.9	507.4	13.5	2.7
Inferred resources				
<USD 260/kgU	2 717.9	3 048.0	330.1	12.1
<USD 130/kgU	1 871.7	2 204.0	332.3	17.8
<USD 80/kgU	1 063.7	745.1	318.6	-30.0
<USD 40/kgU[b]	187.0	175.5	11.5	-6.1

(a) Changes might not equal differences between 2011 and 2013 because of independent rounding. (b) Resources in the cost category of <USD 40/kgU are likely higher than reported, because some countries have indicated that detailed estimates are not available, or the data are confidential.

Figure 1.1. Global distribution of identified resources

(<USD 130/kgU)



The global distribution of identified resources among the 15 countries with more than a 1% share of the total global identified resources available at costs <USD 130/kgU illustrates the widespread distribution of these resources. Together, these 15 countries are endowed with 97% of the global identified resource base in this cost category (the remaining 3% are distributed among another 21 countries). The widespread distribution of uranium resources is an important aspect of nuclear energy in terms of security of energy supply.

Table 1.2. Identified resources (RAR and inferred)

(recoverable resources as of 1 January 2013, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Algeria(c, d)	0	0	0	19 500
Argentina	2 400	9 100	18 500	19 600
Australia	NA	NA	1 706 100	1 798 300
Botswana*	0	0	68 800	68 800
Brazil	137 300	228 700	276 100	276 100
Canada	321 800	418 300	493 900	650 500
Central African Republic*	0	0	32 000	32 000
Chad*(d, e)	0	0	0	2 400
Chile(d, e)	0	0	0	1 500
China(d)	65 700	148 600	199 100	199 100
Congo, Dem. Rep.*(a, c, d)	0	0	0	2 700
Czech Republic	0	0	1 400	119 300
Egypt(a, c, d)	0	0	0	1 900
Finland(c, d)	0	0	1 200	1 200
Gabon(a, c)	0	0	4 800	5 800
Germany(c)	0	0	0	7 000
Greece(a, c)	0	0	0	7 000
Greenland	0	0	0	221 200
Hungary	0	0	0	13 500
India(d, e)	NA	NA	NA	119 900
Indonesia(c, d)	0	1 500	6 300	8 000
Iran, Islamic Republic of	0	0	4 400	4 400
Italy(c)	0	6 100	6 100	6 100
Japan(c)	0	0	6 600	6 600
Jordan(b, d)	0	0	40 000	40 000
Kazakhstan(d)	89 300	515 700	679 300	875 500
Malawi*	0	0	10 500	15 000
Mali*(d)	0	0	13 000	13 000
Mexico(a, d)	0	0	2 900	2 900
Mongolia	0	141 500	141 500	141 500
Namibia*	0	0	382 800	455 600
Niger*	0	15 400	404 900	404 900
Peru(c, d)	0	2 900	2 900	2 900
Portugal(c)	0	5 500	7 000	7 000
Romania*(a, c)	0	0	6 700	6 700
Russian Federation(b)	0	42 300	505 900	689 200
Slovak Republic(b, d)	0	12 700	15 500	15 500
Slovenia(c, d)	0	5 500	9 200	9 200
Somalia*(a, c, d)	0	0	0	7 600
South Africa	0	182 300	338 100	450 800
Spain	0	0	0	14 000
Sweden*(d)	0	0	9 600	9 600
Tanzania*(d)	0	46 800	58 100	58 100
Turkey(b, d)	0	8 700	8 700	8 700
Ukraine	0	59 600	117 700	222 700
United States	0	39 100	207 400	472 100
Uzbekistan*	66 400	66 400	91 300	91 300
Viet Nam*(b, d)	0	0	0	3 000
Zambia*(d)	0	0	24 600	24 600
Zimbabwe*(a, c, d)	0	0	0	1 400
Total(f)	**682 900**	**1 956 700**	**5 902 900**	**7 635 200**

See notes on page 21.

Table 1.3. Reasonably assured resources (RAR)

(recoverable resources as of 1 January 2013, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Algeria[c, d]	0	0	0	19 500
Argentina	0	5 100	8 600	8 600
Australia	NA	NA	1 174 000	1 208 000
Botswana*	0	0	12 800	12 800
Brazil	137 300	155 100	155 100	155 100
Canada	256 200	318 900	357 500	454 500
Central African Republic*	0	0	32 000	32 000
Chile[d, e]	0	0	0	600
China[d]	51 800	93 800	120 000	120 000
Congo, Dem. Rep.*[a, c, d]	0	0	0	1 400
Czech Republic	0	0	1 300	51 000
Finland[c, d]	0	0	1 200	1 200
Gabon[a, c]	0	0	4 800	4 800
Germany[c]	0	0	0	3 000
Greece[a, c]	0*	0*	0*	1 000
India[d, e]	NA	NA	NA	97 800
Indonesia[c, d]	0	1 500	6 300	6 300
Iran, Islamic Republic of	0	0	1 000	1 000
Italy[c]	0	4 800	4 800	4 800
Japan[c]	0	0	6 600	6 600
Kazakhstan[d]	20 400	199 700	285 600	373 000
Malawi*	0	0	8 200	10 400
Mali*[d]	0	0	8 500	8 500
Mexico[a, d]	0	0	2 900	2 900
Mongolia	0	108 100	108 100	108 100
Namibia*	0	0	248 200	296 500
Niger*	0	14 800	325 000	325 000
Peru[c, d]	0	1 400	1 400	1 400
Portugal[c]	0	4 500	6 000	6 000
Romania*[a, c]	0	0	3 100	3 100
Russian Federation[b]	0	11 800	216 500	261 900
Slovak Republic[b, d]	0	8 800	8 800	8 800
Slovenia[c, d]	0	1 700	1 700	1 700
Somalia*[a, c, d]	0	0	0	5 000
South Africa	0	113 000	175 300	233 700
Spain	0	0	0	14 000
Sweden*[c, d]	0	0	4 900	4 900
Tanzania*[d]	0	38300	40 400	40 400
Turkey[b, d]	0	6 800	6 800	6 800
Ukraine	0	42 700	84 800	141 400
United States	0	39 100	207 400	472 100
Uzbekistan*	41 700	41 700	59 400	59 400
Viet Nam*[b, d]	0	0	0	900
Zambia*[d]	0	0	9 900	9 900
Zimbabwe*[a, c, d]	0	0	0	1 400
Total[f]	**507 400**	**1 211 600**	**3 698 900**	**4 587 200**

* Secretariat estimate; NA = not available. (a) Not reported in 2013 responses, data from previous Red Book; (b) Assessment partially made within the last five years; (c) Assessment not made within the last five years; (d) *In situ* resources were adjusted by the Secretariat to estimate recoverable resources using recovery factors provided by countries or estimated by the Secretariat according to the expected production method (Appendix 3); (e) Cost data not provided, therefore resources are reported in the <USD 260/kgU category; (f) Totals related to cost ranges <USD 40/kgU and <USD 80/kgU are higher than reported in the tables because certain countries do not report low-cost resource estimates, mainly for reasons of confidentiality.

Table 1.4. Inferred resources

(recoverable resources as of 1 January 2013, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Argentina	2 400	4 000	9 900	11 000
Australia	NA	NA	532 100	590 300
Botswana*	0	0	56 000	56 000
Brazil	0	73 600	121 000	121 000
Canada	65 600	99 400	136 400	196 000
Chad*(d, e)	0	0	0	2 400
Chile(d, e)	0	0	0	900
China(d)	13 900	54 800	79 100	79 100
Congo, Dem. Rep.*(a, c, d)	0	0	0	1 300
Czech Republic	0	0	100	68 300
Egypt(a, c, d)	0	0	0	1 900
Gabon(a, c)	0	0	0	1 000
Germany(c)	0	0	0	4 000
Greece(a, c)	0*	0*	0*	6 000
Greenland	0	0	0	221 200
Hungary	0	0	0	13 500
India(d, e)	NA	NA	NA	22 100
Indonesia(c, d)	0	0	0	1 700
Iran, Islamic Republic of	0	0	3 400	3 400
Italy(c)	0	1 300	1 300	1 300
Jordan(b, d)	0	0	40 000	40 000
Kazakhstan(d)	68 900	316 000	393 700	502 500
Malawi*	0	0	2 300	4 600
Mali*(d)	0	0	4 500	4 500
Mongolia	0	33 400	33 400	33 400
Namibia*	0	0	134 600	159 100
Niger*	0	600	79 900	79 900
Peru(c, d)	0	1 500	1 500	1 500
Portugal(c)	0	1 000	1 000	1 000
Romania*(a, c)	0	0	3 600	3 600
Russian Federation(b)	0	30 500	289 400	427 300
Slovak Republic(b, d)	0	3 900	6 700	6 700
Slovenia(c, d)	0	3 800	7 500	7 500
Somalia*(a, c, d)	0	0	0	2 600
South Africa	0	69 300	162 800	217 100
Sweden*(c, d)	0	0	4 700	4 700
Tanzania*(d)	0	8500	17 700	17 700
Turkey(b, d)	0	1 900	1 900	1 900
Ukraine	0	16 900	32 900	81 300
Uzbekistan*	24 700	24 700	31 900	31 900
Viet Nam*(b, d)	0	0	0	2 100
Zambia*(d)	0	0	14 700	14 700
Total(f)	**175 500**	**745 100**	**2 204 000**	**3 048 000**

* Secretariat estimate; NA = not available. (a) Not reported in 2013 responses, data from previous Red Book; (b) Assessment partially made within the last five years; (c) Assessment not made within the last five years; (d) *In situ* resources were adjusted by the Secretariat to estimate recoverable resources using recovery factors provided by countries or estimated by the Secretariat according to the expected production method (Appendix 3); (e) Cost data not provided, therefore resources are reported in the <USD 260/kgU category; (f) Totals related to cost ranges <USD 40/kgU and <USD 80/kgU are higher than reported in the tables because certain countries do not report low-cost resource estimates, mainly for reasons of confidentiality.

Table 1.5. Major identified resource changes by country

(recoverable resources in 1 000 tonnes U)

Country	Resource category	2011	2013	Changes	Reasons
Australia	**RAR**				Additional resources were defined at known deposits; however the increase in total resources was partly offset by the transfer of resources in some deposits into higher cost categories as a result of increases in mining and milling costs.
	<USD 80/kgU	962	NA	-962	
	<USD 130/kgU	1 158	1 174	16	
	<USD 260/kgU	1 180	1 208	28	
	Inferred				
	<USD 80/kgU	388	NA	-388	
	<USD 130/kgU	504	532	29	
	<USD 260/kgU	559	590	32	
Botswana	**RAR**				Recent evaluations resulted in an overall decline in identified resources, but an increase in the grade resulted in the re-classification of some resources in lower cost categories.
	<USD 130/kgU	0	13	13	
	<USD 260/kgU	23	13	-10	
	Inferred				
	<USD 130/kgU	0	56	56	
	<USD 260/kgU	59	56	-3	
Canada	**RAR**				New resources identified as a result of recent exploration activities. Most of Canada's identified resources are re-evaluated annually by the mining companies.
	<USD 40/kgU	238	256	18	
	<USD 80/kgU	293	319	26	
	<USD 130/kgU	320	358	38	
	<USD 260/kgU	422	455	33	
	Inferred				
	<USD 40/kgU	113	66	-47	
	<USD 80/kgU	124	99	-25	
	<USD 130/kgU	149	136	-13	
	<USD 260/kgU	193	196	3	
Central African Republic	**RAR**				Re-evaluation of resources associated with a feasibility study.
	<USD 260/kgU	12	32	20	
China	**RAR**				As a result of exploration activities, additional RAR and inferred resources have been added to the resource base in northern China (Yili, Erlian, Erdos, Songliao and Benxi basins) and in southern China (Xiangshan, Taoshan, Zhuguangnanbu and Dazhou uranium fields).
	<USD 40/kgU	46	52	6	
	<USD 80/kgU	89	94	5	
	<USD 130/kgU	110	120	11	
	<USD 260/kgU	110	120	11	
	Inferred				
	<USD 40/kgU	13	14	1	
	<USD 80/kgU	47	55	8	
	<USD 130/kgU	57	79	23	
	<USD 260/kgU	57	79	23	
Czech Republic	**RAR**				An increase in resource totals as a result of technical and economic re-evaluation of the existing resource base.
	<USD 260/kgU	0	51	51	
	Inferred				
	<USD 260/kgU	0	68	68	
France	**RAR**				Resources no longer reported.
	<USD 260/kgU	12	0	-12	

Table 1.5. Major identified resource changes by country (*continued*)

(recoverable resources in 1 000 tonnes U)

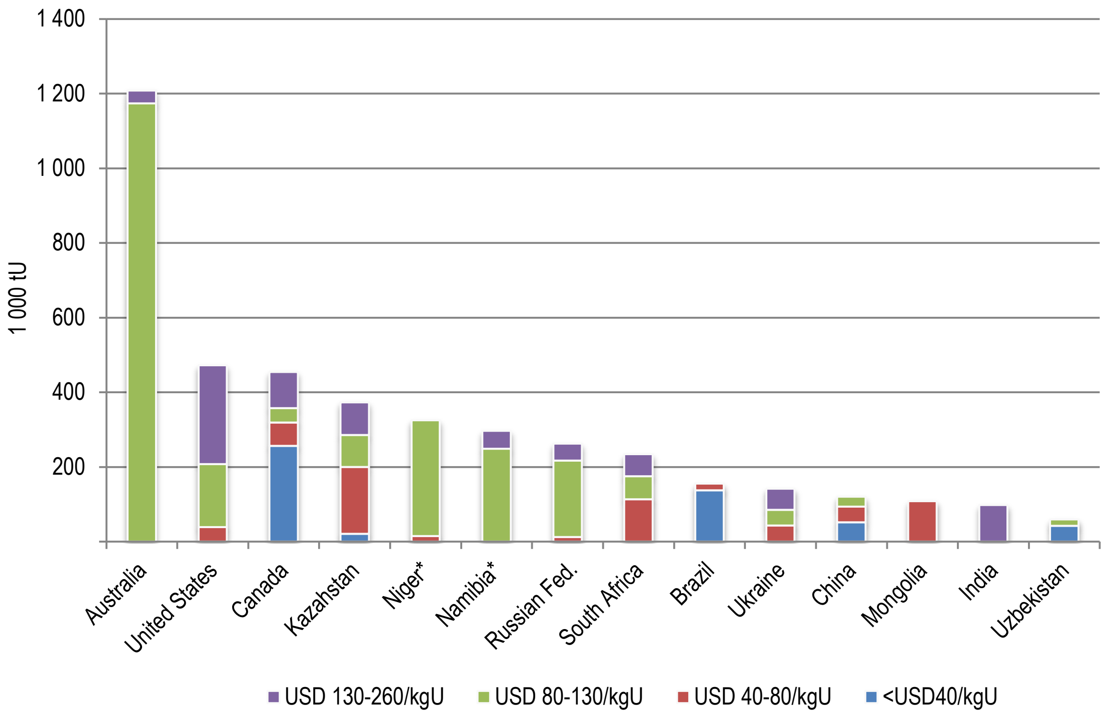
Country	Resource category	2011	2013	Changes	Reasons
Greenland	**Inferred**				Re-evaluation of rare earth elements and uranium resources in the Kvanefjeld deposit in south Greenland.
	<USD 260/kgU	135	221	87	
India	**RAR**				Additional resources identified in the contiguous area of deposits in the Cuddapah Basin and the extension of known deposits in the Singhbhum shear zone and Mazhadek basin.
	<USD 260/kgU	77	98	21	
	Inferred				
	<USD 260/kgU	28	22	-6	
Iran, Islamic Republic of	**Inferred**				Additions based on results of exploration activities.
	<USD 130/kgU	2	3	1	
	<USD 260/kgU	2	3	1	
Jordan	**Inferred**				Re-evaluation of resources.
	<USD 130/kgU	34	40	6	
	<USD 260/kgU	34	40	6	
Kazakhstan	**RAR**				Exploration adding to low-cost RAR and inferred resources, higher cost RAR decrease through mining depletion, increase in higher cost inferred resources through upgrade from prognosticated resources.
	<USD 40/kgU	17	20	3	
	<USD 80/kgU	245	200	-45	
	<USD 130/kgU	320	286	-34	
	<USD 260/kgU	402	373	-29	
	Inferred				
	<USD 40/kgU	30	69	39	
	<USD 80/kgU	241	316	75	
	<USD 130/kgU	309	394	85	
	<USD 260/kgU	417	503	86	
Mali	**RAR**				New Falea deposit.
	<USD 130/kgU	0	9	9	
	Inferred				
	<USD 130/kgU	0	5	5	
Mongolia	**RAR**				Increases primarily due to additional resources associated with the Gurvansaikhan, Ulziit and Zoovch ovoo sandstone-type deposits located in south-east Mongolia (Gurvansaikhan, Ulziit, Zuun Bayan basins).
	<USD 80/kgU	31	108	78	
	<USD 130/kgU	31	108	78	
	<USD 260/kgU	31	108	78	
	Inferred				
	<USD 80/kgU	25	33	8	
	<USD 130/kgU	25	33	8	
	<USD 260/kgU	25	33	8	
Namibia	**RAR**				Decrease in recoverable resources due to adjustment of recovery factors, production depletion and updated mine design plans.
	<USD 80/kgU	6	0	-6	
	<USD 130/kgU	235	248	13	
	<USD 260/kgU	363	297	-67	
	Inferred				
	<USD 80/kgU	1	0	-1	
	<USD 130/kgU	26	135	109	
	<USD 260/kgU	156	159	3	

Table 1.5. Major identified resource changes by country (*continued*)

(recoverable resources in 1 000 tonnes U)

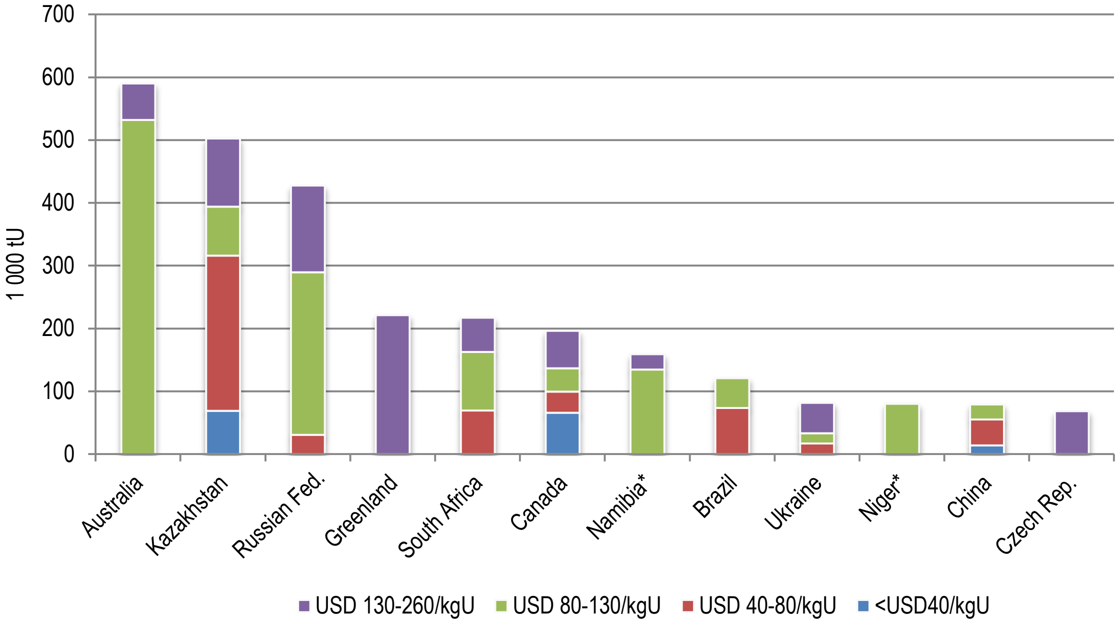
Country	Resource category	2011	2013	Changes	Reasons
Niger	**RAR**				Reductions due to technical and economic re-evaluation of resources and depletion by mining.
	<USD 80/kgU	5.5	15	9	
	<USD 130/kgU	339	325	-14	
	<USD 260/kgU	341	325	-16	
	Inferred				
	<USD 130/kgU	82	80	-2	
	<USD 260/kgU	105	80	-25	
Russian Federation	**RAR**				New inferred resources delineated and recent exploration activities resulted in a transfer of some inferred resources to RAR.
	<USD 130/kgU	173	217	44	
	<USD 260/kgU	218	262	44	
	Inferred				
	<USD 80/kgU	44	31	-13	
	<USD 130/kgU	314	289	-25	
	<USD 260/kgU	432	427	-5	
Slovak Republic	**RAR**				Increases owing to resource calculation in a pre-feasibility study for the Kosice deposit (Kuriskova area).
	<USD 80/kgU	0	9	9	
	<USD 130/kgU	0	9	9	
	<USD 260/kgU	0	9	9	
	Inferred				
	<USD 80/kgU	6	4	-2	
	<USD 130/kgU	9	7	-2	
	<USD 260/kgU	9	7	-2	
South Africa	**RAR**				Additional information from extensive drilling programmes resulted in revised geological modelling and estimates combined with commodity price changes and increased mining costs resulting in cut-off grade increases.
	<USD 80/kgU	96	113	17	
	<USD 130/kgU	145	175	31	
	<USD 260/kgU	193	234	41	
	Inferred				
	<USD 80/kgU	90	69	-20	
	<USD 130/kgU	134	163	28	
	<USD 260/kgU	179	217	38	
Tanzania	**RAR**				Additional drilling and re-evaluation of the Mkuju and Likuyu deposits.
	<USD 130/kgU	29	40	12	
	<USD 260/kgU	30	40	10	
	Inferred				
	<USD 130/kgU	8	18	10	
	<USD 260/kgU	16	18	2	
Zambia	**RAR**				Additional drilling and re-evaluation of the Muntanga and Lumwana deposits.
	<USD 130/kgU	0	10	10	
	Inferred				
	<USD 130/kgU	0	15	15	
	<USD 260/kgU	6	15	9	

Figure 1.2. Distribution of reasonably assured resources (RAR) among countries with a significant share of resources



* Secretariat estimate.

Figure 1.3. Distribution of inferred resources (IR) among countries with a significant share of resources



* Secretariat estimate.

Distribution of resources by production method

In 2013, countries once again were asked to report identified resources by cost categories and by the expected production method, i.e. open-pit or underground mining, *in situ* leaching (ISL, sometimes referred to as *in situ* recovery, or ISR), heap leaching or in-place leaching, co-product/by-product or as unspecified.

In the lowest cost category, <USD 40/kgU, underground mining is the dominant production method for RAR (Table 1.6), mainly from Canada and to a lesser extent China. Production by ISL is the second most important, with Kazakhstan being the primary producer. Resources in the by/co-product category make a significant contribution, mainly from Brazil, with ISL from China and Kazakhstan making up most of the rest. The total is likely underestimated because of the difficulty in assigning mining costs accurately in the by/co-product category, particularly in Australia. In the <USD 80/kgU category, resources produced by underground mining and ISL methods make the largest contributions. This contrasts with the last reporting period where co/by-product resources associated mainly with the Olympic Dam deposit dominated this cost category. Increasing mining costs have resulted in resources at Olympic Dam being transferred to the <USD 130/kgU category. There is now a more even distribution of resources associated with open-pit, underground and co/by-product categories in both the <USD 130/kgU and <USD 260/kgU categories (Table 1.6). However in the highest cost category, underground mining still dominates. Canada holds the largest resource total for underground mining while Namibia and Niger make the largest contribution to open-pit production. Olympic Dam is responsible for the majority of the co/by-product category with South Africa and Brazil making significant contributions. ISL makes an important contribution in all cost categories with Kazakhstan being the major player.

Table 1.6. Reasonably assured resources by production method

(recoverable resources as of 1 January 2013, tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining	8 160	80 141	918 993	1 142 771
Underground mining	331 450	479 089	944 213	1 400 659
In situ leaching acid	96 690	408 864	493 333	542 333
In situ leaching alkaline	0	36 592	88 530	110 991
Co-product/by-product	71 100	201 924	1 199 336	1 303 453
Unspecified	0	4 990	54 495	86 993
Total	**507 400**	**1 211 600**	**3 698 900**	**4 587 200**

The pattern of production method for IR is only slightly different from that of RAR (Table 1.7). In the lowest cost categories (<USD 40/kgU and <USD 80/kgU) ISL is dominant. In the higher cost categories (<USD 130/kgU and <USD 260/kgU) underground mining dominates with co-product/by-product, with ISL and open-pit mining making significant contributions. The United States does not report IR by production method, leading to under-representation in the ISL alkaline category.

Table 1.7. Inferred resources by production method

(recoverable resources as of 1 January 2013, tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining	2 431	17 971	459 316	530 639
Underground mining	69 814	190 998	602 127	903 854
In situ leaching acid	103 255	392 382	488 039	589 039
In situ leaching alkaline	0	0	0	0
Co-product/by-product	0	100 488	571 529	867 769
Unspecified	0	43 261	82 989	156 699
Total	**175 500**	**745 100**	**2 204 000**	**3 048 000**

Distribution of resources by processing method

In 2013, countries were once again requested to report identified resources by cost categories and by the expected processing method, i.e. conventional from open-pit or underground mining, ISL, in-place leaching, heap leaching from open-pit or heap leaching from underground or as unspecified. It should be noted that not all countries reported their resources according to processing method.

In all cost categories for RAR (Table 1.8) conventional processing from underground mining is the major contributor, with Australia dominating because of Olympic Dam. In the higher cost categories, conventional processing from open-pit and ISL make increasing contributions, but even when combined do not surpass the underground resources. In the IR category (Table 1.9), ISL dominates in the two lower cost categories but in the two higher cost categories it is replaced by underground conventional methods with totals more than twice that of ISL. The amount that is reported as unspecified is important because the exploration of many deposits is insufficiently advanced for any mine planning to have been carried out. Note that the United States does not report IR by production method, leading to under-representation in the ISL alkaline category in Table 1.9.

Table 1.8. Reasonably assured resources by processing method

(recoverable resources as of 1 January 2013, tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from OP	6 760	61 259	605 492	711 093
Conventional from UG	331 450	592 113	1 957 606	2 313 312
In situ leaching acid	96 553	408 864	493 333	542 333
In situ leaching alkaline	0	36 592	88 530	110 991
In-place leaching*	0	0	500	3 653
Heap leaching** from OP	1 400	16 410	277 654	306 653
Heap leaching** from UG	0	0	13 680	16 682
Unspecified	71 237	96 362	262 105	582 483
Total	**507 400**	**1 211 600**	**3 698 900**	**4 587 200**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Table 1.9. Inferred resources by processing method

(recoverable resources as of 1 January 2013, tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from OP	2 431	16 483	343 146	414 381
Conventional from UG	69 814	260 284	1 088 556	1 407 079
In situ leaching acid	103 255	392 382	488 039	588 939
In situ leaching alkaline	0	0	0	0
In-place leaching*	0	0	2 100	13 468
Heap leaching** from OP	0	1 488	76 170	76 170
Heap leaching** from UG	0	0	4 400	14 679
Unspecified	0	74 463	201 589	533 284
Total	**175 500**	**745 100**	**2 204 000**	**3 048 000**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Distribution of resources by deposit type

In 2013, countries also reported identified resources by cost categories and by geological types of deposits using a new deposit classification scheme (Appendix 3). In the lowest cost RAR (<USD 40/kgU) category, Proterozoic unconformity-related deposits in Canada dominate, with smaller contributions from sandstone, metasomatite, phosphate, granite-related and unspecified-type deposits (Table 1.10).

Table 1.10. Reasonably assured resources by deposit type

(recoverable resources as of 1 January 2013, tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	256 160	318 917	463 272	569 120
Sandstone	96 553	511 153	1 165 707	1 467 697
Polymetallic iron-oxide breccia complex	0	0	942 300	943 000
Paleo-quartz-pebble conglomerate(a)	0	113 034	169 536	231 303
Granite-related	17 800	40 100	46 670	82 984
Metamorphite	0	2 802	8 332	34 879
Intrusive	0	0	198 879	268 940
Volcanic-related	0	34 082	139 695	164 913
Metasomatite	65 900	101 848	285 958	410 886
Surficial deposits	0	0	110 108	140 154
Carbonate	0	0	0	40 304
Collapse breccia pipe	400	400	400	400
Phosphate	53 200	53 200	94 000	94 000
Lignite – coal	0	0	0	0
Black shale	0	0	0	0
Unspecified	17 387	36 064	74 043	138 620
Total	**507 400**	**1 211 600**	**3 698 900**	**4 587 200**

(a) In South Africa, Paleo-quartz-pebble conglomerate resources include resources contained in tailings.

Sandstone resources (in Kazakhstan, Niger and the United States) dominate the <USD 80/kgU category. Polymetallic iron-oxide breccia complex deposits in Australia become important in the <USD 130/kgU category, and are only surpassed by sandstone-related resources with Proterozoic unconformity-related and metasomatite resources still making important contributions. Other types of deposits take larger shares of the total only in the two highest cost categories with significant shares of resources attributed to metasomatite, intrusive and paleo-quartz-pebble conglomerate types in the <USD 260/kgU category (Table 1.10).

Similar observations can be made in the IR category (Table 1.11). In the <USD 260/kgU and <USD 130/kgU category, sandstone-hosted resources dominate with metasomatite and polymetallic iron-oxide breccia complex resources, the next most important deposit types. Sandstone deposits dominate the <USD 80/kgU cost category, followed by metasomatite and Proterozoic unconformity deposits. In the lowest cost category (<USD 40/kgU) sandstone deposits dominate, followed by the Proterozoic unconformity-type which makes a moderate contribution and volcanic-type deposits which make a very small contribution.

Table 1.11. Inferred resources by deposit type

(recoverable resources as of 1 January 2013, tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	65 614	92 150	166 873	195 607
Sandstone	105 192	425 668	743 333	921 467
Polymetallic iron-oxide breccia complex	0	0	403 400	408 900
Paleo-quartz-pebble conglomerate(a)	0	79 786	114 429	168 283
Granite-related	0	1 000	52 304	60 796
Metamorphite	0	700	825	16 157
Intrusive	0	0	98 744	378 119
Volcanic-related	480	41 907	89 595	126 808
Metasomatite	0	19 535	286 519	460 116
Surficial deposits	0	0	97 140	123 695
Carbonate	0	0	0	5 835
Collapse breccia pipe	0	18 600	18 600	18 600
Phosphate	0	31 200	34 000	36 700
Lignite – coal	0	0	47 844	63 792
Black shale	0	0	0	0
Unspecified	4 214	34 554	50 394	63 125
Total	**175 500**	**745 100**	**2 204 000**	**3 048 000**

(a) In South Africa, Paleo-quartz-pebble conglomerate resources include resources contained in tailings.

Proximity of resources to production centres

A total of ten countries provided estimates on the availability of resources for near-term production by reporting the percentage of identified resources (RAR and inferred resources) recoverable at costs of <USD 80/kgU and <USD 130/kgU that are tributary to existing and committed production centres (Table 1.12). Resources tributary to existing and committed production centres in the ten countries listed total 1 099 921 tU at <USD 80/kgU (about 78% of the total resources reported in this cost category). This is 57% lower than the 2011 value of 2 575 786 tU. This large drop can be attributed primarily to transfer of lower cost resources into higher cost categories in Australia in addition to China and Ukraine not providing data in this reporting period. Resources tributary to existing and committed production centres in the ten countries listed total 3 154 147 tU at <USD 130/kgU (about 66% of the total resources reported in this cost category). This is 9% higher than the 2 906 468 tU reported in 2011.

Table 1.12. Identified resources proximate to existing or committed production centres*

Country	RAR + inferred recoverable at <USD 80/kgU in existing or committed production centres			RAR + inferred recoverable at <USD 130/kgU in existing or committed centres		
	Total resources (tU)	%	Proximate resources (tU)	Total resources (tU)	%	Proximate resources (tU)
Australia	NA	NA	NA	1 706 100	80	1 364 880
Brazil	228 700	66	150 942	276 100	66	182 226
Canada	418 311	80	334 649	493 854	62	306 189
Czech Republic	0	0	0	1 356	100	1 356
Iran, Islamic Rep. of	0	0	0	4 408	59	2 601
Kazakhstan	515 749	93	479 647	679 316	82	557 039
Namibia	0	0	0	382 870	29	137 546
Niger	15 449	100	15 449	404 914	84	338 913
Russian Federation	42 300	75	31 725	505 900	26	131 534
South Africa	182 310	48	87 509	338 109	39	131 863
Total	**1 402 819**	**78**	**1 099 921**	**4 792 927**	**66**	**3 154 147**

NA = not available. * Identified resources only in countries that reported proximity to production centres; not world total.

Additional conventional resources

The Secretariat identified additional identified resources (Table 1.13) since some countries do not include resource determinations by junior exploration companies in national totals until additional information is provided to the pertinent agencies or until a mining licence application is filed (e.g. Peru) and others do not always have sufficient human resources to provide detailed information and evaluation as requested in the questionnaire. The table, included for the first time in the 2011 Red Book, is a Secretariat estimate based on technical reports of resources that have been classified either as Joint Ore Reserves Committee (JORC), NI 43-101 or South African Mineral Resource Committee (SAMREC) compliant.

These additional resources amount to a total of 119 100 tU classified as RAR and IR in several countries that are not included in Tables 1.2, 1.3 and 1.4. The most significant "additional resources" occur in Mauritania (29 100 tU), Peru (22 400 tU) and Spain (18 000 tU).

Table 1.13. Additional identified resources

(rounded to nearest 100 tU)

Country	Deposit/project	RAR and inferred resources
Bulgaria	ISL mineable deposits	7 900
Cameroon	Kitongo	11 100
	Lolodorf	1 000
Colombia	Berlin	8 200
Egypt	Gabal Gutter	2 000
	Abu Zenima	100
Guinea	Firawa	7 500
Guyana	Kurupung	6 200
Mauritania	Bin En Nar	800
	A238	9 000
	Reguibat	19 300
Paraguay	Yuty	4 300
Peru	Kihition	11 200
	Colibri 2 and 3	8 600
	Corachapi	2 700
	Triunfador	1 200
Spain	Salamanca	18 000
Total[a]		**119 100**

(a) Amount not reported in RAR and IR national totals but may include amounts reported as undiscovered resources.

Undiscovered resources

Undiscovered resources (*prognosticated* and *speculative*) refer to resources that are expected to occur based on geological knowledge of previously discovered deposits and regional geological mapping. *Prognosticated resources* (PR) refer to those expected to occur in known uranium provinces, generally supported by some direct evidence. *Speculative resources* (RS) refer to those expected to occur in geological provinces that may host uranium deposits. Both prognosticated and speculative resources require significant amounts of exploration before their existence can be confirmed and grades and tonnages can be more accurately determined. All PR and SR are reported as *in situ* resources (Table 1.14).

Worldwide, reporting of PR and SR is incomplete, as only 26 countries have historically reported resources in this category. A total of 20 countries reported undiscovered resources for this edition, compared to the 37 with RAR. Only 12 countries of those reporting provided updated undiscovered resource figures for this edition. Twenty-one countries report both prognosticated and speculative resources, including Chile which reports SR and PR as one combined figure. Germany, Italy, Jordan, Venezuela, and Zimbabwe reported only speculative resources, whereas Bulgaria, Greece, Portugal, the Slovak Republic, Slovenia and Uzbekistan reported only prognosticated resources. Some of the countries that do not report undiscovered resources, such as Australia are considered to have significant resource potential in as yet sparsely explored areas. The United States did not report data for this edition as previous estimates developed in 1980 need re-evaluation to determine their accuracy.

Table 1.14. Reported undiscovered resources*

(in 1 000 tU as of 1 January 2013)

Country	Prognosticated resources			Speculative resources			Total SR
	Cost ranges			Cost ranges			
	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	<USD 130/kgU	<USD 260/kgU	Cost range unassigned	
Argentina	NA	13.8	13.8	NA	56.4	NA	56.4
Brazil(a)	300.0	300.0	300.0	NA	NA	500.0	500.0
Bulgaria(c)	NA	NA	25.0	NA	NA	NA	NA
Canada	50.0	150.0	150.0	700.0	700.0	0.0	700.0
Chile(b, d)	NA	NA	2.3	NA	NA	2.3	2.3
China(c)	3.6	3.6	3.6	4.1	4.1	NA	4.1
Colombia(c)	NA	11.0	11.0	217.0	217.0	NA	217.0
Czech Republic	0.0	0.2	222.9	0.0	0.0	17.0	17.0
Germany(a)	NA	NA	NA	NA	NA	74.0	74.0
Greece(c)	6.0	6.0	6.0	NA	NA	NA	NA
Hungary	0.0	0.0	13.4	NA	NA	NA	NA
India	NA	NA	84.8	NA	NA	42.4	42.4
Indonesia	NA	NA	23.5	NA	NA	22.0	22.0
Iran, Islamic Republic of(b)	0.0	12.4	12.4	0.0	0.0	32.7	32.7
Italy(a)	0.0	0.0	0.0	10.0	10.0	0.0	10.0
Jordan	0.0	0.0	0.0	0.0	50.0	NA	50.0
Kazakhstan	217.5	403.4	404.9	270.5	300.0	NA	300.0
Mexico(c)	NA	3.0	3.0	NA	NA	10.0	10.0
Mongolia	21.0	21.0	21.0	1 390	1 390.0	NA	1 390.0
Namibia	0.0	0.0	57.0	0.0	0.0	110.7	110.7
Niger(c)	NA	13.6	13.6	0	51.3	NA	51.3
Peru(b)	6.6	20.0	20.0	19.7	19.7	0.0	19.7
Portugal	1.0	1.5	1.5	NA	NA	NA	NA
Romania(c)	NA	3.0	3.0	3.0	3.0	NA	3.0
Russian Federation	0.0	112.0	112.0	NA	NA	452.0	452.0
Slovak Republic(b)	0.0	3.7	10.9	NA	NA	NA	NA
Slovenia(c)	0.0	1.1	1.1	NA	NA	NA	NA
South Africa(a)	34.9	110.3	110.3	0.0	0.0	1 113.0	1 113.0
Ukraine(b)	0.0	8.4	22.5	0.0	120.0	135.0	255.0
United States	NA	NA	NA	NA	NA	NA	NA
Uzbekistan(c)	24.8	24.8	24.8	0.0	0.0	0.0	0.0
Venezuela(c)	NA	NA	NA	0.0	0.0	163.0	163.0
Viet Nam	NA	NA	81.2	NA	NA	321.6	321.6
Zimbabwe(c)	0.0	0.0	0.0	25.0	25.0	NA	25.0
Total	**665.4**	**1 222.8**	**1 755.5**	**2 639.3**	**2 946.5**	**2 995.7**	**5 942.2**

* Undiscovered resources are reported as *in situ* resources.

NA = Data not available.

(a) Reported in 2013 responses, but values have not been updated within last five years.

(b) Reported in 2013 responses, but only partially assessed within last five years.

(c) Not reported in 2013 responses, data from previous Red Book.

(d) National report combines PR and SR.

Total PR in the highest cost category (<USD 260/kgU) amounted to about 1.76 million tU, a notable 52% decrease compared to 2011. Increases reported in Argentina, the Czech Republic, India, Indonesia, the Islamic Republic of Iran, Namibia, the Slovak Republic and Viet Nam amounted to less than the major decline resulting from no data being reported by the United States and declines reported in Hungary, Jordan, Kazakhstan and the Russian Federation. In parallel with the trends observed in the <USD 260/kgU category, the lower cost categories (i.e. <USD 130/kgU and <USD 80/kgU) dropped by 55% and 59% respectively, compared to 2011.

Total SR in the <USD 260/kgU cost category (2.9 million tU) declined by 21% compared to 2011 as only Argentina reported an increase in this category. The total SR in the <USD 130/kgU cost category (2.6 million tU) dropped by 26% from 2011. Similar to PR, the overall decline can be attributed mainly to the United States not reporting SR in this edition. In the unassigned category, despite increases reported for Hungary, the Islamic Republic of Iran, Namibia and Viet Nam, compared to 2011, total SR decreased by 20%, again because of the missing data from the United States as well as lower values reported in the Czech Republic and the Russian Federation.

High-cost (<USD 260/kgU) PR and total SR amount to a combined total of 7 697 800 tU, a decrease of 2 738 800 tU compared to the total of 10 436 600 tU reported in 2011. In 2011, the United States reported a total of 2 613 000 tU total SR and PR, hence a large percentage (95%) of the decline can be attributed to the United States not reporting undiscovered resources in 2013.

Other resources and materials

Conventional resources are defined as resources from which uranium is recoverable as a primary product, a co-product or an important by-product, while *unconventional resources* are resources from which uranium is only recoverable as a minor by-product, such as uranium associated with phosphate rocks, non-ferrous ores, carbonatite, black shale and lignite. Most of the unconventional uranium resources reported to date are associated with uranium in phosphate rocks, but other potential sources exist (e.g. black shale and seawater).

Since 2009, a combination of expectations of rising medium-term demand and sustainability issues, have stimulated investigation of a variety of projects, extraction technologies and business models on the part of both governments and commercial entities. Interest in recovery of uranium from phosphates has been the primary focus for both economic and environmental reasons. This prompted a series of the International Atomic Energy Agency (IAEA) supported consultancies and technical meetings in 2010 and 2011, as well as a sequence of capacity-building workshops and training courses beginning with a major workshop in Marrakech, Morocco in November 2011, followed by Amman, Jordan (2012) and Tunis, Tunisia (2013). A national project was active in Tunisia (2012-13) and new projects are being planned in the Philippines (2014-15) and Egypt (2014-15).

Since few countries reported updated information, a comprehensive compilation of unconventional uranium resources and other potential nuclear fuel materials is not possible. Instead, a summary of information documented over recent years and data reported in this edition is provided. Table 1.15 summarises unconventional resource estimates reported in Red Books between 1965 and 2003 (NEA, 2006) and incorporates unconventional resource assessments included in the national reports of this edition in order to illustrate the evolution of these resource estimates.

Unconventional uranium resources were reported occasionally by countries in Red Books beginning in 1965. Earlier estimates for Jordan appear to have overestimated uranium contained in phosphate, whereas estimates of black schists (shales) in Finland and Sweden appear to have underestimated contained uranium (Table 1.15). Other estimates of uranium resources associated with marine and organic phosphorite deposits point to the existence of almost 9 million tU in Jordan, Mexico, Morocco and the United States alone (IAEA, 2001). Others have estimated the global total to amount to 22 million tU (De Voto and Stevens, 1979). Recent data from the International Fertilizer Development Centre (IFDC) indicates that the latter figure is probably a very conservative estimate of total resources, but is likely to be a reasonably accurate reflection of commercially exploitable resources (Hilton et al., forthcoming).

The figures presented in Table 1.15 can be expected to continue to evolve and are clearly incomplete, since large uranium resources associated with the Chattanooga (United States) and Ronneburg (Germany) black shales, which combined are estimated to contain a total of 4.2 million tU, are not listed. Neither are large uranium resources associated with monazite-bearing coastal sands in Brazil, India, Egypt, Malaysia, Sri Lanka and the United States. Unconventional resources are also not regularly reported in former USSR countries. The total uranium reported in previous Red Books as unconventional resources, dominated by phosphorite deposits in Morocco (>85%), were conservatively estimated to amount to about 7.0-7.3 million tU. The estimated total unconventional uranium resources in this edition are 7.3 to 8.4 million tU, which is an increase of approximately 4.5% since the last report. The potential to expand the unconventional uranium resource base is clear but will likely not be fully realised until market conditions strengthen considerably.

Table 1.15. Unconventional uranium resources (1 000 tU) reported in 1965-2003 Red Books with updated figures from 2011-2013 (in brackets)

Country	Phosphate rocks	Non-ferrous ores	Carbonatite	Black schist/shales, lignite
Brazil*	28.0-70.0 (84.4)	2	13	
Chile	0.6-2.8 (7.2#)	4.5-5.2		
Columbia	20.0-60.0			
Egypt**	35.0-100.0			
Finland	1 (1#)		25 (2.5)	30-9.0 (22)
Greece	0.5			
India	17-2.5	6.6-22.9		4
Jordan	100-123.4 (60#)			
Kazakhstan	58			
Mexico	100-151 (240#)	1		
Morocco	6,526			
Peru	20 (21.6#)	0.14-1.41		
South Africa***				77
Sweden	42.3			300 (967.6)
Syria	60.0-80.0			
Thailand	0.5-1.5			
United States	140-330	1.8		
Venezuela	42			
Viet Nam				0.5

Not reported in 2013 responses, data from 2011 Red Book.

* Considered a conventional resource in Brazil and is thus included in conventional resource figures (Table 1.4).

** Includes an unknown quantity of uranium contained in monazite.

*** Also reports resources in phosphorite but does not provide tonnage estimates.

In 2013, only Finland and Sweden reported new values for unconventional uranium resources (Table 1.15). Finland updated the amount reported for uranium associated with Talvivaara to 22 000 tU and Sweden reported an increase in resources associated with black shales/schists now amounting to 967 617 tU (includes the Haggan deposit, 307 692 tU; MMS Viken, 3 825 tU and Narke uranium oil, 257 000 tU).

The potential to expand the unconventional uranium resource base is strongly tied to the ability to bring these resources into production. This will depend on *i)* market conditions, notably for the commercial recovery of phosphate reserves, since these determine the underlying economics of by-product uranium recovery; and *ii)* changing policy, notably to require uranium and other critical resources such as rare earth elements to be extracted for strategic and sustainability reasons rather than on a commercial basis. Policy drivers might include the need to enhance the security of uranium supply to the national nuclear fuel cycle or to reap the environmental benefits of extracting uranium from phosphoric acid rather than by conventional mining, along with minimising the already very low amounts of uranium contained in fertiliser products.

If uranium prices reach long-term levels in excess of USD 260/kgU (USD 100/lb U_3O_8), and/or improvements are made in reducing mining and processing costs, by-product recovery of uranium from unconventional resources could once again become commercially viable, even without the policy change noted above.

Uranium from phosphates

In the market scenario, phosphate deposits will only be processed commercially when it is intrinsically economically viable to do so. Hence, the phosphate market acts as the determining factor of how much uranium can even theoretically be extracted from phosphate resources.

In the policy-driven scenario, the value of other recoverable elements will be added by various means, such as long-term government contracts, to the overall economic evaluation. Governments could also place a premium on securing the supply of nuclear fuel, especially where this can come from national resources, thereby eliminating dependency on third parties. In some countries, uranium extraction from phosphates could perhaps be mandated.

A hybrid situation (market and policy driven scenario) may, however, be the most sustainable scenario over the long term. The need to combine fuel security to the utility company with commercial viability to the phosphate company and to align these requirements with the equally significant role of phosphates in providing food security could drive new business models. One benchmark in Brazil has already been set for this scenario, the Santa Quitéria greenfield joint venture between the government company, *Indústrias Nucleares do Brasil* (INB), and Galvani phosphates, with a prime customer Eletrobras, owner of the national nuclear power operator, Eletronuclear. This project will produce both yellow cake and diammonium phosphate (DAP) in a single integrated process, thus spreading business risk across both phosphates and uranium. The alternative model is where a government will step in as customer, as in India, on the premise that the wider challenge of sustaining energy production as the fundamental driver of economic development justifies an off-set of risk from the commercial producer to the tax payer. Under the hybrid option, both phosphate and uranium are managed as utility products and not as market-dependent commodities.

An Australian company, Uranium Equities is working with uranium major Cameco on the PhosEnergy process, a market based development to remove uranium from phosphate streams during the fertiliser production process. In May 2012, the company commissioned the construction of a portable demonstration plant in the United States and completed four ten-day tests at two different fertiliser plants. Positive results have been reported with uranium recovery of more than 90%. A pre-feasibility study estimated the production cost of uranium concentrate at about USD 20/lb U_3O_8 (USD 46/kgU), with other costs dependent on the size of the plant. It is estimated that it would cost about USD 156 million for a 1 Mtpa P_2O_5 phosphate facility in south-eastern United States.

Uranium from seawater

Seawater has long been regarded as a possible source of uranium due to the large amount of contained uranium (over 4 billion tU) and its almost inexhaustible nature. However, because of the low concentration of uranium in seawater (3-4 parts per billion), developing a cost-effective method of extraction remains a challenge.

Research on uranium recovery from seawater was carried out in Germany, Italy, Japan, the United Kingdom and the United States from the 1950s through the 1980s and more recently in Japan. In 2012, researchers at the US Department of Energy's Oak Ridge National Laboratory and Pacific Northwest National Laboratory reported encouraging results through the use of innovative improvements to Japanese technology tested in the late 1990s (Ferguson, 2012). By using plastic fibres with a surface area ten times greater than the Japanese design, the amount of uranium recovered has been doubled, reducing overall production costs from about USD 1 230/kgU to USD 660/kgU, with further cost reducing improvements being tested. Although not commercially oriented, the goal of the research is to determine the minimum cost of a virtually limitless supply of uranium in order to guide future fuel cycle decisions. Many Chinese research groups in universities and institutions have also shown interest in uranium extraction from seawater. A 2013 workshop on the subject in Shanghai drew more than 80 attendees from China and 5 delegates from the United States.

Other potential sources

Although uranium recovery from tailings and coal ash is being considered, these projects, as currently outlined, would contribute annually only small amounts of material, likely on the order of a few hundred tU/yr from each operation. In South Africa, extraction of uranium in the Mine Waste Solution Uranium Plant, which will be processing uranium from the tailings, was planned to begin by the end of 2013. AngloGold Ashanti acquired the Mine Waste Solutions (MWS) tailings retreatment operation in the Vaal River region in July 2012. MWS comprises tailings storage facilities that originated from the processing of ore from the Buffelsfontein, Hartebeestfontein and the Stilfontein gold mines. The plant is still being commissioned and the current plan is to extract uranium from the tailings at the end of 2014. Other future operations in South Africa may include processing of uranium from tailings at the Ezulwini Uranium Plant.

Thorium

Thorium (Th) is a silvery white, radioactive metal found in small quantities in most rocks and soils. Its global crustal abundance in the earth's crust is between three and five times that of uranium. Thorium in mineral form occurs as oxides, silicates and phosphates, often with rare earth elements (REE), niobium and tantalum.

Various classification schemes have been proposed for thorium-bearing deposits. At the simplest level thorium is found in four main types of deposits, which are (in decreasing order of importance): placer, carbonatite-hosted, vein-type and alkaline rock-hosted deposits (Table 1.16). Other, less important deposit types are also known.

Placer-type deposits range in age from the Archean, such as the paleo-quartz pebble conglomerates in the Witwatersrand Basin, to Tertiary and recent deposits of heavy mineral coastal sands in Australia, Brazil, India, Mozambique, South Africa and the eastern United States. Carbonatite-hosted thorium deposits are common around the world and are documented in Argentina, Australia, Brazil, Canada, the Russian Federation, Scandinavia (Finland, Norway, Sweden), South Africa and the United States. Vein-type and alkaline-rock-hosted deposits are equally widespread, occurring on all continents. Some thorium-rich deposits, such as the enormous Bayan Obo deposit in

China, are difficult to assign to a specific deposit-type category since they display characteristics of carbonatite, alkaline and vein-type deposits, and accordingly several genetic theories have been proposed. Currently, beach sand deposits in Brazil and India are the only sources of thorium, and this type of deposit is likely to remain an important source of thorium production.

Table 1.16. Major thorium deposit types and resources*

Deposit type	Resources (1 000 t Th)
Placer	2 182
Carbonatite	1 783
Vein-type	1 528
Alkaline rocks	584
Other/unknown	135
Total	**6 212**

* (IAEA ThDEPO, in preparation).

There are a few REE mining-development projects that have possible Th by-product and Th containing residues that have the potential to come into production in the near term. One such project is Nolans Bore in Australia, which contains about 81 810 tonnes of Th in 30.3 Mt of measured, indicated and inferred resources grading 2.8% rare-earth oxides, 12.9% P_2O_5, 0.017% U and 0.27% Th. The proponents are considering establishing an intermediate processing facility to recover REEs at the Nolans Bore mine site in Northern Territory.

At Steenkampskraal, South Africa, from the 1950s and to 1963, about 50 000 tonnes of monazite concentrates were extracted which contained between 3.3 and 7.6% Th before operation of the mine was halted. Historical resource estimates are 15 000 tonnes Th. Total rare-earth oxides (TREO) including yttrium estimates (*in situ* and in tailings) were updated in 2012 to NI 43-101 complaint resources of 86 900 tonnes. A preliminary economic assessment was completed in 2012 and the refurbishment of the mine is under progress for a planned restart in the near future. Thorium will be extracted from the mixed rare-earth chloride concentrate, then mixed with concrete and stored in designated areas and stockpiled at an expected rate of about 360 t/yr.

A pre-feasibility report was released in 2011 for the Kvanefjeld rare-earth element project of the Ilimausaq intrusion. In 2013, Greenland's parliament voted in favour of lifting the country's long-standing ban on the extraction of radioactive materials, including uranium. The move could enable the Kvanefjeld Project to proceed, which is currently the subject of a definitive feasibility study to evaluate a mining operation for the production of uranium, rare earth elements and zinc. If the deposit were to be mined, uranium could be recovered as a by-product while thorium would be precipitated with other impurities such as iron, aluminium and silica and stored in a residue storage facility with the possibility of recovering the Th in the future.

The by-product nature of the occurrence of thorium and a lack of economic interest has meant that thorium resources have seldom, if ever, been accurately defined. Information on thorium resources was published in Red Books between 1965 and 1981, typically using the same terminology as for uranium resources at that time (e.g. reasonably assured resources and estimated additional resources I and II, the latter two categories which are now termed inferred and prognosticated resources, respectively). No further information was published until 2003 when a global estimate of thorium resources of 4.5 million tTh was presented in the 2003 Red Book. A more comprehensive report was presented in the 2007 Red Book where resource estimates were given by deposit type and by countries and this was updated in the 2009 edition.

Currently, the worldwide thorium resources by major deposit types are estimated to total about 6.2 million tonnes Th including undiscovered resources (Table 1.16).

In 2011 and 2013 the IAEA conducted technical meetings on thorium resources. Based on the inputs given in the meetings and details available in other open sources, total thorium resources, regardless of resource category or cost category, have been updated for 16 of the 35 countries listed (Table 1.17).

Thorium as a nuclear fuel

Similar to uranium, thorium can be used as a nuclear fuel. Although not fissile itself, ^{232}Th, when loaded into a nuclear reactor, absorbs neutrons to produce ^{233}U, which is fissile (and long-lived). Much of the ^{233}U will then fission in the reactor. The used fuel can then be unloaded from the reactor and the remaining ^{233}U can be chemically separated from the thorium and used as fuel in a nuclear reactor.

The OECD/NEA (2011) noted an interest in several countries to use thorium as a nuclear fuel over the last few decades. Basic research and development, as well as operation of reactors with thorium fuel, has been conducted in Canada, Germany, India, Japan, the Russian Federation, the United Kingdom and the United States. Some examples include:

- Germany: The 15 MWe AVR (*Arbeitsgemeinschaft Versuchsreaktor*) experimental pebble bed reactor at Jülich operated between 1967-1988, partly as a test bed for various fuel pebbles, including thorium. The 300 MWe THTR (thorium high-temperature reactor), developed from the AVR, operated between 1983 and 1989 with 674 000 pebbles, over half containing Th/highly enriched uranium (HEU) fuel. In addition to these high-temperature reactors, thorium fuel was tested at the 60 MWe BWR in Lingen.
- United Kingdom: Thorium fuel elements with a 10:1 Th/U (HEU) ratio were irradiated in the 20 MWth Dragon reactor at Winfrith, for 741 full power days. The Dragon reactor was run between 1964 and 1973 as an OECD/Euratom co-operation project, involving Austria, Denmark, Sweden, Norway and Switzerland in addition to the United Kingdom.
- United States: Fuel was tested in one light water reactor (Shippingport) and two gas-cooled reactors: *i)* Shippingport operated as a light water breeding reactor between August 1977 and October 1982; *ii)* General Atomics' Peach Bottom high-temperature, graphite-moderated, helium-cooled reactor operated between 1967 and 1974 at 110 MWth, using high-enriched uranium with thorium and *iii)* The Fort St. Vrain reactor, the only commercial thorium-fuelled nuclear plant in the United States, was a high-temperature (700°C), graphite-moderated, helium-cooled reactor with a Th/HEU fuel designed to operate at 842 MWth (330 MWe). The fuel was arranged in hexagonal columns ("prisms") rather than as pebbles. Almost 25 tonnes of thorium were used as fuel for the reactor, and this achieved 170 GWd/t burn-up. The reactor operated from 1979 to 1989.
- Canada: Atomic Energy Canada Limited has more than 50 years of experience with thorium-based fuels, including burn-up to 47 GWd/t. So far some 25 tests have been performed in 3 research reactors and 1 pre-commercial reactor.
- India: The Kamini 30 kWth experimental neutron-source research reactor using ^{233}U started up in 1996 near Kalpakkam. The Kamini reactor was built adjacent to the 40 MWt fast breeder test reactor (FBTR), in which the ThO_2 is irradiated, producing ^{233}U for Kamini.

Table 1.17. Identified[1] thorium resources

Region	Country	Total thorium resources, tTh (*in situ*)
Europe	Turkey*	374 000
	Norway	87 000
	Greenland (Denmark)	86 000-93 000
	Finland*	60 000
	Russian Federation	55 000
	Sweden	50 000
	France	1 000
	Total	**713 000-720 000**
Americas	United States**	595 000
	Brazil	632 000
	Venezuela*	300 000
	Canada	172 000
	Peru	20 000
	Uruguay*	3 000
	Argentina	1 300
	Total	**1 723 300**
Africa	Egypt*	380 000
	South Africa	148 000
	Morocco*	30 000
	Nigeria*	29 000
	Madagascar*	22 000
	Angola*	10 000
	Mozambique	10 000
	Malawi*	9 000
	Kenya*	8 000
	Democratic Republic of the Congo*	2 500
	Others*	1 000
	Total	**649 500**
Asia	CIS* (excluding Russian Federation)	1 500 000
	- includes Kazakhstan, estimated	(>50 000)
	- includes Russian Federation, Asian part, estimated	(>100 000)
	- Uzbekistan, estimated	(5 000-10 000)
	- others	Unknown
	India	846 500
	China, estimated	>100 000 (including 9 000* Chinese Taipei)
	Iran, the Islamic Republic of*	30 000
	Malaysia	18 000
	Thailand*, estimated	10 000
	Viet Nam*, estimated	5 000-10 000
	Korea, Rep. of*	6 000
	Sri Lanka*, estimated	4 000
	Total	**>2 647 500-2 684 500**
Australia		595 000
World total		**6 355 300-6 372 300**

CIS = Commonwealth of Independent States.

1. Identified Th resources may not have the same meaning in terms of classification as identified U resources. Higher range of the estimates wherever given is taken for a region.

* Data not updated. ** Estimate of identified resources (RAR + inferred) of thorium in the United States is based on a recent comprehensive review of published data by the US Geological Survey (Staatz et al, 1979, 1980). Earlier estimates in the Red Book indicated thorium resources as much as 770 000 tonnes in the United States, which may have included estimates of undiscovered resources (prognosticated and speculative). This higher value cannot be replicated or substantiated, so it is not repeated here.

Recent developments

Current research and development is being carried out on several concepts for advanced reactors including: high-temperature gas-cooled reactor (HTGR); molten salt reactor (MSR); Candu-type reactor; advanced heavy water reactor (AHWR); and fast breeder reactor (FBR).

Since 2008, Candu Energy of Canada and China National Nuclear Corporation are co-operating in the development of thorium and recycled uranium as alternative fuels for new CANDU reactors. In India, during mid-2010, a pre-licensing safety appraisal of the planned experimental thorium-fuelled 300 MW(e) AHWR was completed by the Atomic Energy Regulatory Board. The site-selection process started in 2011; the reactor is expected to become operational by 2020. However, full commercialisation of the AHWR is not expected before 2030. In January 2011, the China Academy of Sciences launched a research and development programme on a liquid fluoride thorium reactor, known at the academy as the thorium-breeding molten salt reactor (Th-MSR or TMSR). In April 2013, Thor Energy of Norway commenced a thorium-mixed oxide fuel (MOX) testing programme in the Halden research reactor in Norway. Fuel irradiation is being tested to determine if thorium-plutonium (Th-Pu) mixed oxide fuel can be used in commercial NPPs. Despite these tests, the use of thorium as reactor fuel has yet to be fully commercialised in a modern power reactor. As a result of the low demand for thorium, it has never been a primary exploration target. Its common association with uranium and/or especially REE has the consequence that thorium resources have been identified as a spin-off of exploration activities aimed at those commodities. In current market conditions, primary production of thorium is not economically viable.

Extraction of thorium as a by-product of REE recovery from monazite seems to be the most feasible source of thorium production at this time. Due to its high density and weak magnetism the recovery of monazite from raw sand or crushed ore is possible by physical separation techniques involving gravity and electrostatic methods. The monazite is then dissolved in either sodium hydroxide or sulphuric acid. The resulting solutions contain REE, uranium and thorium. This is followed by a multistage process using organic phases to achieve separation with a final product of ThO_2. Processing of monazite to recover rare-earths and thorium has been done in the past in many countries. Monazite concentrate production is currently taking place in Brazil, India, Malaysia and Viet Nam (USGS, 2011).

Uranium exploration

Non-domestic

Only four countries, China, France, Japan and the Russian Federation reported non-domestic exploration and mine development expenditures since 2008 (Table 1.18). The Russian Federation reported mine development expenditures in 2011 and 2012 were 79% and 71% respectively, of total expenditures. Exploration expenditures have declined since 2011 and 2013 expenditures are expected to be 45% lower than in 2012. China reported the mine development expenditures as 84% and 89% of total expenditures in 2011 and 2012, respectively. Non-domestic mine development expenses in China are expected to reach USD 563 million in 2013 due principally to investment in the Husab mine in Namibia. France and Japan reported only exploration expenditures. Total expenditures in Japan increased from 2011 to 2012 but are expected to decline in 2013. France reported a minor decrease from 2011 to 2012, but exploration expenditures are expected to increase 2013. Several countries do not report non-domestic expenditures or have not reported these expenditures recently so the data are incomplete. Previously, Canada reported significant expenditures (e.g. USD 139 million in 2007) and it is likely that Canada continues to be a leading investor in foreign exploration and development, but no information was reported for this edition. Australia is also known to make non-domestic investments, but figures have not been reported since 2006.

Domestic

Twenty-five countries reported domestic exploration and development expenditures in this edition. Despite a slowdown in the industry in more recent years, following peak levels of activity associated with high uranium prices in 2007-2008, the majority of reporting countries have maintained domestic exploration and mine development expenditures above pre-2007 levels (Table 1.19). From 2011 to 2013, expenditures decreased in a number of countries, partly due to the declining uranium price which slowed down many exploration and mine development projects, particularly in the junior uranium mining sector. In Canada, although overall expenditures decreased, exploration expenditures increased by 3.5% from 2011 to 2012. In contrast, Australia reported a significant decrease in exploration expenditures from 2011 to 2012. Increased total expenditures from 2011 to 2012 were reported for Brazil, China, Ethiopia, the Islamic Republic of Iran, Kazakhstan, Niger, Poland, Spain, Tanzania, Turkey, Ukraine, the United States and Zambia. Expenditures are expected to remain the same or increase slightly in 2013, except in China, Poland and Tanzania, where decreases are expected. For Kazakhstan, a significant increase in exploration expenditures is expected in 2013. For 2011 to 2013, of the countries that reported exploration and development expenditures separately, China, the Islamic Republic of Iran, Namibia, the Russian Federation, South Africa and Ukraine reported more exploration than development expenditures (81-82%, 56-63%, 71-96%, 72-80%, 63-68%, and 73-100% of total exploration and development expenditures, respectively). In contrast, Canada, Tanzania, and the United States reported mainly higher percentages of development expenditures (77-78%, 49-62%, and 71-80%, respectively). In Finland, 90-95% of the total expenditures from 2010 to 2011 were related to exploration expenditures while in 2012, 95% was related to development expenses associated with the construction of the uranium recovery circuit at the Talvivaara nickel mine. In Turkey, development expenditures accounted for 70% of expenditures in 2011 but decreased to 10% in 2012. Expenditures in 2013 are expected to follow a similar trend to the previous few years with the exception of Namibia where development expenditures are expected to dominate (95%) due to development of the Husab deposit.

Table 1.18. Non-domestic uranium exploration and mine development expenditures

(USD thousands in year of expenditures)

Country	Pre-2006	2006	2007	2008	2009	2010	2011	2012	2013 (expected)
Australia	10 426(a)	4 580	NA	NA	NA	NA	NA	NA	NA
Belgium	4 500	0	0	0	0	0	0	0	0
Canada	91 443	124 546	139 655	NA	NA	NA	NA	NA	NA
China	NA	NA	160 000(b)	220 000(b)	193 020(c)	94 950	94 740	81 690	563 370
France	940 895	85 000	53 985	87 092	77 356	61 652	68 670(d)	64 596(d)	72 944(d)
Germany	403 158	0	0	0	0	0	0	0	0
Japan	418 331	NA	1 570(c)	3 810(c)	4 779(c)	3 020(c)	3 030(c)	5 371(c)	4 008(c)
Korea, Republic of	24 049	NA	NA	NA	NA	NA	NA	NA	NA
Russian Federation	NA	NA	NA	49 724	95 613	26 300	31 100	30 100	16 500
Spain	20 400	0	0	0	0	0	0	0	0
Switzerland	29 660	3	16	0	0	0	0	0	0
United Kingdom	61 263	0	0	0	0	0	0	0	0
United States	260 598(a)	NA	NA	NA	NA	NA	NA	NA	NA
Total	**2 264 723**	**214 129**	**355 226**	**360 626**	**370 768**	**185 922**	**197 540**	**181 757**	**656 822**

Note: Domestic exploration and development expenditures represent the total expenditure from domestic and foreign sources within each country. Expenditures abroad are thus a subset of domestic expenditures.

NA = Data not available. (a) From 2011 Red Book. (b) Government development expenditures only. (c) Government expenditures only. (d) Exploration expenditures only.

Table 1.19. Industry and government uranium exploration and mine development expenditures – domestic in countries listed

(USD thousands in year of expenditures)

Country	Pre-2006	2006	2007	2008	2009	2010	2011	2012	2013 (expected)
Algeria	NA	0	0	0	0	0	0	0	0
Argentina	53 581	649	439	7 153	6 854	12 222	14 296	10 647	10 733
Australia	550 286	61 603	149 917	211 612	144 605	166 084	198 742	98 695	93 264
Bangladesh	453	NA	NA	NA	NA	NA	NA	NA	NA
Belgium	2 487	0	0	0	0	0	0	0	0
Bolivia	9 343	NA	NA	NA	NA	NA	NA	NA	NA
Botswana*	825	NA	NA	377	3 727	5 421	1 218	1 061	1 026
Brazil	186 577	0	0	0	0	223	126	1 198	1 705
Cameroon	1 282	0	0	0	0	0	NA	NA	NA
Canada	1 552 074	316 364	532 710	514 751	457 936	750 484	948 223	847 721	873 112
Central African Rep.	21 800	NA	NA	NA	NA	NA	NA	NA	NA
Chile	7 113	100	113	480	540	1 272	NA	NA	NA
China	48 000	28 000	38 000	44 000	55 000	89 000	118 000	131 000	128 000
Colombia	19 946	0	6 000	NA	NA	NA	NA	NA	NA
Costa Rica	364	NA	NA	NA	NA	NA	NA	NA	NA
Cuba	972	NA	NA	NA	NA	NA	NA	NA	NA
Czech Republic[(a)]	314 152	132	33	373	114	5	12	203	222
Ecuador	1 945	NA	NA	NA	NA	NA	NA	NA	NA
Egypt	111 396	1 736	1 761	2 378	NA	NA	NA	NA	NA
Ethiopia	NA	NA	NA	22	NA	NA	NA	NA	NA
Finland	14 997	1 798	1 511	2 449	506	2 367	19 657	58 894	NA
France	907 240	0	0	0	0	0	0	0	0
Gabon	102 433	NA	NA	NA	NA	NA	NA	NA	NA
Germany[(b)]	2 002 789	0	0	0	0	0	0	0	0
Ghana	90	NA	NA	NA	NA	NA	NA	NA	NA
Greece	17 547	NA	NA	NA	NA	NA	NA	NA	NA
Greenland (Denmark)	4 140	NA	NA	NA	NA	NA	NA	NA	NA
Guatemala	610	NA	NA	NA	NA	NA	NA	NA	NA
Hungary	3 700	NA	112	239	NA	NA	NA	NA	NA
India	346 149	16 422	19 793	25 093	39 905	55 778	56 227	49 771	42 946
Indonesia	15 909	120	122	74	266	327	455	275	605
Iran, Islamic Rep. of	17 205	4 826	3 930	8 047	23 084	32 165	53 156	82 070	36 837
Ireland	6 200	NA	NA	NA	NA	NA	NA	NA	NA
Italy	75 060	NA	NA	NA	NA	NA	0	0	0
Jamaica	30	NA	NA	NA	NA	NA	NA	NA	NA
Japan	19 697	0	0	0	0	0	0	0	0
Jordan	920	0	0	419	10 306	11 434	6 766	1 839	2 401
Kazakhstan	49 140	8 500	34 318	78 155	59 740	57 584	70 955	94 303	111 209
Korea, Republic of	17 886	0	0	0	NA	NA	NA	NA	NA
Lesotho	21	NA	NA	NA	NA	NA	NA	NA	NA
Madagascar	5 293	NA	NA	NA	NA	NA	NA	NA	NA

See notes on page 44.

Table 1.19. Industry and government uranium exploration and mine development expenditures – domestic in countries listed (*continued*)

(USD thousands in year of expenditures)

Country	Pre-2006	2006	2007	2008	2009	2010	2011	2012	2013 (expected)
Malawi	NA	NA	NA	NA	NA	NA	NA	NA	NA
Malaysia	10 478	NA	NA	NA	NA	NA	NA	NA	NA
Mali	58 693	NA	NA	NA	NA	NA	NA	NA	NA
Mexico(c)	30 306	NA	NA	50	100	150	NA	NA	NA
Mongolia	8 153	12 527	26 138	29 156	11 332	18 284	30 051	26 040	NA
Morocco	2 752	NA	NA	NA	NA	NA	NA	NA	NA
Namibia	29 488	2 000*	8 000*	46 560*	44 911*	32 984	84 627	76 533	522 104
Niger	226 743	12 453	152 984	207 173	306 828	20 424	5 032	117 290	21 125
Nigeria	6 950	NA	NA	NA	NA	NA	NA	NA	NA
Norway	3 180	0	0	0	0	0	0	0	0
Paraguay	26 360	NA	NA	NA	NA	NA	NA	NA	NA
Peru	4 776	NA	NA	NA	NA	NA	NA	NA	NA
Philippines	3 492	NA	NA	NA	NA	NA	NA	NA	NA
Poland	NA	NA	NA	0	0	90	1 388	1 452	1 108
Portugal	17 637	0	0	0	0	0	NA	NA	NA
Romania	10 060	NA	NA	NA	NA	NA	NA	NA	NA
Russian Federation	94 600	33 496	64 218	221 783	233 998	117 647	99 786	63 521	56 217
Rwanda	1 505	0	0	0	0	0	0	0	0
Slovak Republic	NA	NA	NA	7 465	7 454	3 576	5 579	2 484	NA
Slovenia(d)	1 581	0	0	0	NA	NA	0	0	0
Somalia	10 000	NA	NA	NA	NA	NA	NA	NA	NA
South Africa	143 398	24 698	14 972	11 386	14 552	18 761	35 072	32 788	34 800
Spain	140 455	427	3 887	4 552	3 354	10 223	14 786	15 038	17 241
Sri Lanka	43	NA	NA	NA	NA	NA	NA	NA	NA
Sudan	200	0	0	0	0	0	NA	NA	NA
Sweden	47 900	NA	NA	NA	NA	NA	NA	NA	NA
Switzerland	3 359	0	0	0	0	0	0	0	0
Syria	1 151	NA	NA	NA	NA	NA	NA	NA	NA
Tanzania	NA	NA	NA	NA	NA	23 783	25 557	28 871	7 960
Thailand	11 299	NA	NA	NA	NA	NA	0	0	0
Turkey	22 011	56	50	74	66	91	2 230	2 815	3 268
Ukraine	24 714	6 168	6 560	7 548	3 362	3 207	1 992	2 620	2 648
United Kingdom	3 815	0	0	0	0	0	0	0	0
United States(e)	2 675 213	155 300	245 700	246 400	139 300	144 000	150 400	166 000	NA
Uruguay	231	NA	NA	NA	NA	NA	NA	NA	NA
USSR	3 692 350	0	0	0	0	0	0	0	0
Uzbekistan	177 805	21 230*	21 230*	23 798	25 652	NA	NA	NA	NA
Viet Nam	3 729	NA	NA	NA	NA	3 137	5 383	1 697	961
Zambia(f)	25	NA	NA	NA	NA	NA	2 438	3 518	3 751
Zimbabwe	6 902	NA	NA	NA	NA	NA	NA	NA	NA
Total	**13 991 006**	**708 605**	**1 332 498**	**1 701 567**	**1 593 492**	**1 580 723**	**1 952 154**	**1 918 344**	**1 973 243**

Note: Domestic exploration and development expenditures represent the total expenditure from both domestic and foreign sources in each country for the year. Previously published 2010 expenditures of >USD 2 billion revised downward with new information.

NA = Data not available. * Secretariat estimate. (a) Includes USD 312 560 expended in Czechoslovakia (pre-1996). (b) Includes USD 1 905 920, spent in the German Democratic Republic between 1946 and 1990. (c) Government expenditures only. (d) Includes expenditures in other parts of the former Yugoslavia. (e) Includes reclamation and restoration expenditures from 2004 to 2012. Reclamation expenditures amounted to USD 49.1 million, 62.4 million, 41.7 million, 46.3 million in 2008, 2009, 2010, 2011, 2012, respectively. (f) Non-government industry expenditures between 2011 and 2013.

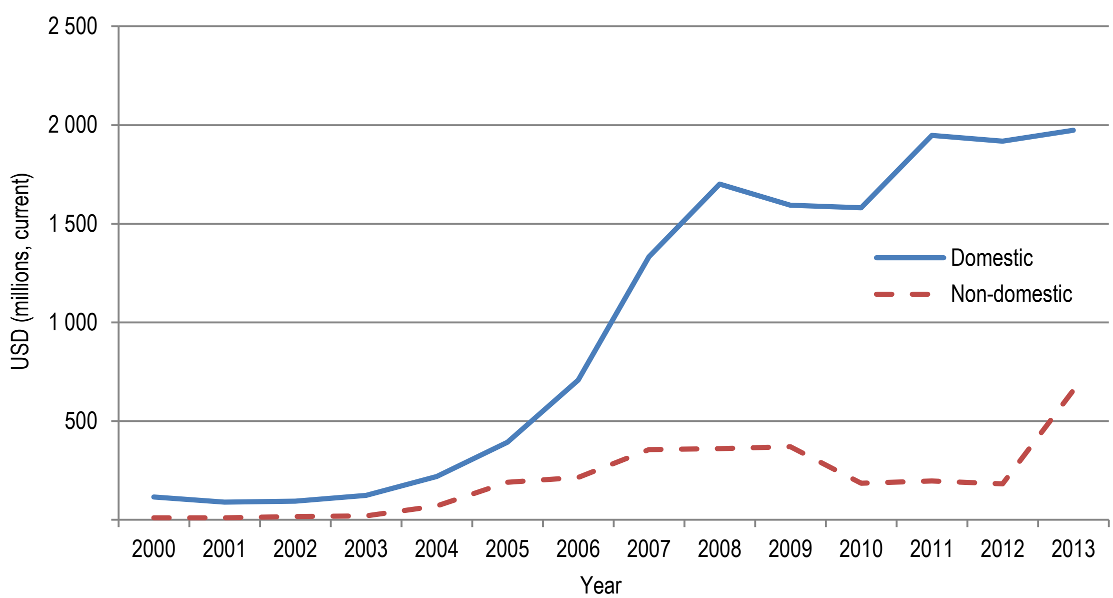
Based on the information provided in national reports, 25 countries reported exploration and development drilling activities for this edition compared to 16 countries in the 2011 edition. In terms of exploration drilling between 2010 to 2012, Argentina, Brazil, India and the Islamic Republic of Iran all reported increases in total metres drilled with trends expected to continue into 2013. However, decreased efforts during this period are noted for Canada, China, India, Jordan, Namibia and Spain. Kazakhstan, the Russian Federation and South Africa all reported a decline in expenditures from 2011 to 2012 but efforts are expected to increase in 2013. Finland only reported drilling in 2012. Tanzania reported an increase in drilling in 2012 but a decline is expected in 2013. Turkey reported drilling in 2012 and an increased effort is expected in 2013.

Six countries reported development drilling: Canada, Kazakhstan, Namibia, South Africa, Turkey and the United States. Canada and South Africa reported an increase over the period from 2010 to 2012 and Kazakhstan reported a decline over the same period with a slight increase from 2012 expected in 2013. The United States and Namibia's efforts were variable with a decrease in 2011 over 2010, an increase in 2012 and then a sharp decrease expected in 2013. Turkey reported an increase from 2010 to 2011, a decline in 2012 and the forecast is for efforts to increase again in 2013.

For the countries reporting in this edition, total drilling in 2010 amounted to 5 714 202 m (3 599 710 m exploration; 2 114 492 m development), 6 102 851 m (4 586 563 m exploration; 1 516 288 m development) in 2011 and 5 864 149 m (4 246 009 m exploration; 1 618 140 m development) in 2012. Development totals exclude some of the activities being undertaken by the Russian Federation as the government reports the number of development holes but not the actual length drilled.

Trends in domestic and non-domestic uranium exploration and development expenditures since 2000 are depicted in Figure 1.4. Both domestic and non-domestic expenditures increased as uranium prices increased from 2003 through 2007. Although non-domestic expenditures levelled off before declining through 2012 to 2012, domestic expenditures have remained strong, increasing to almost USD 2 billion through 2011 to 2013, despite declining uranium prices, particularly after the Fukushima accident in 2011. Non-domestic expenditures are expected to increase dramatically in 2013, principally due to development of the Husab mine in Namibia.

Figure 1.4. Trends in exploration and development expenditures*



* 2013 values are estimates.

Current activities and recent developments

North America

In **Canada**, overall uranium exploration and development expenditures amounted to USD 848 million in 2012 and are expected to increase to USD 873 million in 2013. Less than one-quarter of the overall exploration and development expenditures in 2012 can be attributed to advanced underground exploration, deposit appraisal activities, and care and maintenance expenditures associated with projects awaiting production approvals. Exploration efforts have continued to focus on areas favourable for the occurrence of deposits associated with Proterozoic unconformities in the Athabasca basin of Saskatchewan, and to a lesser extent, similar geologic settings in the Thelon basin of Nunavut and the Northwest Territories. Uranium exploration has also remained active in the Otish Mountains of Quebec where Strateco Resources Inc. has applied for a licence to conduct underground exploration on the Matoush deposit. Mineralisation at Matoush occurs in mafic dykes associated with Proterozoic sandstones. However, these plans have been put on hold since April 2013 when Quebec announced a moratorium on uranium exploration and mining permits in the province. Recent exploration activity has led to new uranium discoveries in the Athabasca Basin in Saskatchewan. Significant, high-grade uranium mineralisation discoveries in the Athabasca Basin include: Centennial (UEM Inc.), Shea Creek (AREVA Resources Canada Inc.), Wheeler River (Denison Mines Inc.), Midwest A (AREVA Resources Canada Inc.) and Roughrider (Rio Tinto). In 2013, the Saskatchewan provincial government announced changes to its system of royalties to encourage the development of new mines and mine expansions.

In the **United States**, private industry expenditures for exploration and mine development activities in 2011 amounted to USD 150.4 million, an increase from 2010, and expenditures continued to rise in 2012 reaching 166.0 million. Much of the increase in development and production expenditures from 2010 to 2012 was due to generally strong uranium (and vanadium) prices as well as the need to meet longer-term demand resulting from the anticipated global expansion of nuclear power, particularly in the developing world. An additional contributing factor to increased expenditures was the end of the 20-year Megatons to Megawatts programme in 2013, which through an agreement between the United States and the Russian Federation brought the equivalent of 9 200 tU/yr to the commercial market. In 2012, expenditures for uranium surface drilling amounted to USD 66.6 million, up USD 23 million from expenditures in 2011 of USD 53.6 million. This 24% increase is a continuation of the upward trend in investment from 2009 to 2012, following the sharp decline in late 2008. In 2010, the number of holes (7 209) and total metres drilled (1 494 744 m) increased from 2009. In 2011 and 2012, the increasing trend continued with 10 597 holes drilled in 2011 and 11 082 in 2012. The total metres drilled increased 13% from 1 927 866 m in 2011 to 2 181 156 m in 2012. Exploration has primarily been for sandstone-type uranium deposits in districts such as the Grants Mineral Belt and Uravan Mineral Belt of the Colorado Plateau and in the Wyoming basins and Texas Gulf Coastal Plain region. Most exploration occurred on deposits that were identified in the 1970s and earlier, or on extensions and satellites of operating mines. However, in 2012 exploration expanded to include previously unexplored targets.

Central and South America

Argentina reported domestic exploration expenditures in 2011 of USD 19.8 million, a 19% increase over 2010 expenditures of USD 16.6 million. However, this declined to USD 98.6 million in 2012 and forecasted expenditures for 2013 are USD 93.2 million. It is worth noting that exploration and development expenditures and drilling totals, as reported by the government, likely do not reflect all activity within the private sector as there is no requirement for private industry to report these expenditures. From 2007 to 2011, a total of 28 431 m have been drilled into the main mineralised areas in the Pichiñan district, including 4 030 m of core sampled for hydrometallurgical analyses. For most of 2011 and until January 2012, the main activities at Cerro Solo ore deposit were related to environmental studies and hydrometallurgical tests. In the south of Argentina (Santa Cruz province) the main exploration works have been focused on shallow low-grade uranium anomalies in six areas under study. At the Las Termas vein-type deposit (Catamarca province), exploration activities were allowed to resume in April 2012 after activities had been halted for five years due to interventions by environmental groups. In the east slope of Velasco Hill (La Rioja province), the National Atomic Energy Commission Argentina (CNEA) is studying promising Alipan I Project uranium occurrences. In the Río Negro province, five exploration licences covering an area with deposits amenable to ISL were requested. In two of the areas granted in 2013 (out of the five requested), superficial geological and geochemical surveys were developed and a minimum exploration drilling plan was outlined. Exploration activities are expected to be continued in 2014.

The **Bolivian** government has not reported any exploration expenditures since 1986 and there is little indication that any significant exploration activities are currently being carried out. Renewed interest was however signalled with a government announcement in 2010 that a preliminary study for a programme of uranium exploration in the southern department of Potosí would be initiated. The programme is expected to be financed by the Potosí departmental government and carried out by the National Mineral Geological and Technical Service (Sergeotecmin). There has also been some speculation that production may resume at the volcanic-associated Cotaje deposit, if the remaining uranium resources are confirmed.

In **Brazil**, USD 0.13 million was reportedly spent on domestic exploration activities in 2011 and an increase of over USD 1 million to USD 1.2 million was reported for 2012, with a further increase to USD 1.7 million expected in 2013. Expenditures of this magnitude have not been reported since 2004 (USD 0.44 million). During 2011 and 2012, exploration efforts were focused on favourable albititic areas in the north part of the Lagoa Real province. A geophysical survey in 2011 and surface drillings in 2012 were used to identify and define the extensions of the uranium deposits.

In **Colombia**, recent exploration activities have focused on sedimentary-hosted deposits, with a total area of 267 km^2 currently being explored under 14 licences (Muriel, 2010). The companies include U3O8 Corp. with activities focusing on the Caldas, Santandar, North Santander and Cundinamarca regions. There are others conducting exploration in these regions but very limited information is available. Of main interest is the work being carried out by U3O8 Corp., a Canadian uranium exploration company that has been conducting exploration at the Berlin Project in Caldas province. The company reported an exploration budget of USD 7 million in 2011 and in January 2012 announced a NI 43-101 indicated resource of 1.5 Mlbs U_3O_8 (577 tU), at 0.11% U_3O_8 (0.09% U) and 19.9 Mlbs U_3O_8 inferred (7 655 tU), at 0.11% U_3O_8 (0.09% U).

Chile did not report exploration and development expenditures for this edition. From 2008 to 2012, the Chilean Nuclear Energy Commission (CCHEN) completed a broad scope co-operation agreement with the National Copper Corporation (CODELCO Norte) for geological and metallurgical investigation of natural atomic material occurrences. From 2009 to 2012, CCHEN and CODELCO Norte completed an agreement on activities to investigate the recovery of uranium and molybdenum from copper ore leaching solutions.

There has been some uranium exploration in **Guyana** where unconformity-type and volcanic-associated deposits are being targeted. U3O8 Corp. obtained uranium exploration rights from the Guyana Geology and Mines Commission (GGMC) for two areas in western Guyana: the Roraima basin and the Kurupung batholith. An updated NI 43-101 filing in 2012 reports uranium resources from the Kurupung Batholith amounting to 8.4 Mlb U_3O_8 at an average grade of 0.09% U_3O_8 (indicated resources; 3 200 tU at 0.8% U) and 7.7 Mlb at an average grade of 0.08% U_3O_8 (inferred resources; 3 000 tU at 0.7% U). AZIMUTH Resources, an Australian-based junior explorer, has an ongoing uranium exploration project in the Amakura region of north-western Guyana. It is an early stage exploration project which was previously explored in the 1980s by COGEMA who had concluded that uranium mineralisation in Amakura was likely similar to Kurupung (where U3O8 Corp. currently conducts exploration). Argus Metals Corp., a Canadian-based mineral exploration company, holds rights to the Kaituma east uranium-gold project in Guyana, reportedly a low-grade, large-tonnage uranium target modelled on the Rössing and Husab deposits in Namibia, as well as Lago Real in Brazil. Historically, the Kaituma Project has been explored by various companies including COGEMA and BHP. The company completed a drill programme on the Kaituma Uranium/Gold Project in 2012.

The government of **Paraguay** did not report domestic exploration or development expenditures for this edition. However, there have been recent exploration activities in the country including the Yuty Project in the Paraná basin that was originally held by Cue Resources. In 2012, a US-based exploration company, Uranium Energy Corp. (UEC), acquired the rights to the project through a takeover agreement. NI 43-101 compliant measured, indicated and inferred resources for the project were updated in 2011 to 9.98 Mt at 507 ppm eU_3O_8 for 11.1 Mlbs eU_3O_8 (4 300 tU). UEC also holds rights to approximately 399 425 ha in the Coronel Oviedo region in central Paraguay.

Peru does not report exploration and development expenditures and industry is not required to report expenditures to the government. Currently, there are five active exploration companies, all from Canada: Vena Resources/Cameco, Southern Andes Energy Inc., Global Gold S.A.C. subsidiary of Macusani Yellowcake, Fission Energy Corp., and Wealth Minerals Ltd. In order to further develop uranium resources through drilling in different prospects, several companies have focused on the Macusani, Puno uraniferous district. Since 2003, exploration has been undertaken in Macusani, Santa Lucia-Rio Blanco and Pampacolca (Arequipa), as well as in the Tertiary volcanic environment. Uranium potential in other parts of Peru is important and *Instituto Peruano de Energía Nuclear* (IPEN), through its promotional activities, has proposed to highlight new areas of interest. In 2012, IPEN discovered new uranium occurrences in the San Ramón-Oxapampa region, where initial results demonstrate important uraniferous potential. An IAEA initiative was undertaken in 2012-2013, within the Technical Cooperation (TC) project PER/2/016 "Evaluating the uraniferous potential in the magmatic environments in the eastern Andes region." The project supported uranium exploration in volcanic and intrusive granite environments in the Macusani Uranium District.

In **Uruguay**, the government is developing a law that will give *Administración Nacional de Combustibles, Alcoholes y Portland* (ANCAP) facilities for uranium prospection, exploration and exploitation. ANCAP governs the state oil company responsible for supervising energy initiatives. However, no plans for uranium development have been announced. The IAEA through its TC programme supported two programmes in Uruguay in 2012 and 2013, *i)* "Supporting Exploration and Exploitation of Uranium and Developing National Capacity for this Activity" and *ii)* "Improving Exploration and Exploitation Mining Processes and their Environmental Consequences". Support through these projects included national training, fellowships and procurement of analytical equipment.

European Union

In the **Czech Republic**, exploration and development expenditures increased dramatically from USD 12 000 in 2011 to USD 203 000 in 2012 and similar expenditures (USD 222 000) are expected in 2013. This increase is related to the preparation in 2012 of the new State Energy Concept as well as the Concept of the Raw Materials and Energy Security of the Czech Republic. As a result, technical and economic re-evaluation of remaining uranium resources was undertaken and has resulted in an increase of uranium resources in some cost categories.

Exploration and development expenditures in **Finland** have fluctuated in the past few years but a significant increase in expenditures was reported from USD 506 000 in 2009 to USD 2.37 million in 2010. Mawson Resources Ltd has been the most active company in uranium exploration the past three years. The company is focused on the Rompas-

Rajapalot gold and uranium exploration project in Paleoproterozoic Peräpohja Schist Belt in northern Finland. Mawson recently announced a new discovery at the Rajapalot area located 8 km to the east of the Rompas trend. In early 2012, European Uranium Resources Ltd acquired a portfolio of exploration licences and applications for uranium projects in Finland from Mawson involving three uranium exploration projects (Riutta, Asento and Nuottijärvi). In March 2013, the company was awarded a three-year exploration licence for the Asento Project in north-central Finland.

Although no domestic uranium activities have been carried out in **France** since 1999, AREVA and its subsidiaries have been active abroad. In 2011 and 2012, efforts have been focused on targets aimed at the discovery of exploitable resources in Australia, Canada, Central Africa Republic, Finland, Gabon, Jordan, Kazakhstan, Mongolia, Namibia, Niger and South Africa. Total non-domestic exploration expenditures reported by the government decreased from USD 68.7 million in 2011 to USD 64.6 million in 2012. Expenditures are expected to be USD 72.9 million in 2013. No development expenditures were reported.

Greenland does not report uranium exploration and development expenditures as uranium exploration and mining has not been allowed since 1988 under home state rule. In October 2013 however, Greenland's parliament voted in favour of lifting this long-standing ban on the extraction of radioactive materials, including uranium. Prior to the removal of the ban, a renewed interest in REE deposits spurred Greenland Minerals and Energy Limited, an Australian Securities Exchange (ASX)-listed company, to acquire the Kvanefjeld deposit in 2007. Kvanefjeld is part of the Ilimaussaq complex, a peralkaline igneous complex which contains elevated concentrations of rare earth elements, uranium and zinc. An updated, inferred resource of 260 815 tU_3O_8 (221 172 tU) has been recently determined and the recent decision to lift the uranium mining ban could enable the Kvanefjeld Project to proceed.

The government of **Hungary** did not report any exploration or development expenditures. Exploration activities appear to be limited to activities conducted by Wildhorse Energy in four uranium exploration project areas: Mecsek, Bátaszék, Dinnyeberki and Máriakéménd which are covered by seven exploration licences. Exploration drilling of 2 422 m in 5 holes was reported for 2010. In 2012, the Hungarian government announced that it will allow state-owned companies Mecsek-Öko and Mecsekérc and Hungarian Electricity Ltd. to enter into a joint venture with Wildhorse Energy in order to assist the development of the Mecsek Hills Uranium Project.

In 2009, the government of **Poland** decided to introduce nuclear energy and the possibility of mining domestic uranium resources is being studied. Exploration expenditures of USD 90 000 in 2010 were reported for the first time and expenditures for 2011 and 2012 amounted to USD 1.39 million and USD 1.45 million, respectively. In 2013, expenditures of USD 1.10 million are expected. There are no documented uranium deposits and no concessions for uranium have been granted. However, there are some perspective regions based on past work.

In the **Slovak Republic**, a pre-feasibility study was finalised in 2012 and a new reserves calculation report for Kosice (Kuriskova area) was approved by the Commission for reserves classification in the Ministry of Environment and these resources were added to RAR in the national report. Exploration and development expenditures were USD 3.5 million in 2010 and rose to USD 25 million in 2011, followed by a decrease to USD 3.8 million in 2012. At present, ten uranium exploration licences are active in the Slovak Republic. Exploration companies involved include: Ludovika Energy Ltd (related to European Uranium Resources), performing exploration in six areas; Beckov Minerals Ltd (related to Ultra Uranium, Canada), performing exploration on two areas in western Slovak Republic; and Crown Energy Ltd (related to GB Energy, Australia), performing exploration in two prospecting areas in eastern Slovak Republic. Note that Tournigan Gold Corporation, a private Canadian company, changed its name to European Uranium Resources Ltd on 1 March 2012 and formed a strategic alliance with AREVA. Ludovika

Energy Ltd (a subsidiary of European Uranium Resources) is continuing exploration in six prospecting areas in the eastern Slovak Republic. The most prospective exploration licence covers uranium mineralisation in Kuriskova, near Kosice where 16 additional exploration holes were drilled (totalling 5 179 m) in 2011 and 2012. Crown Energy Ltd (a subsidiary of GB Energy) drilled five exploration holes (totalling 204 m) in 2011. During 2012, GB Energy completed exploration programmes over the Kluknava and Vitaz-II exploration areas.

Spain reported increases in domestic expenditures from USD 10.22 million in 2010 to USD 14.79 million in 2011 and USD 15.0 million in 2012, with projected expenditures of USD 17.24 million in 2013. This reflects uranium exploration and development activities by Berkeley Resources on a total of 20 exploration licences covering a total of 66 400 ha in the provinces of Salamanca and Cáceres. Berkeley's "Salamanca" Project comprises the Retortillo, Alameda and Gambuta (in the Cáceres province) deposits plus a number of other satellite deposits located in western Spain. In 2012, Berkeley completed an initial assessment of the integrated development of Retortillo and Alameda and reported the results of the scoping study, which according to that company demonstrated the potential of the Salamanca Project to support a significant scale uranium mining operation.

The government of **Sweden** did not report exploration and development expenditures but a number of exploration programmes have been ongoing in the country since 2007. In many cases work is focused on areas where discoveries were made during the initial phase of exploration. Mawson Resources and Continental Precious Minerals have been the most active. During 2011 and 2012, work has been focused on the potential of the alum (black) shale where uranium can be recovered as a by-product along with other co-products such as molybdenum, vanadium, nickel, zinc and petroleum products. Exploration expense figures for the course of these two years is however not available.

Europe (non EU)

An **Armenian**-Russian joint venture CJ-SC "Armenian-Russian Mining Company" was established in April 2008 for geological exploration, mining and processing of uranium. The document "Geologic Exploration Activity for 2009-2010" aimed at the uranium ore exploration in the Republic of Armenia was developed and approved. The geologic prospecting works were carried out on the 1st Voghchi zone of the Pkhrut-Lernadzor licensed area in 2011. Geologic prospecting identified some anomalies. All plans for geologic prospecting in 2011 were fulfilled by January 2012. Exploration of the block 1st Voghchi zone identified resources of uranium ores classified in category C2 (inferred). Calculations of inferred resources of the Voghchi zone of the Pkhrut deposit indicate that the deposit is prospective.

The **Russian Federation** reported a decline in domestic exploration and development expenditures from USD 99.8 million in 2011 to USD 63.5 million in 2012, with forecasted expenditures of USD 56.2 million in 2013. The decreases were primarily by industry as government exploration expenditures have increased somewhat over the past few years. There are two types of uranium exploration activities in the Russian Federation, one aimed at new deposit discovery and the second directed at exploration of earlier discovered deposits with a view to developing resource estimates and deposit delineation.

In the Republic of Buryatia and the Trans-Baikal region, exploration was focused on the expansion of the resource base near the existing production centres (Khiagda and Priargunsky) and exploration for large deposits suitable for either conventional or ISL mining in new areas. Preliminary exploration was completed at the Balkovskoe deposit (Republic of Kalmykia) and the Dulesminskoe occurrence in the Vitimsky area (Republic of Buryatia). As a result of exploration at the Sirotinka occurrence (Transbaikal region), inferred resources have been estimated as 4 000 tU. In the Irkutsk region (Akitkan area), prognosticated resources have been estimated as 3 100 tU and speculative resources as

13 500 tU. Subsidiaries of the uranium holding company "Atomredmetzoloto" (ARMZ) performed exploration and resource estimation of uranium deposits which are being prepared for development. Exploration and resource estimation activities were also undertaken in the Elkonsky area (the South Yakutia and Khiagda ore field) in the Vitim area of the Republic of Buryatia. In 2012, uranium resource estimation of deposits in the Elkonsky area (South Yakutia) was completed based on 2008-2011 exploration results. The resource feasibility study for the deposits in the Khiagda ore field was also completed in 2012. Additionally, exploration was carried out at the Dalmatovskoye deposit (Kurgan region) and the Berezovoe deposit in the Transbaikal region.

Non-domestic expenditures by the Russian Federation decreased moderately from USD 31.1 million in 2011 to USD 30.1 million in 2012 and are estimated to decrease dramatically to USD 16.5 million in 2013. In 2011-2012, ARMZ, through its subsidiary Uranium One based in Canada, performed exploration in Kazakhstan at all joint ventures with Kazatomprom (Akbastau, Karatau, Betpakdala, Zarechnoye and Kyzylkym). The Australian public company Mantra Resources, which owns rights to the Mkuju River uranium project in Tanzania, was acquired in 2011 by ARMZ. In 2011-2012, Mantra Resources continued exploration drilling focused on new mineralised zones and resources estimation. There were also minor investments in exploration of prospective areas in Armenia made by the Armenian-Russian Mining Co.

Exploration and development expenditures in **Turkey** increased from USD 2.2 million in 2011 to USD 2.8 million in 2012 while projected expenditures are expected to increase further to around USD 3.3 million in 2013. Public sector activities were focused on granitic, acidic igneous and sedimentary rocks in several areas totalling 15 000 km^2. Private sector activities were focused in Yozgat province, with resource evaluation drilling programmes undertaken at the Temrezli and Sefaatli uranium prospects. The majority of the work was conducted at Temrezli, resulting in a JORC compliant indicated and inferred resource estimate amounting to 17.4 Mlb U_3O_8 (6 693 tU). In late 2012, hydrological test drilling was initiated at Temrezli in order to assess regional groundwater conditions and test hydraulic conditions in the mineralised zone for mining by ISL.

Exploration and development expenditures in **Ukraine** declined from 2010 expenditures of USD 3.21 million to USD 1.99 million; however, in 2012 expenditures increased to USD 2.62 million and are expected to continue to increase, with USD 2.65 million forecasted for 2013. From 2011 to 2012, prospecting work for discovery of deposits of different geological/commercial types was conducted. This included prospecting of sandstone-type uranium deposits on the Troytskaya and Vladimirskaya regions and for vein-type occurrences in the Rozanovskaya region. In addition, geological prognostic work at a scale of 1:25 000 within the southern part of Kirovogradskiy uranium ore fault was undertaken. Prospecting for granite-related type uranium deposits in the Pokrovskiy territory and uranium ore occurrences in the crystalline foundation of Ukrainian Shield, within the borders of the Nikolaevskiy ore field, was also conducted. Exploration is planned for metasomatite-type deposits, particularly within the areas of current operating mines.

Africa

The IAEA TC programme Regional Africa Project, RAF/3/007 "Strengthening Regional Capabilities for Uranium Mining, Milling and Regulation of Related Activities" was carried out from 2009 to 2013. The objectives were to address common regional priority needs in uranium exploration, mining, milling and regulation using the available infrastructure and expertise, including regional designated centres and specialised teams. Regional workshops, training courses and technical meetings in DR Congo, Egypt, Gabon, Ghana, Madagascar, Malawi, Morocco, Mozambique, Namibia, Tanzania, Uganda and Zambia provided opportunities for experts to receive updated information on technology, operations and environmental aspects of uranium production, leading to improved understanding of regulatory requirements for mining and processing. The first Uranium

Production Cycle Appraisal Team (UPSAT) review in Africa was carried out in the planned uranium mining and processing facility in Tanzania. In 2014, workshops/training courses are planned in Botswana, South Africa and Morocco under a new TC training programme, RAF/2/011.

In **Algeria**, no uranium prospecting or mine development work was carried out between January 2007 and January 2013 and although the government of Botswana has not reported exploration expenditures, a Secretariat estimate indicates that expenditures have decreased significantly from USD 5.4 million in 2010 to USD 1.2 million in 2011, and 1.1 million in 2012 and 2013.

Exploration activities in **Botswana** have focused on uranium occurrences in the Karoo Group, targeting similar deposits to those currently being mined by Paladin Energy in Malawi (i.e. the sandstone-type Kayelekera deposit). Surficial calcrete-type mineralisation is a secondary target. Despite decreased expenditures, exploration activities continue. The Letlhakane uranium deposit has been the focus of detailed technical work by A-Cap since 2010, resulting in the February 2013 release of a positive scoping study. Impact Minerals Ltd, another Australian junior company, acquired permits around A-Cap's areas in early 2008. Exploration activities in 2009 began with airborne radiometric surveys, followed by field reconnaissance, mapping and drilling, leading to the discovery of four prospects in Karoo siltstones and sandstones. In addition to sandstone-hosted mineralisation, uranium-bearing alaskitic rocks similar to those found at Rössing in Namibia and mineralisation related to Proterozoic sedimentary and basement rocks with similarities to the unconformity-related deposits in Canada and Australia were discovered. At the end of 2012, A-Cap's prospecting licences for uranium totalled 5 000 km^2 while Impact Minerals Ltd controlled 26 000 km^2. The two companies drilled a total of 12 462 m in 95 reverse circulation holes during 2011, but no drilling was reported in 2012. Both companies completed regional ground gravity surveys and Impact Minerals Ltd completed a soil geochemical survey over an area of 250 km^2 at the Ikongwe prospect.

The Bakouma deposit in the **Central African Republic** was discovered in the 1960s. It is small, but has a relatively high uranium content of approximately 2 700 ppm U (0.27% U). In August 2008, AREVA and the Central African government signed an agreement which stipulates that the country will receive financial support of CFA francs 18 billion over five years. It also provides for the construction of infrastructure and employment of 900 people (primarily from the region) once the mine is operating at full capacity. Following a test phase, the Bakouma Project was originally planned to gradually ramp up to full production by 2014-2015. However, AREVA suspended investment in the development of the Bakouma mine in 2011 due to current market conditions, even though inferred resources at Bakouma were raised from 32 224 tU to 36 475 tU.

Egypt last reported exploration expenditures in 2008. It has had ongoing support over the last several years in developing uranium exploration and production capacities through a number of IAEA TC projects.

The Ministry of Mines of **Gabon** authorised AREVA to resume uranium prospecting activities in late 2006. After some initial success AREVA founded AREVA Gabon SA in 2008, a 100% owned subsidiary of AREVA with headquarters in Franceville. No updates have been provided in the last few years regarding exploration activities by AREVA in Gabon.

The Karoo Group of the Morondava basin in **Madagascar** has a similar geological setting to sandstone-hosted uranium deposits in the Karoo Group in other African countries including Botswana, Zambia, Malawi, South Africa and Tanzania. These similarities have prompted some interest in exploration for potentially economic deposits of this type. UMC Energy PLC dominates the majority of prospective holdings through its 80% equity interest in URAMAD S.A, holder of a number of exploration permits including the Folakara deposit which has a historical resource estimate of 500 tU at 0.01% U. The deposit is hosted by the Triassic to Jurassic Isalo I and Isalo II formations of the Karoo Group. Exploration permits in Madagascar are normally granted for ten years and UMC's current holdings expire in 2015 and 2016, but there appears to have been very little exploration activity on these permits since their acquisition. A few other less extensive areas with uranium exploration permits have been held by various companies over the past few years that also do not show any exploration activity in recent years.

Uranium exploration activities continued in **Malawi** due to the interest in expanding resources at the Kayelekera mine operated by Paladin Energy and the potential for discovery of additional deposits in a similar geological setting in the Karoo Group sedimentary rocks. Paladin continues to explore around Kayelekera. The orebody remains open to the west where exploration drilling continued in 2011 and 2012 and additionally, drilling was undertaken on nearby leases including Mpata to the east and Juma to the south. Resource Star, the operator of the Livingstonia Project, has reported that thickened zones of mineralisation are open to the north-east and the sparse drilling in the southern zone increases potential for additional mineralisation being defined. The mineralisation is also open to the north where the project adjoins tenements owned by Paladin Energy Ltd. In 2011-2012, Globe Metals & Mining continued the development of the Kanyiba deposit. Total drilling, reverse circulation and diamond drilling amounted to 40 540 m. As of December 2012, total resources amount to 68.3 Mt of ore at average grade of 0.28% Nb_2O_5, 0.0135% Ta_2O_5 and 0.0666% U (4 550 tU). Globe Metals and Mining submitted the environmental impact assessment for the Kanyika Niobium Project for public review in May 2012.

According to the Ministry of Mines in **Mali**, uranium potential occurs in three main regions. The best covers 150 km^2 of the Falea-North Guinea basin where the estimated potential is thought to be 5 000 tU. The 19 930 km^2 Kidal Project in north-eastern Mali is part of a large crystalline geological province known as *L'Adrar Des Iforas*. The sedimentary basin of the Gao region hosts the Samit deposit that contains an estimated potential of 200 tU. In 2011, a heliborne VTEM-magnetics-radiometrics survey was flown over the central Falea area. The survey comprised 933 line-km at a 1 100-metre line spacing covering an area of approximately 90 km^2. Drilling data used for the 2009 mineral resource estimate totalled 149 drill holes. Since then additional drilling has been undertaken. In 2011 and 2012, 247 and 754 holes were drilled respectively. Further drilling is planned, mainly to test potential extensions of high-grade mineralisation on the north zone structures. As of 1 January 2013, seven uranium exploration permits had been granted to five exploration companies. However, due to the rebellion in the north-eastern part of the country, exploration activities are only being undertaken in the western part of the country.

In 2007, Aura Energy commenced exploration on the Reguibat Craton in northern **Mauritania**, a region with strong uranium radiometric anomalies recorded in airborne geophysical data. Aura has eight wholly owned permits and two permits in joint venture with Ghazal Minerals Limited. Aura drilled 2 022 holes (9 100 m) at the Reguibat Project in 2011 and 392 holes in January 2010. Drilling confirmed the presence of widespread calcrete uranium mineralisation and in July 2011, Aura established JORC inferred resources of 19 300 tU at 280 ppm U (0.028% U), based on a cut-off grade of 85 ppm U (0.0085% U). Drilling in 2012 confirmed major extensions to calcrete uranium mineralisation well beyond the boundaries of current resource limits. The Bir En Nar Project, 180 km south-east of Bir Moghrein, is the most advanced project in terms of historic drilling completed by AREVA. The uranium mineralisation is comprised of shallow, narrow vein, high-grade deposits. In July 2010, Forte Energy announced an initial estimate of indicated and inferred resources totalling 792 tU. Forte Energy has another project, A238, which contains 23.4 Mlbs U_3O_8 (9 000 tU).

Namibia reported a decrease in exploration and development expenditures to USD 84.6 million in 2011 and USD 76.5 million in 2012. However a large increase is expected for 2013 with projected expenditures of USD 522.1 million principally related to development of the Husab mine. Two major types of deposits are currently being targeted; the intrusive-type associated with alaskites, as at Rössing, and the surficial, calcrete-type, as at Langer Heinrich and Trekkopje. During 2011 and 2012, the two operating uranium mines, Rössing and Langer Heinrich, focused efforts on expanding the resource base and increasing production. Reptile Uranium Namibia Ltd (RUN), the subsidiary of Australia's Deep Yellow Ltd, has been exploring for paleodrainage (calcrete), metamorphic/metasomatic and alaskite-hosted uranium since 2009. In January 2013, RUN announced *in situ* resources for their Omahola Project of 17 286 tU at 0.036% U, the majority of which will be mineable by open-pit methods. Reverse circulation and diamond drilling during 2012 have increased resources at both the MS7 and Ongolo prospects highlighting both extensive high-grade intercepts and new discoveries. Forsys Metals Corp. reported drilling on the Namibplaas property and announced in September 2012 a NI 43-101 indicated *in situ* resources of 12 850 tU at 0.013% U plus 4 230 tU of *in situ* inferred resources. Between 2007 and 2012, Zhonghe Resources undertook exploration work on Exclusive Prospecting Licence 3602, located in Happy Valley area. This included geological, radioactivity, geophysical and geochemical surveys, drilling (372 holes for 89 512 m) and trenching, leading to the discovery of deposits No. 18, No. 2 and No. 15. In 2012, JORC compliant resource declarations using an 85 ppm U (0.0085% U) cut-off grade amounted to indicated *in situ* resources of 25 772 tU and inferred *in situ* resources of 15 000 tU for the No. 18 deposit, as well as inferred resources of 11 539 tU in associated deposits on the lease. In 2011, Xemplar Energy Corp., subsidiary Namura Minerals Resources (Pty) Ltd, drilled 113 holes for 2 336 m in the Cape Cross calcrete-type deposit. While a number of samples recorded values in the region of 100 to 200 ppm U (0.01% to 0.02% U), there was insufficient data to justify a more extensive exploration programme, particularly in the current market.

Uranium exploration and development expenditures in **Niger** have been variable over the past few years due to security risks and market conditions. In 2009, USD 306.8 million was spent on exploration but decreased dramatically to 20.4 and 5.0 million in 2010 and 2011, respectively. This sharp decline was largely due to security issues. In 2012, expenditures increased again to USD 117.3 million but are forecasted to again decline to USD 21.1 million in 2013. A total of 6 new exploration permits have been granted and by 2011 uranium exploration activities were being carried out on 160 concessions by foreign companies. However since 2011, there have been increasing geopolitical tensions in the region, resulting in foreign companies like Paladin and URU Metals suspending exploration activities in Niger. URU Metals Limited reported a SAMREC compliant inferred resource of 1 654 tU on their In Gall deposit and in 2011 continued to drill the Aboye, Akenzigui and Fagochia targets within their Irhazer and In Gall permits. Project commitments elsewhere and security risks in Niger caused URU Metals to take steps to terminate activities in Niger by 2014. In December 2010, Paladin completed the takeover of NGM Resources Ltd (NGM), the owner of the local company Indo Energy Ltd that held concessions in the Agadez region. NGM Resources had announced an inferred mineral resource of 4 320 tU. Paladin indicates that they have developed an exploration programme to identify higher-grade uranium mineralisation in local Lower Carboniferous stratigraphies. In early 2011, Paladin carried out a drilling programme that further defined targets for follow-up and information from the drilling was used to plan a 15 000 m follow-up drilling campaign. However, this was put on hold due to security concerns. All fieldwork has ceased and *force majeure* has been requested from the government authorities for an indefinite suspension of further expenditures. The Imouraren mine, which is being developed by AREVA, was originally scheduled to begin production in 2012, but has been delayed due to security risks and unfavourable market conditions.

Exploration and development expenditures in **South Africa** increased from USD 18.8 million in 2010 to USD 35.1 million in 2011 and remained near these levels at USD 32.78 million in 2012. Between January 2011 and June 2012, Peninsula Energy Limited drilled 601 holes totalling about 21 640 m at sites 22, 29 and 45 (previously known as Matjieskloof, Quaggasfontein and Davidskolk respectively). In the same period, a total of 343 drill holes (~15 284 m) were re-probed. Drilling programmes at these sites have been successful in confirming the historic uranium mineralisation at each site. HolGoun Uranium and Power Limited completed a pre-feasibility study of its project in the Springbok Flats basin in 2012 and have begun a bankable feasibility study. AngloGold Ashanti Limited has continued with near-mine gold exploration (uranium is associated with gold in South Africa) as well as extensions of existing mining areas. Drilling has been ongoing in the extensions of the Great Noligwa mining lease to determine the extent of remnant blocks of the Vaal Reef. More than 4 500 m of diamond drilling is planned for 2013 to increase the geological confidence at the Great Noligwa. Exploration targets have also been identified within the Kopanang mining lease and adjacent areas and surface and underground drilling programmes are underway. Furthermore, brownfield exploration is in progress at Moab Khotsong to provide required additional geological information for capital development as well as improve geological confidence. Six surface drilling machines and nineteen underground drilling machines were in operation during 2011 and 2012.

Harmony Gold Ltd has developed two uranium projects to feasibility stage: Harmony Uranium TPM (Tshepong, Phakisa and Masimong); and the Free State Tailings Uranium Project. Witwatersrand Consolidated Gold Resources Limited (Wits Gold) holds 14 prospecting rights in the southern Free State, Potchefstroom and Klerksdorp areas adjacent to operating mines. Wits Gold's assets include its most advanced projects, the De Bron-Merriespruit (DBM) and Bloemhoek projects as well as three other projects; Robijn, Beisa North and Beisa South. An independent feasibility study for the DBM Project was completed in June 2012 and a bankable feasibility study is at an advanced stage. On the other hand, a pre-feasibility study has been completed for the Bloemhoek Project and synergies with adjacent operating mines are being investigated to fast track Bloemhoek's development timeline. Namakwa Uranium has continued exploration in the Henkries Project, in which the area has been subdivided into Henkries Central, Henkries North and Henkries South.

Exploration efforts have been focused on the uranium prospective Karoo Group sediments of southern **Tanzania** and to a lesser extent, paleochannel associated calcrete and sandstone-hosted uranium targets within the Bahi catchment of central Tanzania. Exploration and development expenditures totalled USD 25.6 million in 2011 and increased to USD 28.9 million in 2012. However, a sharp decline to USD 7.96 million is forecast for 2013. Mantra Resources who operated the Nyota Project was acquired in 2011 by the Russian Atomredmetzoloto (ARMZ). An updated resource of the Nyota deposit estimate in September 2011 boosted total *in situ* resources by over 40% to 119.4 Mlbs U_3O_8 (45 924 tU) and formed the basis of a feasibility study. Drilling activities and historical data analysis resulted in a 28% total resources increase in March 2013 to 152.1 Mlbs U_3O_8 (58 505 tU), including 124.6 Mlbs U_3O_8 (47 927 tU) measured and indicated at an average grade of 303 ppm U_3O_8 (0.0257% U) at a 100 ppm U_3O_8 (0.0085% U) cut-off grade. Exploration potential has been identified in areas adjacent to Nyota. In 2012, continued regional exploration drilling at the Mkuju River regional area and near Nyota, which focused on new mineralised zones and resources estimation. Recent activity at the Mkuju River Project focused on feasibility study optimisation and update, licensing and permitting. Drilling to date by Uranex at Likuyu North has identified a mineralised zone extended to 2.6 km of the 5 km zone defined by the surface radiometric anomaly. In April 2012, a maiden resource was estimated at 6.1 Mlb U_3O_8 (2 346 tU). Efforts have been undertaken to define economic uranium mineralisation within the project area that is not associated with surface radiometric anomalism and three zones were targeted for drilling at Likuyu North during the 2012 drilling programme.

Uranium Resources Plc. completed 159 diamond drill holes (39 000 m) and announced the maiden resource of 3.6 Mt ore containing 769 tU grading 0.00216% U at the Mtonya

Project. The resource is potentially amenable to ISL recovery. In 2010, a Memorandum of Understanding signed between Japan Oil, Gas and Metal National Corporation (JOGMEC) and the Geological Survey of Tanzania (GST) has resulted in the two institutions joining efforts to explore and assess mineral resources in the country. In 2013, Australian-based East African Resources Ltd (EAR) obtained prospecting licences for the Madaba property, where work carried out from 1979-1982 by Uranerzbergbau GmbH identified six anomalous uranium zones. The site is also located within the Selous World Heritage Game Reserve. EAR has commissioned an environmental impact assessment as requested by the Ministry of Natural Resources and Tourism (MNRT) in support of an application for site access. Mantra Resources contributed 75% to the total metres drilled for uranium exploration in Tanzania during 2010-2013 and 88% to the total number of drill holes. The bulk of Mantra's exploration expenditures have been devoted to new resources identification at the Nyota deposit and resources conversion from inferred to RAR. The remaining exploration drilling was carried out by Uranex at Likuju North and by Uranium Resources Plc. at Mtonya deposit. All development expenditures in Tanzania were invested by Mantra Resources for the Mkuju River feasibility study. Since 2012, Mantra also started to invest in detailed engineering and grade control projects for the Mkuju River development.

In **Zambia**, exploration activities are focused on identifying sandstone-type deposits in the Karoo Group. Exploration expenditures increased from USD 2.4 million in 2011 to USD 3.5 million in 2012 and are expected to rise to USD 3.8 million in 2013. Denison completed extensive drilling in 2011 and 2012 on their Mutanga Project and updated the resource estimate to 18 923 tU at an average grade of 252 ppm U (0.0252% U). Airborne geophysics techniques were used to locate anomalies for potential uranium mineralisation. Future exploration activities are expected to be focused on field programmes including an extensive surficial geochemistry and surface radon surveys, geological mapping and airborne geophysics to assist in defining drill targets. In mid-2011, Equinox Minerals was taken over by Barrick Gold Corp. for CAD 7.3 billion. At that time, a total of 4.2 Mt of uraniferous ore at a grade of 0.118% U_3O_8 (0.1% U) was stockpiled at the Lumwana copper mine which could be processed at a later date if Barrick decides to build a uranium mill for an estimated cost of USD 200 to 230 million. In 2012, drilling programmes at Lumwana were focused on a resource definition programme at Chimiwungo, reserve delineation at Chimiwungo and Malundwe, extension exploration drilling at Chimiwungo and condemnation drilling to test for economic mineralisation in areas of planned mining infrastructure. A total of 237 277 m of diamond drilling and 49 029 m of reverse circulation drilling was completed during 2012 in order to better define the limits of mineralisation and develop an updated, more comprehensive block model of the orebody for mine planning purposes. At the end of 2012, African Energy concluded baseline environmental studies for the Chirundu Uranium Project, the only work completed by African Energy on its uranium projects. African Energy is now focusing efforts on its coal projects in Botswana and intends to divest all uranium projects.

Middle East, Central and Southern Asia

In **India**, government exploration expenditures have gradually declined over the past few years with USD 56.2 million reported in 2011, USD 49.8 million in 2012 and USD 42.9 million expected in 2013. In recent years, exploration activities have been concentrated in the following areas: Proterozoic Cuddapah basin, Andhra Pradesh; Mesoproterozoic Singhbhum Shear Zone, Jharkhand; Mesoproterozoic North Delhi Fold Belt, Rajasthan and Haryana; Cretaceous sedimentary basin, Meghalaya; Neoproterozoic Bhima basin, Karnataka; and Neoproterozoic alkaline complexes in the Southern Granulite Terrain, Tamil Nadu.

The **Islamic Republic of Iran** reported an increase in exploration and development expenditures from USD 53.2 million in 2011 to USD 82.1 million in 2012 with a decline to USD 36.8 million forecasted for 2013. Exploration activities are being undertaken on several prospects including the Saghand mining district, the Champeh and Moghuyeh salt plugs, the Kerman-Sistan mineralisation trend, Naiin-Jandagh mineralisation trend, and on the Birjand-Kashmar mineralisation trend.

Exploration expenditures by government and industry in **Jordan** decreased significantly from USD 6.8 million in 2011 to USD 1.8 million in 2012, with expected expenditures of USD 2.4 million in 2013. During 2011-2012, The Jordanian-French Uranium Mining Company (JFUMC) started the second phase of the exploration programme in the southern part of the central Jordan licence area. The second phase of the exploration programme included geological mapping; a carborne radiometric survey; borehole drilling and trenching; limited sampling and chemical analysis; and a preliminary resource evaluation using the radiometric data collected from the gamma logging of the boreholes. However, the JFUMC did not meet the timelines of the agreement signed in 2008. As a result, the Jordanian government did not agree to the extension of the longstop date of the agreement and cancelled the joint venture activities. During 2011-2012, Jordanian Energy Resources Inc. (JERI) continued the same prospecting programme in other areas with a similar geological setting, located to the north of the three anomalous areas mentioned above. The prospecting programme included geological studies; carborne radiometric surveys; a trenching programme (443 trenches); sampling programme (1 951 samples); chemical analyses (X-ray fluorescence, inductively coupled plasma and gamma spectrometry); delineation of mineralised zones (four areas); and a preliminary resource estimate of 15 265 tU (18 000 tU_3O_8). An additional three areas were delineated during 2009-2010 resulting in a preliminary resource estimation of the seven areas of 28 000 tU.

Increased expenditures are reported by **Kazakhstan** from USD 70.96 million in 2011 to USD 94.3 million 2012 with further increases to 111.2 million expected in 2013. Projected estimates for exploration and development expenditures for 2013 support Kazakhstan remaining the top global producer of uranium in the near future with estimated total production of 22 500 tU in 2013. During 2011 and 2012, exploration of deposits was performed at Moinkum, Inkai, Budenovskoye in the Shu-Saysu uranium province and the Northern Kharassan and South Zarechnoe deposits in the Syrdaria uranium province. JV Katco continues exploration at site No. 3 (central) and detailed exploration at site No. 2 (Tortkuduk) of the Moinkum deposit and JV Inkai continues exploration at site No. 3 of the Inkai deposit. The Akbastau JSC started exploration at sites No. 1, 3 and 4 of the Budenovskoye deposit. ISL pilot production is ongoing at sites No. 1 and 3. The Kyzylkum LLP and the Baiken-U LLP are performing exploration at the Northern Kharassan deposit and the Karatau LLP finished exploration on site No. 2 of the Budenovskoye deposit. In 2011, GRK LLP began exploration and ISL pilot production at the new Moinkum site No. 3 (central) deposit and exploration of the Zhalpak deposit was postponed. Zarechnoe LLP also postponed exploration on the South Zarechnoe deposit. The Volkovgeology JSC renewed geological prospecting of sandstone-type deposits amenable for ISL mining in new perspective areas of the Shu-Sarysu uranium provinces, with funding from the NAK Kazatomprom JSC budget.

South-eastern Asia

Exploration expenditures in **Indonesia** were variable during this reporting period, in 2011 USD 0.45 million was spent and declined to USD 0.28 million in 2012 while in 2013 it is expected to increase to USD 0.61 million. In 2011, exploration drilling was carried out at Sarana (Kalan Sector) to a total depth of 116 m, targeting uranium mineralisation hosted in metasiltstone and metapelite schists. A general survey was completed in the eastern part of the central mountain of Papua Island (Nalca District, Yahukimo Region), covering an area of 300 km^2. The exploration target is Proterozoic unconformity-type mineralisation in Paleozoic to middle-Proterozoic rocks. In 2012, the general survey of Papua continued in the central area of the central mountain, targeting sandstone-type deposits hosted in the Paleozoic Aiduna Formation that contains carbonaceous material. In 2013, a general survey was conducted over an area of 80 km^2 in Miocene age potassic volcanic rocks in West Sulawesi. A general survey will also be conducted in Biak Island, Papua where a uranium anomaly from an environmental survey has been reported. Exploration drilling is also planned with a total of 1 500 m in the Lemajung sector and a total of 600 m in Lembah Hitam, Kalan.

Since 2010, the Geological Division for Radioactive and Rare Elements in the Ministry of Natural Resources and Environment (GDRRE) has been carrying out uranium exploration in the Parong area in the Quang Nam province in central **Viet Nam**. The project consists of an investigation and evaluation of Triassic sandstone-type deposits. Recent exploration activities on the Parong deposit consisted of geophysical and geological surveys, trenching, drilling and mining tests. A drilling programme from 2010 to 2011 over the main part of the deposit resulted in 712 holes being drilled for a total of 60 954 m.

East Asia

Total non-domestic development expenditures reported by **China** decreased from USD 94.7 million in 2011 to 81.6 million in 2012. A dramatic increase is forecasted for 2013 with total expenditures of USD 563.4 million. This is primarily due to the acquisition and development associated with the Husab mine in Namibia which was acquired in 2012 by CGNPC Uranium Resources Co., Ltd, a subsidiary of China General Nuclear Power Group (CGNPC). Chinese companies have carried out exploration activities in Australia, Kazakhstan, Mongolia, Namibia, Niger, Uzbekistan and Zimbabwe. In China, domestic exploration and development expenditures have continued to increase since 2004 with an all-time high of USD 131.0 million in 2012 and a similar amount of USD 128.0 million forecasted for 2013. The majority is exploration related with only 8-9% of the total coming from development activities. Domestic uranium prospecting and exploration have intensified and increased due to additional financial input. The scope of work has also been expanded to potential prospects selected after regional prognosis and assessment has been completed, apart from the continued prospecting and exploration on areas within previously discovered metallogenic regions/belts. The exploration, including regional uranium potential assessment and further works on previously discovered mineralisation and deposits in northern China has principally been focused on the Yili, Turpan-Hami, Junggar and Tarim basins of the Xinjiang Autonomous Region; the Erdos, Erlian, Songliao, Badanjili and Bayingebi basins of Inner Mongolia; the Caidaum basin in Qinghai province and the Jiuquan basin in Gansu province. The total drilling footage completed in the last two years amounted to 1 700 000 m (820 000 m in 2011 and 920 000 m in 2012). As a result, uranium resources in northern China such as those contained in the Yili, Tarim, Erdos, Erlian, Songliao basins have been dramatically increased, especially the large Daying deposit which was discovered in the Erdos basin. In addition, important progress has been achieved in old mining areas of southern China, such as the Xiangshan, Taoshan, Xiazhuang, Zhuguangnanbu and Dazhou uranium fields. CGNPC has carried out domestic uranium resources exploration on several uranium exploration projects in the northern edge of Tarim basin in Xinjiang Uygur Autonomous Region and the northern part of Guangdong province.

Non-domestic government exploration expenditures from **Japan** increased from USD 3.0 million reported in 2011 to USD 5.4 million in 2012, and a moderate decrease is expected in 2013 of USD 4.0 million. Japan-Canada Uranium Co. Ltd, which took over Japan Nuclear Cycle Development Institute's (JNC) Canadian mining interests, is continuing exploration activities in Canada while Japan Oil, Gas and Metals National Corporation (JOGMEC) continues exploration activities in Australia, Canada and elsewhere. Japanese private companies hold shares in companies developing uranium mines and also with those operating mines in Australia, Canada, Kazakhstan and Niger.

Reported domestic exploration and development expenditures in **Mongolia** fluctuated over the past few years from USD 18.3 million in 2010 to USD 30.1 and USD 26.0 million in 2011 and 2012, respectively. Overall the trend has been for increased expenditures. In

2011-2012, most uranium prospecting was performed in the Ulziit, Gurvansaikhan and Zuunbayan basins (south-east Mongolia), with the objective of identifying sandstone-type uranium mineralisation suitable for ISL mining.

Pacific

Domestic exploration expenditures in **Australia** decreased significantly from USD 198.7 million in 2011 to USD 98.7 million in 2012 and are expected to further decline to USD 93.2 million in 2013. Exploration was carried out in Western Australia, South Australia, Northern Territory and Queensland. Despite the decline in expenditures, attributed primarily to market conditions, several exploration programmes are being carried out. In Western Australia several companies explored for sandstone-hosted uranium deposits in sands and lignite of the Gunbarrel basin. In mid-2012, Energy and Minerals Australia Ltd discovered a new uranium deposit Princess, within the Mulga Rock Project area 250 km east-northeast of Kalgoorlie. Toro Energy continued exploration at the Theseus prospect, in the Lake Mackay region of North East Western Australia adjacent to the Northern Territory border. Drilling intersected significant mineralisation in Cainozoic paleochannel sands adjacent to uranium-rich rocks of the Amadeus basin. Companies also explored for calcrete-hosted deposits in palaeochannels overlying the Yilgarn Craton.

In South Australia there has been an increased amount of exploration for sandstone-hosted uranium deposits in the Frome Embayment. Quasar Resources continued exploration drilling at the Pepegoona, Pannikan and North Mulga deposits, which are 8 to 12 km north of the Beverley mine. Cauldron Energy discovered uranium mineralisation in paleochannel sands at its Macdonnell Creek prospect, north of Mount Babbage Inlier. In addition, several companies explored for sandstone-hosted deposits along the northern portion of the Ngalia basin, 200 km north-west of Alice Springs. Drilling during 2011 intersected mineralisation at Anomalies 15 and 4 (near the Bigrlyi deposit) and at the Camel Flat prospect (35 km south-east of Bigrlyi). In the Northern Territory high-grade unconformity-related mineralisation was discovered at the Angularli prospect in western Arnhem Land in 2011. Angularli is the first discovery in Alligator Rivers region of significant high-grade uranium mineralisation above the unconformity in the Kombolgie Sandstone. Exploration also intersected high-grade unconformity-related mineralisation in the Ranger 3 Deeps area, east of the Ranger open-cut, and the Caramal prospect in western Arnhem Land. In Queensland, Paladin Energy Ltd continued exploration drilling for metasomatite deposits in an area extending from 10 km to 110 km north of Mount Isa in North West Qld. During 2011 and 2012, several Australian companies explored for uranium in Namibia and Malawi but these expenditures are not reported by the government.

Uranium production

In 2011, 2012 and 2013, uranium was produced in 21 different countries, with Germany, Hungary and France producing small amounts of uranium only as the result of mine remediation activities (Bulgaria did not report uranium recovery from mine remediation for this edition of the Red Book; hence there is one less producing country than in 2010). Kazakhstan's growth in production continued, albeit at a slower pace, and it remains the world's largest producer with 21 240 tU produced in 2012 and 22 500 tU expected in 2013. In 2012, production in Kazakhstan amounted to more than the combined 2012 production of Canada and Australia, respectively the second and third largest producers. Table 1.20 summarises major changes in uranium production in a number of countries and Table 1.21 shows production in all producing countries from 2010 to 2012, with expected production in 2013. Figure 1.5 shows 2012 production shares and Figure 1.6 illustrates the evolution of production shares from 2006 to 2012.

Table 1.20. Production in selected countries and reasons for major changes

(tonnes U)

Country	Production 2010	Production 2012	Difference	Reason for changes in production
Australia	5 900	7 009	1 109	Return to normal production at Ranger after high rainfall events flooded the open pit, disrupting mine production and ore processing in 2010 and 2011.
Brazil	148	326	178	Increase of production at Caetité.
Canada	9 775	8 998	-777	Production suspended at McClean Lake.
China	1 350	1 450	100	Ongoing expansion of existing mines.
Kazakhstan	17 803	20 981	3 178	New deposits brought into production.
Malawi	681	1 103	422	Expansion of the Kayelekera mine.
Namibia	4 503	4 653	150	Decrease of production at Rössing, but increase at Langer Heinrich and first test production at Trekkopje.
Niger	4 197	4 822	625	Additional production at Somaïr and Azelik.
Russian Federation	3 563	2 862	-701	Decline in production due to lower ore grade at Priargunsky mines.
South Africa	582	467	-115	Decrease caused by suspension of production at Ezulwini; lower uranium grade, industry wide strike actions and safety-related stoppages at other production centres.
Ukraine	837	1 012	175	Start of production at Novokonstantinovskiy mine.

Table 1.21. Historical uranium production

(tonnes U)

Country	Pre-2010	2010	2011	2012	Total to 2012	2013 (expected)
Argentina	2 582				2 582	
Australia	164 363	5 900[(a)]	5 967	7 009	183 239	6 700
Belgium	686				686	
Brazil	3 186	148	265	326	3 925	340
Bulgaria	16 363	1[(d)]	0*	0*	16 364	0*
Canada[(a)]	437 571	9 775	9 145	8 998	465 489	9 000
China	32 599*	1 350	1 400	1 450	36 799*	1 450
Congo, Dem. Rep. of*	25 600				25 600	
Czech Republic[(b)]	110 685	254	229	228	111 396	213
Finland	30				30	
France[(a)]	80 945	9[(d)]	6[(d)]	3[(d)]	80 963	3[(c)]
Gabon	25 403				25 403	
Germany[(c)]	219 517	8[(d)]	51[(d)]	50[(d)]	219 626	30[(c)]
Hungary	21 053	6[(d)]	2[(d)]	1[(d)]	21 062	3[(c)]
India*	9 443	400	400	385	10 628	400

See notes on page 61.

Table 1.21. Historical uranium production *(continued)*

(tonnes U)

Country	Pre-2010	2010	2011	2012	Total to 2012	2013 (expected)
Iran, Islamic Rep. of	25	7	12	15	59	40
Japan	84				84	
Kazakhstan	140 920	17 803	19 450	21 240	199 413	22 500
Madagascar	785				785	
Malawi	90	681	842	1 103	2 716	1 200
Mexico	49				49	
Mongolia	535				535	
Namibia	100 089	4 503	4 078	4 653	113 323	4 820
Niger	110 149	4 197	4 264	4 822	123 432	3 859
Pakistan*	1 214	45	45	45	1 349	45
Poland	650				650	
Portugal	3 720				3 720	
Romania*	18 499	80	80	80	18 739	80
Russian Federation	143 300	3 563	2 993	2 862	152 718	3 133
Slovak Republic	211				211	
Slovenia	382				382	
South Africa	156 808	582	556	467	158 413	540
Spain	5 028				5 028	
Sweden	200				200	
Ukraine	125 202	837	873	1 012	127 924	1 075
United States	365 270	1 630	1 582	1 667	370 149	1 700*
USSR[(e)]	102 886				102 886	
Uzbekistan	115 017	2 874	2 500*	2 400*	122 791*	2 400*
Zambia	86				86	
OECD	1 410 444	17 582	16 982	17 956	1 462 964	17 649
Total	**2 541 225**	**54 653**	**54 740**	**58 816**	**2 709 434**	**59 531**

Note: For pre-2010, other sources cite 6 156 tU for Spain, 91 tU for Sweden.

* Secretariat estimate.

(a) Historical total updated from 2011 Red Book.

(b) Includes 102 241 tU produced in the former Czechoslovakia and CSFR from 1946 through the end of 1992.

(c) Production includes 213 380 tU produced in the former the German Democratic Republic from 1946 through the end of 1989.

(d) Production from mine rehabilitation efforts only.

(e) Includes production in former Soviet Socialist Republics of Estonia, Kyrgyzstan, Tajikistan and Uzbekistan.

Figure 1.5. Uranium production in 2012: 58 816 tU

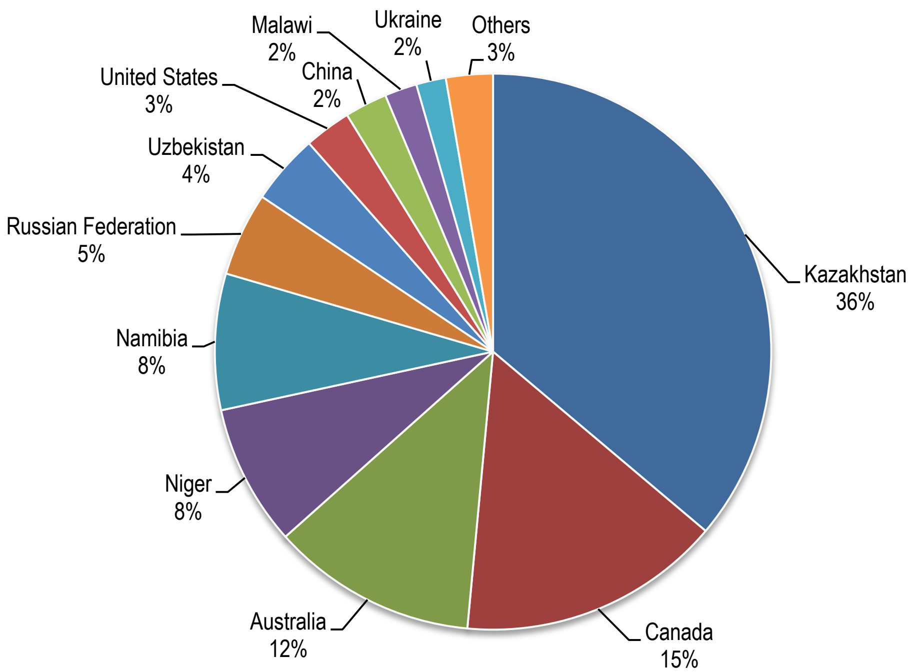
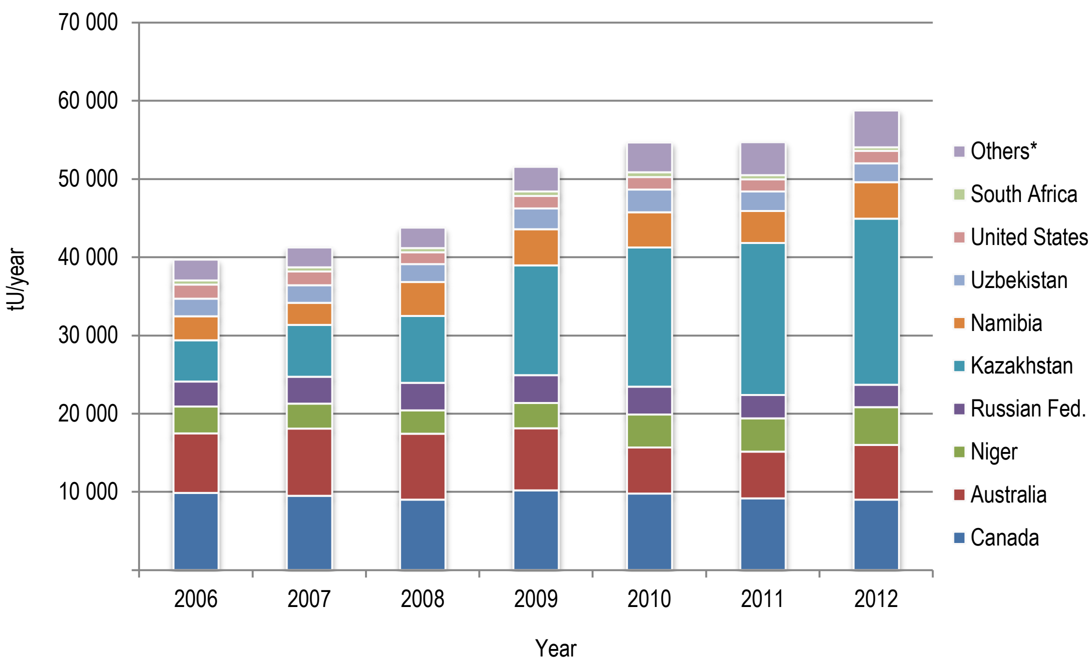


Figure 1.6. Recent world uranium production



Note: Values for China (pre-2008), India, Namibia, Pakistan and Romania are estimates.
* "Others" includes the remaining producers (Table 1.21).

Niger produced 4 822 tU in 2012 which is only slightly more than Namibia which produced 4 653 tU. The top five producing countries (Kazakhstan, Canada, Australia, Niger and Namibia) retained their dominance accounting for 79% of world production in 2012. Eleven countries, Kazakhstan (36%), Canada (15%), Australia (12%), Namibia (8%), Niger (8%), the Russian Federation (5%), Uzbekistan (4%) and the United States (3%), China (2%), Malawi (2%), and Ukraine (2%) accounted for about 97% of world production (Figure 1.5).

Overall, world uranium production increased only 0.2% from 54 653 tU in 2010 to 54 740 tU in 2011 and in 2012 amounted to 58 816 tU, an increase of 7.4% from 2011. These recent increases are principally the result of increased production in Kazakhstan (accounting for 83% of global production increases in 2011 and 2012), with smaller additions from Australia, Brazil, China, Malawi, Namibia, Niger, Ukraine and the United States. Within OECD countries, production increased slightly from 16 982 tU in 2011 to 17 956 tU in 2012 and is expected to decrease slightly to 17 649 tU in 2013.

Present status of uranium production

North American production amounted to 18% (10 665 tU) of world production in 2012, a decrease of 740 tU since 2010. Current Canadian uranium production remains below full production capability and is forecasted to remain at 9 000 tU in 2013 but will increase significantly when the Cigar Lake mine reaches full production, expected in 2016-17. In the United States, production remained relatively steady with a slight increase in production from 2011 to 2012. The share of world production from North America continues to decline because of increased production elsewhere. **Canada** has been far outstripped in production increases by Kazakhstan, but remains the dominant North American producer and the second largest producer in the world. Production at the McArthur River mine, the world's largest high-grade uranium mine, was 7 626 tU and 7 460 tU in 2011 and 2012, respectively. Ore from the McArthur River mine is crushed and treated underground to produce high-grade ore slurry that is pumped to surface and transported by specially designed trucks to the Key Lake mill for processing.

The Key Lake mill maintained its standing as the world's largest uranium production centre by producing 7 686 tU and 7 520 tU in 2011 and 2012, respectively. These totals represent a combination of high-grade McArthur River ore slurry and stockpiled, mineralised Key Lake special waste rock that is used to blend down high-grade McArthur River ore to produce a mill feed grade of about 3.4% U. The McClean Lake mill has been on care and maintenance since July 2010 and is expected to restart in 2014 when ore from Cigar Lake becomes available. The Rabbit Lake production centre produced 1 459 tU and 1 479 tU in 2011 and 2012, respectively. Exploratory drilling in the Eagle Point mine during the last several years has increased identified resources to 14 700 tU, extending the life of the mine to at least 2017.

In the United States uranium mines produced 1 582 tU in 2011, 3% less than in 2010. In 2012, US uranium mines produced 1 667 tU, 5% more than in 2011. Production in 2012 was from 11 mines, 6 underground mines and 5 ISR mines, 1 more than in 2011. Uranium ore from underground mines is stockpiled and shipped to the White Mesa Mill, to be milled into uranium concentrate (a yellow or brown powder).

At the end of 2012, one uranium mill (White Mesa in Utah) was operating with a capacity of 1 814 tonnes ore per day. Two mills (Shootaring Canyon in Utah and Sweetwater in Wyoming) were on standby status with a combined capacity of 3 400 tonnes ore per day. One mill (Piñon Ridge) was planned for Colorado. The US Nuclear Regulatory Commission received letters of intent for mill licence applications from Uranium Resources Inc. (Juan Tafoya mine area, New Mexico), General Atomics (Mt. Taylor Mine area, New Mexico) and Oregon Energy LLC (Aurora deposit area, Oregon).

Five ISR plants were operating in 2012 with a combined capacity of 3 770 tU per year (Crow Butte, Nebraska; Alta Mesa, Texas; La Palangana, Texas; Smith Ranch-Highland

and Willow Creek in Wyoming). Smith Ranch, Crow Butte, Alta Mesa and Willow Creek processed lixiviant at the mine site and loaded resins were trucked from La Palangana to the Hobson plant in Texas for processing. The Kingsville Dome and Rosita ISR mines in Texas were on standby with a total capacity of 770 tU per year. The Lost Creek and Nichols Ranch ISR projects were under construction in Wyoming and seven other ISR plants are planned in New Mexico, South Dakota, Texas and Wyoming. Existing and new ISR properties are most likely to be the largest contributors to expanded US production in the near term.

Work continues in **Argentina** to restart production at the Sierra Pintada mine of the San Rafael complex, but regulatory and environmental issues remain to be addressed. A strategic plan recently submitted by CNEA to national authorities includes development of a new production centre in the province of Chubut in the vicinity of the Cerro Solo deposit, with first production targeted in 2018. **Brazil** was the only producing country in **South America** with production of 265 tU and 326 tU in 2011 and 2012, respectively at the country's only production centre, Lagoa Real, Caetité. Expansion of this facility to 670 tU/year is progressing but has been delayed somewhat to around 2016. The expansion involves replacement of the current heap leaching process by conventional agitated leaching. The phosphate/uranium project of Santa Quitéria, an INB-Brazilian fertiliser producer partnership agreement, remains under development. In 2012, the project applied for a construction licence and the operation is now scheduled to begin production in 2016. The Engenho deposit, located 2 km from the currently mined Cachoeira deposit, is under study and is expected to provide additional feed to the Caetité mill after 2016.

Primary uranium production in the **European Union** (EU) was from only two countries, the **Czech Republic** and **Romania.** A further three countries, **France**, **Germany** and **Hungary** produced minor amounts of uranium from mine remediation activities only (a small portion of Czech Republic production results from similar activities).

Total reported EU production in 2012 was 308 tU of which the Czech Republic contributed 228 tU. Romania has not reported production data in almost a decade but the Secretariat estimates that it produces about 80 tU per year. Finland is poised to become a uranium producer through the Talvivaara Mining Company Plc., which operates the Talvivaara Ni-Zn-Cu-Co mine in Sotkamo, eastern Finland, one of the largest sulphide nickel deposits in Europe. On 1 March 2012, the Finnish government granted a licence for the extraction of uranium as a by-product and the company plans to begin uranium production sometime in 2013-2014. The licence is valid until the end of 2054.

Output from **non-EU countries in Europe** in 2012 amounted to 3 874 tU, a slight increase from 2011, as production decreased in the **Russian Federation** by 131 tU but increased in **Ukraine** by 139 tU from 2011 to 2012. Russian Federation output is expected to increase to about 3 133 tU in 2013 and ongoing development projects, particularly in the Elkon uranium district, should see production capacity increased substantially in coming years.

The four producing countries in **Africa**, **Namibia**, **Niger** and **South Africa** were joined by **Malawi** in 2009 when production commenced at the Kayelekera mine. African production increased from 9 963 tU in 2010 to 11 045 tU in 2012. A decline is expected in 2013 due to decreased production in Niger as the Somaïr plant was closed for about 2 months following an attack by insurgents that required parts of the plant to be rebuilt. The Imouraren mine in Niger which is being developed by AREVA, was originally scheduled to begin production in 2012, but has been delayed due to security risks and unfavourable market conditions. Possible production in **Botswana**, **Tanzania** and **Zambia** and several projects under investigation in **South Africa** could contribute to regional production increases in the future should market conditions improve.

Dramatic increases in production in the **Middle East**, **Central** and **Southern Asia** continued into 2012 with a total of 24 085 tU produced. This was driven mainly by **Kazakhstan** where production increased from 17 803 tU in 2010 to 19 450 tU in 2011 and 21 240 tU in 2012. It is now by far the largest uranium-producing country in the world. Production growth is expected to slow into the future but is still expected to increase to almost 22 500 tU in 2013. **India** and **Pakistan** do not report production figures but their combined total is estimated to amount to about 430 tU in 2012, down slightly from an estimated 450 tU in 2010. **Uzbekistan** did not report production for this edition and the Secretariat estimates that production declined slightly to 2 400 tU. **The Islamic Republic of Iran** continues to produce small amounts of uranium from its Gachin deposit and plans to commence production from its Saghand facility in the near future. At present the development of mines No. 1 and 2 is being carried out in the Saghand ore field. In mine No. 1, the open-pit method is being developed whereas ore at mine No. 2 is planned to be extracted by the underground method. **Jordan** continues to develop resources with the aim of producing uranium in the near future but current market conditions could delay mine development.

China, the only producing country in **East Asia**, reported a small but steady increase in production of 1 350 tU in 2010, 1 400 tU in 2011 and 1 450 tU in 2012 from six production centres. Production is equally spread between sandstone-hosted and volcanic-hosted deposits with a third of total production coming from unidentified "other" sources.

Australia is the only producing country in the **Pacific** region. Production increased slightly from 5 900 tU in 2010 to 5 967 tU in 2011 and further increased to 7 009 tU in 2012. The Olympic Dam Expansion Project, based on the development of a large open pit to access the south-eastern portion of the deposit, was formally approved by the Australian and South Australian governments in October 2011. However, in August 2012, the company announced that it would delay the project and investigate an alternative, less capital-intensive design alternatives involving new technologies which would substantially improve the economics of the project. Heap leach and other technological solutions were being studied. Market conditions, including subdued commodity prices and higher capital costs led to the decision to delay the expansion project.

Ownership

Table 1.22 shows the ownership of uranium production in 2012 in the 21 producing countries. Domestic mining companies controlled about 59.2% of 2012 production, a decrease from the 67.9% reported in 2010. Domestic government participation basically remained the same at 38.6% compared to 38.8% in 2010. Non-domestic mining companies controlled about 40.8% of 2012 production with private companies controlling about 62.5%.

Employment

Although the data are incomplete, Table 1.23 shows that employment levels at existing uranium production centres rose by 1.8% from 2010 to 2011, then declined by 1.4% from 2011 to 2012 and are expected to decline by a further 1% in 2013. However, if future production expansions in countries such as Australia, Canada, India, Kazakhstan, Namibia and the Russian Federation are successfully completed, employment will increase in the longer term. Table 1.24 provides, in selected countries, employment directly related to uranium production (excluding head office, R&D, pre-development activities, etc.).

Table 1.22. Ownership of uranium production based on 2012 output

Country	Domestic mining companies				Non-domestic mining companies				Total
	Government-owned		Privately owned		Government-owned		Privately owned		
	tU	%	tU	%	tU	%	tU	%	tU
Australia*	0	0	4 380	62	119	2	2 510	36	7 009
Brazil	326	100	0	0	0	0	0	0	326
Canada	0	0	6 737	75	2 261	25	0	0	8 998
China	1 450	100	0	0	0	0	0	0	1 450
Czech Republic	228	100	0	0	0	0	0	0	228
France	3	100	0	0	0	0	0	0	3
Germany	50	100	0	0	0	0	0	0	50
Hungary	1	100	0	0	0	0	0	0	1
India*	385	100	0	0	0	0	0	0	385
Iran, Islamic Rep. of	15	100	0	0	0	0	0	0	15
Kazakhstan	11 931	56	0	0	2 481	12	6 828	32	21 240
Malawi	165	15	0	0	0	0	938	85	1 103
Namibia	69	1	0	0	973	21	3 611	78	4 653
Niger*	1 675	35	0	0	3 147	65	0	0	4 822
Pakistan*	45	100	0	0	0	0	0	0	45
Romania*	80	100	0	0	0	0	0	0	80
Russian Federation	2 862	100	0	0	0	0	0	0	2 862
South Africa	0	0	467	100	0	0	0	0	467
Ukraine	1 012	100	0	0	0	0	0	0	1 012
United States*	0	0	517	31*	0	0	1 150*	69*	1 667
Uzbekistan*	2 400	0	0	0	0	0	0	0	2 400
Total	**22 697**	**38.6**	**12 101**	**20.6**	**8 981**	**15.3**	**15 037**	**25.5**	**58 816**

* Secretariat estimate.

Table 1.23. Employment in existing production centres of listed countries

(person-years)

Country	2006	2007	2008	2009	2010	2011	2012	2013 (expected)
Argentina	133	133	133	133	133	128*	123*	123*
Australia[(a)]	959	3 010	4 787	3 830	4 813	4 888	5 574	5 620
Brazil	580	580	640	620	620	620	620	650
Canada[(b)]	1 665	1 873	1 984	2 205	2 399	2 060	2 109	2 400
China	7 300	7 400	7 450	7 500	7 560	7 650	7 660	7 670
Czech Republic	2 251	2 294	2 287	2 248	2 164	2 118	2 126	2 141
Germany[(c)]	1 835	1 775	1 770	1 638	1 489	1 452	1 372	1 204
India	4 300	4 300	4 634	4 643	4 917	4 917	4 962	4 962
Iran, Islamic Rep. of	285	285	285	320	325	340	350	600
Kazakhstan	6 941	7 845	7 940	9 261	8 828	8 550	9 760	10 232
Malawi	0	2000*	1 250	1 033	1 036	766	759	750
Namibia	1 400	1 900	>2 543	>2 781	2 554	1 886	2 786	2 340
Niger	1 741	1900*	2 156	2 764	2 915	2 915	2 915	2 915
Romania*	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Russian Federation	12 575	12 950	12 870	9 975	8 989	9 028	9 526	10 335
Slovenia[(c)]	20	NA	NA	NA	NA	NA	NA	NA
South Africa	150	1 150	3 364	4 494	4 825	4 320	237	3 900
Spain[(c)]	58	58	43	43	25	24	23	22
Ukraine	4 310	NA	4 260	4 350	4 310	4 470	4 490	NA
United States	600	1 076	1 409	934	948	1 089	1 017	NA
Uzbekistan	8 700*	8 700*	8 750	8 800	8 860	NA	NA	NA
Total	**57 803**	**61 229**	**>70 555**	**>69 572**	**69 710**	**59 221**	**58 409**	**57 864**

* Secretariat Estimate; NA = Data not available.

(a) Olympic Dam does not differentiate between copper, uranium, silver and gold production. Employment has been estimated for uranium-related activities.

(b) Employment at mine sites only.

(c) Employment related to decommissioning and rehabilitation.

Table 1.24. Employment directly related to uranium production and productivity

Country	2010		2011		2012	
	Production employment (person-years)	Production (tU)	Production employment (person-years)	Production (tU)	Production employment (person-years)	Production (tU)
Australia[(a)]	4 514	5 900	4 590	5 967	3 720	7 009
Brazil	340	148	340	265	340	326
Canada[(b)]	1 305	9 775	1 316	9 145	1 361	8 998
China	6 860	1 350	6 950	1 400	6 960	1 450
Czech Republic	1 118	254	1 139	229	1 147	228
India	NA	NA	400*	NA	385*	NA
Iran, Islamic Rep. of	NA	7	NA	12	NA	15
Kazakhstan	6 718	17 803	6 792	19 450	5 809	21 240
Malawi*	1 036	681	NA	842	NA	1 103
Namibia*	1 915	4 503	1 737	4 078	2 628	4 653
Niger*	1 900	4 197	NA	4 264	NA	4 822
Russian Federation	5 669	3 563	5 687	2 993	5 810	2 862
South Africa	1 286	582	1 270	556	182	467
Ukraine	1 420	837	1 580	873	1 600	1 012
United States	737	1 626	881	1 535	856	1 595
Uzbekistan	8 860	2 874	NA	2 400*	NA	2 400*

* Secretariat estimate. NA = Data not available.

(a) Olympic Dam does not differentiate between copper, uranium, silver and gold production. Employment has been estimated for uranium-related activities.

(b) Employment at mine sites only.

Production methods

Historically, uranium production has been produced mainly using open-pit and underground mining techniques processed by conventional uranium milling. Other mining methods include *in situ* leaching, co-product or by-product recovery from copper, gold and phosphate operations, heap leaching and in-place leaching (also called stope or block leaching). Stope/block leaching involves the extraction of uranium from broken ore without removing it from an underground mine, whereas heap leaching involves the use of a leaching facility on the surface once the ore has been mined. Small amounts of uranium are also recovered from mine water treatment and environmental restoration activities.

Over the past two decades, ISL mining, which uses either acid or alkaline solutions to extract the uranium directly from the deposit, has become increasingly important. The uranium dissolving solutions are injected into and recovered from the ore-bearing zone using a system of wells. ISL technology is currently being used to extract uranium from sandstone deposits only and in recent years has become the dominant method of uranium production.

The distribution of production by type of mining or "material sources" for 2009 through 2013 is shown in Table 1.25. The category "other methods" includes recovery of uranium through treatment of mine waters as part of reclamation and decommissioning.

As can be seen in Table 1.25, ISL production has continued to dominate uranium production, largely because of the rapid growth of production in Kazakhstan along with other ISL projects in Australia, China, the Russian Federation, the United States and Uzbekistan. World uranium production by ISL is forecasted to reach 47.5% of total production in 2013. The co-product/by-product method could increase in importance in coming years if the planned expansion of Olympic Dam proceeds.

Table 1.25. Percentage distribution of world production by production method

Production method	2009	2010	2011	2012	2013 (expected)
Open-pit mining	25.6	20.6	17.6	19.9	18.5
Underground mining	32.6	29.8	28.6	26.2	25.6
ISL	33.8	42.1	44.5	44.9	47.5
Co-product/by-product	7.3	5.3	7.1	6.6	6.4
Heap leaching	0.7	1.5	1.5	1.7	1.3
Other	0.0	0.7	0.7	0.7	0.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Projected production capabilities

To assist in developing projections of future uranium availability, member countries were asked to provide projections of *production capability* through 2035. Table 1.26 shows the projections for *existing and committed production centres* (A-II columns) and for *existing, committed*, *planned and prospective production centres* (B-II columns) in the <USD 130/kgU category through 2035 for all countries that either are currently producing uranium or have the plans and the potential to do so in the future. Note that both the A-II and B-II scenarios are supported by currently identified local RAR and IR in the <USD 130/kgU category, with the exception of Pakistan and Romania.

Several current or potential uranium producing countries including China, India, Jordan, Malawi, Mongolia, Namibia, Niger, Pakistan, Romania, South Africa, Tanzania, the United States, Uzbekistan and Zambia did not report projected production capabilities to 2035. Estimates of production capability for these countries were developed by the Secretariat using data submitted for past Red Books and company reports. Projections of future production capability for Pakistan and Romania in Table 1.26 are based on reports that these countries intend to meet their future domestic reactor requirements with domestic production, even though the currently identified resource bases are insufficient to meet these projected requirements.

The reported production capability of existing and committed production centres in the A-II category in 2013 is 74 310 tU. For comparison, estimated 2011 production capability totalled 73 305 tU whereas actual 2011 production amounted to 54 740 tU, or about 74% of stated production capability. In 2010, production amounted to 54 653 tU, or about 78% of stated production capability, in 2007 production was 76% of production capability, in 2005 (84%) and in 2003 (75%), demonstrating that full capability is rarely, if ever, achieved. Total production capability for 2013, including planned and prospective centres (category B-II), amounts to 74 410 tU, slightly lower than the 2011 B-II total capability of 75 090 tU. In 2011, 2010 and 2007, production amounted to 73% of total B-II capability – in 2005 and 2003, production amounted to 81% and 74%, respectively.

Table 1.26. World uranium production capability to 2035

(in tonnes U/year, from RAR and inferred resources recoverable at costs up to USD 130/kgU, except as noted)

Country	2013		2015		2020		2025		2030		2035	
	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II
Argentina	120	120*	150	150*	150	250	300*	300*	300*	300*	300*	300*
Australia	9 700	9 700	9 700	10 200	10 100	20 800	10 100	28 400	9 800	28 100	9 800	28 100
Brazil	340	340	340	340	1 600	2 000	1 600	2 000	2000*	2000*	2000*	2000*
Canada	16 430	16 430	17 730	17 730	17 730	19 000	17 730	19 000	17 730	19 000	17 730	19 000
China*	1 500	1 600	1 800	2 000	1 800	2 000	1 800	2 000	1 800	2 000	1 800	2 000
Czech Republic	500	500	500	500	50	50	50	50	50	50	30	30
Finland**	0	0	0	350	0	350	0	350	0	350	0	350
India*	610	610	740	740	1 080	1 200	1 200	1 600	1 200	2 000	1 200	2 000
Iran, Islamic Rep. of	70	70	90	90	90	120	100*	100*	100*	100*	100*	100*
Jordan*	0	0	0	0	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Kazakhstan	22 000	22 000	24 000	25 000	24 000	25 000	14 000	15 000	11 000	12 000	5 000	6 000
Malawi*	1 200	1 200	1 400	1 460	1 400	1 460	0	0	0	0	0	0
Mongolia*	0	0	0	500	150	1 000	150	1 000	150	1 000	150	1 000
Namibia*	6 000	6 000	10 000	10 000	15 700	15 700	16 100	16 100	16 100	16 100	12 000	12 000
Niger*	5 400	5 400	5 400	10 500	10 500	10 500	10 500	10 500	7 500	7 500	7 500	7 500
Pakistan*(a)	70	70	70	110	140	150	140	150	140	650	140	650
Romania*(a)	230	230	230	230	350	475	350	475	350	630	350	630
Russian Federation	3 135	3 135	3 920	3 970	4 140	4 180	5 520	7 250	5 180	10 830	4 900	9 900
South Africa*	540	540	1 100	1 380	1 540	3 180	1 360	3 000	1 185	2 830	890	2 530
Tanzania*	0	0	0	0	3 000	3 000	2 000	2 000	1 000	1 000	0	0
Ukraine	1 075	1 075	1 075	3 230	810	5 500	250	5 800	170	6 400	0*	6 400*
United States(b)	2 040	2 040	3 400	6 100	3 800	6 600	3 700	6 500	3 100	5 600	3 100	5 600
Uzbekistan	3 350	3 350	4 150	4 150	4 500	4 500	5 000	5 000	5 000*	5 000*	5 000*	5 000*
Zambia*	0	0	0	0	0	650	0	650	0	650	0	650
Total	**74 310**	**74 410**	**85 795**	**98 730**	**104 630**	**129 665**	**93 950**	**129 225**	**85 855**	**126 090**	**73 990**	**113 740**

A-II = Production capability of existing and committed centres supported by RAR and inferred resources recoverable at <USD 130/kgU.

B-II = Production capability of existing, committed, planned and prospective centres supported by RAR and inferred resources recoverable at <USD 130/kgU.

* Secretariat estimate.

** By-product of nickel production.

(a) Projections are based on reported plans to meet domestic requirements through the discovery of additional resources.

(b) Data from previous Red Book.

Expansion in production capability is principally being driven by generally higher uranium prices since 2003. Production has also increased in recent years despite declining uranium prices since 2011, although not as rapidly as the projected production capability. Kazakhstan continued to rapidly increase production in 2011 and 2012, accounting for 83% of the growth in global production over these two years. In most other countries turning stated production capability into production takes time, expertise and investment and can be confounded by unexpected geopolitical events, technical challenges and other factors.

The influence of the Fukushima Daiichi accident and its impact on the development of nuclear power and in turn uranium prices has slowed the rate of increase in production capabilities in the short term. Furthermore, the delay in the significant expansion of the Olympic Dam mine in Australia (announced in August 2012) and uncertainties about the Rössing expansion makes establishing the timing of the additional production capability more uncertain than usual.

As of 2013, projections show a marked decrease in production capability in 2015 compared to the last Red Book (decreases of 1 700 tU and 11 600 tU in the A-II and B-II categories, respectively), as developments are being brought in line with the slowdown in nuclear generation capacity growth since the Fukushima Daiichi accident (Table 1.26). Although the longer-term growth prospects for nuclear power have not been greatly affected, the accident has caused a near-term slowdown in the rate of growth and the role of nuclear power in Japan remains uncertain. Despite the slowdown and remaining uncertainties, longer term projections of production capability from existing and committed production centres (A-II category) from 2020 to 2035 have nonetheless been slightly increased compared to the 2011 Red Book.

The current overall picture is that the closure of existing mines due to resource depletion is expected to be offset by the opening of new mines. As currently projected, production capability of existing and committed production centres is expected to reach about 105 000 tU/yr in 2020, declining thereafter to about 94 000 tU in 2025, 86 000 tU in 2030 and 74 000 tU in 2035. Total potential production capability (including planned and prospective production centres, category B-II) could climb to over 129 000 tU/yr by 2020 and 2025, followed by a slow decline to around 114 000 tU/yr in 2035. However, these projections are based on currently known uranium resources that will in all likelihood be supplemented by new discoveries in the future, with the appropriate market signals.

Recent, planned, committed mines and expansions

Table 1.27 summarises production capacity (the nominal level of output based on plant design), adding some detail to the capability expansions outlined in Table 1.26. Committed production centres (C) are either under construction or are firmly committed for construction, planned production centres (P) are those where feasibility studies are either completed or under way, but for which construction commitments have not yet been made. Expansions (Exp) are capacity increases at existing sites (E).

During 2011 and 2012, three new mines opened; Honeymoon in Australia, Mohuldih in India and Novokonstantinovskiy in Ukraine. The Langer Heinrich stage 3 expansion in Namibia was also completed in 2012. Until 2021, the majority of the increases in uranium capacity arising from new mine openings, the expansion of existing mines and planned mines are expected to take place from 2014 to 2016. In 2014, an additional 7 890 tU of production capacity is expected to be brought on line, mainly owing to the opening of the Cigar Lake and Four Mile mines, the initiation of uranium production as a by-product of nickel production at Talvivaara (Finland) and the commissioning of two new ISL mines in the United States.

Table 1.27. Recently opened, planned and committed mine capacity expansion and expansions of existing facilities

(in year of estimated first production with tU/yr estimated production capacity and capacity increases for expansions in brackets)

	Production centre	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Argentina	Cerro Solo						P (100)					
Australia	Honeymoon	E (340)										
	Olympic Dam[(1)] Exp (12 280)											
	Beverley[(2)] Exp (420)											
	Four Mile[(3)]				P (650*)							
	Yeelirrie[(4)]											
	Wiluna					P (850)						
Botswana	Letlhakane						P (1 350)					
Brazil	Lagoa Real/Caetité[(5)]						Exp (330)					
	Santa Quitéria[(6)]						C (970)					
	Engenho[(7)]						P (300)					
Canada	Cigar Lake				C (5 000)							
	Midwest[(8)] P (2 300)											
	Millennium[(8)] P (2 750)											
	Kiggavik[(9)] P (3 000)											
China	Fuzhou[(10)] Exp (150)											
	ChongyI[(10)] Exp (100)											
	Yining[(10)] Exp (120)											
	Benxi[(10)] Exp (100)											
	Shaoguan[(10)] Exp (100)											
Finland	Talvivaara[(11)]				C (350)							
India	Mohuldih	E (50*)										
	Tummalapalle				C (220)							
	Gogi				C (130)							
	Lambapur-Peddagattu						P (130)					
	KPM[(12)]							P (340)				
	Turamdih					Exp (100*)						
Iran, Islamic Republic of	Ardakan/Saghand			C (50)								
Kazakhstan[(13)]	Kharasan-1					Exp (1 000*)						Exp (1 000)
	Kharasan-2							Exp (1 115*)				
	Moinkum site 3			C (Unk)								
Malawi	Kanyika							P (60)				
Mongolia	Emeelt								P (Unk)			
	Gurvansaikhan								P (Unk)			
	Coge-Gobi								P (Unk)			

See notes on page 73.

Table 1.27. Recently opened, planned and committed mine capacity expansion and expansions of existing facilities *(continued)*
(in year of estimated first production with tU/yr estimated production capacity and capacity increases for expansions in brackets)

	Production centre	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Namibia	Etango						P (3 000)					
	Husab					C (5 800)						
	Langer Heinrich[14]		Exp (680)									
	Rössing Exp[4]											
	Trekopje[15] C (1 600)											
	Norassa						P (1 900)					
Niger	Imouraren					C (5 000)						
	Madaouela							P (1 040)				
Russian Federation	Kiagda										Exp (Unk)	
South Africa	Beaufort West						P (1 035)					
	Free State Tailings						P (700)					
	Mine Waste Solution			C (300)								
	Springbok Flats							P (600)				
	TPM uranium						P (340)					
Tanzania	Mkuju River						P (1 400)					
Ukraine	Novokonstantinovskiy	E (1 500)										
	Safonovskiy					C (150)						
	Severinskiy										P (1 200)	
United States	Goliad					P (385)						
	Lost Creek				C (770)							
	Hank/Nichols Ranch				C (770)							
	Moore Ranch							P (190)				
Zambia	Lumwana P (650)[9]											
	Mutanga P[4]											

* Secretariat estimate; E = existing (new) production centre; Exp = expansion; C = committed; P = planned; Unk = unknown.
(1) Expansion by mining the southern portion of the deposit by a large open pit delayed in 2012 pending investigation of less capital intensive options for the project. (2) Approval granted to expand the production capacity of the facility, when commercially viable. (3) Solutions are to be treated at Beverley. (4) Start-up date and capacity unknown. (5) Expansion of Caetité mill capacity. (6) Phosphate/uranium by-product project. (7) Ore to be treated at Caetité. (8) Postponed due to market conditions, start-up date unknown. (9) Start-up date unknown. (10) Date of expansion unknown. (11) Nickel by-product. (12) KPM = Kylleng-Pyndengsohiong Mawthabah. (13) Planned expansions of Mynkuduk, Budenovskoe, Zhalpak, Inkai and other ISL facilities noted but capacities and start-up dates unknown. (14) Stage 4 expansion by 1 800 tU delayed due to market conditions. Start-up date unknown. (15) Project placed in care and maintenance in 2012; start-up date unknown.

In 2015, over 13 000 tU of production capacity is expected to be brought online, in major part due to the projected start-up of the Imouraren (Niger) and Husab (Namibia) mines. In 2016, another 11 500 tU is expected to be added through possible new mine start-ups in Botswana, Brazil, Namibia, South Africa and Tanzania. With these and other developments, total production capacity could increase by as much as 40 000 tU by 2021 (Table 1.27). Included in these figures are by-product centres that are expected to be producing uranium from unconventional sources (i.e. Talvivaara in Finland and Santa Quitéria in Brazil), the first time in several years that production from unconventional sources is expected to take place.

It is important to note however, that many of these projected increases in production capacity will only go forward with strengthening market conditions. Increased mining costs and development of new technologies combined with uncertainties associated with producing in jurisdictions that have not previously hosted uranium mining, mean that strong market conditions will be needed to secure the required investment to develop these mines. As also noted in Table 1.27, as of 2013 over 24 000 tU/yr of additional capacity in various stages of development (about half of which is the planned expansion of Olympic Dam) has been delayed due to poor market conditions.

In addition, a number of prospective production centres (those for which construction plans have not yet been made) were noted in national reports for which a projected start-up date, and in some cases mine capacities, have not yet been determined (Table 1.28). While there is greater uncertainty surrounding the development of these production centres, such potential capacity additions underscore the availability of uranium deposits of commercial interest. Once again it must be noted that strengthened market conditions will be necessary before mine developments will proceed. Additionally, since these sites span several stages of approvals, licensing and feasibility assessments, it can reasonably be expected that at least some will take a number of years to be brought into production.

Tables 1.26 and 1.27 clearly show that the uranium mining industry is poised to increase production further with the appropriate market signals.

Table 1.28. Prospective mines (estimated production capacity in tU/yr)*

Country	Production centre
Australia	Yeelirrie
	Kintyre (2 300 tU)
Canada	Michelin
Russian Federation	Elkon (5 000 tU/yr) in 2025
	Gornoe (300 tU/yr)
Turkey	Temrezli (385 tU/yr)
United States	Jab and Antelope (769 tU/yr)
	Dewey-Burdock
	Lance-Ross
	Church Rock-Mancos
	Reno Creek
	Pinon Ridge Mill (385 tU/yr)

* As noted in country reports, but in several cases start-up dates and capacity unknown.

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Chapter 2. Uranium demand

This chapter summarises the current status and projected growth in world nuclear electricity generating capacity and commercial *reactor-related uranium requirements*. Relationships between uranium supply and demand are analysed and important developments related to the world uranium market are described. The data for 2013 and beyond are estimates and actual figures may differ.

Current commercial nuclear generating capacity and reactor-related uranium requirements

World (371.8 GWe net as of 1 January 2013)

On 1 January 2013, a total of 437 commercial nuclear reactors were connected to the grid in 30 countries and 68 reactors were under construction (a total of about 64 GWe net).[1] During 2011 and 2012, 10 reactors were connected to the grid (a combined total of about 7.0 GWe net) and 16 reactors were permanently shut down (about 12.7 GWe net). Table 2.1 and Figures 2.1 and 2.2 summarise the status of the world's NPPs as of 1 January 2013. The global NPP fleet generated a total of about 2 465 TWh of electricity in 2011 and about 2 323 TWh in 2012 (Table 2.2).

World annual uranium requirements amounted to 61 600 tU in 2012 and are expected to decrease to 59 270 tU in 2013.

OECD (303.0 GWe net as of 1 January 2013)

As of 1 January 2013, the 331 reactors connected to the grid in 18 OECD countries constituted about 81% of the world's nuclear electricity generating capacity. A total of 11 reactors were under construction with a net capacity of about 13.3 GWe (IAEA, PRIS; IAEA 2013a). During 2011 and 2012, 2 reactors were connected to the grid (about 2.0 GWe net) and 16 reactors were permanently shut down (about 12.7 GWe net).

The accident at the Fukushima Daiichi NPP in Japan on 11 March 2011 was directly responsible for all but four of the permanent shutdowns in 2011 and 2012, as Germany accelerated its phase-out from nuclear power in response to the accident and the four damaged reactors at Fukushima Daiichi were permanently shut down. As of 1 January 2013, only 2 of the remaining 50 operational reactors in Japan were in service as the debate on the role of nuclear energy continued. Countries with NPPs conducted safety reviews ("stress tests") and the pace of nuclear energy development slowed. Despite the Fukushima Daiichi accident a number of OECD member countries (the Czech Republic, Finland, Hungary, the Slovak Republic, the Republic of Korea, Sweden and the United Kingdom) remain committed to maintaining or increasing nuclear generating capacity in their energy mix. In North America, some new build construction plans made significant progress while others were put on hold, at least temporarily.

The OECD reactor-related uranium requirements were 48 030 tU in 2012 and are expected to decline to 44 045 tU in 2013.

1. Figures include the reactors operating and under construction in Chinese Taipei.

Table 2.1. Nuclear data summary

(as of 1 January 2013)

Country	Operating reactors	Generating capacity (GWe net)	2012 uranium requirements (tU)	Reactors under construction	Reactors started up during 2011 and 2012	Reactors shut down during 2011 and 2012	Reactors using MOX
Argentina	2	0.9	120	1	0	0	0
Armenia	1	0.4	65	0	0	0	0
Belgium	7	5.9	1 030	0	0	0	0
Brazil	2	1.9	400	1	0	0	0
Bulgaria	2	1.9	310*	0	0	0	0
Canada	19	13.5	1 600	0	0	1	0
China[(a)]	17	12.9	4 200	29	4	0	0
Czech Republic	6	3.8	670	0	0	0	0
Finland	4	2.7	370	1	0	0	0
France	58	63.1	8 000	1	0	0	22
Germany[(b)]	9	12.1	2 000	0	0	8	9
Hungary	4	1.9	430	0	0	0	0
India	20	4.4	715	7	1	0	1
Iran, Islamic Rep. of	1	0.9	40	0	1	0	0
Japan	50	44.2	1 960	2	0	4	NA
Korea, Republic of	23	20.7	4 200	5	2	0	0
Mexico[+]	2	1.4	180	0	0	0	0
Netherlands[+]	1	0.5	60	0	0	0	0
Pakistan	3	0.7	120*	2	1	0	0
Romania	2	1.3	210*	0	0	0	0
Russian Federation	33	23.6	3 800	11	1	0	0
Slovak Republic	4	1.8	375	2	0	0	0
Slovenia	1	0.7	150	0	0	0	0
South Africa	2	1.8	290	0	0	0	0
Spain	8	7.5	1 320	0	0	0	0
Sweden	10	9.3	1 470	0	0	0	0
Switzerland	5	3.3	290	0	0	0	3
United Arab Emirates	0	0.0	0	1	0	0	0
Ukraine	15	13.1	2 480	2	0	0	0
United Kingdom	16	9.2	1 220	0	0	3	0
United States	104	101.4	23 085	3	0	0	0
OECD	331	303.0	48 030	14	2	16	34
Total	**437**	**371.8**	**61 600**	**68**	**10**	**16**	**35**

* Secretariat estimate.

+ Data from 2013 edition of *OECD Nuclear Energy Data*.

(a) The following data for Chinese Taipei are included in the world total but not in the total for China: six NPPs in operation, 5 028 GWe net; 820 tU; two reactors under construction; none started up or shut down during 2011 and 2012.

(b) All nine operating reactors are licensed to use MOX, but only six used MOX in 2012.

Source: IAEA Power Reactor Information System (www.iaea.org/programmes/a2) except for generating capacity and 2012 uranium requirements, which use government-supplied responses to a questionnaire, unless otherwise noted and rounded to the nearest five tonnes. MOX not included in U requirement figures.

Figure 2.1. World installed nuclear capacity: 371.8 GWe net

(as of 1 January 2013)

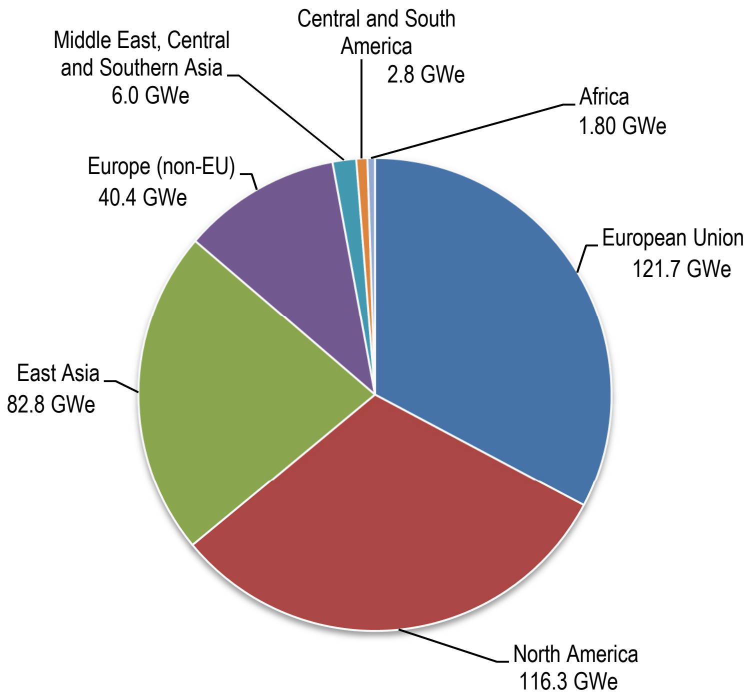


Figure 2.2. 2012 world uranium requirements: 61 600 tU

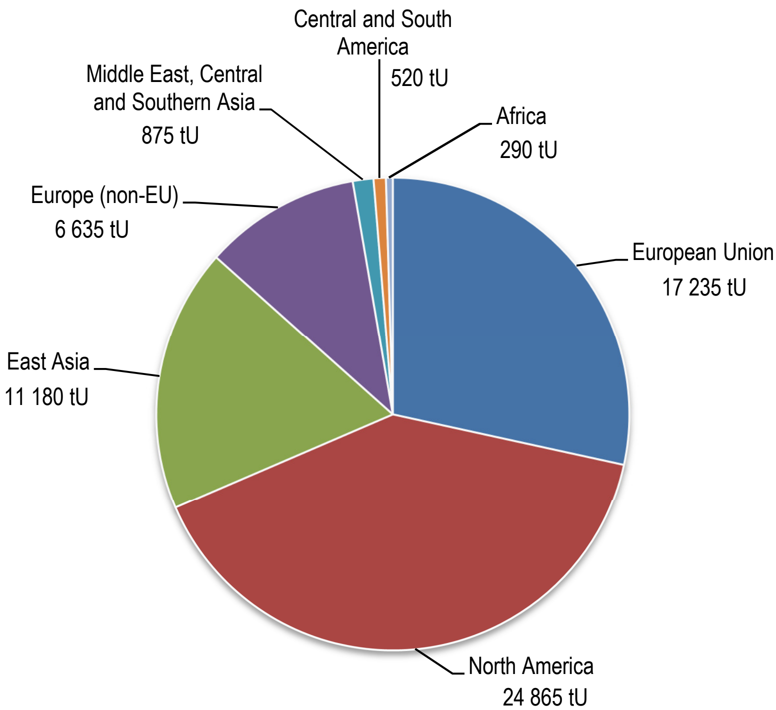


Table 2.2. Electricity generated at nuclear power plants

(TWh net)

Country	2009	2010	2011	2012
Argentina	7.6[(d)]	6.7[(d)]	5.9*	5.9*
Armenia	2.3	2.3	2.4[(d)]	2.1[(d)]
Belgium	45.0	45.7	45.9+	40.0+
Brazil	12.2[(d)]	13.9[(d)]	14.8[(d)]	15.2[(a, d)]
Bulgaria*	14.2*	14.2*	15.3	14.9
Canada	85.3	85.3	88.3	91.0
China[(c)]	65.7[(a, d)]	71.0*[(a, d)]	82.6*[(a, d)]	92.7*[(a)]
Czech Republic	25.7[(a)]	26.4[(a)]	26.7[(a)]	28.6[(a)]
Finland	22.7[(a)]	21.9[(a)]	22.3	22.1
France	390.0	407.9	405.0	421.0
Germany	128.0	133.0	102.0	94.5
Hungary	14.6+	14.8[(a)]+	14.7+	14.8[(a)]+
India	14.8[(d)]	20.5[(d)]	29.0[(d)]	29.7[(d)]
Iran, the Islamic Rep.	0.0	0.0	0.1	1.3
Japan	263.1+	279.3+	156.2*	17.2*
Korea, Republic of	141.0+	142.0+	154.7*	143.5*
Lithuania	10.0*	0.0	0.0	0.0
Mexico	10.1+	5.6+	9.3	8.4
Netherlands	4.0+	4.0+	3.9+	3.9+
Pakistan	2.6*	2.6*	3.8*	5.3*
Romania*	10.8	10.7	10.8*	10.6*
Russian Federation	152.8[(a, d)]	159.4[(a, d)]	162.0[(d)]	166.3[(d)]
Slovak Republic	13.1	13.5	14.3	14.4
Slovenia	5.5+	5.4+	5.9	5.2
South Africa*	11.6	12.9	12.9*	12.4*
Spain+	50.5	59.2	55.1	58.6
Sweden	50.0+	55.7+	58.0+	61.2+
Switzerland	26.3*	25.3*	25.7*	24.4*
Ukraine	78.0[(d)]	84.0[(d)]	84.9[(d)]	84.9[(d)]
United Kingdom	62.9+	56.9+	62.7*	64.0*
United States+	799.0	803.0	790.0	769.0[(b)]
OECD	2 136.8	2 184.9	2040.7	1881.8
Total	**2 559.3**	**2 623.0**	**2 465.2**	**2 323.1**

* Secretariat estimate.

+ 2013 edition of *OECD Nuclear Energy Data*.

(a) Generation record.

(b) Provisional data.

(c) The following data for Chinese Taipei are included in the world total but not in the total for China: 39.9 TWh in 2009, 39.9 TWh in 2010, 40.4 TWh in 2011 and 38.7 TWh in 2012.

(d) Gross capacity converted to net by Secretariat.

European Union (121.7 GWe net as of 1 January 2013)

As of 1 January 2013, 132 nuclear reactors were operational in the European Union (EU) with a total installed generating capacity of 121.7 GWe (net). The Santa Maria de Garoña reactor in Spain (0.4 GWe net) is included in this total even though it was taken out of service in December 2012 for economic reasons, since the decision to permanently shut down the reactor was not made until July 2013. During 2011 and 2012, no new reactors were connected to the grid and 11 (a total of 9.3 GWe) were shut down, eight of which in Germany (8.4 GWe) as a direct result of the Fukushima Daiichi accident and three in the United Kingdom that had reached the end of their operational lifetime (a total of 0.92 GWe). A total of four reactors were under construction that are currently expected to be finalised between 2014 and 2016, adding a total of 4.1 GWe (net) generating capacity. Preliminary construction work on two reactors in Bulgaria was halted in 2012 owing to rising costs and challenges in securing the required investment.

Nuclear phase-out policies remain in place in Belgium and Germany, although the implementation of both policies was affected by the accident at the Fukushima Daiichi NPP in March 2011. All reactors in Germany are now expected to be permanently shut down by the end of 2022 as the phase-out policy was accelerated after the accident. In Belgium, all reactors (with one exception) are now expected to be shut down after 40 years of operation, overturning a 2009 policy to extend the lifetimes of the three oldest units. Following through with these two phase-out policies will result in a reduction of nuclear generating capacity of 17.9 GWe (net) by 2025. However, other countries in the EU remain committed to nuclear power and plan to add nuclear generating capacity in the coming years.

In response to the Fukushima Daiichi accident, stress tests were carried out on the entire EU reactor fleet as well as those in adjacent countries in order to assess safety and robustness of NPPs in case of extreme natural events, in particular floods and earthquakes. In this process, NPP operators conducted self-assessments that were later reviewed by national safety authorities and then by multinational teams in a peer review process. Although it was concluded that the level of safety is generally high and that no reactors needed to be taken offline for safety reasons, a need for significant and tangible improvements was identified for all plants evaluated. Work at some plants has already been undertaken, such as improving seismic instrumentation, evaluating risks posed by seismically induced floods and fires, reinforcing structures against extreme weather phenomena, strengthening flood protection measures and ensuring an adequate backup of cooling water supply and mobile generators. The deadline for completing all required improvements is 2015. The implementation of these additional safety measures and assessments has been estimated to amount to about EUR 200 million (about USD 270 million) per reactor.

In **Belgium**, the government announced in 2009 the intention to relax the 2003 policy to phase-out nuclear power by granting a one-time, ten-year lifetime extension to the three oldest units in the fleet (Doel 1, 2 and Tihange 1). Following the Fukushima Daiichi accident however, the 2003 decision to phase-out all reactors after 40 years of service was reinstated, with the exception of the Tihange 1 reactor that would be allowed to operate for 50 years until 2025 to ensure security of energy supply. As of October 2013 this policy change had not yet been confirmed by law. In June 2013, GDF Suez subsidiary Electrabel, operator of all NPPs in the country, filed an appeal to the Constitutional Court of Belgium against an annual federal tax on nuclear power generation that had been doubled in 2012 to EUR 550 million. During the course of routine inspections in 2012, a number of fault indications in pressure vessels were discovered with new ultrasonic equipment, leading to the temporary shutdown of Doel 3 and Tihange 2 for further testing and investigation by the regulator. In May 2013, the Belgian safety authorities concluded that the fault indications did not constitute a danger to the structural integrity of the units and the reactors were allowed to restart. In 2012, the seven operational reactors in Belgium provided over 50% of domestic electricity generation, despite the unexpected need to idle the Doel 3 and Tihange 2 reactors for several months.

In **Bulgaria**, following the closure of four older reactors by the end of 2006, only two larger units (about 0.95 GWe net each) remain operational at the Kozloduy NPP. These two units generated about 30% of the country's electricity in 2012. To compensate for the loss of nuclear generating capacity and to regain its position as a regional electricity exporter without increasing greenhouse gas emissions, the government of Bulgaria has made efforts to build additional nuclear generating capacity. In 2008, work began at the Belene site on two VVER reactors (0.95 GWe net each) supplied by the Russian Federation, but this project was abandoned in favour of building new gas-fired generation plants after the project failed to attract the required foreign investment. It was later reported that the government was considering the construction of a new unit at the Kozloduy site and supporting a project to extend the lifetime of the two existing reactors. Results of a referendum held in early 2013 supported the continuation of the Belene construction project, albeit with only a 20% voter turnout. In February 2013, increased electricity bills sparked public protests. The government continues to assess the situation but as of October 2013, no definitive plans for reactor construction had been announced.

In the **Czech Republic**, a total of six reactors were operational on 1 January 2013 with an installed capacity of 3.8 GWe net. The scheduled upgrade of Dukovany 4 was completed in 2012, bringing to a close the modernisation and power uprate programme for all reactors at the Dukovany NPP (four VVERs, now with a total capacity of 1.9 GWe net). This, combined with the good performance of all reactors resulted in a record amount of electricity produced by nuclear power in 2012 (35% of domestic electricity production). The public tender for the construction of two new units at the Temelin NPP launched by the Czech Power Company ČEZ in August 2009 continues. A total of three bids were received for evaluation, but the bid from AREVA was subsequently excluded from further consideration, a decision that remains under appeal. ČEZ had expected to select a supplier of the two new Temelin reactors by the end of 2013, but decided to delay the decision by a year after the unexpected fall of the government in June 2013. This delay will give a new government, formed after elections in October 2013, time to update the national energy strategy and negotiate a power purchase agreement with ČEZ.

In **Finland**, four units (two each at the Olkiluoto and Loviisa NPPs) with a total generating capacity of 2.7 GWe (net) were operational on 1 January 2013, providing about 30% of domestic electricity generation. Construction of the Olkiluoto 3 European pressurised reactor (EPR; about 1.6 GWe net) continues but may not be completed until 2016, some seven years later than the originally planned. In 2010, the Finnish parliament ratified the decision-in-principle for the construction of the sixth and seventh reactors in the country, one at the existing Olkiluoto site and a single reactor at the greenfield Pyhäjoki site. By mid-2012, bids for the Olkiluoto 4 reactor from AREVA, GE Hitachi, Kansai Electric Power Company (KEPCO) and Mitsubishi Heavy Industries were under review. Fennovoima, a company formed by a group of investors seeking to secure long-term electricity supply to power energy intensive industries, is the proponent of the Pyhäjoki development. In January 2012, Fennovoima received bids from AREVA and Toshiba, but after review decided to terminate the bidding process and invited Toshiba to engage in direct negotiations. In October 2012, E.ON announced that it was divesting all operations in Finland, including its 34% share in Fennovoima, which was subsequently purchased by the major shareholder in the consortium, Voimaoskeyhtiö SF. As a result of this ownership change, Fennovoima began assessing smaller, mid-sized reactors for Pyhäjoki, leading to negotiations with AREVA, Toshiba and Rosatom.

In **France**, 58 operational reactors generated 78% of domestically produced electricity in 2012. Construction of a new EPR at the Flamanville NPP began in late 2007 and the unit is scheduled to begin commercial operation by 2016. Following the Fukushima Daiichi accident, the French Institute for Radiological Protection and Nuclear Safety (IRSN) undertook a six-month review of reactor safety. The report, released in conjunction with the French Nuclear Safety Authority (ASN), proposed a new set of safety requirements to ensure the protection of vital safety structures and equipment. Regional rapid response forces (FARN) were brought into service at the end of 2012. A national debate on the French energy transition was launched in late 2012 to address how energy efficiency and conservation can be improved and to define options for the future energy mix and how they can be achieved by 2025 while maintaining commitments to reduce greenhouse gas emissions. It is also expected to define renewable energy and new technology options, industrial and regional development strategies and the costs involved in implementing each option. The current government has indicated that it intends to shut down the Fessenheim NPP (two reactors, each 880 MWe net) by the end of 2016 (before the end of the current presidential term) and provide a plan to reduce nuclear power generation from about 75% of domestic electricity generation today to 50% by 2025. Construction of the Georges Besse II centrifuge uranium enrichment plant continued with a total of 2.5 million SWU installed by 2012 of the total target capacity of 7.5 million SWU by 2016. Commercial production began in 2011 and the energy intensive gaseous diffusion centrifuge plant (Eurodif) was closed at the end of June 2012 after 33 years of operation.

In **Germany**, nine reactors were operational on 1 January 2013, producing about 16% of domestic electricity generation in 2012. Changes to the Nuclear Power Act (NPA) in 2002 enshrined the nuclear phase-out in German law and necessitated the early shutdown of two reactors. In December 2010, the NPA was amended to extend the operating lives of the existing reactors by an average of 12 years. However, following the Fukushima Daiichi accident the German government decided to reassess the risks posed by nuclear energy by launching a comprehensive safety review of all 17 operational NPPs and taking the oldest 7 NPPs, commissioned prior to 1980, out of service for the duration of a 3-month moratorium and review. On 30 May 2011, the German cabinet announced that it was accelerating the nuclear phase-out by permanently shutting down the seven oldest reactors taken offline during the review, plus the Krümmel NPP which was offline for maintenance. The remaining nine reactors are to be permanently shut down in a stepwise manner in the following order: Grafenrheinfeld by the end of 2015; Gundremmingen B by the end of 2017; Philippsburg 2 by the end of 2019; Grohnde, Gundremmingen C and Brokdorf by the end of 2021 and the three most recently built facilities – Isar 2, Emsland and Neckarwestheim – by the end of 2022. A tax on spent fuel rods, under consideration since the December 2010 NPA amendments, is to remain in place despite the accelerated phase-out schedule. This tax has been challenged by utilities operating reactors in the country who are also seeking compensation for the shutdown of the eight reactors in 2011. With reduced nuclear generating capacity, renewable energy sources are being added at a rapid rate but it has also been necessary to increase use of coal-fired plants, which in turn increases greenhouse gas emissions.

In **Hungary**, four operational VVER reactors at the Paks NPP (a total of 1.9 GWe net) at the end of 2012 accounted for over 46% of Hungarian electricity generation in that year. A programme of power uprates, maintenance optimisation and a 20-year lifetime extension (to a total lifetime of 50 years) initiated in 2005 continues, with an important milestone achieved in late 2012 when all work was completed on the first unit and a licence for extended operation was received. Activities are underway on the remaining three units to complete the programme. The target safety reassessment of the Paks NPP was undertaken in 2012 in compliance with the EU stress tests. The report identifies a number of options and measures to further enhance safety that will be considered in a peer review process. Any actions deemed necessary are to be implemented in a consistent and transparent manner. The Hungarian Energy Strategy, adopted by parliament in October 2011, aims to develop an optimal balance between security of supply, competitiveness and sustainability. The current government considers energy production as a way of emerging from the economic crisis and one pillar of the strategy is to maintain the current share of nuclear generating capacity in the long term. To this end, the MVM Paks II Nuclear Power Plant Development Ltd was established in early 2012 to conduct preparatory work for the construction of new units.

In **Italy**, processes to bring about the removal a 20-year ban on nuclear power and install up to 13 GWe of nuclear power generating capacity by 2030 came to an abrupt end in 2011 following the Fukushima Daiichi accident. Immediately after the accident the government declared a one-year moratorium on nuclear development plans in order to reconsider the energy strategy following stress tests conducted by the European Commission (EC). However, results of a referendum in June 2011 firmly rejected the government's proposed nuclear development plans, an outcome that is binding for five years. Italy is heavily reliant on imported fuels to meet over 85% of its energy needs, has high electricity prices and is subjected to occasional electricity shortages. The referendum result does not however restrict ongoing work on the disposal of radioactive waste, including the development of a national repository.

In **Lithuania**, the Ignalina 2 (1.2 GWe net) reactor was shut down at the end of 2009 in accordance with agreements governing entry into the EU (Ignalina 1 had been shut down on 31 December 2004 for the same reason). The closure of these reactors significantly reduced domestic electricity generation (Ignalina 2 alone provided over 70% of the electricity generated in the country in 2008). Facing a looming electricity shortage the government made efforts to have new reactors in operation by 2020 (to a maximum capacity of 3.4 GWe), but an investment decision has not yet been made. Following the election of a new coalition government in October 2012 led by a party that had opposed the construction of the proposed Visaginas NPP on economic grounds and the rejection of the project in a non-binding referendum, prospects for a new NPP diminished. However, the new government has stated that such an important decision should be made only after detailed economic study and discussions have continued with the potential strategic investor, Hitachi-GE. A final investment decision on a proposal to build a 1.35 GWe advanced boiling water reactor, with Hitachi-GE holding a 20% share in the project (along with Lithuania 38%, Estonia 22% and Latvia 20%), is not expected until 2015. With no nuclear generating capacity, Lithuania relies heavily on imports, in particular natural gas from the Russian Federation.

In the **Netherlands**, the single operational reactor (0.5 GWe net) supplied 3.5% of domestically generated electricity in 2012. In February 2011, the government issued a list of conditions that must be met to build a new NPP, including that the reactor design and safety levels meet the highest standards (e.g. withstanding an airplane crash) and that the plant owner is responsible for dealing with waste and decommissioning, as well as posting financial guarantees to do so. Companies had originally expressed an interest in building a new unit at the existing Borssele site, but in January 2012 prospective investors Delta (in partnership with *Électricité de France* – EDF) and RWE announced that such plans had been put on hold for at least a few years owing to the financial crisis, the size of the investment required and current over-capacity in the electricity market.

In **Poland**, where coal-fired plants currently generate more than 90% of domestic electricity, the government continues to advance plans to construct 6 GWe of new nuclear power generation in the next 20 years. The strategy calls for the first unit (between 1.2 and 1.6 GWe) to be in operation by 2024, with three additional similar-sized units added by around 2030. A consortium led by state-owned *Polska Grupa Energetyczna* (PGE, the Polish Energy Group), the largest power supplier in the country, has been put in charge of organising the project. The legal framework for the development of nuclear power was established in 2011 and the Council of Ministers instructed the Ministry of Economy to prepare a new national strategy concerning radioactive waste and spent fuel management. In early 2013, PGE awarded a contract to carry out site characterisation, licensing and permitting services for the construction of the first units with three potential sites under consideration: Choczewo, Gaski and Zarnowiec.

In **Romania**, the two CANDU reactors at the Cernavoda NPP provided about 20% of the electricity generated in the country in 2012. Facing the coming retirement of as much as one-third of non-nuclear electricity generating capacity, the government developed plans to expand nuclear generating capacity by adding two more units by 2035. A tender for the construction of Cernavoda units 3 and 4 (each with a capacity of 0.72 GWe) was launched and EnergoNuclear SA was formed with foreign investors to undertake the construction, commissioning and operation of the new units. The project has made little progress however, principally due to market uncertainties and the current investment climate. The withdrawal of GDF Suez, RWE, ČEZ and Iberdrola from the project, along with declining demand and electricity prices, suggests that an investment decision to add reactors to the Cernavoda NPP will be delayed until economic conditions improve. In June 2013, the government announced the partial privatisation of the state-owned nuclear power corporation *Societatea Nationala Nuclearelectrica*.

In the **Slovak Republic**, a total of four reactors with a combined capacity of 1.8 GWe net were operational as of 1 January 2013. In 2012, the reactors provided 55% of the total electricity generated in the country. Power uprating of Mochovce 1 and 2 and Bohunice 3 and 4 has been completed. Fuel with higher enrichment (4.87% ^{235}U) has been used in the Mochovce reactors since 2011 and in the Bohunice units since 2012. Work to complete construction of Mochovce 3 and 4 (construction of the two reactors was stopped in 1992) was officially initiated in 2008 with completion now expected in 2014 and 2015. When in operation, the new units will add 0.9 GWe of electrical generating capacity to the grid. Discussions with six NPP vendors were reportedly ongoing in 2013 for the construction of a single large reactor at Bohunice. The government of the Slovak Republic supports the construction of NPPs as part of a plan to increase the security of energy supply.

In **Slovenia**, the single nuclear reactor in operation (Krško, 0.70 GWe) is jointly owned and operated with Croatia by *Nuklearna Elektrana Krško*. The Krško reactor began commercial operation in 1983 and was recently granted a conditional 20-year lifetime extension to 2043. The single unit accounted for 34% of the electricity generated in Slovenia in 2012, although a proportion of this is exported to meet about 20% of Croatia's electricity requirements. The Slovenian government had been considering the construction of a second unit by 2025, subject to parliamentary approval and a possible referendum, but the effects of the ongoing financial crisis have limited progress.

In **Spain**, eight operational reactors provided about 20.5% of the total domestically generated electricity in 2012. The Spanish government supports a balanced electricity mix that takes into account all energy sources and available capacities. In addition, it notes that since nuclear energy contributes both to the diversification of energy supply and the reduction of greenhouse emissions, it cannot be disregarded when the reactors are in compliance with nuclear safety and radiological protection requirements enforced by the Nuclear Safety Council. Through 2010 and 2011, the Spanish government approved ten-year licence extensions for Ascó units 1 and 2, Almaraz units 1 and 2, Vandellós unit 2 and the lone Cofrentes unit. The single Trillo unit has a licence to operate until 2014. The lone Santa María de Garoña unit (0.466 GWe net) had been expected to continue operation until 2019 but new taxes on electricity generation combined with costs associated with extending the reactor's lifetime caused the operator to stop operations in December 2012. A decision to permanently shut down the unit was taken in July 2013 when the operating licence expired.

In **Sweden**, ten operational reactors (a total of 9.4 GWe net) generated over 35% of domestic electricity supply in 2012. While actively promoting the installation of additional renewable energy sources, the government gave new life to the country's nuclear power programme in 2010 by passing legislation that allows the construction of replacement reactors at existing sites, effectively overturning the 1980 ban on the construction of new NPPs and the phase-out of nuclear energy. Replacement reactors can only begin operation once an existing unit is permanently shut down (not expected until after 2020) and the government will not provide subsidies for the development of new reactors despite high upfront investment costs. Following the Fukushima Daiichi accident, the government ordered a comprehensive review of the current reactor fleet ahead of the EU stress tests but indicated that the recent legislative changes allowing replacement would not be reconsidered. Nationally owned Vattenfall, the largest Nordic utility, filed an application to build up to two reactors to replace its older units in 2012, at the same time noting that an investment decision would not be made for a number of years. In response to the application, the Swedish Radiation Safety Authority indicated that the application process may take up to 15 years in total and that regulations for new reactors would not be finalised until the end of 2014, at the earliest. In 2013, Vattenfall announced that it is planning to invest USD 2.4 billion between 2013 and 2017 to modernise and upgrade its 5 most recently built units (Ringhals 3, 4 and Forsmark 1-3) in order to continue operations for up to 60 years.

In the **United Kingdom**, 16 operational reactors with a combined capacity of 9.2 GWe (net) on 1 January 2013 provided about 17% of total domestic electricity generation in 2012. Since the fleet is comparatively old and operators have stated that they expect up to 7.4 GW of existing nuclear capacity to close by 2019 (one unit permanently closed in 2011 and two in 2012) and coal-fired generating capacity is ageing and in decline, the government has taken a series of actions to encourage nuclear new build. Industry has announced ambitions of adding up to 16 GWe of new nuclear generating capacity by 2025, with the first reactor scheduled to go online in 2019. New nuclear investments are expected to be part of the total estimated expenditure of GBP 75 billion in new power generation capacity needed by 2020. Three consortia: NNB Generation Company, a joint venture led by EDF; Horizon Nuclear Power (Hitachi-GE) and NuGen (GDF Suez and Iberdrola) are currently making preparations for the construction of new units. Interest by Russian, Korean and Chinese vendors has also been reported. Among the existing consortia, NNB GenCo has made the most progress having received regulatory approval (a site licence, environmental permits and a generic design assessment of its EPR reactor design). The government has made clear that investments in new nuclear will not be subsidised by government. It has however made changes to the energy market in order to encourage the installation of low-carbon energy sources such as nuclear power. One important part of the reformed energy market is long-term guaranteed prices for low-carbon power generation in order to reduce uncertainties associated with such investments. Negotiations between the NNB GenCo and the government over the guaranteed price (referred to as a contract for difference or "strike price") were finalised in October 2013, improving prospects of new build, but an investment decision is not expected until 2014, subject to an EU determination on the legitimacy of using a strike price to stimulate investments in nuclear power.

The reactor-related uranium requirements for the EU in 2012 amounted to about 17 235 tU and are expected to increase to 18 320 tU in 2013.

North America (116.30 GWe net as of 1 January 2013)

At the beginning of 2013, a total of 104 reactors were connected to the grid in the United States, 19 in Canada and 2 in Mexico. A decision by Hydro Quebec to not proceed with the refurbishment of the Gentilly 2 reactor in Quebec led to the permanent shutdown of this unit in late 2012. No other reactors were shut down and no new units were brought into operation in 2011 and 2012. Refurbishment of three CANDU reactors in Canada was completed in 2012 (Bruce A units 1, 2 and Point Lepreau) and the reactors began generating electricity once again. Work to complete the construction of one reactor in the United States (Watts Bar 2; 1.2 GWe net) was ongoing. A decision to defer new build in Canada combined with abundant supplies of low-cost natural gas and competition from subsidised renewable energy sources currently limit prospects for growth in nuclear generating capacity in this region.

In **Canada**, the government of Ontario stated after the Fukushima Daiichi accident that it remained committed to a policy of nuclear energy supplying 50% of the province's electricity. The bidding process for new units at the Darlington NPP was resumed, after being suspended in 2009 because of high costs, and in 2012 an environmental assessment was approved and a site preparation licence for as many as four reactors was issued (the first of three licences required to build and operate a nuclear facility in Canada). A decision on whether to proceed with the construction of two units at Darlington was to be made after detailed construction plans, schedules and costs are submitted in late 2013 by two preferred suppliers, Atomic Energy of Canada Ltd (AECL) for the enhanced Candu 6 and Westinghouse for the AP-1000. However, the Minister of Energy in Ontario announced in October 2013 that the Ontario government had postponed plans to build new nuclear generating capacity owing to declining demand for electricity. For the existing reactors, a two-part investment strategy for the Pickering and Darlington stations is being pursued, involving a detailed planning phase for the mid-life refurbishment of the four existing Darlington reactors (to extend operations another 25-30 years, with work expected to begin in 2016) and a CAD 200 million investment to ensure the continued safe and reliable performance of the six operational Pickering reactors until 2020, after which they will be decommissioned. In October 2011, the federal government completed the sale of the assets of the CANDU Reactor Division of AECL to Candu Energy Inc., a wholly owned subsidiary of SNC Lavalin. In 2012, the second phase of the restructuring of AECL was launched, focusing on the corporation's nuclear laboratories.

In **Mexico**, a 4-year, USD 600 million refurbishment and uprate programme of the 2 units at Laguna Verde by the Federal Electricity Commission was successfully completed in 2011, increasing the power of the 2 units by about 20% and extending the plant's operating life to 40 years (to 2029 and 2034). The two units (a total of 1.4 GWe net) typically provide about 4% of the electricity generated in the country. It was reported in 2012 that the Energy Minister supported the addition of two new units at Laguna Verde as part of strategic energy plan to meet rising demand and reduce carbon emissions. Since the election of a new coalition government later that year, focus has shifted to liberalising the state-run oil industry. No plan to add additional nuclear generating capacity has been announced, although it has been reported that the government is still considering adding more units in the longer term.

In the **United States**, 104 reactors were operational on 1 January 2013 contributing about 20% of the total electricity generated in the country. The construction of two AP-1000 reactors officially began in early 2013, one each at Vogtle (Georgia) and Virgil C. Summer (South Carolina), the initial phase of a plan to have two AP-1000 reactors in operation at each site by 2020. The Tennessee Valley Authority (TVA) continues to work toward the completion of the Watts Bar 2 reactor, a construction project resumed in 2007 after being halted in 1988. TVA announced in 2012 that it was delaying the planned restart of construction of the single Bellefonte unit until work at Watts Bar 2 was completed. As of the end of 2012, the Nuclear Regulatory Commission (NRC) had granted licence renewals to 73 of the 104 operating reactors to continue operating for another 20 years (to a total of 60 years lifetime operation) and was in the process of reviewing similar applications for 15 additional reactors. NRC regulations do not limit the number of licence renewals and the industry is reportedly preparing applications for continued operation beyond 60 years. However, low natural gas prices and the installation of subsidised renewable generating sources led to announcements in 2013 of the closure of two smaller reactors in liberalised energy markets on economic grounds (Kewaunee in Wisconsin and Vermont Yankee in Vermont). Three other reactors were permanently shut down in 2013 owing to technical issues (San Onofre 2 and 3 in California and Crystal River 3 in Florida). In response to the Fukushima Daiichi accident, the NRC and the nuclear industry initiated an immediate co-ordinated response to the accident as well as long-term actions to assure the safety of all operating and planned reactors in the United States. Following this review, the NRC stated that it remains safe for the existing fleet to continue operations. Nonetheless, orders were issued to enhance safety and this work must be completed by no later than 31 December 2016. In December 2010, the NRC amended the Waste Confidence Rule, stating that spent nuclear fuel could be stored safely at reactor sites for 60 years. This amendment was challenged and struck down, causing the NRC to suspend actions related to issuing operating licences and licence renewals until the Waste Confidence Rule is revised (expected in 2014).

Annual uranium requirements for North America were about 24 865 tU in 2012 and are expected to decline to 20 255 tU in 2013.

East Asia (82.8 GWe net as of 1 January 2013)

As of 1 January 2013, 96 reactors[2] were operational in East Asia. In 2011 and 2012, four reactors in China (CFER, Ling Ao 4, Qinshan 2.4 and Ningde 1) and two in the Republic of Korea (Shin Kori 2 and Shin Wolsong 1) were connected to the grid (a combined total of 4.6 GWe net) and four reactors at Fukushima Daiichi were shut down after the accident. During these same two years construction of a total of five reactors was initiated, bringing the regional total of 38 reactors under construction in this region as of mid-2013. When all construction is successfully completed, a total of about 40.3 GWe (net) will be added to the grid. Prospects for nuclear growth are greatest here than any other region in the world, principally driven by rapid growth underway in China. However, political developments and public dissent in Japan and the Republic of Korea could limit somewhat the overall expected growth in the region.

In **China**, 17 operational reactors (12.9 GWe net) provided about 2% of national electricity production in 2012 and a total of 28 reactors were under construction (about 27.7 GWe net) as of 1 January 2013. The government plans to add significant nuclear generating capacity in order to meet rising energy demand and limit greenhouse gas and other atmospheric emissions since poor air quality, mainly due to emissions from coal-fired plants, is a significant health issue. Following the Fukushima Daiichi accident, the government imposed a freeze on new nuclear projects, suspended approvals of planned reactors and ordered safety checks of all operating units and those under construction. By June 2011 safety checks had been completed and although no reactors were laid up for safety reasons, the government reaffirmed a commitment to safety by stating its intention to incorporate all IAEA safety standards and formally requested public input on the draft safety plan. In late 2012, approvals for new units were resumed after the safety plan was finalised, and although at a slower pace than prior to the Fukushima Daiichi accident, at a rate sufficient to increase total nuclear capacity to as much as 58 GWe by 2020. The government stated that only projects that complied with new generation safety standards would be approved and that no approvals would be granted for inland sites in seismically active areas prone to water shortages until 2015. It was reported in 2013 that work was underway to develop a domestic Gen III reactor, the ACPR-1000, by upgrading a Gen II French PWR design. Work was also underway to develop the CAP-1400 based on the Westinghouse AP-1000 design, with components sourced locally. China has also increased efforts to export these and other designs and to secure long-term uranium supply for its growing fleet by acquiring stakes in mining projects abroad, purchasing supply on the open market and increasing domestic mine output. By mid-2013, construction of five reactors had been initiated, four in 2012 (Fuqing 4, 1 GWe; Shidao Bay, a 0.2 GWe high-temperature gas reactor; Tianwan 3, 0.933 GWe and Yangjiang 4, 1 GWe) and work on the Tianwan 4 reactor (1.05 GWe) was begun in early 2013. Construction projects initiated prior to the Fukushima Daiichi accident continued although some delays resulted from the safety inspections. In mid-2013, local protests led to the cancellation of a proposal to build a uranium processing and nuclear fuel manufacturing facility in Heshan. It was also reported that construction of an AP-1000 reactor at Sanmen had fallen one year behind schedule.

In **Japan**, the future role of nuclear power in the national power generation mix remains uncertain after the Fukushima Daiichi accident. Following this serious accident, four Fukushima Daiichi reactors (units 1-4) were permanently shut down and units 5 and 6 were taken out of service before being permanently retired in late 2013. The remaining

2. There were also six NPPs in operation in Chinese Taipei (about 5.0 GWe net) and two plants under construction (about 2.6 GWe net).

48 reactors in the country were progressively taken off line for mandatory maintenance outages, with only two reactors operating periodically since (generating less than 2% of domestic electricity production in 2012). As of September 2013, the entire fleet had been idled until permission to restart is granted in accordance with a new, more stringent regulatory regime. The previous government had stated the intention of moving toward the elimination of nuclear power, but after elections in December 2012 a new government has worked toward allowing the restart of at least a portion of the nuclear fleet. The Japanese Nuclear Regulation Authority (NRA) was established as the new independent regulator and new regulations for reactor restarts came into force in July 2013, leading a number of utilities to apply to restart 14 reactors. According to the new regulations, utilities will be required to show that reactors are prepared for extraordinary external events (such as the severe earthquake and tsunami of 2011), that they are not situated on active faults, sufficient mobile generators are on hand in waterproof buildings to supply power in case of a blackout and that secure sources of make-up water and the means to inject water into the reactor for emergency cooling are on-site. Filtered vents will be required in all BWR reactors before restart and must be installed in PWR reactors within five years after restart. Hydrogen combiners that operate without power supply will also be required and, within five years, secondary control rooms outside the reactor will be required. The NRA has indicated that the restart process could take between 6 to 12 months. Approval by local government was not a legally binding requirement prior to the Fukushima Daiichi accident and it is unclear to what the extent local political consent is required in the new regulatory system. How many of the laid-up reactors will be successful in obtaining regulatory approval to restart remains to be seen. In 2012, it was reported that construction of the Ohma ABWR (1.383 GWe net) had been resumed, with the understanding of the local community. Construction of the Shimane 3 reactor remains suspended and the start date for construction of the Higashidori unit has been deferred. With most NPPs out of service, Japanese utilities have been importing large amounts of oil and natural gas for electricity generation, driving electricity prices and greenhouse emissions upward. The government has urged citizens and industry to conserve energy in order to avoid electricity shortages and created incentives for the installation of renewable energy sources. The government is reportedly planning to release a revised energy plan outlining the role of nuclear power in December 2013.

In the **Republic of Korea**, 23 operational units produced about 30% of the total electricity generated in 2012. Construction of Shin Kori 2 (0.96 GWe) and Shin Wolsong 1 (0.997 GWe) was completed in January 2012 and both units were connected to the grid in July 2012, increasing total nuclear generating capacity to 20.7 GWe (net). Construction of five reactors is underway, with work on two 1.34 GWe reactors (Shin-Hanul 1 and 2) initiated in 2012 and 2013, respectively. Shin-Hanul is the new name for the second phase of this NPP, formerly known as Shin-Ulchin (Yonggwang was renamed Hanbit and Ulchin as Hanul after pressure from local fishermen who felt that problems at the plants named after the region had led to reduced sales of their traditional regional catch). Following the 2012 election, the government pledged to continue with a strategy of increasing nuclear generating capacity to provide 40-50% of electricity supply by 2030. However, a station blackout at Gori 1 that was not reported to the Nuclear Safety and Security Commission as required, combined with revelations of forged safety reports that forced the temporary closure of several reactors and a delay in the construction of two units (Shin Kori 3, 4), have undermined public trust in nuclear power. The unexpected closure of reactors for safety checks led to concerns of maintaining an adequate supply of electricity. It has been reported that the government is reviewing the role of nuclear power in its National Energy Master Plan, due to be released at the end of 2013. Following the Fukushima Daiichi accident, safety vulnerability assessments of NPPs were conducted and a resident inspection team for each NPP site was established in April 2012. Each team, consisting of six to eight inspectors, makes it possible to conduct field inspections in a more in-depth way, strengthening verification of safety on a real time basis.

Although **Mongolia** does not currently have nuclear generating capacity, it has signalled its interest in the use of small and medium-sized reactors after signing an agreement with the Russian Federation on the exploration, extraction and processing of uranium resources.

The 2012 reactor-related uranium requirements for the East Asia region were 11 180 tU and for 2013 are expected to increase to about 11 320 tU.

Europe (non EU) (40.4 GWe net as of 1 January 2013)

As of 1 January 2013, 54 reactors were operational in 4 countries. This region is also undergoing strong growth with 12 reactors under construction that will add about 10.3 GWe net generating capacity when completed. During 2011 and 2012, one new plant was connected to the grid in the Russian Federation, none were shut down and construction was initiated on one reactor in the Russian Federation. Although Switzerland decided to phase-out nuclear power following the Fukushima Daiichi accident, several other countries in this region continue to support nuclear power and overall growth in nuclear generating capacity is expected.

In **Armenia**, the single operational reactor (Armenia 2; 0.38 GWe) provided 27% of the electricity generated in the country in 2012. It was reported in 2012 that the government had decided to extend the life of the unit to 2020 given its significance in domestic energy supply, despite concerns of continued operation in a seismically active region. According to the Armenian energy sector development plan to 2035, construction of two new units (1 GWe each) is envisaged, with the second unit operating by 2030 to 2035. The Ministry of Energy and Natural Resources released in 2011 an environmental assessment of the new build project, an engineering firm was engaged to manage the project and a confidentiality agreement with Russian NPP vendor JSC Atomstroyexport (a subsidiary of Rosatom that constructs NPPs abroad) was signed.

In **Belarus**, a USD 10 billion agreement was signed with Atomstroyexport in 2012 to build the country's first NPP, consisting of two 1 180 MWe VVER reactors, with expected completion dates in late 2018 and mid-2020. It was reported that the Russian Federation would extend a loan to Belarus for construction costs. In early 2013, site preparation and construction activities on both units was reported to be months ahead of schedule.

In the **Russian Federation**, 33 operational reactors (23.6 GWe net) provided about 18% of the total electricity generated in the country in 2012 and a total of 10 reactors were under construction (8.4 GWe net combined), including the Beloyarsk 4 fast neutron reactor (0.8 GWe net). Construction of Kalinin 4 (0.95 GWe net) was completed and the reactor connected to the grid in 2011 and construction was initiated on Baltic 1 (1.1 GWe net) in 2012. No reactors were permanently shut down over these two years. Following a safety review after the Fukushima Daiichi accident, the government continued with the implementation of a 2010 national energy strategy that envisioned the commissioning of a total of 26 new reactors along with the development and integration of fast neutron reactors to close the nuclear fuel cycle. In addition to an active domestic programme, the state-run energy company Rosatom is adding to a portfolio of building contracts in several countries (e.g. Bangladesh, China, India, Turkey and Viet Nam) through active participation in numerous tenders for new build projects using its build, own, operate model, supplemented by possibilities for loans to fund the projects, lifetime fuel supply and spent fuel take-back. This is proving a particularly attractive model for countries with no previous experience with nuclear power and those that lack sufficient resources to fund nuclear development. In January 2013, the nuclear safety regulator agreed to extend the operating licence of the Smolensk 1 RBMK reactor by 10 years to 2022 (for a total operational lifetime of 40 years) after an extensive modernisation programme. A graphite-moderated design made infamous in the Chernobyl accident, modernised RBMK reactors remain the backbone of the Russian nuclear programme, providing about 45% of total domestic nuclear power electricity generation. In April 2013, it was reported that 7of the remaining 11 RBMKs may have to be decommissioned ahead of scheduled retirement owing to technical issues arising from the deformation of graphite stacks. Efforts were underway in early 2013 to find a technical solution to keep the reactors in operation until the planned retirement age is reached, with a report on the future of the reactors expected by the end of the year. Construction of the Kursk 5 RBMK was officially cancelled in August 2012.

In **Switzerland**, proposals to build three reactors to replace plants that reach the end of their operational lifetime were abruptly terminated following the Fukushima Daiichi accident. Three days after the accident, the government suspended the approval process for replacement reactors and ordered a safety review of the existing five operational reactors. Later in the year, cabinet cancelled the approval process for replacement reactors and proposed that all five existing reactors be shut down at the end of 50 years of operation (i.e. between 2019 and 2034). After a thorough review (EU stress tests plus its own test programme), the national safety authority concluded that since the cooling of the core and fuel rod storage pools would remain operational in the event of an earthquake followed by flooding, the power plants could remain in service. It nonetheless issued a series of requests in order to complete the analysis and the five operating plants are required to demonstrate, by the end of 2013, that they are sufficiently protected against incidents caused by extreme weather events. The five operating reactors in Switzerland typically produce about 35-40% of the electricity generated in the country. To ensure that Switzerland has a competitive and safe supply of electricity, a phased transformation of the energy system has been planned. A reduction of energy and electricity consumption, combined with an increased share of renewable energy sources and the introduction of combined heat and power fossil fuel plants is planned to fill the gap created by the phase-out of nuclear power. Modernisation and enlargement of the electricity grid is also considered necessary to accommodate increased input from variable renewable energy sources.

In **Turkey**, the government continues to advance its nuclear development programme as its fast growing economy faces rapidly escalating electricity demand. Nuclear energy is seen as a cost-effective means of meeting rising demand despite regional earthquake hazards. An intergovernmental agreement (IGA) signed with the Russian Federation for the construction of four VVER-1200 units at the Mediterranean Akkuyu site on the build, own, operate model entered into force on 21 July 2010. A project company established by the Russian Federation started site surveys and environmental impact assessment (EIA) studies. Under the terms of the IGA, the Russian Federation will retain the majority share of ownership of the power plant during the entire lifetime of operation and will provide fuel supply, take back spent fuel for reprocessing, train personnel and decommission the facility. Construction was expected to begin in 2014 with commissioning of the four units planned for 2019, 2020, 2021 and 2022, but in late October 2013 it was announced that work had fallen behind schedule by at least one year owing to shortcomings with the EIA and other process delays. Negotiations with countries and nuclear supplier companies for a second NPP, the Sinop-İnceburun site on the Black Sea coast were underway. The technology to be employed, its installed capacity, annual generation, fuel cycle strategy and related issues had not been finally determined by October 2013, although exclusive negotiating rights were established with a consortium led by AREVA and Mitsubishi Heavy Industries that has proposed construction of a four-unit NPP (4.6 GWe in total) using the Atmea 1 design. The government is also reported to be considering a third NPP at a site yet to be determined.

In **Ukraine**, 15 reactors with a combined installed capacity of 13.1 GWe net were operational on 1 January 2013, producing 46% of the electricity generated in the country in 2012. The national energy programme foresees that nuclear energy will continue to generate 45% of total electricity production by 2030. Achieving this target will require a combination of lifetime extensions of existing reactors, the construction of 12 additional units (with 10 of these new units having a gross capacity of 1.5 GWe) and the decommissioning of 12 reactors at the end of their operational lifetime. Two reactors are currently under construction (Khmelnitski 3 and 4) that, when completed (expected in 2016, 2017), will add 1.9 GWe capacity to the grid. Construction of these two reactors originally began in the mid-1980s, but was suspended in 1989. The agreement reportedly involves the Russian Federation providing finances for the design, construction and commissioning of the two reactors. In 2013, the European Bank for Reconstruction and Development backed a EUR 300 million loan in support of a safety upgrade programme, comprising up to 87 safety measures per reactor for all operating reactors in Ukraine. The total cost of the programme is estimated to amount to EUR 1.4 billion, which Euratom will contribute EUR 300 million.

Albania had been considering the construction of new NPPs but in 2012 it was reported that it had postponed its new build plans to consider all potential environmental impacts in light of the Fukushima Daiichi accident.

Reactor-related uranium requirements in 2012 and 2013 for the Europe (non-EU) region amount to about 6 635 tU.

Middle East, Central and Southern Asia (6.0 GWe net as of 1 January 2013)

As of 1 January 2013, 24 reactors were operational in this region and 10 were under construction (a total of 6.8 GWe net). During 2011 and 2012, three reactors were connected to the grid, construction was initiated on five units and none were shut down. Growth in nuclear generating capacity in this region is expected in the coming years as governments continue to work toward implementing plans to meet rising electricity demand without increasing greenhouse gas emissions.

In **Bangladesh**, cabinet ratified a deal with Rosatom in March 2012 to build two 1 GWe reactors at the Rooppur site. Under the terms of the agreement, the Russian Federation will reportedly provide support for construction and infrastructure development, supply fuel for the entire lifetime of the two reactors and take back spent fuel. Soft loans from the Russian Federation will also finance 90% of the estimated USD 4 billion cost. Construction is expected to begin in 2015, with a target date of 2020 for first electricity generation from the first unit. In October 2013, an official ceremony was held to mark the initiation of the project that will begin with final design selection, an environmental assessment and licensing actions. This is the first step in a plan to install 5 GWe of nuclear generating capacity by 2030 to help alleviate periodic electricity shortages in the face of declining domestic natural gas supply.

In **India**, 20 reactors (4.4 GWe net) were operational on 1 January 2013, providing about 4% of domestic electricity generation in 2012. Kaiga 4 (0.2 GWe net) was connected to the grid and construction of Rajasthan 7 and 8 was initiated in 2011 (0.62 GWe net each), bringing the total number of reactors under construction at the end of 2012 to 7 with a total capacity of 4.8 GWe net (4 PHWRs, 2 PWRs of Russian design and a prototype fast reactor). In July 2013, criticality was achieved at the first of the two PWRs (Kudankulam 1 and 2, 0.917 GWe net each), a project originally agreed to in 1988. The government has indicated that as many as six units could be added to this site. Following a review of safety and security at all operating plants after the Fukushima Daiichi accident that identified the need to strengthen defences against extreme events in select reactors, the government is proceeding with plans to significantly increase nuclear generating capacity, close the existing uranium fuel cycle and develop a thorium fuel cycle. Agreements in 2008 that granted India the ability to import uranium and nuclear technology have resulted in improved reactor performance through adequate uranium supply. However, concerns expressed about the 2010 Civil Liability for Nuclear Damages Act that leaves vendors potentially open to unlimited accident liabilities have slowed the development of agreements on imported technology. Public demonstrations at the Kudankulam site that delayed commissioning of the reactor, as well as at the proposed Jaitapur and Haripur sites, largely stemming from the Fukushima Daiichi accident, threaten to delay the implementation of at least some aspects of the national nuclear development plan.

In the **Islamic Republic of Iran**, commissioning of the Bushehr-1 reactor (about 0.9 GWe net) supplied by Atomstroyexport took place on 4 September 2011. The reactor reached full capacity in January 2013 and in September that year the two-year handover process from the Russian constructor to the Iranian customer began. The Iranian government plans to develop up to 8 GWe net of installed nuclear capacity by 2025 in order to reduce its reliance on fossil fuels, beginning with the installation of three more units at Bushehr. It has reportedly been in discussions with the Russian Federation to expand co-operation and engaged in identifying potential sites for additional reactors. In February 2013, the Atomic Energy Organisation of Iran announced that it had designated 16 new sites for NPPs in coastal areas of the Caspian Sea and the Persian Gulf, as well as in south-western and north-western regions of the country.

In **Jordan**, a plan to construct two reactors to generate electricity and desalinate water, along with development of the country's uranium resources, has been under development since as early as 2004, driven by rising energy demand and the current need to import around 95% of its energy needs. The situation has worsened in recent years as natural gas supply has become less reliable owing to regional geo-political turmoil. Nuclear co-operation agreements have been signed with several countries, including Argentina, Canada, France, Japan, the Russian Federation, the United Kingdom and the United States. In 2012 it was reported that the review of bids for reactor installation had been narrowed to Atomstroyexport and a consortium of companies led by AREVA and Mitsubishi Heavy Industries, the process was nearing completion and a final decision was imminent, as required to meet the target date of commissioning the first reactor by 2020. However in late May 2012, Jordan's parliament voted to suspend the nuclear development plan until the necessary funding is identified and feasibility studies have been completed. Finding a suitable site for the NPP that is acceptable to local residents has also proven challenging. Jordan has thus far not given up its right to enrich uranium and reprocess spent fuel.

In **Kazakhstan**, the First Deputy Prime Minister announced in 2012 that the country intended to follow-up on a plan announced earlier to provide 4.5% of domestic electricity production with nuclear power by 2030. This is part of the significant investment required to replace ageing generation plants, modernise others and to develop the grid. Adding nuclear power to the generation mix will also diversify energy sources by lessening reliance on fossil fuels. In 2013, it was reported that the political decision to install nuclear generating capacity had been taken and the most likely location for the facility is in the western region of Aktau on the Caspian coast, site of past NPP operation between 1973 and 1999.

In **Pakistan**, three reactors (0.725 GWe net) were operational on 1 January 2013, supplying about 5% of domestic electricity production in 2012. The Chasnupp 2 reactor (0.3 GWe net), completed under an agreement with the China National Nuclear Corporation (CNNC) and placed under IAEA safeguards, was added to the grid in 2011. In the face of severe power shortages, the government of Pakistan began construction of two additional units (Chasnupp 3, 4; 0.3 GWe each) later that same year with financial and technical assistance from China following approval of a safeguards agreement by the IAEA Board of Governors. These two units are expected to be completed in 2016. As part of an effort to address chronic power shortages, a growing population and increasing electricity demand, the government established the Energy Security Action Plan with a target of 8.8 GWe of installed nuclear generating capacity by 2030. In mid-2013, it was reported that the government had signed contracts for the construction of two ACP-1000 reactors supplied by the CNNC to be built at the coastal Karachi site (home of the 42-year-old Kanupp 1 PWHR reactor). This contract has been challenged as lying outside norms established by the Nuclear Suppliers Group but China maintains that the arrangement is for peaceful purposes and within the IAEA safeguard regime.

In the **United Arab Emirates**, a consortium from the Republic of Korea led by KEPCO won a contract in 2009 to build four APR-1400 reactors (a total of 5.4 GWe net) for USD 20 billion. The contract reportedly includes provisions that require the KEPCO consortium to hold an equity interest in the facility, assist in the design, operation and maintenance of the reactors, provide training and education and initial fuel loads for all four units. Construction of the first and second units (Barakah 1, 2) officially began in July 2012 and May 2013, respectively. Work is reportedly on track for the completion of Barakah 1 in 2017, with the other three reactors scheduled to be completed in successive years. In late 2012, it was announced that fuel for the reactors would be sourced through contracts with Techsnabexport, AREVA, Uranium One, Rio Tinto and Coverdyn for uranium concentrates, conversion and enrichment services, in addition to KEPCO's contractual obligations. When all units are in operation, the Barakah NPP is expected to produce about 25% of national electricity requirements. Increasing energy demand, combined with policies to reduce greenhouse gas emissions and domestic consumption of natural gas in order to maintain the inflow of foreign capital through exports were central considerations in the government's decision to develop the Barakah NPP. After signing agreements with the IAEA for the use of nuclear power for peaceful purposes and nuclear co-operation agreements with a number of countries, in which the domestic enrichment and reprocessing initiatives were forgone, the United Arab Emirates is proceeding with nuclear development plans with full international co-operation.

In 2012, it was reported that **Saudi Arabia** planned to build as many as 16 reactors with 22 GWe installed capacity by 2030 at an estimated cost of USD 100 billion in order to meet rising electricity demand and reduce oil exports. The first reactor was targeted for operation in ten years. In early 2013, the government endorsed a nuclear energy pact signed in 2011 with France to contribute to the development of technical skills and personnel development as well as the use and transfer of knowledge of the peaceful uses of nuclear energy. The government has also signed nuclear co-operation agreements with Argentina and the Republic of Korea.

Other countries in the region, currently without NPPs, have been considering the development of such facilities, including **Bahrain**, **Iraq**, **Israel**, **Kuwait**, **Oman**, **Qatar**, **Syria** and **Yemen**. In 2012, it was announced that **Bahrain** had postponed its nuclear development plans and **Kuwait** abandoned plans to build four reactors by 2020, both in response to the Fukushima Daiichi accident. Other countries listed above have not advanced stated intentions in the last two years.

Reactor-related uranium requirements for the Middle East, Central and Southern Asia region were about 875 tU in 2012 and are expected to increase to 1 680 tU in 2013.

Central and South America (2.82 GWe net as of 1 January 2013)

As of 1 January 2013, a total of four reactors were operational in two countries and two reactors were under construction. Governments in Argentina and Brazil continue to support nuclear power suggesting growth in nuclear generating capacity in the long term, despite other countries in the region reportedly turning away from plans to install nuclear generating capacity following the Fukushima Daiichi accident.

In **Argentina**, two reactors (Atucha 1 and Embalse; 0.34 GWe and 0.6 GWe, respectively) were operational on 1 January 2013, accounting for a little less than 5% of domestic electricity production in 2012. In August 2006, the state generating company *Nucleoeléctrica Argentina* restarted construction of Atucha 2 (0.75 GWe net), a Siemens heavy water reactor design unique to Argentina. Fuel loading began in late 2012 and the unit is expected to begin generating electricity in June 2014. Argentina's government is also considering the initiation of construction of another two reactors in 2017 and 2020. It has been reported that the Atmea 1 (1.1 GWe net) PWR design (a joint venture with AREVA and Mitsubishi Heavy Industries) has been preselected as one option for the third Atucha unit. Discussions have also been held with Canadian, Chinese, French, Japanese, South Korean and American reactor vendors, with a final decision on the supplier to be made after Atucha 2 is in operation. In support of the national nuclear development plan, initiatives are underway to reactivate heavy water production, further develop the 25 MWe CAREM reactor and reopen an enrichment plant. With the licence for the Embalse reactor due to expire in 2014, the government intends to conduct the necessary work to upgrade equipment, increase power output and extend the life of the reactor by 25 years. In early 2013, the Development Bank of Latin America issued a USD 240 million loan in support of this project.

In **Brazil**, two reactors (Angra 1 and 2; 0.5 GWe net and 1.3 GWe net, respectively) were operational on 1 January 2013, providing about 3% of the electricity generated in the country in 2012. Construction of the Angra-3 reactor (1.2 GWe net) was restarted in 2010 with completion of the USD 5.1 billion project expected in 2018. Work on this reactor originally began in 1984 but was suspended in 1986. The national long-term electricity supply plan includes a total of 4 GWe nuclear generating capacity installed by 2030 in order to help meet rising energy demand, with the first unit to be installed at a new site by 2022 (siting studies are underway). In 2013, it was announced that USD 150 million would be invested in strengthening safety measures at the two existing units in a programme referred to as the Fukushima Response Plan. The work involves 30 studies and 28 projects that will be undertaken through 2016 to improve plant protection against assorted risks, loss of cooling capability and reducing the possibility of off-site radioactive contamination in a serious accident. Earlier plans to install several reactors have reportedly been scaled back in the aftermath of the Fukushima Daiichi accident.

Other countries in the region, currently without NPPs, have been considering the development of such facilities, including **Bolivia**, **Chile**, **Cuba**, **Uruguay** and **Venezuela**. Given the risk of strong seismic events in **Chile**, the government is reconsidering nuclear development plans while observing the response of the Japanese authorities to the Fukushima Daiichi accident. **Venezuela** has also put its nuclear development plans on hold. Legislation in **Uruguay** promotes development of renewable energy sources, for the time being putting nuclear development plans on hold.

The uranium requirements for Central and South America amount to about 520 tU in 2012 and are expected to increase to 770 tU in 2013.

Africa (1.8 GWe net as of 1 January 2013)

Nuclear capacity remained constant in Africa with the region's only two operational reactors located in South Africa. Government plans to increase nuclear generating capacity are projected to drive growth in this region, but no construction activities have been initiated. Although several countries are considering adding NPPs to the generation mix to help meet rising electricity demand, development of the required infrastructure and human resources could delay these ambitions.

In **South Africa**, two operational units (a total of 1.8 GWe net) accounted for about 5% of the total electricity generated in the country in 2012. Coal-fired plants dominate current electricity generation, accounting for about 90% of generating capacity. In order to meet electricity demand, avoid additional power shortages and reduce carbon emissions, South Africa's state-owned utility Eskom solicited bids for a fleet of up to 12 reactors in 2007, but the process was put on hold owing to the financial crisis. In 2010, the South African government approved the Integrated Resources Plan that sees nuclear generating capacity increasing from 1.8 GWe today to over 11 GWe by 2030, with the first units online by 2025. The government reconsidered this nuclear development plan following the Fukushima Daiichi accident but after reassessing the safety of its nuclear facilities announced that it remains committed to nuclear power remaining a necessary and growing component of the energy strategy. Three proposed coastal sites for new NPPs are being investigated: Thyspunt (in the Eastern Cape province), Bantamsklip and Duyneyfontein (both in the Western Cape province). In 2013, the government signed an agreement with the EU to co-operate in the supply of nuclear and non-nuclear materials, equipment and technologies associated with civil nuclear power. The government has announced its intention to invite bids for new build in early 2014. Plans to restart enrichment for both domestic and export purposes are also reportedly under consideration.

Although no other countries in Africa have NPPs at this time, several have expressed interest in developing nuclear power for electricity generation and desalination in recent years, including **Algeria**, **Egypt**, **Ghana**, **Kenya**, **Morocco**, **Namibia**, **Niger**, **Nigeria**, **Tunisia** and **Uganda**. Both **Egypt** and **Nigeria** reaffirmed plans to install nuclear generating capacity in the long term after the Fukushima Daiichi accident. In 2012, a commission to co-ordinate and promote the development of nuclear energy in Africa established by the African Union became fully operational. South Africa has agreed to host the African Commission on Nuclear Energy (Afcone) in Pretoria.

Annual reactor-related uranium requirements for Africa amounted to about 290 tU in 2012 and 2013.

South-eastern Asia (0 GWe net as of 1 January 2013)

No reactors were operational in this region at the end of 2012 but several countries are considering nuclear development plans, suggesting growth in nuclear generating capacity in the longer term as the region continues to experience strong economic growth. Concerns about climate change, security of energy supply and energy mix diversification along with volatile fossil fuel prices are driving nuclear development policies but political support has generally been weak (except in Viet Nam) owing to public safety and cost concerns. Moreover, public confidence in nuclear power has been undermined by the Fukushima Daiichi accident.

In **Malaysia**, since the decision to develop a national nuclear policy in 2008, the government established the Malaysian Nuclear Power Corporation in late 2011 to plan, spearhead and co-ordinate the implementation of a nuclear energy development programme and take the necessary action to realise the first NPP in the country. Driven by an emerging gap in electricity production and the need to diversify the energy mix, a target of 2 GWe of nuclear generating capacity was adopted, with the first unit to be operational by 2021. Although work continues toward realising this goal through efforts to promote public acceptance, adopt the necessary regulations, sign required international treaties and obtain low-cost financing, it was reported that the programme had fallen behind schedule as a result of public distrust following the Fukushima Daiichi accident.

In **Thailand**, the third revision of the National Energy Policy Council released in 2012 scaled back the planned contribution from nuclear energy from 10% to 5% and set back the schedule for the installation of the first unit from 2020 to 2026; the second three-year postponement since the Fukushima Daiichi accident. The postponements were implemented in order to ensure safety and improve public understanding of nuclear energy. Currently, Thailand relies on natural gas to generate over 70% of its electricity. Domestic fossil fuel energy reserves are in decline and electricity demand is expected to double by 2024. The Thailand Power Development Plan of 2010 called for the installation of a total of 5 GWe of nuclear generating capacity.

In **Viet Nam**, with annual economic growth of over 5%, increasing electricity demand that already requires rationing and further shortages forecast by 2020, a reliance on hydro (over one-third of supply) with little prospect for expansion and a shortage of fossil fuels, the government established a master plan with a goal of nuclear power supplying as much as 25% of domestic electricity production by 2050. The first step in achieving this goal was made when the Ministry of Industry and Trade signed an agreement with Atomstroyexport in 2010 to construct the country's first NPP. This agreement covers two VVERs (1.0 GWe each) to be built at PhuocDinh in the NinhThuan province on a turnkey basis, the first of what is expected to be as many as ten NPPs (15 GWe total) to be operational by 2030. Construction was initially expected to begin by the end of 2014 with the first reactor commissioned by 2020, but this schedule has reportedly been delayed by as much as three years. The agreement also reportedly includes a low interest loan of USD 10 billion, the provision of nuclear fuel and the return of used fuel for reprocessing for the life of the plant. A second agreement has reportedly been signed with a Japanese consortium for two units at VinhHai in the NinhThuan province, including finance and insurance for up to 85% of total costs. The Republic of Korea is reportedly expected to win a contract for the third, two-unit NPP after agreeing to conduct a feasibility study of the project, and negotiations are reportedly underway with the Russian Federation to add four units to PhuocDinh. The potential bottleneck of an insufficient number of qualified personnel to operate and regulate the industry is being addressed with a USD 140 million budget for training, initially in the Russian Federation and Japan. In August 2013, it was announced that construction of a centre for nuclear science technology would be undertaken, funded by loans of up to USD 500 million from the Russian Federation to further accelerate training. The government has also launched an information campaign to better inform the public on nuclear power.

The governments of **Indonesia**, the **Philippines** and **Singapore** have considered the use of nuclear power to help meet rising electricity demand despite recurring large-scale natural hazards. In 2012, the Prime Minister of **Cambodia** had reportedly not allowed a feasibility study of establishing an NPP in the Koh Kong province to proceed owing to the Chernobyl and Fukushima Daiichi accidents and **Singapore** concluded that no available nuclear technology is suitable for deployment in the city-state in 2010.

Pacific (0 GWe net as of 1 January 2013)

This region currently has no commercial nuclear capacity. Current policy prohibits the development of commercial nuclear energy in **Australia**. The government of **New Zealand** also has a policy prohibiting the development of nuclear power but is reported to be considering options for future electricity supply in light of greenhouse gas reduction targets and declining supplies of natural gas.

Projected nuclear power capacity and related uranium requirements to 2035

Factors affecting capacity and uranium requirements

Reactor-related requirements for uranium, over the short term, are fundamentally determined by installed nuclear capacity, or more specifically by the number of kilowatt-hours of electricity generated in operating NPPs. Since the majority of the anticipated near-term capacity is already in operation or under construction, short-term requirements can be projected with greater certainty. However, both short-term and long-term requirements are much more challenging to project following the accident at the Fukushima Daiichi NPP in 2011.

Uranium demand is also directly influenced by changes in the performance of installed NPPs and fuel cycle facilities, even if the installed base capacity remains the same. Energy availability and capacity factors have increased from 71.0% to generally over 80% since 2000 (IAEA, 2014). In 2010, the average world nuclear energy availability factor (as defined by the IAEA) was 81%. Increased availability tends to increase uranium requirements, but unexpected events in recent years have disrupted the trend of increasing availability factors. After reaching 82.9% in 2006, the world average availability factor declined slightly because of an extended shutdown of seven large reactors at the Kashiwazaki Kariwa station in Japan that were damaged by a strong earthquake in July 2007. After recovering to 81% in 2010, the world average availability factor declined to 78.7% in 2011 and further to 73.5% in 2012 following the Fukushima Daiichi accident that eventually led to the entire Japanese nuclear fleet being taken off line pending safety checks. These reactors will not be restarted until applications from utilities are reviewed in light of new, more stringent safety requirements administered by the Nuclear Regulation Authority (NRA), a new independent regulatory body created in 2012, part of the Japanese government's response to the Fukushima Daiichi accident. Once restarts are approved by the NRA, consent will also have to be received from local and national governments.

Other factors that affect uranium requirements include fuel-cycle length and discharge burn-up as well as strategies employed to optimise the relationship between the price of natural uranium and enrichment services.[3] Generally increased uranium prices since 2003 have provided incentive for utilities to reduce uranium requirements by specifying lower tails assays at enrichment facilities, to the extent possible in contracts and the ability of the enrichment facilities to provide the increased services. Overcapacity in the enrichment market since the Fukushima Daiichi accident that led to a political decision to close eight reactors in Germany before the end of their operational lifetime and the entire nuclear fleet being taken offline in Japan, has provided incentive to enrichment facility operators to "underfeed" facilities by extracting more ^{235}U from the uranium feedstock, reducing the amount of uranium required to produce contracted quantities of enriched uranium that, in turn, creates a stockpile of uranium. In recognition of these recent market trends, uranium requirements for the operational lifetime of projected new reactors in this publication have been reduced from 175 tU/GWe/yr assuming a tails assay of 0.30%, to 163 tU/GWe/yr assuming a tails assay of 0.25% (including first core requirements over the lifetime of the reactor). This uranium requirement factor has been applied in recent editions of this publication in the absence of uranium requirement data provided by governments.

Enrichment providers have indicated that they are considering re-enrichment of depleted uranium tails in modern centrifuge facilities as an economic means of creating additional fissile material suitable for use in civil nuclear reactors. In addition, technological development of laser enrichment led to an agreement in 2013 between the US Department of Energy (DOE) and Global Laser Enrichment to further develop the technology using a portion of the US inventory of high assay uranium tails (about 115 000 tonnes), estimated to amount to a total of between 25 000 and 35 000 tU. Successful deployment of laser enrichment to re-enrich depleted uranium tails could bring a significant source of secondary supply to the uranium market in the mid-term, although technological hurdles remain to be overcome before commercial deployment can be achieved. Nonetheless, developments like these in the enrichment sector have put further downward pressure on uranium prices.

The combined impact of tails assay variation and strategies to optimise reactor operation and fuel costs, as well as unanticipated reactor closures and the idling of reactors in Japan, are evident in the uranium requirements data collected for this edition, since global requirements have decreased from 65 180 in 2011 to 61 600 tU in 2012 and are expected to decline further to 59 270 tU in 2013, despite global installed nuclear capacity remaining relatively steady through 2012 and 2013. Uranium requirements (defined in the Red Book as anticipated acquisitions, not necessarily consumption) are however expected to increase in the coming years as the significant amount of capacity currently under construction comes online, particularly in Asia.

The strong performance and economic competitiveness of existing plants, chiefly because of low operating, maintenance and fuel costs, has made retention and improvement of existing plants desirable in many countries. This has resulted in a trend

3. A reduction of the enrichment tails assay from 0.3 to 0.25% ^{235}U would, all other factors being equal, reduce uranium demand by about 9.5% and increase enrichment demand by about 11%. The tails assay selected by the enrichment provider is dependent on many factors including the ratio between natural uranium and enrichment prices.

to keep existing plants operating as long as can be achieved safely and upgrading existing generating capacity, where possible. This strategy has been undertaken in the United States and other countries (e.g. Canada, France, Hungary, Mexico, the Netherlands, the Slovak Republic, the Russian Federation and Sweden) have or are planning to upgrade their generating capacities and/or extend the lives of existing NPPs. However, competition from subsidised intermittent renewable energy sources and low natural gas prices as a result of technological advances in shale gas recovery have nevertheless recently rendered some plants uneconomic in liberalised energy markets in the United States, leading to shut downs before the end of the originally planned operational lifetime (e.g. Kewaunee and Vermont Yankee). Regulatory responses to the Fukushima Daiichi accident have also increased operating costs that may affect the competitiveness of other reactors, in particular the smaller, single units operating in liberalised markets in the United States.

Installation of new nuclear capacity will increase uranium requirements, particularly since first load fuel requirements are roughly some 60% higher than reloads for plants in operation, providing that new build capacity outweighs retirements (first load requirements are included in the lifetime requirement figure of 163 tU/GWe/yr used in this edition of the Red Book). A wide range of factors must be taken into consideration before any new significant building programmes are undertaken. These factors include projected electricity demand, security and cost of fuel supplies, the cost of financing these capital intensive projects, the cost competitiveness of nuclear compared to other generation technologies and environmental considerations, such as greenhouse gas emission reduction targets. Proposed waste management strategies and non-proliferation concerns stemming from the relationship between the civil and military nuclear fuel cycles also must be addressed. Following the Fukushima Daiichi accident, public acceptance of the safety of nuclear energy will require greater attention and this remains a pivotal issue in the yet to be determined role that nuclear power will play in the coming years in Japan.

Declining electricity demand in several developed countries during the lengthy recession following the financial crisis of 2008, the low cost of natural gas in the United States, competition from subsidised renewable energy sources in Europe and the United States and the challenge of raising the significant investment required for capital intensive projects with lengthy regulatory approval and construction times like NPPs, has made nuclear power development generally more challenging, particularly in liberalised energy markets.

However, despite these challenges and the reaction of a few countries to back away from nuclear power following the Fukushima Daiichi accident (i.e. the strengthening of nuclear phase-out programmes in Belgium, Germany and Switzerland and the decision to not proceed with nuclear power development in Italy for at least five years following a national referendum), many countries have decided that, on balance, objective analysis of these factors supports development of nuclear power. This is particularly so in countries with growing air pollution issues like China and India where coal-fired generation presently provides the majority of electricity. Significant nuclear building programmes are underway in India and following a near 24-month pause to reassess safety requirements, are continuing in China. Although the impacts of the global financial crisis have slowed the implementation of ambitious new build plans in some countries (e.g. South Africa), several other nations remain committed to long-term growth in nuclear generating capacity. Smaller scale programmes to increase nuclear generating capacity are underway in for example, the Czech Republic and Finland, while Poland continues to work towards construction of its first reactors. In the United States, despite the unexpected closure of five reactors, construction activities are underway on five reactors.

The International Energy Agency's (IEA) 2013 *World Energy Outlook* (WEO) once again notes that if governments follow the current path of current energy policy, severe climate change impacts can be expected and greenhouse gas emissions from electricity production is at the heart of the issue (IEA, 2013). Moreover, climate change appears to be slipping down the policy agenda and although energy efficiency policies are gaining momentum and growth in renewable energy sources is continuing, investment in renewables slowed in 2012. Economic implementation of carbon capture and storage remains distant and, as noted above, nuclear power faces a number of challenges. In setting a goal of stopping growth in emissions by 2020, four policy measures are proposed: implementation of select energy efficiency policies, limiting the use of inefficient coal power plants, reducing methane emissions from upstream oil and gas facilities and the partial removal of fossil fuel subsidies.

Global electricity demand to 2035 is expected to increase by two-thirds, or about 2.2% a year on average, with the largest increases expected from China, India and Southeast Asia. The success of policy measures proposed to reduce emissions in the face of rising demand hinges on the transition from fossil-fuelled to low-carbon generation sources. In the IEA New Policies Scenario for example, a marked difference is projected between OECD member countries, where the shift is towards renewable generating sources, and non-OECD member countries, where coal remains the dominant source of electricity generation. In terms of nuclear power, the New Policies Scenario projects growth in nuclear generating capacity, mainly in non-OECD countries, but the share of nuclear generating capacity in the energy mix is projected to remain at about 12% globally. The WEO notes that the expansion of nuclear power is mainly policy driven and can be limited by public opposition and long permitting processes that heighten uncertainties about project completion dates that in turn increases cost.

Projections to 2035[4]

Forecasts of installed capacity and uranium requirements, although uncertain due to the above-mentioned factors, continue to point to long-term growth. Installed nuclear capacity is projected to increase from about 372 GWe net at the beginning of 2013 to between about 400 GWe net (low case) and 678 GWe net (high case) by the year 2035. The low case represents growth of about 7% from 2013 nuclear generating capacity, while the high case represents an increase of about 82% (Table 2.3 and Figure 2.3). By 2025, low and high case scenario projections see increases of 12% and 51% respectively, indicating that significant expansion activities are already underway in several countries.

However, these projections are subject to even greater uncertainty than usual following the Fukushima Daiichi accident, since the role that nuclear power will play in the future generation mix in Japan has not yet determined and China did not report official targets for nuclear power capacity beyond 2020 for this edition. As a result, projections submitted in 2011 by the Chinese government are once again used. The almost two-year pause in the implementation of China's nuclear power development programme to review safety following the Fukushima Daiichi accident and the lack an officially announced capacity expansion targets beyond 2020 justifies this approach.

The low case installed nuclear capacity projection to 2035 has decreased by 26% compared to the last edition of this publication in 2011, due in part to incorporating the current policy of the French government to diversify electricity generation and reduce nuclear generation share of electricity production from 75% to 50%, strengthened phase-out policies in Belgium and Germany and reduced expectations of low case capacity additions in Canada and the United States. In Japan, installed nuclear capacity is

4. Projections of nuclear capacity and reactor-related uranium requirements are based on official responses from member countries to questionnaires circulated by the Secretariat. For countries that did not provide this information, Secretariat projections are based on data from the IAEA *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050*. Because of the uncertainty in nuclear programmes in the years 2015 onward, high and low values are provided.

projected to decline from 44 GWe in 2013 to about 10 GWe by 2035 as reactors are permanently shut down owing to a range of factors including location near active faults, technology, age and local political resistance.

The high case projection to 2035 has also declined, but only by 9% compared to 2011, as projections in a number of countries (e.g. Bangladesh, Bulgaria, Canada, India, the Republic of Korea, the Netherlands, Pakistan, the Russian Federation, Slovak Republic, Slovenia, South Africa, Sweden and Chinese Taipei) have been reduced or delayed somewhat as the safety of nuclear power was reviewed and other factors. New safety requirements have in general strengthened the robustness of responses to extreme events and the costs of implementing these measures could reduce the competitiveness of nuclear power in some liberalised markets. The high case scenario for Japan sees capacity remaining about the same as several reactors remain in service and ageing units are replaced by new reactors.

Nuclear capacity projections vary considerably from region to region. The East Asia region is projected to experience the largest increase that, by the year 2035, could result in the installation of between 55 GWe and 125 GWe of new capacity in the low and high cases respectively, representing increases of about 65% and 150% over 2013 capacity. While representing significant regional capacity increases, it is important to note that while the projections are based on recently revised nuclear development plans in the Republic of Korea, they are based on 2011 data from China that may not completely reflect the results of an extensive review of the safety of nuclear power conducted by the government following the Fukushima Daiichi accident. The regional projection also estimates that installed (not necessarily in operation) nuclear generating capacity in Japan by 2035 will be reduced by either 75% or will increase slightly by about 5% from 2013 installed capacity in the low and high cases, respectively. Should either of these projections prove incorrect, significant regional and global capacity adjustments could result.

Nuclear capacity in non-EU member countries on the European continent is also projected to increase considerably, with between 20 and 45 GWe of capacity additions projected by 2035 (increases of about 50% and 110% over 2013 capacity, respectively). Other regions projected to experience significant nuclear capacity growth include the Middle East, Central and Southern Asia and South-eastern Asia regions, with more modest growth projected in Africa and the Central and South America regions. For North America, nuclear generating capacity in 2035 is projected to either decrease by almost 30% in the low case or increase by 20% in the high case by 2035, depending largely on future electricity demand, lifetime extension of existing reactors and government policies with respect to greenhouse gas emissions. In the EU, the outlook is similar, with nuclear capacity in 2035 either projected to decrease by 45% in the low case scenario or increase by 15% in the high case. The low case projection includes the implementation of phase-out or reduced nuclear generation policies, continued subsidisation of intermittent renewable energy sources and weak growth in electricity demand. In the high case, phase-out policies are maintained but plans for the installation of additional nuclear generation capacity are assumed to be successfully realised in the Czech Republic, Finland, Hungary, Romania and the United States.

World reactor-related uranium requirements by the year 2035 (assuming a tails assay of 0.25%) are projected to increase to a total of between 72 200 tU/yr in the low case and 121 100 tU/yr in the high case, representing increases of about 20% and 105%, respectively, compared with 2013 requirements (Table 2.4 and Figure 2.4). Due to a combination of reductions in installed nuclear capacity projections compared to 2011 and the use of a lower uranium requirements figure in cases where governments do not provide this information (163 tU/GWe/yr compared to 175 tU/GWe/yr in previous editions), projected uranium requirements to 2035 have declined by 25% in the low case and 10% in the high case, compared to 2011.

Table 2.3. Installed nuclear generating capacity[(a)] to 2035

(MWe net, as of 1 January 2013)

Country	2012	2013	2015		2020		2025		2030		2035	
			Low	High	Low	High	Low	High	Low	High	Low	High
Algeria*	0	0	0	0	0	0	0	0	0	0	0	600
Argentina[(b)]	935	935	1 450	1 450	2 350	2 350	4 665	5 865	4 815	4 815*	4 815*	4 815*
Armenia	375	375	375	375	375	375	1 000	1 000	1 000	2 000	2 000	2 000
Bangladesh*	0	0	0	0	0	1 000	1 000	2 000	2 000	2 000	2 000	3 000
Belarus*	0	0	0	0	0	1 140	2 085	2 280	2 280	2 280	2 280	2 280
Belgium[+]	5 927	5 927	5 927	5 927	4 099	4 099	3 000	4 099*	0	4 099*	0	0
Brazil	1 875	1 875	1 875	1 875	3 120	3 120	3 120	5 120	3 120	7 120	4 575*	7 485*
Bulgaria*	1 906	1 906	1 906	1 906	1 906	1 906	1 906	1 906	1 906	2 906	953	2 906
Canada	13 500	13 500	13 500	13 500*	10 100	10 400*	10 100*	10 400*	8 900*	12 400*	6 145*	12 400*
China[(a)]	12 860	16 040	25 000	35 000	40 000	58 000	58 000	71 300	71 300	83 800	83 800	108 800
Czech Republic	3 760	3 884	3 850	3 880	3 900	3 920	5 900	6 100	5 900	6 100	7 100	7 200
Egypt*	0	0	0	0	0	0	0	0	0	1 000	0	1 000
Finland	2 700	2 700	2 750	4 400	2 750	4 500	5 600	7 800	5 100	7 300	5 600	6 800
France	63 130	63 130	63 130	63 130	62 900	62 900	43 885*	64 410*	42 060*	64 410*	37 865*	61 475*
Germany	12 100	12 100	10 800*	12 100	5 460*	8 100	0	0	0	0	0	0
Hungary	1 890	1 890	1 890	1 890	2 000	2 000	2 000	3 000	2 000	4 000	950	3 000
India[(b)]	4 391	5 308	5 990*	6 915	9 575	10 905	15 215*	23 750	18 445*	36 730*	18 240*	36 745*
Indonesia*	0	0	0	0	0	0	0	0	0	1 000	0	2 000
Iran, Islamic Republic of	915	915	915	915	3 175	5 075	6 975	7 925	6 975*	7 925*	6 975*	7 925*
Italy	0	0	0	0	0*	0*	0*	6 400	0*	13 000	0*	13 000
Japan*	44 215	42 400	30 730	43 690	26 645	44 650	22 990	44 210	17 855	46 690	10 195	44 130
Jordan*	0	0	0	0	0	0	0	0	1 000	2 000	1 000	2 000
Kazakhstan*	0	0	0	0	0	600	300*	600*	300*	600*	300*	600*
Korea, Republic of[+]	18 700	20 710*	24 500*	24 500	27 900*	31 500	35 900	37 000*	42 700	46 000*	42 700	45 300*
Lithuania*	0	0	0	0	0	0	0	0	0	1 500	0	1 500
Malaysia*	0	0	0	0	0	0	0	0	0	1 000	0	1 000
Mexico[+]	1 400	1 400	1 400	1 600	1 500*	1 600	1 500*	1 600	1 500*	2 600	1 500*	2 600

See notes on page 103.

Table 2.3. Installed nuclear generating capacity[(a)] to 2035 (*continued*)

(MWe net, as of 1 January 2013)

Country	2012	2013	2015		2020		2025		2030		2035	
			Low	High	Low	High	Low	High	Low	High	Low	High
Morocco*	0	0	0	0	0	0	0	0	0	1 000	0	1 000
Netherlands+	480	480	480	480	480	480	480	480	480	480	0	0
Pakistan*	725	725	600	725	900	1 325	1 200	1 200	1 200	3 200	1 200	3 200
Poland	0	0	0	0	0	0	1 000	1 650	4 500	7 000	7 000	10 000
Romania*	1 300	1 300	1 300	1 300	1 300	1 300	2 000	2 000	2 000	2 700	2 000	2 700
Russian Federation(b)	23 640	23 640	22 765	22 765	22 960	25 890	26 475	34 000	27 550	37 710	29 310	39 375
Saudi Arabia*	0	0	0	0	0	0	0	2 690	0	2 690	0	2 690
Slovak Republic	1 816	1 816	2 692	2 692	2 692	2 894	2 692	2 894	2 692	2 894	2 692	2 894
Slovenia+	698	698	698	698	698	698	698	698	698	698	698	698
South Africa	1 840	1 840	1 840	1 840	1 840	1 840	1 840	7 200	1 840	14 400	1 840	20 000
Spain	7 515	7 120	7 070	7 070	7 070	7 070	7 115*	7 315*	7 115*	7 315*	2 050*	7 315*
Sweden+	9 300	9 500*	9 600*	9 600*	10 100	10 100*	10 100*	10 100*	10 100	10 800*	200*	7 800*
Switzerland	3 280	3 280	3 280	3 280	2 175	3 280	1 190	3 280	0	2 905	0	2 175
Thailand	0	0	0	0	0	0	0	0	0	3 000	0	3 000
Turkey	0	0	0	0	0*	1 200	1 140*	7 040	2 280*	9 280	2 280*	9 280
Ukraine(b)	13 100	13 100	15 000	17 000	15 800	19 200	17 900	24 900	19 000	24 900	24 700	29 000
United Arab Emirates*	0	0	0	0	2 690	5 380	5 380	5 380	5 380	5 380	5 380	5 380
United Kingdom+	9 200	9 200*	8 700	9 200*	7 700	10 240*	3 600	12 980*	1 200	12 600*	1 200	13 190*
United States+	101 400	99 600	99 100*	100 020*	103 420*	105 650*	104 900	121 900	102 800	121 900	74 900	122 500
Viet Nam*	0	0	0	0	0	0	2 000	3 000	2 000	6 000	2 000	6 000
OECD total	**303 071**	**299 271**	**290 097**	**307 657**	**281 589**	**315 281**	**262 875**	**353 356**	**257 880**	**382 471**	**203 075**	**371 757**
World total(a)	**371 961**	**372 258**	**374 1421**	**407 451**	**394 100**	**462 415**	**416 831**	**563 200**	**432 691**	**650 455**	**399 143**	**678 486**

* Secretariat estimate, to 2030, based on *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050*, IAEA (Vienna), August 2013.

+ Data from *Nuclear Energy Data*, NEA (Paris), 2013.

(a) Projections for years 2015 to 2035 from 2011 Red Book. The following data for Chinese Taipei are included in the world total but not in the totals for China: 5 028 MWe in 2011 and 2012, respectively; 5 028 and 7 728 net for the low and high cases in 2015; 6 520 and 7 728 MWe net for the low and high cases in 2020; 2 700 and 7 728 MWe net for the low and high cases in 2025; 2 700 and 10 328 for the low and high cases in 2030 and 2035, respectively. These projections are based on government policy announcements as of May 2013.

(b) MWe gross converted to net by the Secretariat.

Table 2.4. Annual reactor-related uranium requirements[(a)] to 2035

(tonnes U, rounded to nearest five tonnes)

Country	2012	2013	2015		2020		2025		2030		2035	
			Low	High	Low	High	Low	High	Low	High	Low	High
Algeria*	0	0	0	0	0	0	0	0	0	0	0	100
Argentina	120	120	140	140	285	285	635	850	660	660*	660*	660*
Armenia	65	65	65	65	65	65	315	315*	155	470	310	310
Bangladesh*	0	0	0	0	0	165	165	330	330	330	330	495
Belarus*	0	0	0	0	0	185	365	365	365	365	365	365
Belgium	1 030	1 160	950	950	670*	670*	340*	670*	0	670*	0	0
Brazil	400	650	600	600	550	550	550	1 000	550	1 400	745*	1 400*
Bulgaria*	310	310	310	310	310	310	310	310	310	475	155	475
Canada	1 600	1 675	1 500	1 650	1 500	1 695*	1 645*	1 695*	1 450*	2 020*	1 000*	2 020*
China[(a)]	4 200*	4 800*	6 450	8 200	6 450	8 200	12 300	16 200	12 300	16 200	14 400	20 500
Czech Republic	670	640	650	655	955	970	885	890	1 090	1 100	1 100	1 500
Egypt*	0	0	0	0	0	0	0	0	0	165	0	165
Finland	370	370	700	760	700	1 360	870	1 250	690	1 050	690	1 050
France	8 000	8 000	8 000	9 000	8 000	9 000	7 155*	10 500*	6 855*	10 500*	6 175*	10 020*
Germany	2 000	2 000	1 970*	2 000	895*	1 200	0	0	0	00	0	0
Hungary	430	365	435	435	390	390	390	490*	390	650*	195	490*
India	715*	1 400	975	1 300	1 800	2 050	2 480*	4 400	3 005*	5 985*	2 975*	5 990*
Indonesia*	0	0	0	0	0	0	0	0	0	165	0	330
Iran, Islamic Republic of	40	160	160	160	590	910	1 230	1 390	1 230*	1 390*	1 230*	1 390*
Italy	0	0	0	0	0*	0*	0*	1 045*	0*	2 120*	0*	2 120*
Japan	1 960+	1 200*	2 500*	3 500*	4 345*	7 280*	3 745*	7 205*	2 910*	7 610*	1 660*	7 195*
Jordan*	0	0	0	0	0	0	0	0	165	330	165	330
Kazakhstan	0	0	0	0	0	60	50*	100*	50*	100*	50*	100*
Korea, Republic of+	4 200	4 500	4 600	4 700	6 000	6 200	7 200	7 700	8 600	9 100	10 000	10 700
Lithuania*	0	0	0	0	0	0	0	0	0	245	0	245
Malaysia*	0	0	0	0	0	0	0	0	0	165	0	165
Mexico+	180	230	385	435*	190	435*	410	410*	395	410*	395	410*
Morocco*	0	0	0	0	0	0	0	0	0	165	0	165

See notes on page 105.

Table 2.4. Annual reactor-related uranium requirements[(a)] to 2035 *(continued)*

(tonnes U, rounded to nearest five tonnes)

Country	2012	2013	2015		2020		2025		2030		2035	
			Low	High	Low	High	Low	High	Low	High	Low	High
Netherlands+	60	60	60	60	60	60	60	60	60	60	0	0
Pakistan*	120	120	100	195	145	195	195	195	195	520	195	520
Poland*	0	0	0	0	0	0	165*	270*	790	900	900	1 000
Romania*	210	210	210	210	210	210	210	210	330	330	330	440
Russian Federation	3 800	3 800	3 700	3 700	3 700	4 200	4 300	5 500	4 450	6 150	4 800	6 400
Saudi Arabia	0	0	0	0	0	0	0	440	0	440	0	440
Slovak Republic	375	360	660	660	505	555	515	555	515	555	515	555
Slovenia	150	140	120	180	120	180	120	180	120	180	120	180
South Africa	290	290	290	290	290	290	290	1 190	290	2 375	290	3 300
Spain	940	1 655	1 250	1 350	1 250	1 350	1 250	1 350	1 160*	1 190*	335*	1 190*
Sweden+	1 470	1 550*	1 565*	1 900	1 650*	1 900	1 650*	1 900	1 650*	1 900	35*	1 270*
Switzerland	290	290	230	355	170	535	170	535	0	470	0	365
Thailand	0	0	0	0	0	0	0	0	0	490	0	490
Turkey*	0	0	0	0	0	195	185	1 150	370	1 550	370	1 550
Ukraine	2 480	2 480	2 480	3 230	3 020	3 600	3 020	3 660	3 600	4 800	4 800	5 300
United Arab Emirates*	0	0	0	0	440	875	875	875	875	875	875	875
United Kingdom+	1 220	1 500	1 350	1 650*	580	1 665*	305	2 115*	305	2 055*	0	2 150*
United States	23 085	18 350	19 170*	19 170*	19 300*	19 300*	21 260	24 650	20 835	26 650	15 270	24 735
Viet Nam*	0	0	0	0	0	0	330	490	330	980	330	980
OECD total	**48 030**	**44 045**	**46 095**	**49 410**	**47 280**	**54 940**	**48 320**	**64 620**	**48 185**	**70 740**	**38 760**	**68 500**
World total	**61 600**	**59 270**	**62 755**	**69 075**	**66 200**	**78 355**	**76 380**	**103 705**	**77 815**	**117 990**	**72 205**	**122 110**

* Secretariat estimate, to 2030, based on *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050*, IAEA (Vienna), August 2013; if uranium requirement data are not provided in questionnaire response, requirements are calculated assuming lifetime requirements of 163 tU/GWe/yr.

+ Data from *Nuclear Energy Data*, NEA (Paris), 2013.

(a) The following data for Chinese Taipei are included in the world total but not in the totals for China: 820 tU in 2012; 820 tU and 1 265 tU in the low and high cases in 2015; 1 065 tU/yr and 1 265 tU in the low and high cases in 2020; 440tU and 1 265 tU in the low and high cases in 2025; 440 tU and 1 690 tU in the low and high cases in 2030 and 2035, respectively.

Figure 2.3. Projected installed nuclear capacity to 2035

(low and high projections)

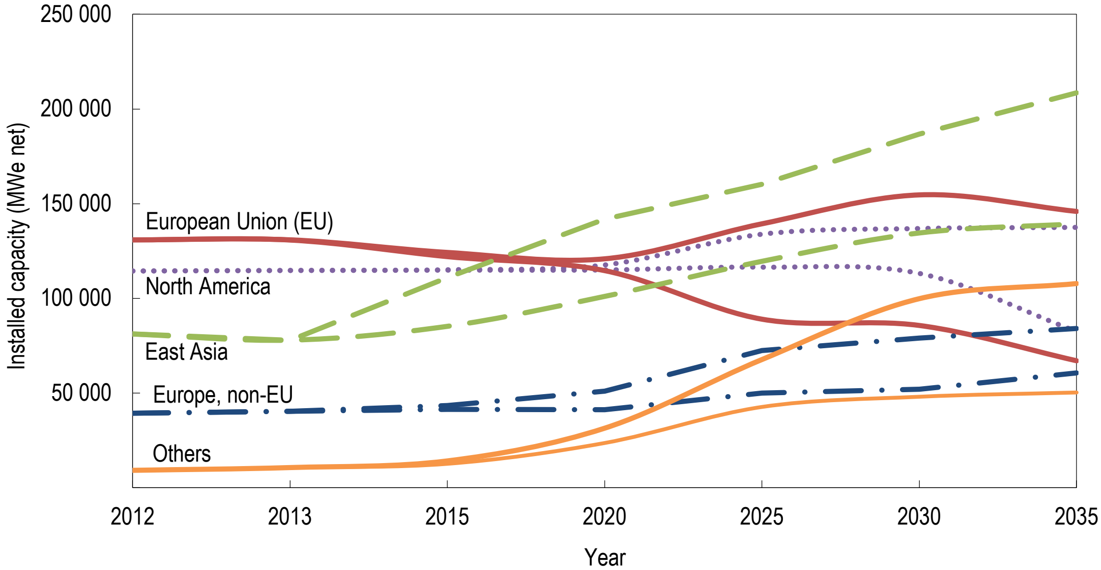
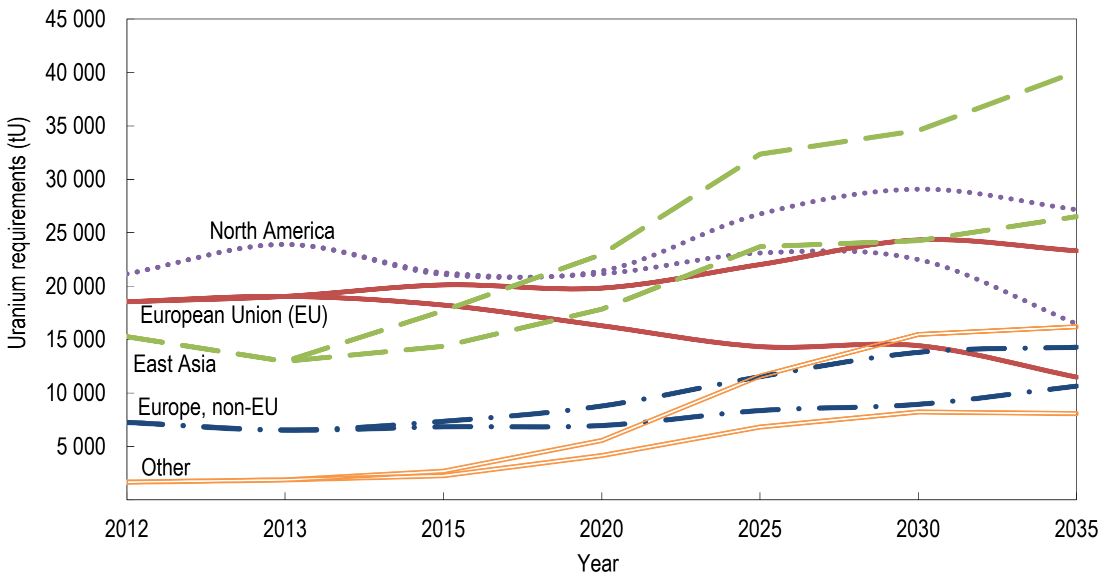


Figure 2.4. Annual reactor-related uranium requirements to 2035

(low and high projections)



As in the case of nuclear capacity, uranium requirements vary considerably from region to region reflecting projected capacity increases and possible inventory building. Annual uranium requirement increases are projected to be largest in the East Asia region where increased installed nuclear generating capacity (particularly in China and the Republic of Korea) drives significant growth in uranium requirements. In contrast to steadily increasing uranium requirements in the rest of the world, annual requirements in the EU are either projected to decline by about 40% (low case) or increase by 25% (high case) by 2035, compared to 2013 requirements. Projected North American uranium requirements show a similar wide range, varying from a decline of almost 20% (low case) to growth of almost 35% (high case) by 2035.

Uranium supply and demand relationships

Uranium supply has been adequate to meet demand for decades and there have been no supply shortages since the last edition of this report. However, a number of different sources of supply are required to meet demand. The largest is the primary production of uranium that, over the last few years, has satisfied as much as 95% of world requirements. The remainder has been provided or derived from secondary sources including stockpiles of natural and enriched uranium, blending down weapons grade uranium, reprocessing of spent fuel and the re-enrichment of depleted uranium tails.

Primary sources of uranium supply

Uranium was produced in 21 countries in 2012, 1 less than in 2010 (no mine remediation production was reported for Bulgaria in 2012), with total global production amounting to 58 816 tU (representing increases of 7% and 8% from 2011 and 2010, respectively). Of these 21 producing countries, 3 reported limited production through mine remediation efforts only (France, Germany and Hungary). Kazakhstan passed Canada in 2009 to become the world's largest producer and has remained in this position through 2012, continuing its run of production increases of 8% each year over the past two years, albeit levelling off from the more significant increases of 65% and 27% in 2009 and 2010, respectively. Production in Kazakhstan is projected to increase by 6% in 2013 to 22 500 tU. The top five producing countries in 2012 (Kazakhstan, Canada, Australia, Niger and Namibia) accounted for 79% of world production and ten countries, Kazakhstan (36%), Canada (15%), Australia (12%), Niger (8%), Namibia (8%), the Russian Federation (5%), Uzbekistan (4%), the United States (3%), China (2%) and Malawi (2%) and Ukraine (2%) accounted for 97% of global mine production.

Of the 30 countries currently using uranium in commercial NPPs, only Canada and South Africa produced enough uranium in 2012 to meet domestic requirements (Figure 2.5) creating an uneven distribution between producing and consuming countries. All other countries with nuclear power must make use of imported uranium or secondary sources and, as a result, the international trade of uranium is a necessary and established aspect of the uranium market. Given the uneven geographical distribution between producers and consumers, the safe and secure shipment of nuclear fuel will need to continue without unnecessary delays and impediments. Difficulties that some producing countries, in particular Australia, have encountered with respect to international shipping requirements and transfers to international ports have therefore always been a matter of some concern. However, efforts to objectively inform port authorities on the real risks involved and better recognition of the longstanding record of successful shipments of these materials have helped avoid unnecessary delays.

Due to the current availability of secondary supplies, primary uranium production volumes have been for some time significantly below world uranium requirements. However, this has changed in recent years as production has increased and requirements have declined. In 2012, world uranium production (58 816 tU) provided about 95% of world reactor requirements (61 600 tU). In OECD countries, the gap between production and requirements has changed little as both have declined in the past two years. In 2012, production of 17 956 tU provided 37% of requirements (48 030 tU; Figure 2.6). Remaining reactor requirements were met by imports and secondary sources.

Secondary sources of uranium supply

Uranium is unique among energy fuel resources in that a significant portion of demand has been supplied by secondary sources rather than direct mine output. These secondary sources include: stocks and inventories of natural and enriched uranium, both civilian and military in origin; nuclear fuel produced by reprocessing spent reactor fuels and from surplus military plutonium; uranium produced by the re-enrichment of *depleted uranium* tails.

Figure 2.5. Estimated 2013 uranium production and reactor-related requirements for major producing and consuming countries

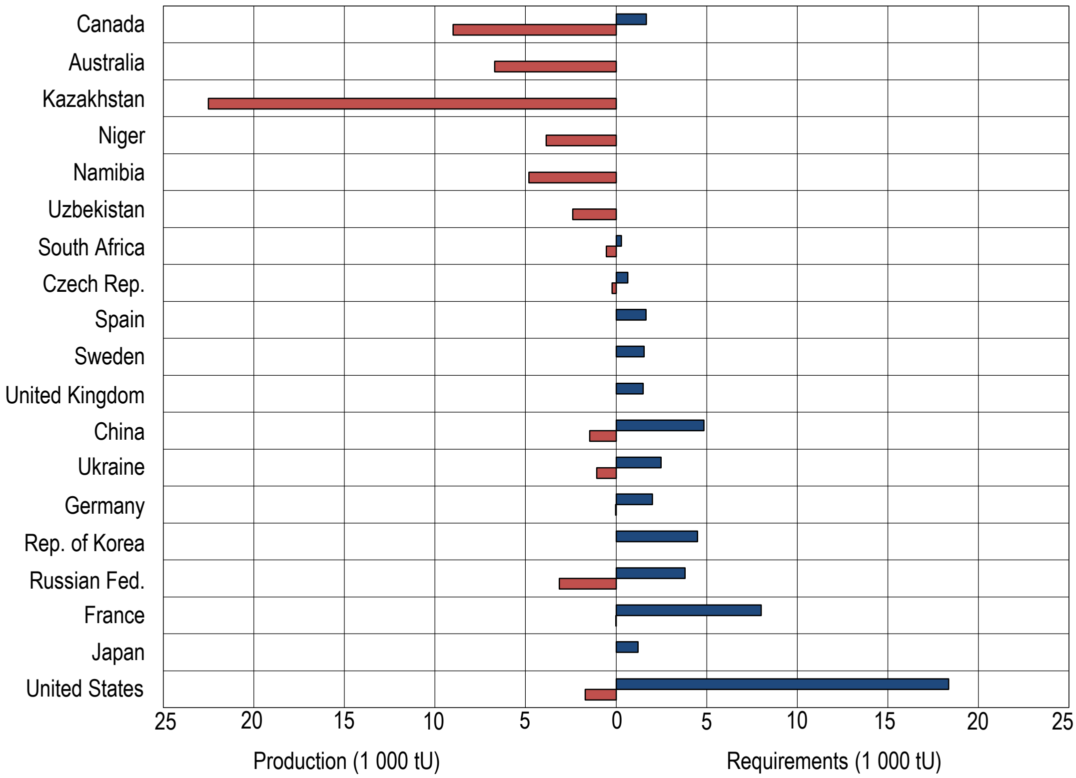
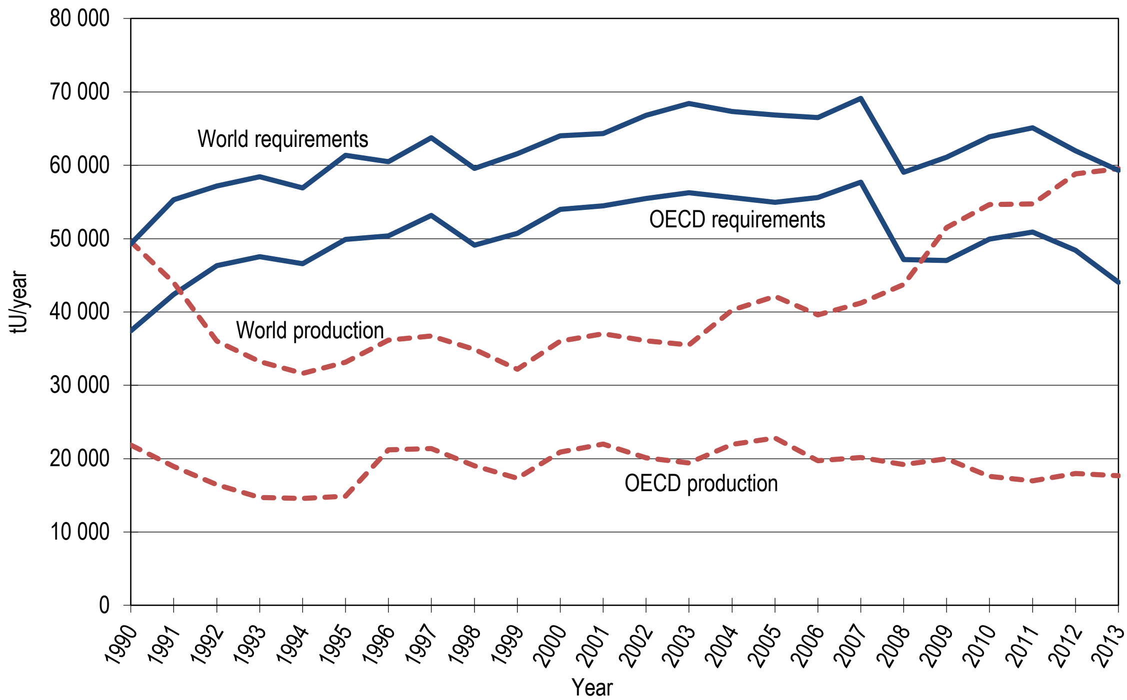


Figure 2.6. OECD and world uranium production and requirements*

(1990-2013)



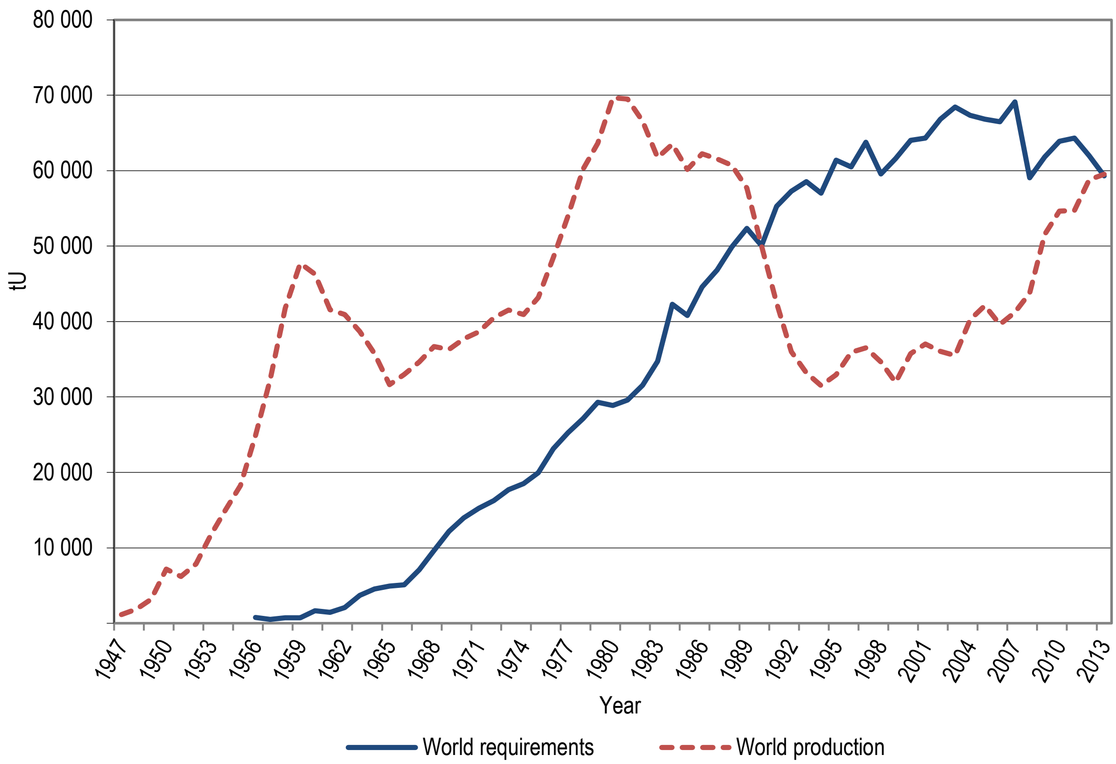
* 2013 values are estimates.

Natural and enriched uranium stocks and inventories

From the beginning of commercial exploitation of nuclear power in the late 1950s to 1990, uranium production consistently exceeded commercial requirements (Figure 2.7). This was mainly the consequence of a lower than projected growth rate of nuclear generating capacity combined with high levels of production for strategic purposes. This period of over production created a stockpile of uranium potentially available for use in commercial power plants. After 1990, production fell well below demand as secondary supplies fed the market. Initially, production dropped well below demand but the gap has closed in the last two years as mine production is increasing and uranium requirements are declining, at least temporarily. The decline in requirements in 2008 was likely related to utilities specifying lower tails assays at enrichment facilities and a reduced number of reactors being refuelled. Since 2008, requirements increased slightly before declining again owing to unplanned reactor closures in Germany and Japan following the Fukushima Daiichi accident. Production since 2007 has generally increased and has closed the gap to reactor requirements.

Figure 2.7. Annual uranium production and requirements*

(1947-2013)



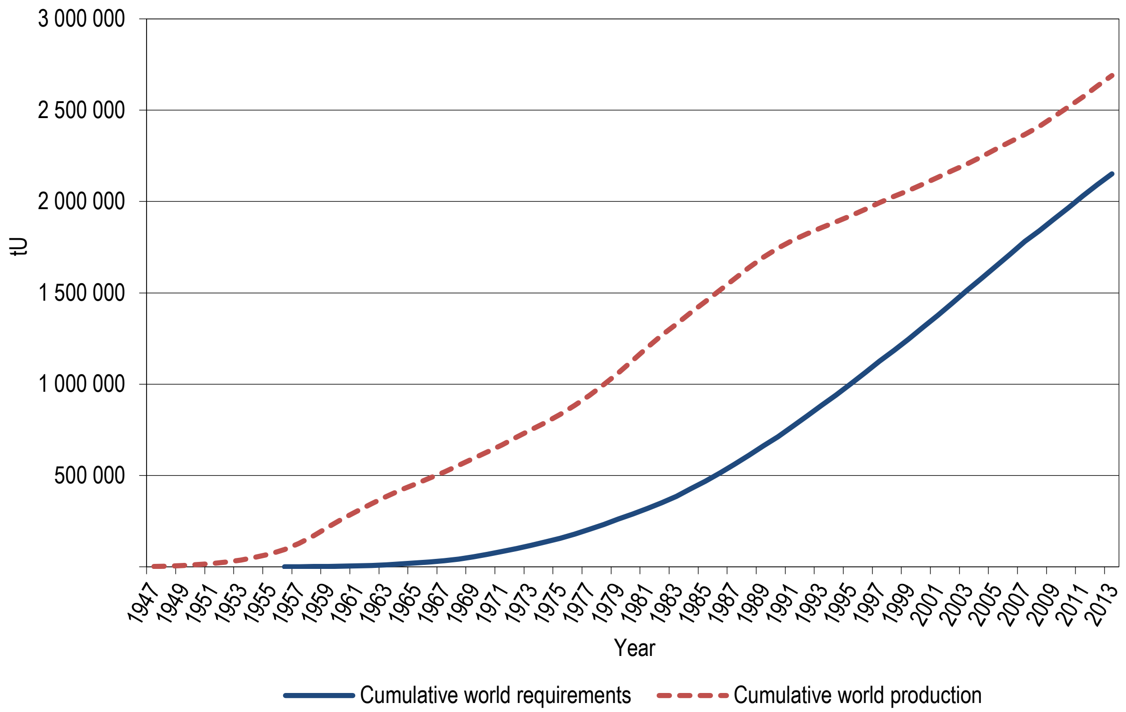
* 2013 values are estimates.

Following the political and economic reorganisation in Eastern Europe and the former Soviet Union in the early 1990s, steps have been taken to move towards the development of an integrated global commercial market. More uranium is now available from the former Soviet Union, most notably Kazakhstan, but also the Russian Federation and Uzbekistan, as is more information on the production and use of uranium in the former Soviet Union. Despite these developments and some better information on the amount of uranium held in inventory by utilities, producers and governments, uncertainties remain regarding the size of these inventories as well as the availability of uranium from other potential secondary supply sources. This, combined with uncertainty about the desired levels of commercial inventories continues to influence the uranium market.

Data from past editions of this publication, along with information provided by member states, give a rough indication of the possible maximum upper level of potentially commercially available inventories. Cumulative production through 2012 is estimated to have amounted to over 2 700 000 tU, whereas cumulative reactor requirements through 2012 amounted to about 2 150 000 tU. This leaves an estimated remaining stock of roughly 550 000 tU; a rough estimate of the upper limit of what could potentially become available to the commercial sector (Figure 2.8). This base of already mined uranium, minus an unknown but not insignificant amount lost during processing, has essentially been distributed into two sectors, with the majority used and/or reserved for the military and the remainder used or stockpiled by the civilian sector. Since the end of the Cold War, increasing amounts of uranium, previously reserved for strategic purposes, have been released to the commercial sector.

Figure 2.8. Cumulative uranium production and requirements*

(1947-2013)



* 2013 values are estimates.

Civilian inventories include strategic stocks, pipeline inventory and excess stocks available to the market. In recent years material held by financial investors has been a part of the inventory, although reports indicate that the major investment banks are in the process of exiting commodity markets because of declining demand and increased regulation. Utilities are believed to hold the majority of commercial stocks because many have policies that require carrying the equivalent of one to two years of natural uranium requirements. Despite the importance of this secondary source of uranium, information about the size of these stocks is limited because few countries are able or willing, due to confidentiality concerns, to provide detailed information on stockpiles held by producers, consumers or governments (Table 2.5).

Table 2.5. Uranium stocks in countries responding to 2013 questionnaire

(tonnes natural U equivalent as of 1 January 2013)

Country	Natural uranium	Enriched uranium
Argentina[(a)]	52	0
Australia[(b)]	0	0
Belgium	NA	NA
Brazil	0	0
Bulgaria[(c)]	0	81
Canada[(b)]	NA	0
China	NA	NA
Czech Republic[(d)]	NA	NA
Finland[(e)]	NA	NA
France[(f)]	NA	NA
Germany	NA	NA
Hungary[(g)]	3	0
India	NA	NA
Iran, Islamic Republic of	NA	NA
Japan	NA	NA
Kazakhstan	NA	NA
Korea, Republic of[(c, h)]	2 000	6 000
Mexico	NA	NA
Mongolia	0	0
Netherlands	NA	NA
Niger	0	0
Poland	0	0
Portugal	168	0
Russian Federation	NA	NA
Slovak Republic	0	NA
South Africa	NA	NA
Spain[(i)]	NA	>608
Switzerland[(j)]	1 543	673
Turkey	2	0
Ukraine	0	0
United Kingdom	NA	NA
United States[(k)]	34 375	33 196
Viet Nam	0	0
Total	**38 143**	**>40 558**

(a) Government data only. Commercial data are not available.
(b) Government stocks are zero in all categories. Commercial data are not available.
(c) Data from 2009 Red Book.
(d) ČEZ maintains strategic and working inventories in various forms, including fuel assemblies, amounting to about two years of requirements.
(e) The nuclear power utilities maintain reserves of fuel assemblies sufficient for 7-12 months of use.
(f) A minimum strategic inventory, amounting to of a few years of forward fuel requirements, is maintained by EDF.
(g) Inventory from mine water treatment only.
(h) A strategic inventory is maintained along with about one year's forward consumption in pipeline inventory.
(i) Regulations require a strategic inventory of at least 611 tU be maintained jointly by nuclear utilities.
(j) Utilities also hold 48 t (U equivalent) of reprocessed uranium.
(k) Does not include 9 247 tU natural uranium hexafluoride (UF_6) and 20 648 tU enriched uranium in fuel assemblies held in storage by utilities. Government stocks also include 25 950 t (U equivalent) of depleted uranium.

Nonetheless, available data suggest that industry has been increasing inventories in recent years. In the United States, 2012 year-end total commercial uranium inventories (natural and enriched uranium equivalent held by producers and utilities) amounted to 46 438 tU, an increase of almost 20% compared to 2010 levels of 38 517 tU. Uranium inventories held by EU utilities at the end of 2012 totalled 52 362 tU, enough for three years fuel supply, an increase of 10% since the end of 2011 and 21% since the end of 2007 (ESA, 2013). These data from the two largest regions of nuclear power generation suggest that global commercial inventories have been increasing.

Uranium requirements are growing rapidly in East Asia (in particular in China where 29 reactors were under construction at the end of 2012). By the early 2020s, demand in this region is expected to surpass both that of North America and the EU. Questionnaire responses received during the compilation of this volume revealed little about national inventory policies in the East Asia region.

The World Nuclear Association (WNA) reports that questionnaire responses from industry show a clear build-up of utility inventory since 2003, mainly in East Asia. At the end of 2012 global inventories totalled 155 000 tU, an increase of 35 000 tU since 2010. The WNA (2013) considers this build-up to be a response to the Fukushima Daiichi accident (since reactors have been laid up in Japan pending restart and fuel deliveries have continued) and lower uranium prices since the accident. Although not reported in the questionnaire response, the WNA (2013) estimates that China has accumulated an inventory of over 30 000 tU between 2009 and 2012 in anticipation of increasing uranium requirements due to the significant number of reactors under construction and planned.

In recent years, commercial entities other than utilities have been holding quantities of uranium for investment purposes. Although commercially confidential, variable and largely dependent on uranium price dynamics, the WNA (2013) notes that financial investors have reduced their holdings by about 50%, compared to the estimated 5 000 tU in April 2010. Efforts by governments and international agencies have also resulted in actions to create nuclear fuel banks, another form of inventory. These are discussed below.

In July 2013, the US DOE outlined to Congress its plan to manage its excess uranium inventory in various forms that amounts to between 46 000 and 56 000 tNatU (tonnes of natural uranium equivalent; DOE, 2013). It identifies uranium inventories that have entered the commercial uranium market since the issuance of the last plan in 2008, as well as transactions that are ongoing or being considered through 2018. A Secretarial Determination must be made every two years in advance of sales or transfers in order to provide assurance that the transactions would not have an adverse material impact on the domestic uranium mining, conversion or enrichment industries.

The most recent transactions involve the transfer of up to 9 082 t of depleted uranium (DU) to Energy Northwest in 2012 and 2013, the majority of which would be enriched for use in the company's power reactor and the remainder sold to the TVA as part of a commercial transaction to support future power generation and tritium production from 2013 through 2030; the transfer of up to 2 400 tU to DOE contractors for clean-up services at the Paducah and Portsmouth gaseous diffusion plants and up to 400 tNatU transferred to the National Nuclear Security Administration (NNSA) for blending down HEU to low-enriched uranium (LEU).

Also noted is approximately 123 000 t of the total DOE inventory of 510 000 t DU believed to have economic value for enrichment (referred to as high assay tails). Transfers to Energy Northwest have reduced this high assay tails total to around 114 000 t DU, half of which are located at the Paducah gaseous diffusion enrichment facility. Operations at Paducah, a DOE facility leased to United States Enrichment Corporation (USEC), were brought to an end in May 2013. Ahead of the closure, the DOE issued a request for expressions of interest for the DU inventory and in late 2013 selected a proposal by GE-Hitachi Global Laser Enrichment to build and operate a tails processing plant using Silex laser enrichment technology.

Large stocks of uranium, previously dedicated to the military in both the United States and the Russian Federation, have become available for commercial applications, bringing a significant secondary source of uranium to the market. Despite the programmes outlined below, the remaining inventory of HEU and natural uranium held in various forms by the military is significant, although official figures on strategic inventories are not available. If additional disarmament initiatives are undertaken to further reduce strategic inventories, several years of global supply of NatU for commercial applications could be made available.

- HEU from the Russian Federation

The Russian Federation and the United States signed a 20-year, government-to-government agreement in February 1993 for the conversion of 500 t of Russian HEU from nuclear warheads to LEU suitable for use as nuclear fuel (referred to as the Megatons to Megawatts agreement). USEC, the US executive agent for this agreement, announced that as of 31 December 2012 472.5 tonnes of HEU had been recycled into 13 603 tonnes of LEU, eliminating 18 899 warheads. As of 31 December 2012, the programme, which will expire in late 2013, had not been extended.

Under a separate agreement, the natural uranium feed component of the HEU purchase agreement is sold under a commercial arrangement between three western corporations (Cameco, AREVA, and Nukem) and Techsnabexport (TENEX) of the Russian Federation. Imports of uranium from the Russian Federation outside of these agreements have been limited by the *Agreement Suspending the Antidumping Duty Investigation on Uranium from the Russian Federation* (suspension agreement) signed between the US Department of Commerce (DOC) and the Ministry of Atomic Energy of the Russian Federation in 1992. As a result of the suspension agreement, DOC suspended antidumping investigations and the Russian Federation agreed to sell uranium to the United States under a quota system whereby Russian imports would have to be matched by an equivalent quantity of newly produced uranium in the United States.

A February 2008 amendment to the suspension agreement allows very small quantities of Russian LEU to enter the United States beginning in 2011 and much higher sales of Russian uranium products directly to US utility companies under quota from 2014 to 2020. In addition, Russian-origin fuel supply to new reactors will be quota-free. Since the signing of this amendment, agreements for nuclear fuel supply deliveries have been signed by US utilities and the Russian Federation, including a contract between USEC and TENEX in March 2011 for the ten-year supply of LEU through 2022. By mid-2012, it was reported that TENEX had signed 13 commercial contracts with 10 US utilities, representing more than 50% if the permitted quota. By 2015, the LEU supplied will amount to about one-half the level currently supplied under the HEU purchase agreement. However, quantities supplied under these new arrangements will come from the Russian Federation's commercial enrichment activities as opposed to blending down excess Russian weapons material.

- HEU from the United States

In 1995, the United States declared 200 t of fissile material, about 175 t of which is HEU, as surplus to defence needs and committed to its disposition. The preferred option for the disposition of this material is blending down HEU to LEU suitable for fuel in research and commercial reactors. The remainder that is not suitable for such uses would be blended down and disposed of as low-level radioactive waste (DOE, 1996). As of 2007, approximately 100 of the 175 t HEU had been blended down, another 10 t HEU was in the blending down process and about 18 t HEU was considered unsuitable for use as nuclear fuel (DOE, 2007).

In 2001, the DOE and TVA signed an interagency agreement, whereby TVA committed to utilising LEU derived from blending down about 33 t of US surplus HEU for the production of "off-spec" LEU fuel (termed BLEU). This fuel is considered "off-spec" because it contains ^{234}U and ^{236}U in excess of the specifications established for commercial nuclear fuel. In 2004, this agreement was modified to increase the total to 39 t of HEU and an additional 5.6 t of HEU was added to the programme in 2008.

From 1999 to 2000, four BLEU fuel assemblies loaded in the Sequoyah NPP successfully demonstrated the use of "off-spec" LEU. Since 2005, BLEU has been used in TVA's Browns Ferry and Sequoyah reactors and TVA plans to continue to use BLEU in these reactors until 2016, since it has proven to be a reliable source of lower cost fuel (TVA, 2011).

In 2005, an additional 200 t HEU was declared as surplus, the majority of which was designated for use in naval propulsion and with a portion to be blended down to LEU fuel for use in power or research reactors (DOE, 2007). DOE proposed to allocate about 61 t HEU for BLEU production over the next few decades, with the LEU gradually being made available to power reactors over a 25-year period. TVA subsequently prepared an environmental assessment of obtaining an additional 28 t of HEU for blending down in order to meet Browns Ferry and Sequoyah fuel requirements from 2016 through 2022 (TVA, 2011). By October 2010, 22.8 t HEU had been blended down, creating 312 t of LEU.

Also in 2005, DOE announced its intention to set aside 17.4 t of HEU to be blended down to LEU fuel and held in reserve to address any disruptions in domestic or foreign nuclear fuel supply. In August 2011, DOE announced that the American Assured Nuclear Fuel Supply had been established to secure sufficient LEU for six reloads of an average 1 000 MWe reactor (230 t LEU), derived from blending down this HEU. The remaining 60 t LEU produced from blending down the 17.4 t HEU is expected to be sold on the market to pay for processing costs.

In December 2008, the DOE excess uranium inventory included 67.6 t of HEU that was declared unallocated (not presently obligated or approved for a specific purpose or programme). The disposition plan for this material noted that the HEU will be made available gradually over several decades at a rate controlled by weapons dismantlement initiatives and the rejection of material from naval reactors (DOE, 2008).

As of 31 December 2012, DOE reported that it held 11.4 t of surplus HEU remaining in the active disposition programme and approximately 18 t of unallocated surplus HEU, (DOE, 2013). These amounts reflect the material blended down since 2008, the allocation of 5 t HEU to the BLEU programme and the reallocation of significant quantities of surplus HEU to activities not expected to impact uranium markets (i.e. research reactor and naval fuel requirements).

Nuclear fuel produced by reprocessing spent reactor fuels and surplus weapons-related plutonium

The constituents of spent fuel from NPPs are a potentially substantial source of fissile material that could displace primary uranium production. When spent fuel is discharged from a commercial reactor it is potentially recyclable, since about 96% of the original fissionable material remains along with the plutonium created during the fission process. The recycled plutonium can be reused in reactors licensed to use MOX. The uranium recovered through reprocessing of spent fuel, known as reprocessed uranium (RepU), is not routinely recycled; rather, it is stored for future reuse.

The use of MOX has not yet significantly altered world uranium demand because only a relatively small number of reactors are using this type of fuel. Moreover, the number of recycles possible using current reprocessing and reactor technology is limited by the build-up of plutonium isotopes that are not fissionable by the thermal neutron spectrum found in light water reactors and by the build-up of undesirable elements, especially curium.

As of January 2013 there were 35 reactors, or about 8% of the world's operating fleet, licensed to use MOX fuel, including reactors in France, Germany and India (Table 2.1). Japan had planned to use MOX fuel in 16 to 18 reactors by 2015, but the status of this plan and the current MOX licensing situation is unknown. Reprocessing and MOX fuel fabrication facilities exist or are under construction in China, France, India, Japan, the Russian Federation, the United Kingdom and the United States. However, in 2011 it was announced that the Sellafield MOX plant in the United Kingdom would be closed owing to reduced demand for services in Japan following the Fukushima Daiichi accident.

Following on basic research and MOX fuel fabrication for experimental reactors by the Japan Atomic Energy Agency (JAEA), Japan Nuclear Fuel Ltd (JNFL) began testing plutonium separation at the Rokkasho reprocessing facility in 2006. Japanese utilities began using MOX initially in fuel manufactured overseas. The use of imported MOX fuel was to be followed by the use of MOX produced at JNFL's MOX fuel fabrication facility (JMOX) adjacent to the Rokkasho reprocessing plant. JMOX construction began in 2010. By mid-2010, three reactors in Japan had received fuel loads with MOX produced overseas, the last being reactor No. 3 at Fukushima Daiichi. Commercial operation of JMOX is expected to begin in 2016 (130 tHM/yr capacity). In January 2013, JNFL reported that it planned to reprocess 880 tHM over three years following completion of the Rokkasho facility in 2014, once consultation with local residents on plant safety and reprocessing plans had been completed. The recovered plutonium and uranium would be stored until MOX fuel fabrication could begin at JMOX.

Following the closure in 2003 of the Cadarache MOX fuel production plant in France and the MOX fuel plant in Belgium (BELGONUCLÉAIRE) in 2006, the MELOX plant in Marcoule, France was licensed in 2007 to increase annual production from 145 tHM to 195 tHM of MOX fuel (corresponding to 1 560 tNatU). Annual MOX production in France varies below this licensed capacity, in accordance with contracted quantities. Most of the French MOX production is used to fuel French NPPs (a total of about 120 t/yr; 960 tNatU) and the remainder is delivered abroad under long-term contract arrangements.

The Euratom Supply Agency (ESA) reported that the use of MOX fuel in the EU increased by 10% in 2012 to 10 334 kg Pu from 9 410 kg Pu in 2011. Use of plutonium in MOX fuel reduced natural uranium requirements in the EU by an estimated 897 tU in 2012 and 824 tU in 2011. Since 1996, MOX fuel use in EU reactors has displaced a cumulative total of 18 753 tU through the use of 161.5 t of Pu (ESA, 2013). Since the great majority of world MOX use occurs in Western Europe, this figure provides a reasonable estimate of the impact of MOX use worldwide on uranium requirements during that period. Responses to the questionnaire provide some additional data on the production and use of MOX (Table 2.6).

Uranium recovery through reprocessing of spent fuel, known as RepU, has been conducted in the past in several countries, including Belgium and Japan. It is now routinely done only in France and the Russian Federation, principally because the production of RepU is a relatively costly endeavour, in part due to the requirement for dedicated conversion, enrichment and fabrication facilities. Available data indicate that it represents less than 1% of projected annual world requirements. Reprocessing could become a more significant source of nuclear fuel supply in the future if China successfully commercialises the process. In 2012, it was reported that China planned to move beyond conducting research and development of reprocessing and recycling technologies to build and operate a large-scale commercial reprocessing facility with a capacity of 800 tHM/yr in order to achieve maximum utilisation of uranium resources, given the country's rapidly rising requirements. Since 2007, China and France have reportedly been discussing the possibility of France supplying a commercial scale reprocessing facility.

Table 2.6. MOX production and use

(tonnes of equivalent natural U)

Country	Pre-2010	2010	2011	2012	Total to 2012	2013 (expected)
MOX production						
Belgium	523	0	0	0	523	0
France	15 598	1 560	1 160	1 200	19 518	NA
Japan	645	37	2	0	684	0
United Kingdom	NA	NA	NA	NA	NA	NA
MOX use						
Belgium	520	0	0	0	520	0
France	NA	880	880	880	NA	NA
Germany	6 530	100	100	100	6 830	260
Japan	702	146	64	0	912	0
Switzerland	1 407	0	0	0	1 407	0

NA = Not available or not disclosed.

Table 2.7. Reprocessed uranium production and use

(tonnes of equivalent natural U)

Country	Pre-2010	2010	2011	2012	Total to 2012	2013 (expected)
Production						
France[(a)]	13 900	1 000	1 000	1 000	16 900	1 000
Japan[(b)]	645	0	0	0	645	0
Russian Federation	NA	NA	NA	NA	NA	NA
United Kingdom[(c)]	53 819	NA	NA	NA	NA	NA
Use						
Belgium[(d)]	508	0	0	0	508	0
France[(a)]	3 500	600	600	600	5 300	600
Germany	NA	NA	NA	NA	NA	NA
Japan[(b)]	215	0	0	0	215	0
Switzerland	2 563	291	309	291	3 454	304
United Kingdom[(c)]	~15 000	NA	NA	NA	~15 000	NA

NA = Data not available.

(a) Figures updated from 2011 Red Book.

(b) For fiscal year.

(c) 2013 edition of *OECD Nuclear Energy Data*.

(d) From 1993 to 2002.

- MOX produced from surplus weapons-related plutonium

In September 2000, the United States and the Russian Federation signed the Plutonium Management and Disposition Agreement that committed each country to dispose of 34 t of surplus weapons-grade plutonium (enough to make several thousand nuclear weapons), at a rate of at least two tonnes per year in each country, once production facilities are in place. Both countries agreed to dispose of the surplus plutonium by fabricating MOX fuel suitable for irradiation in commercial nuclear reactors that would convert the surplus plutonium into a form that cannot be readily used to make a nuclear weapon. In 2009, US President Obama and Russian President Medvedev signed a joint statement on nuclear co-operation in Moscow that reaffirmed this commitment.

In the United States, the MOX fuel is to be fabricated at the DOE's Savannah River complex in South Carolina. In February 2011, the TVA and AREVA signed a Letter of Intent to begin evaluating the use of MOX at TVA's Sequoyah plant in Tennessee and the Browns Ferry plant in Alabama. As of late 2013 however, no formal agreements with utilities to use the MOX fuel had been signed.

DOE's National Nuclear Security Administration awarded a contract for construction of a Mixed Oxide Fuel Fabrication Facility at Savannah River in 2001 and construction was officially started on 1 August 2007. In late 2012, construction was reportedly 88% complete. Cold start-up is expected to begin in 2016, followed by PWR and BWR MOX fuel fabrication in 2019. The facility is expected to be in operation for about 20 years.

In mid-2013 however, it was reported that the project had encountered technical difficulties and was running over budget. Work at the Russian MOX facility had reportedly been undertaken at an estimated cost of USD 2 billion, but the WNA (2013) reported that the project had been abandoned in favour of burning excess plutonium in fast reactors.

If the current agreement is implemented as planned, the 68 t of weapons-grade plutonium would displace about 14 000 to 16 000 tonnes of natural uranium over the life of the programme. This represents about 1% of world annual uranium requirements over this period.

Uranium produced by re-enrichment of depleted uranium tails[5]

Depleted uranium (DU) stocks represent a significant source of uranium that could displace primary production. However, the re-enrichment of depleted uranium has been limited since it is only economic in centrifuge enrichment plants with spare capacity and low operating costs.

At the end of 2005, the inventory of depleted uranium was estimated to amount to about 1 600 000 tU and to be increasing by about 60 000 tU annually based on uranium requirements of 66 000 tU per annum (NEA, 2007). If this entire inventory was re-enriched to levels suitable for nuclear fuel it would yield an estimated 450 000 tNatU; sufficient for about seven years of operation of the world's nuclear reactors at the 2006 uranium requirement levels.[6] Following the construction of new centrifuge enrichment facilities and declining demand since the Fukushima Daiichi accident, spare enrichment capacity is currently available and it has been reported that tails assays are being driven downward at enrichment facilities to underfeed the centrifuge plants and create additional uranium inventory.

5. Depleted uranium is the by-product of the enrichment process having less ^{235}U than natural uranium. Normally, depleted uranium tails contain between 0.25 and 0.35% ^{235}U compared with the 0.711% ^{235}U found in nature.

6. This total assumes 1.6 million tU at 0.3% ^{235}U assay is re-enriched to produce 420 000 tU of equivalent natural uranium, leaving 1 080 000 tU of secondary tails with an assay of 0.14% ^{235}U.

Deliveries of re-enriched tails from the Russian Federation had been an important source of uranium for the EU, representing 1-3.7% of the total natural uranium delivered annually to EU reactors between 2005 and 2009 (Table 2.8). However, contracts with EU utilities came to an end in 2010 and in 2011 the Russian Federation stopped the re-enrichment of depleted uranium tails. EU enrichers are now putting in place long-term strategies to manage enrichment tails remaining from enrichment activities, including deconversion of UF_6 to the more stable form U_3O_8. Currently deconversion takes place in France and URENCO UK is constructing a tails management facility.

Table 2.8. Russian Federation supply of re-enriched tails to European Union end users

Year	Re-enriched tail deliveries (tU)	Percentage of total natural uranium deliveries
2007	388	1.8
2008	688	3.7
2009	193	1.1
2010	0	0.0
2011	0	0.0
2012	0	0.0

Source: Euratom Supply Agency (2011, 2012), *Annual Report 2009, 2010*, Luxembourg.

In the United States, the DOE and the Bonneville Power Administration initiated a pilot project to re-enrich 8 500 tonnes of the DOE's enrichment tails inventory. Between 2005 and 2006, this project produced approximately 1 940 tU equivalent for use between 2007 and 2015 at Northwest Energy's 1 190 MWe Columbia generating station in Washington State. In mid-2012, Northwest Energy and USEC, in conjunction with the DOE, developed a new plan to re-enrich a second portion of DOE's high-assay tails. The resulting LEU is to be used to fuel Northwest Energy's Columbia generating station through 2028. Northwest Energy is also to provide some LEU created in this process to TVA starting in 2015.

Until 2009, a fraction of the depleted UF_6 flow generated through enrichment activities in France was sent to the Russian Federation for re-enrichment. This fraction was limited to materials with mining origins that would allow their transfer (in accordance with international and bilateral agreements dealing with the exchange of nuclear materials). The return flow was exclusively used to overfeed the enrichment plant in France (the Georges Besse gaseous diffusion plant run by EURODIF, an AREVA subsidiary).

In addition, in 2008 and 2009, a few thousand tonnes of DU were removed from storage, converted to UF_6 and enriched to natural uranium grade at the Georges Besse gaseous diffusion plant, thanks to the then prevailing economic conditions (primarily high uranium spot prices). Following the completion of additional centrifuge enrichment capacity sufficient to meet global demand, gaseous diffusion enrichment plants became uneconomic and the Georges Besse plant as closed in 2012 and the Paducah facility was closed in 2013.

As noted above, GE-Hitachi Global Laser Enrichment's proposal to build and operate a tails processing plant using Silex laser enrichment technology at the closed Paducah gaseous diffusion enrichment plant has been accepted by DOE. Successful development of laser enrichment could potentially result in an additional supply of uranium to the market in the longer term. Moreover, commercial enrichment providers have indicated an interest in using centrifuge enrichment capacity to create additional uranium inventory by re-enriching DU stored at existing enrichment facilities. These developments suggest that re-enrichment of DU tails may become a more important part of uranium supply in the coming years.

Additional information on the production and use of re-enriched tails is not readily available. However, the information provided in questionnaire responses (Table 2.9) indicates that its use has been limited between 2010 and 2012.

Table 2.9. Re-enriched tails production and use

(tonnes of equivalent natural U)

Country	Pre-2010	2010	2011	2012	Total to 2012	2013 (expected)
Production						
France	NA	NA	NA	NA	NA	NA
United States	1 940	0	0	0	1 940	0
Use						
Belgium[(a)]	345	0	0	0	345	0
Finland	843	0	0	0	843	0
France	NA	NA	NA	NA	NA	NA
Sweden[(b)]	1 697	0	0	0	1 697	0
United States	1 376	0	191	0	1 567	373

NA = Data not available.

(a) Purchased for subsequent re-enrichment.

(b) 2013 edition of *OECD Nuclear Energy Data*.

Uranium market developments

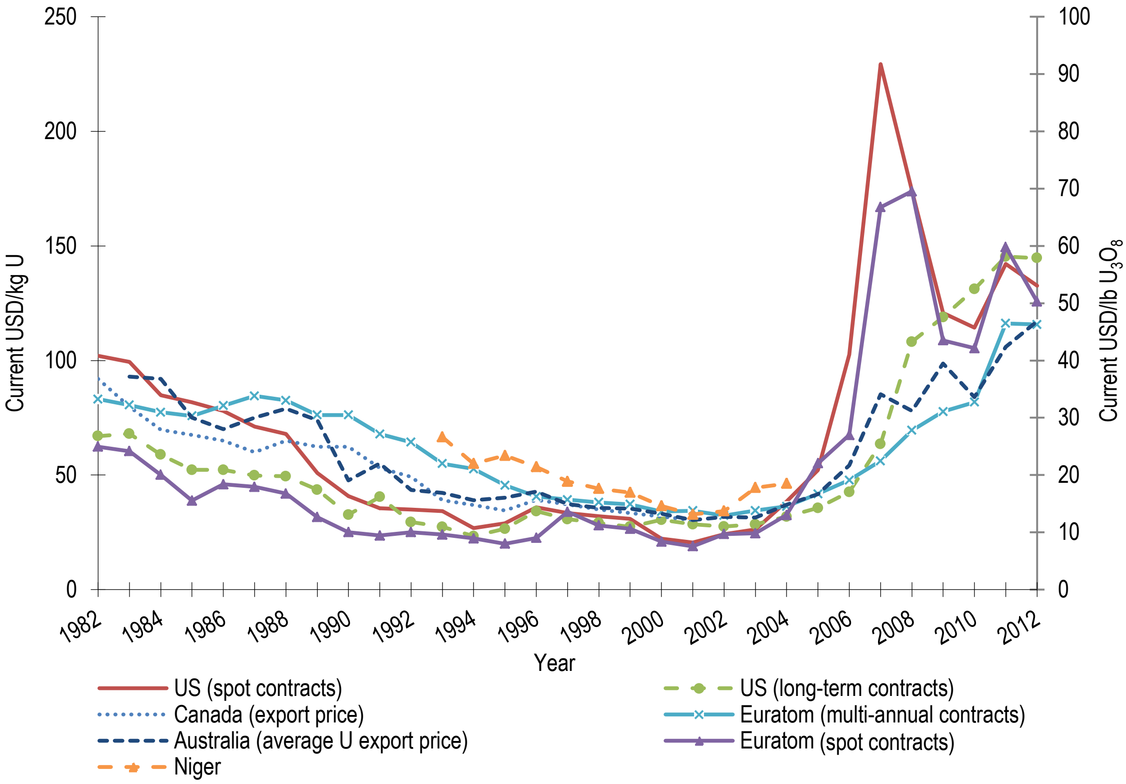
Uranium price developments

Some national and international authorities (Australia, the United States and the ESA), publish price indicators to illustrate uranium price trends for both long-term and short-term (spot price) contract arrangements. Australian data record average annual prices paid for exports, whereas ESA and US data show costs of uranium purchases in a particular year. Canada and Niger published export prices for some years but neither continue to do so. Figure 2.9 displays this mix of annual prices reported for both short-term (spot market) and longer-term purchases and exports.

The overproduction of uranium, which lasted through 1990 (Figure 2.7), combined with the availability of secondary sources, resulted in uranium prices trending downward from the early 1980s through the mid-1990s, bringing about significantly reduced expenditures in many sectors of the world uranium industry, including exploration, production and production capability. The bankruptcy of an important uranium trading company resulted in a modest recovery in prices from late 1994 through mid-1996, but the regime of low prices returned shortly thereafter.

Beginning in 2002, uranium prices began to increase, eventually rising to levels not seen since the 1980s, then rising more rapidly through 2005 and 2006 with spot prices reaching a peak through 2007 and 2008, then falling off rapidly, recovering somewhat in 2011 and declining in 2012 (Figure 2.9). In contrast, EU and US long-term price indices continued to rise until 2011 before levelling off in 2012. Fluctuations in these indicators do not rival the peak in spot market in 2007 and 2008 or the degree of declining prices since 2011 since they reflect contract arrangements made earlier under different price regimes. The Australia average export price has generally followed the trend of other long-term price indices, but with greater variation since it is a mix of spot and long-term contract prices. Depending on the nature of the purchases (long-term contracts versus spot market), the information available indicates that prices ranged between USD 116/kgU and USD 133/kgU (USD 45/lbU_3O_8 and USD 52/lbU_3O_8) in late 2012.

Figure 2.9. Uranium prices: 1982-2012



Source: Australia, Canada, Euratom Supply Agency, Niger, and the United States.

1. Euratom prices refer to deliveries during that year under multi-annual contracts.
2. Beginning in 2002, Natural Resources Canada (NRCan) suspended publication of export price pending policy review.

In addition to this information from government and international sources, spot price indicators for immediate or near-term delivery (less than one year) that typically amount to less than 15% of all annual uranium transactions, are provided by the industry trade press, such as TradeTech and the Ux Consulting Company LLC (UxC). While the trend of increasing prices outlined above is evident for spot market transactions since 2002, and in particular after 2004, the spot price shows more volatility than long-term price indicators since 2006 (Figure 2.10). In June 2007, the spot market price reached as high as USD 136/lb U_3O_8 (USD 354/kgU) before declining to USD 40.50/lb U_3O_8 (USD 105/kgU) in February 2010. It recovered to USD 72.25/lb U_3O_8 (USD 188/kgU) at the end of January 2011, before declining to USD 34.50/lb U_3O_8 (USD 90/kgU) at the end of 2013 (Figure 2.10) after the Fukushima Daiichi accident.[7]

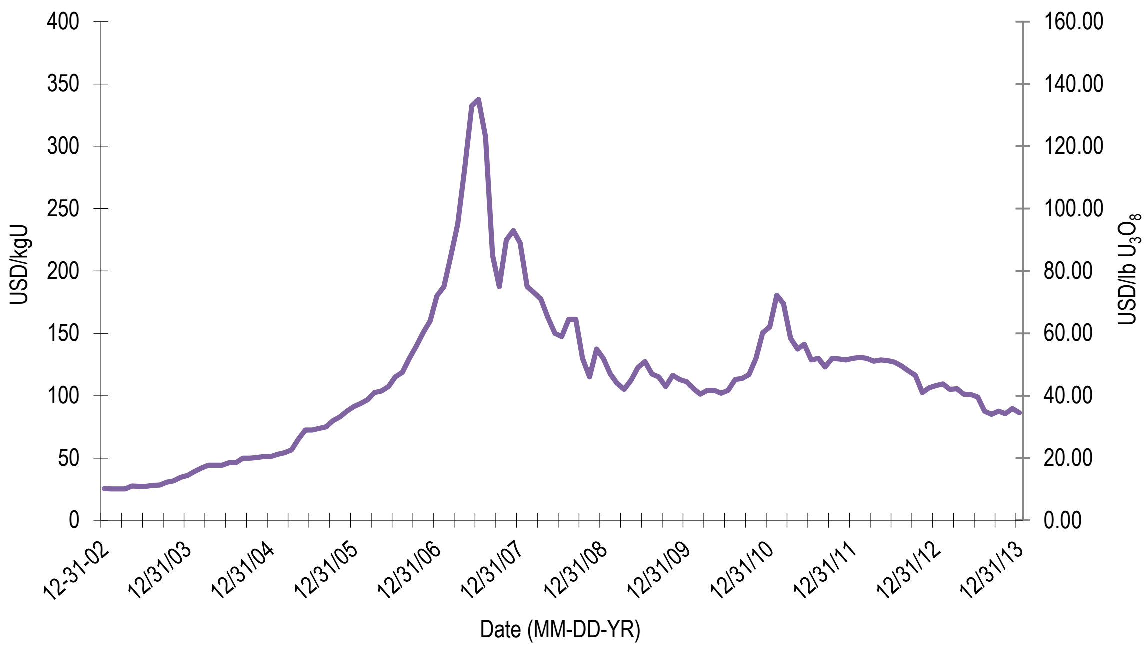
A variety of factors have been advanced to account for the spot price dynamics between 2003 and 2013, including problems experienced in nuclear fuel cycle production

7. Spot price data courtesy of TradeTech (www.uranium.info).

centres in 2003 that highlighted dependence on a few critical facilities in the supply chain, as well as changes in the value of the US dollar, the currency used in uranium transactions. In addition, an increasing sense of declining inventories, the expected expansion of nuclear power generation in countries such as China, India and the Russian Federation, combined with the recognition by many governments that nuclear power can produce competitively priced baseload electricity that is essentially free of greenhouse gas emissions and the role that nuclear can play in enhancing security of energy supply, contributed to the strengthening market through 2007. The influence of speculators in the market also helped accelerate upward price movement at this time. The downturn in the spot price since June 2007 began with reluctance on behalf of traditional buyers to purchase at such high prices and the global financial crisis that stimulated sales by distressed sellers needing to raise capital.

Figure 2.10. NUEXCO exchange value trend

(31 December 2002-31 December 2013)



In late 2007, the uranium spot price began a gradual decline that settled in the USD 40/lb U_3O_8 (USD 104/kgU) to USD 50/lb U_3O_8 (USD 130/kgU) range in 2009. Proposed US government inventory sales appeared to offset rising demand as government programmes in China and India to increase nuclear generating capacity began to be implemented. In the second half of 2010, the spot price began to rally once again on news that China was active in the long-term market, stimulating speculative activity on perceptions of tightening supply-demand. However, the Fukushima Daiichi accident precipitated an initial rapid decline in price that has continued more gradually through to the end of 2013 as reactors were shut down in Germany and gradually laid-up in Japan as new nuclear safety regime was established. Projects to increase uranium production, implemented before the accident, resulted in increasing production even as demand weakened and the market became saturated with supply, putting further downward pressure on prices through to the end of 2013.

Policy measures in the European Union

Since its establishment in 1960 under the Euratom Treaty, the Euratom Supply Agency (ESA) has pursued a policy of diversification of sources of nuclear fuel supply in order to avoid overdependence on any single source. Within the European Union, all uranium purchase contracts by EU end-users (i.e. nuclear utilities) must be approved by ESA. Based on its contractual role and its close relations with industry, ESA monitors the market with a particular focus on supplies of natural and enriched uranium to the EU. ESA continues to stress the importance of maintaining an adequate level of strategic inventory and using market opportunities to increase inventories, where possible. It also recommends that utilities cover the majority of their needs under long-term contracts and continues with efforts to promote transparency and predictability in the market.

Nuclear materials for EU reactors came from diverse sources in 2012 (ESA, 2013). Russian-origin uranium supplied 27% of the uranium delivered to the EU, followed by Canada (17%), Niger (13%), Kazakhstan and Australia (12% each). HEU feed (material blended down from weapons-grade in the Russian Federation) declined to 2% of total deliveries, about the same amount as uranium supplied from sources within the EU (mainly the Czech Republic and Romania). These deliveries were made under terms and conditions contained in a number of contracts of variable duration with 96% of total deliveries covered under long-term contracts and 4% under spot market contracts. In 2012, ESA processed a total of 63 contracts and amendments, of which 10 were classified as multi-annual (long-term) and 8 as purchases on the spot market.

In 2013, natural uranium supplies to the EU continued to come from diverse sources. Kazakhstan and Canada were the top two countries delivering natural uranium to the EU, providing 40% of the total. Uranium originating in Kazakhstan represented the largest proportion, with 21 % of total deliveries, followed by uranium of Canadian origin, with a 19% share. In third place, uranium produced in the Russian Federation (including purchases of natural uranium contained in enriched uranium product) amounted to 18%. Niger and Australia accounted for 13% and 12% respectively in 2013. European uranium delivered to EU utilities originated in the Czech Republic and Romania, covering approximately 2% of the EU's total requirements.

Since uranium is sold mostly under long-term contracts and the terms are not made public, the ESA traditionally published two categories of natural uranium prices on an annual basis, i.e. multi-annual and spot, both being historical prices calculated over a period of many years. With at least some uranium market participants seeking greater price transparency, the ESA introduced in 2009 a new natural uranium multi-annual contracts index price (MAC-3). This index price, developed to better reflect short-term changes in uranium prices and to more closely track market trends, is a three-year moving average of prices paid under new multi-annual (long-term) contracts for uranium delivered to EU utilities in the reporting year.

In 2012, the MAC-3 average price index was EUR 103.42/kgU, an increase of 3% from 2011, and the multi-annual contract price increased by 8% over the same period to EUR 90.03, whereas the average spot price for deliveries in 2012 decreased by 9% from 2011 to EUR 97.80/kgU (Table 2.10). The depreciation of the Euro against the US dollar in 2012 accounts for the different trajectories in these price indices expressed in USD/lbU_3O_8. In 2012, spot price data were narrowly distributed whereas multi-annual contract prices varied widely. On average, the multi-annual contracts which led to deliveries in 2012 had been signed 8 years earlier, in contrast to spot contract deliveries that are concluded over a maximum period of 12 months (ESA, 2013).

In 2013, the MAC-3 average price index was EUR 84.66, down by 18% from 2012 and the ESA U_3O_8 spot price was EUR 78.24/kgU, 20% lower than in 2012. The ESA long-term U_3O_8 price was EUR 85.19/kgU. On average, the multi-annual contracts which led to deliveries in 2013 had been signed nine years earlier. For the first time in nine years, ESA's spot price in 2013 was lower than its long-term price. As in previous years, long-term supplies constituted the main source for meeting demand in the EU. Deliveries of natural uranium to EU utilities under long-term contracts accounted for 15 809 tU or 92.9% of the total deliveries, whereas the remaining 7.1% (1 214 tU) was purchased under spot contracts. On average, the quantity of natural uranium delivered was 150 tU under long-term contracts and 45 tU under spot contracts.

The year 2013 was marked by an appreciation of the Euro in nominal effective terms against the US dollar, on average appreciating by 3% against the US dollar as compared with 2012.

Table 2.10. ESA average natural uranium prices (2008-2012)

Year	Multi-annual contracts		Spot contracts		New multi-annual contracts (MAC-3)	
	EUR/kgU	*USD/lb U_3O_8*	*EUR/kgU*	*USD/lb U_3O_8*	*EUR/kgU*	*USD/lb U_3O_8*
2008	47.23	26.72	118.19	66.86	84.75	47.94
2009	55.70	29.88	77.96	41.83	63.49	34.06
2010	61.68	31.45	79.48	40.53	78.12	39.83
2011	83.45	44.68	107.43	57.52	100.02	53.55
2012	90.03	44.49	97.80	48.33	103.42	51.11
2013	85.19	45.32	78.24	39.97	84.66	43.25

Nuclear energy activities in the EU in 2011 and 2012 were dominated by responses to the Fukushima Daiichi accident. Comprehensive risk and safety assessments (stress tests) were completed in 2012 for all NPPs in the EU and associated neighbouring countries and follow-up measures were determined. The stress tests were an unprecedented exercise in terms of extent, collaboration and commitment of all parties involved. While confirming the high level of nuclear safety in Europe, the tests revealed the need for technical improvements at nuclear facilities and further improvements in the regulatory and legislative frameworks governing nuclear safety. National action plans for implementing the stress test recommendations received from all participating countries were reviewed in 2013. Presentations and in-depth discussions on the status of these plans took place at a dedicated workshop organised by the European Nuclear Safety Regulators Group (ENSREG) in Brussels in April 2013. The EC and ENSREG will keep track of progress with the implementation of the national action plans submitted during 2013.

The EC organised in 2013 an EU review team from its ENSREG group as well as from its own services for conducting a peer review of stress tests carried out in Chinese Taipei. Regarding neighbouring countries not included in the 2011/12 European peer reviews (i.e. Russian Federation, Belarus, Armenia and Turkey), separate meetings were organised in 2013 to discuss their stress tests.

Implementation of the nuclear safety directive adopted in 2009, with the goal of maintaining and promoting continuous improvements in nuclear safety moved ahead through 2012 with all but one member state incorporating the directive completely. Preparatory work for the revision of the Euratom nuclear safety legislation also continued with a legislative proposal planned that could, among other items, strengthen the effectiveness of nuclear regulatory authorities by ensuring effective independence of these authorities.

The EC advocates improvements in the global legal framework for nuclear safety, especially the Convention on Nuclear Safety (CNS), with the aim of increasing its effectiveness, governance and enforceability. The Council of the EU has mandated the EC to ensure during negotiations that the proposed improvements are compatible with the objectives and provisions of the treaty and secondary legislation. At the second extraordinary meeting of the CNS in August 2012, it was decided to establish a Working Group on Effectiveness and Transparency to present to the sixth review meeting of the CNS in 2014 a list of actions to strengthen the CNS and to propose, where necessary, amendments to the Convention.

Following the adoption of the radioactive waste directive in 2011, member states are required to submit a national programme to the EC by 2015 that includes plans and a specific timetable for the construction of disposal facilities. Other activities included the establishment of a European Observatory on the Supply of Medical Radioisotopes in order to ensure a sustainable supply of these short-lived isotopes for nuclear medicine.

Supply and demand to 2035

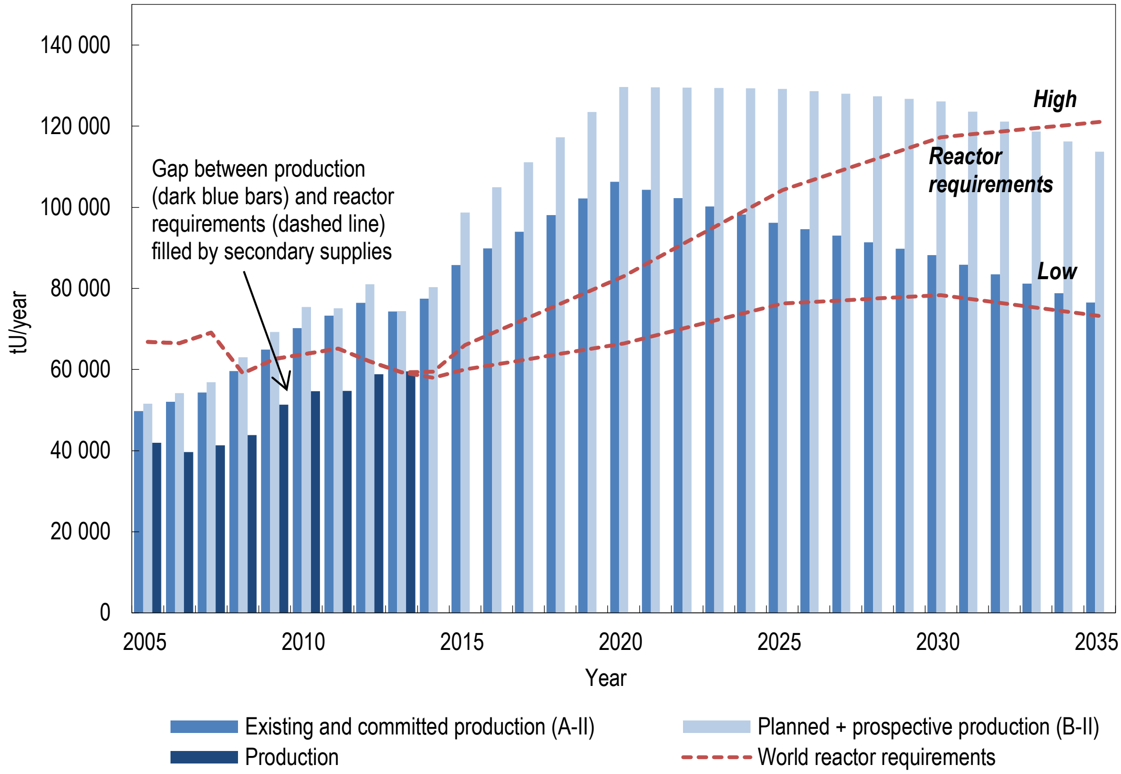
Market conditions are the primary driver of decisions to develop new or expand existing primary production centres. Market prices have generally increased since 2003, and even with declining prices since the onset of the financial crisis and following the Fukushima Daiichi accident, plans for increasing production capability continued through 2012. A number of countries, notably Kazakhstan but also Australia, Brazil, Canada, Namibia, Niger and the Russian Federation, have plans for significant additions to future production capability. In addition to production beginning in Malawi in 2009, other countries, notably Botswana, Jordan, Mongolia, Tanzania and Zambia, are working toward producing uranium in the near future. These developments are important as global demand is projected to increase in the longer term, despite the Fukushima Daiichi accident, and secondary sources are expected to decline somewhat in availability.

However, with rising mining and development costs and the long pause in nuclear development following the Fukushima Daiichi accident, notably in China and Japan, along with the continuing decline of market prices through 2013, delays in some of the higher cost planned mine developments have been announced and more could follow should prices decline further. A return to more favourable market conditions should see at least some of these delayed projects reactivated in order to ensure supply to a growing global nuclear fleet. Since several of these projects have been advanced through regulatory and other developmental steps, the time required to bring these facilities into production should be reduced overall and production will likely be able to respond more rapidly to increasing demand.

Despite some uncertainties and challenges in raising investment for mine development, producers have moved to increase production capability in recent years and governments are laying the groundwork (e.g. legislation and regulations) for mine development in countries that have not previously hosted uranium production. However, should uranium demand increase as projected producers still face a number of significant and at times unpredictable issues in bringing new production facilities on stream, including geopolitical factors (e.g. from the moratorium on uranium mine development in the province of Quebec, Canada, to terrorist attacks and kidnappings in Niger), technical challenges and risks at some facilities (e.g. Cigar Lake, Canada), the development of more stringent regulatory requirements, heightened expectations of governments hosting uranium mining (e.g. increased taxes and contributions to regional socio-economic development) and generally increasing mining costs.

As reactor requirements are projected to rise through 2035, an expansion of production capability is also projected to occur (Figure 2.11). As of 1 January 2013, these expansion plans, if successfully implemented, would cover high case demand requirements throughout much of this period, even without secondary supplies that have met anywhere from 5% to 50% of annual requirements between 2000 and 2012. As noted above, secondary sources can be expected to continue to be a source of supply for some years to come, despite the end of the Russian-US programme to blend down HEU. However, limited available information on secondary supplies makes it difficult to determine how long they will contribute to meeting future demand and how much material will make its way to the market.

Figure 2.11. Projected annual world uranium production capability to 2035 compared with projected world reactor requirements*



Source: Tables 1.26 and 2.4.

* Includes all existing, committed, planned and prospective production centres supported by RAR and inferred resources recoverable at a cost of <USD 130/kgU.

If all existing and committed mines produce at or near stated production capability, high case demand is projected to be met or exceeded through 2023. If planned and perspective production centres are included, high case demand requirements are projected to be met through 2032. Planned capability from all existing and committed production centres is projected to satisfy low case requirements and about 60% of high case requirements in 2035. With the inclusion of planned and prospective production centres, primary production capability would more than satisfy low case requirements through 2035 and would fall only slightly short of meeting high case demand (supplying more than 90% of high case requirements in 2035). However, mine production is rarely more than 85% of mine production capability and, as noted above several challenges will need to be overcome in order for all planned and prospective to be successfully brought into production.

The total identified uranium resource base in 2013 is more than adequate to meet even optimistic (high case) projections of growth in nuclear generating capacity. Meeting high case demand requirements would consume less than 40% of the total 2013 identified resource base by 2035. With the appropriate market signals as significant new nuclear generating capacity is added, additional resources of economic interest are likely to be identified with additional exploration effort.

Although Figure 2.11 could be taken to suggest an oversupplied market in the near term, experience shows that this is not likely to be the case. Production capability is not production. The gap between production (dark blue bars) and requirements (dashed line) from 2005 (and earlier) to 2012 has been met by drawing down secondary supplies. In 2013, producers are projected to close the gap between world production and reactor requirements, albeit with requirements likely only temporarily depressed owing to reactor closures and idling of reactors in Japan following the Fukushima Daiichi accident. Maintaining production at the level required to meet reactor requirements in the coming years, particularly in light of increased production costs and declining market prices for uranium through 2011 and 2012, will be a challenge. Producers with high-cost operations will be hard pressed to continue producing if prices decline further from levels in mid-2013.

World production has never exceeded 89% of reported production capability (NEA, 2006) and since 2003 has varied between 73% and 84% of full production capability. In addition, delays in the establishment of new production centres can reasonably be expected, especially in the prevailing risk-averse investment environment. As always, technical and geopolitical challenges in the operating and developing mine and mill facilities will need to be effectively dealt with. These factors can be expected to reduce and/or delay development of planned and prospective centres. Hence, even though the industry has responded vigorously to the market signal of generally higher prices since 2003, compared to the previous 20 years, additional primary production will likely be required, supplemented by secondary supplies and uranium savings achieved by specifying low enrichment tails assays, to the extent possible. After 2013, secondary sources of uranium are generally expected to decline in availability and reactor requirements will have to be increasingly met by primary production (NEA, 2006). Therefore, despite the significant additions to production capability reported here, bringing facilities into production in a timely fashion remains important. To do so, strong market conditions will be fundamental to bringing the required investment to the industry.

A key uncertainty of the uranium market continues to be the availability of secondary sources, particularly the level of stocks available and the length of time remaining until those stocks are exhausted. As Table 2.5 shows, information on secondary sources of uranium, especially inventory levels, is in general not publicly available. However, the possibility that at least a portion of the potentially large inventory (including from the military) continues to make its way to the market after 2013 cannot be discounted. These uncertainties complicate investment decisions on new production capability. However, it is clear that the generally stronger market of recent years, compared to the last two decades of the 20th century, has driven exploration activity that has built up the resource base, stimulated the development of additional production capability and led to increased production.

The long-term perspective

Uranium demand is fundamentally driven by the number of operating reactors, which ultimately is driven by the demand for electricity. The 2013 WEO New Policies Scenario projection (the central scenario that incorporates current announcements and commitments by governments that may not yet be official policy) suggests that 6 500 GW (gross) of new generating capacity will be needed by 2035 (growth of over 70% from 2012) if projected increases in electricity demand are to be met and ageing infrastructure replaced (IEA, 2013). About 60% of the retirements are anticipated in OECD countries, where about two-thirds of the coal fleet is already over 30 years old. Global electricity demand is expected to increase by about 2.2% a year on average, faster than demand for any other final form of energy. Non-OECD countries account for the greater part of incremental electricity demand by far, led by China (36%), India (13%), Latin America (6%)

and the Middle East (6%). The role that nuclear energy will play in helping meet projected electricity demand will depend on government policy decisions affecting nuclear development and how effectively a number of factors discussed earlier are addressed (i.e. economics, safety, non-proliferation concerns, security of energy supply, waste disposal, environmental considerations, etc.). Public acceptance of the technology in the wake of the Fukushima Daiichi accident in some countries remains an issue that needs to be addressed.

The extent to which nuclear energy is seen as beneficial in meeting greenhouse gas reduction targets could increase the role that nuclear energy plays in meeting future electricity demand. The International Panel on Climate Change (IPCC) noted that electricity generated from fossil fuels has been the biggest source of greenhouse gas emissions growth since 1970, two times greater than the next largest energy contributor and growing at a much faster rate (IPCC, 2007). The WEO notes that the power sector currently accounts for two-thirds of global greenhouse gas emissions (IEA, 2013). In the WEO New Policies Scenario, fossil fuel use continues to rise (in particular coal) to 2035, with consequent increases in global emissions and heightened concerns for security of energy supply. General circulation models indicate that this scale of growth in emissions produces a global temperature increase that would trigger severe consequences and societal costs in terms of sea-level rise, changes in rainfall patterns and in turn floods, droughts and heat wave incidence.

An alternative 450 scenario outlines a set of challenging policy actions required to avoid the most serious consequences of climate change (so-named for the 450 ppm atmospheric level of CO_2 equivalent that climate scientists have deemed necessary to achieve a 50% chance of limiting warming to 2°C in order to avoid serious impacts). This scenario calls for more vigorous policy action to restrain greenhouse gas emissions, including the implementation of strong energy efficiency measures, increased adoption of renewable energy (including biofuels), rapid growth in nuclear power and increasing deployment of carbon capture and storage. Energy security is expected to be enhanced by reducing import dependence through diversification of the energy mix. Although considerable financial, environmental and health benefits would be achieved (e.g. reduced emissions of air pollutants such as sulphur dioxide, nitrogen oxides and particulate matter that severely impact health), considerable investment is required (USD 17 trillion in the New Policies Scenario from 2013 to 2035, averaging about USD 740 billion per year). Increased costs of CO_2 emissions and an effective carbon market would certainly improve prospects of growth in nuclear generating capacity by helping offset increased costs resulting from safety reviews following the Fukushima Daiichi accident.

Several alternative uses of nuclear energy also have the potential to increase nuclear power installation worldwide, including desalination and heat production for industrial and residential purposes. The prospect of using nuclear energy for desalination on a large scale is attractive since desalination is an energy intensive process that can utilise either the heat from a nuclear reactor and/or the electricity produced (NEA, 2008). About one third of the world population lives in water stressed areas, mostly in Sub-Saharan Africa, the Middle East and South Asia, and with climate change, access to fresh water could become increasingly challenging (IAEA, 2013b). In recent years several governments have been actively evaluating the possibility of using nuclear energy for desalination (e.g. China, Jordan, Libya and Qatar), building on experience gained through the operation of integrated nuclear desalination plants in India, Kazakhstan and Japan. Global installed desalination capacity has more than doubled between 2004 and 2012 with the majority operating on fossil fuels.

Cogeneration, combining industrial heat applications with electricity generation, is not a new concept; some of the first civilian reactors in the world were used to supply heat as well as electricity. District heating using heat generated in reactors has been used in some countries for decades. Industrial process heating has also been used and potential for further development exists, but the extent to which reactors will be used for such applications will depend on the economics of heat transport, international pressure to reduce CO_2 emissions and national desires to reduce dependence on imported fossil fuels (NEA, 2008). Workshop participants at a recent event held to identify technical and economic challenges to increased usage concluded that there is a proven record of operating non-electric applications of nuclear energy in the field of district heating and desalination and other areas, and although feasibility studies, lab-scale or prototype testing have been undertaken, significant industrial experience is lacking. It was also noted that since the public and decision makers are not sufficiently aware of the potential of non-electric applications of nuclear energy, better communication practices should be developed (NEA/IAEA, 2013).

Energy use for transportation, which is projected to continue to grow rapidly over the coming decades, is also a major source of greenhouse gas emissions. Both electric and hydrogen-powered vehicles are seen as potential replacements for those powered by fossil fuels. Nuclear energy offers baseload electricity production that could be used to power electric vehicles, as well as the potential of producing hydrogen that could make this alternate energy carrier available with significantly less greenhouse gas emissions compared to current methods of hydrogen production (IAEA, 2013b).

Small and medium-sized reactors (SMRs; reactors with effective electric power of less than 700 MWe, sometimes referred to as small modular reactors) could be suitable for areas with small electrical grids and for deployment in remote locations. SMRs offer smaller upfront investment costs and reduced financial risks compared to larger reactors typically being built today (1 000-1 700 MWe). A recent report summarises the development status and deployment potential of SMRs expected to be available for commercial use in the next 10-15 years, with a principal focus on reactors of less than 300 MWe (NEA, 2011). A number of these designs are under development (e.g. SMART, mPower, NuScale, Flexblue and CAREM), others are undergoing licensing and examples are under construction in China and the Russian Federation (with other designs under development in both countries). The DOE began a cost sharing programme in 2012 to support the development of SMRs (small modular reactors with power output less than 300 MWe), given high costs associated with developing and certifying a reactor design, in order to meet national economic, environmental and security goals with a technology that potentially offers lower initial capital costs, scalability and siting flexibility (DOE, 2012).

Multilateral fuel cycle initiatives also have the potential to impact uranium demand. Driven by rising energy needs, non-proliferation and waste concerns, governments and the IAEA have made a number of proposals aimed at strengthening non-proliferation by establishing multilateral enrichment and fuel supply centres.

In December 2010, the first LEU reserve was inaugurated in the Russian Federation at the International Uranium Enrichment Centre in Angarsk under IAEA auspices. This LEU reserve is comprised of 120 t LEU in the form of UF_6, with enrichment of 2.00% to 4.95%. Under IAEA safeguards, the reserve will be made available to IAEA member states in good standing whose supplies of LEU are disrupted for reasons unrelated to technical or commercial issues. It is to be made available for nuclear power generation at market prices and the proceeds are to be used to replenish the LEU stock. The Russian Federation is covering the cost of LEU storage, maintenance, safety, security and safeguards. The LEU reserve is not intended to distort the functioning of the commercial market, but rather to reinforce existing market mechanisms of member states. Intergovernmental shareholder agreements have since been signed with Armenia, Kazakhstan and Ukraine. Decisions to release materials are to be made by the IAEA Director-General.

Also in December 2010, the IAEA Board of Governors authorised the IAEA Director-General to establish a LEU bank (owned and operated by the IAEA) to serve as a supply of last resort for nuclear power generation. The IAEA reserve, expected to be about half the size of the Russian LEU reserve, is to be a backup mechanism to the commercial market in the event that an eligible member state's supply of LEU is disrupted and cannot be restored by commercial means. The plan is to have sufficient LEU in the bank to meet the fuel fabrication needs for three 1 000 MWe light water reactor reloads. Donors have pledged about USD 125 million and EUR 25 million to cover the estimated initial operational expenses and the purchase and delivery of the LEU to a host state or states. Kazakhstan is the only member state that has formally expressed interest in hosting the IAEA LEU bank and the IAEA has assessed two sites offered as a potential location of the fuel bank.

In March 2011, the IAEA approved a proposal for nuclear fuel assurance led by the United Kingdom, co-sponsored by the member states of the European Union, the Russian Federation and the United States. This initiative is designed to assure that a commercial contract for nuclear fuel is not interrupted for non-commercial reasons. Although no stockpile of fuel is involved, contractual agreements between supplier and recipient states are proposed. As a response to this initiative, Germany proposed the establishment of a multilateral uranium enrichment plant administered by the IAEA, referred to as the Multilateral Enrichment Sanctuary Project (MESP). The proposal foresees the construction of one or more enrichment facilities under the exclusive supervision of the IAEA. The MESP is designed to allow independent access to nuclear fuel cycle services, complementing other proposals on assurances of supply of nuclear fuel.

In August 2011, DOE announced that the American Assured Nuclear Fuel Supply had been established to secure 230 t LEU, sufficient for six reloads of an average 1 000 MWe reactor, derived from the downblending of the 17.4 t HEU. The fuel will be available for use in civilian reactors by nations that are not pursuing uranium enrichment and reprocessing technologies. Qualifying countries will have access to the fuel at the current market price only in the event of an emergency that disrupts the normal flow of fuel supply.

Technological developments also promise to be a factor in defining the long-term future of nuclear energy and uranium demand. Advancements in reactor and fuel cycle technology are not only aimed at addressing economic, safety, security, non-proliferation and waste concerns, but also at increasing the efficiency of uranium resource utilisation. The introduction and use of advanced reactor designs would also permit the use of other materials as nuclear fuel, such as uranium-238 and thorium, thereby expanding the available resource base. Fast neutron reactors capable of producing more fuel than they consume, since spent fuel could be recovered, reprocessed and reused to produce additional energy, are being developed to make more efficient use of the energy contained in uranium.

Many national and several major international programmes are working to develop advanced technologies, for example, the Generation IV International Forum (GIF) and the IAEA International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). In GIF, Argentina, Brazil, Canada, China, France, Japan, the Republic of Korea, the Russian Federation, South Africa, Switzerland, the United Kingdom, the United States and Euratom have been working together to carry out the research and development needed to establish the feasibility and performance capabilities of the next generation (Gen IV) of reactor designs. These designs have stated objectives of construction and operation in a manner that will provide sustainable energy generation that meets clean air objectives, optimises resource utilisation, has clear life-cycle cost advantages over other energy sources, excels in safety and reliability and minimises nuclear waste. In 2002, GIF reviewed 130 proposals and selected 6 nuclear energy system concepts to be the focus of continued collaborative research and development. These concepts are the sodium-cooled fast reactor, the very-high-temperature reactor, the supercritical-water-cooled reactor, the lead-cooled fast reactor, the gas-cooled fast reactor and the molten salt reactor. In 2013, the Technology Roadmap was updated, taking into account plans to accelerate the development of some technologies by deploying prototypes and demonstrators within the next decade. The two systems that are the focus of the most active research efforts are the sodium-cooled fast reactor and the very-high-temperature reactor. China has begun construction of a prototype high-temperature reactor while France and the Russian Federation are developing advanced sodium-fast reactor designs for near-term demonstration. A prototype lead fast reactor is also expected to be built in the Russian Federation in the 2020 time frame.

Established in 2000, the objective of INPRO is to help to ensure that nuclear energy is available to contribute, in a sustainable manner, to the energy needs in the 21st century. As of 2013, 38 IAEA member states (Algeria, Argentina, Armenia, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, the Czech Republic, Egypt, France, Germany, India, Indonesia, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, the Republic of Korea, Malaysia, Morocco, Netherlands, Pakistan, Poland, Romania, the Russian Federation, the Slovak Republic, South Africa, Spain, Switzerland, Turkey, Ukraine, the United States and Viet Nam) along with the European Commission were engaged in the INPRO project and several other member states or international organisations were observers in INPRO meetings. Holders and users of nuclear technology are being brought together to consider international and national actions that would produce the innovations required in nuclear reactors, fuel cycles or institutional approaches. INPRO assists member states in building national long-range nuclear energy strategies and making informed decisions on nuclear energy development and deployment.

Belarus, Indonesia, Kazakhstan and Ukraine are currently applying the INPRO methodology in national nuclear energy assessments to guide strategies for nuclear power. A new project being developed with GIF is aimed at assessing proliferation resistance and safeguards for emerging nuclear energy systems. In 2012, INPRO completed a study of the potential role thorium could play in supplementing the uranium-plutonium fuel cycle, concluding that sufficient knowledge and experience is available for the feasible implementation of a "once-through" thorium fuel cycle. Other initiatives included a study of the performance of passive safety systems in advanced water-cooled reactors, an investigation into load-following capabilities of innovative reactor designs, drivers and impediments for regional co-operation on nuclear energy systems and long-term prospects for nuclear energy following the Fukushima Daiichi accident.

Conclusion

As documented in this volume, sufficient uranium resources exist to support continued use of nuclear power and significant growth in nuclear capacity for electricity generation and other uses in the long term. Identified resources[8] are sufficient for over 120 years, considering 2012 uranium requirements of 61 600 tU. If estimates of current rates of uranium consumption in power reactors[9] are used, the identified resource base would be sufficient for over 150 years of reactor supply. Exploitation of the entire conventional resource [10] base would increase this to well over 300 years, though signify-cant exploration and development, motivated by significantly increased demand and prices, would be required to move these resources into more definitive categories.

8. Identified resources include all cost categories of RAR and inferred resources for a total of about 7 635 200 tU (Table 1.2).

9. Uranium usage per TWh is taken from the NEA *publication Trends in the Nuclear Fuel Cycle* (NEA, 2002). These were used to define how much electricity could be generated for the given levels of uranium resources. Years of generation were then developed by factoring in the 2012 generation rate (2 323 TWh net, Table 2.2) and rounding to the nearest five years.

10. Total conventional resources include all cost categories of RAR, inferred, prognosticated and speculative resources for a total of about 15 332 900 tU (Tables 1.2 and 1.14). This total does not include secondary sources or unconventional resources, e.g. uranium from phosphate rocks.

The uranium resource base described in this document is more than adequate to meet projected growth requirements to 2035. Meeting projected low case requirements to 2035 would consume a less than 30% of the identified resources available at a cost of <USD 130/kgU and about 20% of identified resources available at a cost of <USD 260/kgU. Meeting high case growth requirements to 2035 would consume less than 40% of identified resources available at a cost of <USD 130/kgU and 30% of identified resources available at a cost of <USD 260/kgU. Given the limited maturity and geographical coverage of uranium exploration worldwide, there is considerable potential for the discovery of new resources of economic interest. As clearly demonstrated in the last few years, with appropriate market signals, new uranium resources can be readily identified and mined.

As noted in Chapter 1, there are also considerable unconventional resources, including phosphate deposits, that could be utilised to significantly lengthen the time that nuclear energy could supply energy demand using current technologies. However, considerable effort and investment would need to be devoted to better defining the extent of this potentially significant source of uranium and developing cost-effective extraction techniques.

Deployment of advanced reactor and fuel cycle technologies could also significantly add to world energy supply in the long term. Moving to advanced technology reactors and recycling fuel could increase the long-term availability of nuclear energy from hundreds to thousands of years. In addition, thorium, which is more abundant than uranium in the earth's crust, is also a potential source of nuclear fuel, if alternative fuel cycles are developed and successfully introduced in a cost-effective manner. Thorium-fuelled reactors have been demonstrated and operated commercially in the past.

Sufficient nuclear fuel resources exist to meet energy demands at current and increased demand well into the future. However, to reach their full potential considerable exploration, research and investment will be required in order to develop new mining projects in a timely manner and to facilitate the deployment of promising technologies.

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Chapter 3. National reports on uranium exploration, resources, production, demand and the environment

Introduction

Chapter 3 of the report presents the national submissions on uranium exploration, resources and production. These reports have been provided by official government organisations (Appendix 2) responsible for the control of nuclear raw materials in their respective countries and the details are the responsibility of the individual organisations concerned. In countries where commercial companies are engaged in exploration, mining and production of uranium, the information is first submitted by these companies to the government of the host country and may then be transmitted to the NEA or the IAEA at the discretion of the government concerned. In certain cases, where an official national report was not submitted and where deemed helpful to the reader, the Secretariat has provided additional comments or estimates to complete this report. Where utilised, the Secretariat estimates are clearly indicated.

The agencies are aware that exploration activities may be currently proceeding in a number of other countries which are not included in this report. They are also aware that in some of these countries uranium resources have been identified. However, it is believed that the total of these resources would not significantly affect the overall conclusions of this report. Nevertheless, both agencies encourage the governments of these countries to submit an official response to the questionnaire for the next edition exercise.

Finally, it should be noted that the national boundaries depicted on the maps that accompany the country reports are for illustrative purposes and do not necessarily represent the official boundaries recognised by the member countries of the OECD or the member states of the IAEA.

Additional information on the world's uranium deposits is available in the IAEA online database *World Distribution of Uranium Deposits – UDEPO* (www-nfcis.iaea.org). A snapshot of this database is published as *World Distribution of Uranium Deposits (UDEPO) with Uranium Deposit Classification*, 2009 Edition (IAEA-TECDOC-1629). UDEPO contains information on location, ranges of uranium tonnage and average grade, geological type, status, operating organisations (in case the deposit is being mined) and other technical and geological details about the deposits. The IAEA publication is accompanied with the database as of end of 2008 on a CD-ROM. It may be ordered from:

International Atomic Energy Agency
Sales and Promotion Unit, Division of Publications
P.O. Box 100, Wagramerstrasse 5, A-1400 Vienna, Austria
Telephone: (43) 1-2600-22529 (or 22530)
Facsimile: (43) 1-26007-29302
Electronic mail: sales.publications@iaea.org
Website: www-pub.iaea.org/MTCD/publications/publications.asp

Thirty-six member countries submitted a response to the questionnaire and the Secretariat drafted nine country reports. As a result, there are a total of 45 national reports in the following section. This edition uses the revised format introduced in 2005, where the data tables are provided at the end of each country's report.

Algeria

Uranium exploration and mine development

Historical review

Over the past forty years, uranium exploration in Algeria, which began with the launching of the mineral prospecting programme in the Hoggar region, went through an initial phase (1969-1973) marked by a significant investment effort which led to the discovery of the first uranium deposits in the Hoggar Pre-Cambrian crystalline basement (Timgaouine-Abankor-Tinef).

These results, obtained through ground radiometric surveys and geological mapping, very swiftly identified the uranium mining potential of the Hoggar region which has highly promising geological and metallogenic properties.

The aerial magnetic and spectrometric survey of the entire national territory carried out in 1971 lent fresh direction and impetus to uranium exploration. The processing of the data collected in this survey identified potential regions for further uranium prospecting, including Eglab, Ouggarta and the Tin Serinine sedimentary basin (South Tassili; where the Tahaggart deposit was discovered), as well as individual sectors in Tamart-n-Iblis and Timouzeline.

While these developments were taking place, uranium prospecting entered into a new phase (1973-1981) primarily aimed and focused on the assessment of reserves and the exploitation of previously discovered deposits.

Despite a very sharp slowdown in prospecting activities in the following phase (1984-1997), the work undertaken in the immediate vicinity of the previously discovered deposits and in other promising regions revealed indications of uranium deposits and radiometric anomalies in the Amel and Tesnou zones situated in the north-west and north respectively of the Timgaouine region.

Surveys conducted in the Tin Seririne basin (Tassili south Hoggar) provided a basis on which to establish a geological map and revealed also the distribution of uranium-bearing minerals in Palaeozoic sedimentary formations.

Recent and ongoing uranium exploration and mine development activities

No uranium prospecting or mine development work was carried out between January 2007 and January 2013.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Reasonably assured resources in Algeria fall into one of two geological categories: upper Proterozoic vein deposits in the western Hoggar and a deposit linked to the Pre-Cambrian basement and its Palaeozoic sedimentary unconformity in the central Hoggar. The first category includes vein deposits linked to the faults traversing the pan-African batholith in the Timgaouine region, represented by the Timgaouine, Abankor and Tinef deposits of the south-west Ahaggar.

Unconformity-related resources are represented by the Tahaggart deposit, which is linked to the weathering profile (regolith) developed at the interface between the Pre-Cambrian basement and the Palaeozoic cover, and to the conglomerates at the base of the Palaeozoic sedimentary sequence in the Tin Seririne basin (south-east Hoggar).

It is worth noting that the uranium indications discovered in the Ait Oklan-El Bema (north Hoggar) region have not been assessed in terms of the corresponding uranium resources.

Undiscovered conventional resources (prognosticated and speculative resources)

Algeria does not report resources in any other category than RAR.

Uranium production

Historical review

Algeria does not produce uranium.

Regulatory regime

The protection of the environment in relation to mining activities is covered by the following legislation:

- Law No. 01-10 of 3 July 2001 on mining activities.
- Law No. 03-10 of 19 July 2003 on the protection of the environment for sustainable development.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

From a mining perspective, in a world market dominated in the short and medium term by a small number of producers, it is currently not economically feasible to exploit the uranium resources in Algeria.

Algeria's uranium resources can only be exploited in a sustainable manner as part of an integrated development of the nuclear sector and its main applications. The latter include in particular nuclear power generation and seawater desalination plants, together with applications in medicine, agriculture, water resources and industry.

With regard to the current situation in the global energy market, Algeria is working towards the integrated development of the uranium sector, ranging from exploration to production and encompassing research and development, training and long-term nuclear power generation prospects.

Gaining control over the uranium cycle and its applications would require the acquisition of technical expertise that can only be gained through ambitious research, development and training programmes. Through its nuclear research centres, Algeria currently has the appropriate tools in place to start work in the future, either alone or through bilateral or multilateral co-operation on these various research, development and training programmes.

It is in a spirit of openness and transparency that Algeria applied itself to the task of putting in place the most supportive and appropriate institutional and regulatory framework to provide a basis on which to pursue the energy development of the country, including in particular a Mining Act, Electricity Act and Oil and Gas Act.

The passing of the Mining Act on 3 July 2001 enshrined the liberalisation of the mining sector by encouraging both domestic and foreign investment in this major sector of economic activity in Algeria. The act sets out in a clear and simple manner the legal conditions applicable to the pursuit of mining activities in Algeria and provides for a special tax regime for mining companies.

Uranium stocks

None.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity				2 000
Granite-related				24 000
Total				**26 000**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	0	26 000
Total	**0**	**0**	**0**	**26 000**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	0	26 000
Total	**0**	**0**	**0**	**26 000**

* *In situ* resources.

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Argentina

Uranium exploration and mine development

Historical review

Uranium exploration activities in Argentina began in 1951-1952, leading to the discovery of the Huemul, Don Otto and Los Berthos sandstone deposits. During the late 1950s and the early 1960s, airborne surveys also led to the discovery of the Los Adobes sandstone deposits in Patagonia.

During the 1960s, the Schlagintweit and La Estela vein deposits were discovered and subsequently mined. During the 1970s, follow-up exploration in the vicinity of the previously discovered uranium occurrences in Patagonia led to the discovery of two new sandstone deposits: Cerro Condor and Cerro Solo. At the end of the 1980s, a nationwide exploration programme was undertaken to evaluate geological units with uranium potential.

Recent and ongoing uranium exploration and mine development activities

Government

The National Atomic Energy Commission (CNEA) owns 71 exploration licences in Argentina among both requested and conceded permit explorations areas and orebodies. They are located at the following Argentinean provinces: Salta, Catamarca, La Rioja, San Juan, Mendoza, La Pampa, Río Negro, Chubut and Santa Cruz.

So as to improve uranium resources, the CNEA selected the Cerro Solo sandstone-type uranium-molybdenum deposit to perform an assessment project in 1990, based on the deposit's promising grade. Mineralised layers are distributed in fluvial sandstone conglomerates belonging to the Cretaceous Chubut Group, at depths of 50 to 130 m.

An intensive exploration programme was developed in order to define the main morphological features of the orebodies, the mineralisation model, update resource estimates and select preliminary mining-milling methods in order to carry out an economic assessment of the project.

In 1990, exploration was initiated in the vicinity of the Cerro Solo deposit (Chubut province) and since that time more than 56 000 m have been drilled to test the potential of favourable portions of the paleochannel structure. The results included the localisation and partial evaluation of specific mineralised bodies with a content of recoverable uranium resources estimated to amount to 4 600 tU, taking into account reasonably assured and inferred resources.

These results allowed conclusion of a pre-feasibility study on this U-Mo deposit. The CNEA then developed a programme to complete a feasibility study of the Cerro Solo deposit, including exploration and evaluation of the surrounding areas.

As a consequence of the policy to reactivate the nuclear programme announced in August 2006 by the national government, active exploration/evaluation concentrated on the Cerro Solo ore deposits have been undertaken since 2007. From 2007 to 2011, a total of 28 431 m have been drilled into the main mineralised areas in the Pichiñan district, including 4 030 m of core sampled for hydrometallurgical analyses. The uranium resources to December 2012 for the same categories previously indicated are 6 405 tU.

For most of 2011 and until January 2012 the main activities at Cerro solo ore deposit were related to environmental studies and several continued hydrometallurgical tests. Among the first ones to be completed were the hydrological, paleontological socio-economic and air quality studies. Others such as archaeological, flora and fauna and pedological studies are currently being developed.

In the south of Argentina (Santa Cruz province) the main exploration works have been focused on shallow low-grade uranium anomalies in six areas under study. The extension of Laguna Sirven has been outlined and has been shown to have continuity at a depth of between 2-3 m.

The mineralisation is defined as a calcrete-type deposit. The laboratory hydrometallurgical tests demonstrated that if the fine fraction can be separated (about 35% of the total volume) and concentrated, the original grade would be increased by two times.

At the perigranitic Las Termas vein-type deposit (Catamarca Province), exploration activities were allowed to resume in April 2012 by the Judge of Mine. Activities at the project were halted for five years due to interventions by environmentalist groups.

The Las Termas deposit (Sierras Pampeanas geological province), is contained within the Precambrian metamorphic basement close to the contact with the Los Ratones Carboniferous granite. This deposit was originally linked to greisenisation associated with Carboniferous magmatic activity. Recent data concerning pitchblende (113.6 Ma [million years ago] and 51.4 Ma) and the spatial relationship between the mineralisation and Cretaceous rifting volcanism led to development of a new genetic model developed in two stages. During the first stage, Carboniferous greisenisation included the leaching of uranium from granite and during the second stage Cretaceous rift-magmatism led to a hydrothermal system which would have been responsible for uranium mineralisation.

In 2012, tasks undertaken include updating environmental reports and conditions of access to the zone under study. For 2013, trenching and geophysical surveys are planned and for 2014 an exploratory drilling programme is planned.

At Vaquería hill (Salta province), several uranium anomalies were recognised towards the top of Yacoraite Formation – Salta Group Cretaceous marine-continental sediments. The exploration works consisted of detailed surface radiometric-geological recognition and rebuilding of 19 vertical profiles. The Don Otto deposits are also located in Salta province and classified as sandstone-type. Uranium mineralisation is hosted within marine-continental sediments at the bottom of the Cretaceous Yacoraite formation. The deposit was mined from 1963 to 1981. Since 2012, an intensive exploration plan was carried out by CNEA from the mined zone towards the north in order to add new resources to the historical resources and to sufficiently define the deposit in order to consider restarting uranium production at this deposit. Activities included development of a strategic deep drilling target, the application of geophysical technologies such as Telluric Magnetic and Geo-electrical and an intensive structural study.

In the east slope of Velasco Hill (La Rioja province), the CNEA is studying promising Alipan I project uranium occurrences. The mineralisation occurs within metamorphic rocks of Cambric-Ordovician age of the La Cebila Formation and appears to be closely related to the contact with the Huaco granite of Devonian-Carboniferous age. Activities included exploratory trenching and 1 400 m of drilling which was supported by ground geophysical and geochemical surveys to track subsurface extensions of the tectonic structures and geologic formations hosting the uranium mineralisation.

In the Río Negro province, five exploration licences covering an area with positive geological deposits amenable to ISL were requested. In these areas, through the oil well data, uranium anomalous values were determined at depths between 100 and 150 m. In two of the areas granted in 2013 (out of the five requested), superficial geological and geochemical surveys were developed and a minimum exploration drilling plan was outlined. Exploration activities will be continued in 2014.

Private industry

There are six private uranium exploration companies in Argentina: Meseta private Exploraciones; Sophia Energy S.A.; Minera Cielo Azul S.A.; Cauldron Minerals LTD; Gaia Energy Argentina S.A. and Uramerica LTD, all of which are currently members of the *Cámara Argentina de Empresas de Uranio* (CADEU – Argentine Chamber of Uranium Companies). This chamber reports 38 employees related directly to the industry (and 26 indirect) at the end of 2012.

The information about non-government exploration expenditures must be taken as only partially complete as industry is not required to report these expenditures to the government.

The aforementioned companies undertake uranium exploration in the provinces of La Rioja, Mendoza, Chubut and Santa Cruz. According to the available information, on neighbouring areas to the Cerro Solo ore deposit, Uramerica Ltd undertook an intensive underground exploratory programme supported by 17 185 m drilled in 146 holes in 2012, and plans to drill 90 holes in 2013 for a total of approximately 10 000 m.

Uranium resources

There are no changes in reasonably assured, inferred and prognosticated resources from the last edition (Red Book 2011). The results of private sector exploration activities are not included in these figures since this data is not collected by CNEA. This issue is discussed further in Chapter 1.

Uranium production

Historical review

Argentina produced uranium from the mid-1950s until 1999 from a total of seven commercial-scale production centres and a pilot plant that operated from 1953-1970. The closure of one of the last of these facilities in 1995 (Los Colorados) resulted in a change in the ownership structure of uranium production in Argentina and since 1996, the uranium mining industry has been wholly owned by CNEA. The last facility that remained in operation at that time, San Rafael, was placed on stand-by in 1999. Between the mid-1950s and 1999, cumulative uranium production totalled 2 582 tU (revised from the previously reported figure of 2 513 tU).

Status of production facilities, production capability, recent and ongoing activities and other issues

The production projects

Argentina produced about 120 tU/year for about 20 years to provide raw material to fuel the nuclear power plants Atucha I and Embalse, with ore from different sites distributed throughout the national territory. But in the late 1990s, the decline in the international price of uranium made domestic production no longer competitive and the decision to shut down the remaining production plants and import uranium was taken. However, changes in recent years caused CNEA to review its plans and consider reopening production facilities. These changes include the general increase in uranium prices since 2000, uncertainties in future external supply and the impending increase in domestic uranium requirements to 265 tU/yr upon completion of the Atucha II reactor. In addition, the potential addition of two new nuclear power plants and the development of the new CAREM 25 reactor will further increase domestic uranium requirements.

The San Rafael Mining-Milling Complex Remediation and Reactivation Project (CMFSR)

Once CNEA evaluated the possibility of reopening the production facilities of San Rafael mining-milling complex (Sierra Pintada mine), an environmental impact assessment (EIA-2004, according to provincial Act 5.961) was presented to the authorities in the province of Mendoza and to the Nuclear Regulatory Authority. This study evaluated the potential impacts of uranium concentrate and dioxide production and the treatment of the former wastes simultaneously.

This EIA concluded that former operations had not affected the quality of underground and surface waters in the area, or any other environmental component of the surroundings. Provincial authorities nonetheless rejected this proposal, maintaining that CNEA must first remediate the open-pit water and milling wastes stored in drums before restarting the production. In response, CNEA prepared and submitted a new EIA (2006) addressing only the treatment of wastes in temporary storage and pit water. This proposal received technical approval, but not final approval because it lacked the statutory public hearing. In all these studies, modern technology was used to preserve the environment along with additional security measures. A further complication that increases the difficulty of reopening the plant is the approval of Mendoza Provincial Act 7.722 that prohibits the use of sulphuric acid in mining.

Currently CNEA is dealing with two major issues. On one hand, updating the general environmental impact manifestation (MGIA 2006) related to the treatment of open-pit water and solid wastes through a competitive bidding process, and on the other hand preparing for the construction of evaporation ponds and effluent treatment at the San Rafael complex.

CNEA secured sufficient funds for the rehabilitation works of uranium production facilities from the Bank for Investment Projects in the Ministry of Economy. Before beginning the work however, it is necessary to obtain both provincial approval and agreement to amend the law that prevents the use of sulphuric acid. Having secured an approved budget means that greater time and resources can be devoted to addressing the remediation and rehabilitation work. These activities involve the removing of obsolete facilities, constructing effluent ponds, purchasing equipment and facilities and other associated activities.

Three effluent evaporation ponds have been finished and an update of the MGIA 2006 was developed, which will soon be presented to the provincial control authorities.

The Cerro Solo Project

CNEA also continues to develop feasibility studies for the proposed mining of the Cerro Solo deposit (Chubut province). At present, laboratory-scale sample testing is underway in order to determine the most economically competitive milling process. Given that the ore contains not only uranium but also molybdenum, finding an appropriate and feasible process is a challenge. For this reason, all preliminary investigations are critical steps in order to move beyond laboratory testing.

In the mining sector a conceptual study was conducted, using specific software for geological modelling. A pre-technical-economic feasibility study was started, with prior validation of all information (grade, geotechnical, geostructural, hydrogeological) with some surface works. It is estimated that this stage will take one year and a half, and then continue with more advanced feasibility studies.

Apart from technical considerations, a Chubut provincial law (5001/03) that prevents open-pit mining – very similar to the previously mentioned legislation in Mendoza – is in effect. However, Chubut is considering splitting the province into regions, including one that would allow such operations and Cerro Solo is located in this proposed region.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2
Name of production centre	Complejo Minero Fabril San Rafael	Yacimiento Cerro Solo
Production centre classification	Stand-by	Planned
Date of first production	1976	2018
Source of ore:		
Deposit name(s)	Sierra Pintada	Cerro Solo
Deposit type(s)	Volcaniclastic	Sedimentary
Recoverable resources (tU)	6 000	NA
Grade (% U)	0.107	NA
Mining operation:		
Type (OP/UG/ISL)	OP	OP-UG
Size (tonnes ore/day)	550	NA
Average mining recovery (%)	90	NA
Processing plant:		
Acid/alkaline	Acid	Acid
Type (IX/SX)	IX	SX
Average process recovery (%)	78	NA
Nominal production capacity (tU/year)	150	200
Plans for expansion	Yes	NA
Other remarks		Preliminary stage

Ownership structure of the uranium industry

In Argentina, all of the uranium industry is currently government owned. Private sector participation exists only in the exploration phase, although legislation provides for the participation of both public and private sectors in uranium exploration and development activities.

Employment in the uranium industry

With continued development of the uranium production industry, the employees' number varied from 133 in 2010, 123 in 2013 and is expected to increase slightly to a total of 145 in the near future. Most of them (about 90) are working on development of the San Rafael mining-milling complex.

Future production centres

The strategic plan recently submitted by CNEA to national authorities includes development of a new production centre in the province of Chubut in the vicinity of the Cerro Solo deposit. The beginning of operations is targeted for 2018.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Argentina neither produces MOX fuel nor uses it in its nuclear power plants.

Environmental activities and socio-cultural issues

A number of Argentina's provinces have legislation in place limiting certain aspects of mining activities (e.g. use of certain substances, open-pit mining). Efforts continue on the part of the public and private sectors to improve communication, information and education about the mining sector in general and uranium mining in particular.

The San Rafael Mining-Milling Complex Remediation and Reactivation Project

Although all activities related to the "Temporary Storage Waste Management" Project are not yet authorised, the reconstruction of some effluent treatment ponds has been authorised. The reconstruction of the ponds, in the same location as those of the former production stage, involves the management of other former wastes such as barren and low-grade mineralised ore that could be used in the stabilisation of solid precipitates and embankment construction. At this point the construction of an evaporation pond (about 3 ha [hectares]) with a waterproof HDPE (High-density polyethylene) geo-membrane has been completed. Detailed engineering of an additional two ponds (about 5 ha) for civil works tender is well advanced. These ponds will have security drainage systems and double waterproofing HDPE geo-membrane in order to control leaks.

Other activities in progress related to waste management include waterproofing of cisterns, recycling of the wastewater neutralisation plant, repairing of facilities used for the storage and distribution of sulphuric acid and the installation of pipes for pumping effluent between the quarries and processing and treatment facilities.

Furthermore, modelling studies on the waterproofing behaviour of cohesive material and other hydrogeological studies are being carried out through agreements with the National Institute of Water. Tendering an updated environmental impact assessment for waste management in transient storage is also in process. This update will also include a study related to the socio-economic aspects of the project. Also foreseen is the development of an EIA on the rehabilitation of uranium concentrate production at CMFSR.

Cerro Solo ore deposit

The environmental authority of the Chubut province has determined that mining projects must complete baseline environmental studies during the exploration stage. This task is being realised since 2009 by CNEA through cross contract with universities and institutes. The environmental studies that are being carried out in the Uraniferous East Pichiñan District include the collection of environmental data and assessments of hydrological, atmospheric particulate, pedagogical, gamma spectrometry, ecological, flora and fauna, archaeological, paleontological and socio-economic impact data. Also, in the last two years social communication and diffusion of information on mining activities has been intensified in the localities near the proposed mining projects and areas of exploration.

Uranium requirements

Uranium requirements listed below correspond to an estimation made in the Strategic Nuclear Energy Planning 2010-2030 and the reactivation of the Argentine Nuclear Energy Planning in 2006. The nuclear plan includes:

- completion of the construction of the Atucha II NPP;
- extending the life of the Embalse NPP;
- reactivation of heavy water production;
- reactivation of development of the small CAREM nuclear power reactor;
- reactivation of uranium enrichment;

- reactivation of the uranium mining industry.

Also proposed is the expansion of the nuclear energy field including a portfolio of 1 500 MW, which would be covered by means of the construction of a fourth NPP consisting of either two PHWR-type reactors of 750 MW each or of a PWR-type of 1 000-1 200 MW NPP that would start operations in 2020/22. A fifth NPP of 1 500 MW is also planned that would start operations in 2026/28 with technology to be defined. In addition, CNEA is completing development and construction of the CAREM25 (25 MW) prototype small modular reactor and it is planned to build another second larger unit, the CAREM150 (150 MW) to be located in the Formosa province for which the siting study is being carried out at present.

Supply and procurement strategy

Argentina is carrying out an exploration programme and developing projects for restarting domestic uranium production in order to achieve self-sufficiency in uranium supply.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The Nuclear Activity Law of 1997 establishes the respective roles of the CNEA and the Nuclear Regulatory Authority. It also provides for the participation of both public and private sectors in uranium exploration and development activities.

The National Mining Code of 1994 stipulates that the government has the first option to purchase all uranium produced in Argentina and that export of uranium is dependent upon first guaranteeing domestic supply. It also regulates development activities to ensure the use of environmental practices that conform to international standards.

Uranium stocks

As of 7 May 2013, total stocks held by CNEA amounted 15 131 tU.

Uranium prices

There is no uranium market in Argentina.

Uranium exploration and development expenditures and drilling effort – domestic

(in Argentine pesos [ARS])

	2010	**2011**	**2012**	**2013** (expected)
Industry* exploration expenditures	21 533 056	30 805 866	9 654 545	20 781 104
Government exploration expenditures	26 500 000	27 809 490	38 362 566	31 920 200
Total expenditures	**48 033 056**	**58 615 356**	**48 017 111**	**52 701 304**
Industry* exploration drilling (m)	5 530	11 300	17 185	10 000
Industry* exploration holes drilled	214	276	146	120
Government exploration drilling (m)	13 314	6 000	1 952	9 384
Government exploration holes drilled	129	53	13	58
Total drilling (m)	**18 844**	**17 300**	**19 137**	**19 384**
Total number of holes drilled	**343**	**329**	**159**	**178**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Sandstone		2 890	4 599	4 599	72
Volcanic and caldera-related		2 240	4 000	4 000	72
Total		**5 130**	**8 599**	**8 599**	

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	180	180	72
Open-pit mining (OP)		5 130	8 419	8 419	72
Total		**5 130**	**8 599**	**8 599**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Heap leaching* from UG	0	0	180	180	
Heap leaching* from OP	NA	5 130	8 419	8 419	72
Total		**5 130**	**8 599**	**8 599**	**72**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Sandstone	1 951	2 201	3 762	4 812	72
Volcanic and caldera-related	480	1 800	6 170	6 170	72
Total	**2 431**	**4 001**	**9 932**	**10 982**	

Inferred conventional resources by production method

(tonnes U recoverable, assuming 72% mining and milling recovery)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	2 431	4 001	9 932	10 982	72
Total	**2 431**	**4 001**	**9 932**	**10 982**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP	2 431	4 001	9 932	10 982	72
Total	**2 431**	**4 001**	**9 932**	**10 982**	**72**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
NA	13 810	13 810

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
NA	56 432*	NA

* Estimated over seven geological units.

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	2 581.7	0	0	0	2 581.7	0
Total	**2 581.7**	**0**	**0**	**0**	**2 581.7**	**0**

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	1 858.7	0	0	0	1 858.7	0
Underground mining[1]	723	0	0	0	723	0
Total	**2 581.7**	**0**	**0**	**0**	**2 581.7**	**0**

1. Pre-2008 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrate)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	752.7	0	0	0	752.7	0
Heap leaching*	1 829	0	0	0	1 829	0
Total	**2 581.7**	**0**	**0**	**0**	**2 581.7**	**0**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Short-term production capability

(tonnes U/year)

2011				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	120	0	0	0	150	0	0	0	150	100

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	5.1	4.9

Installed nuclear generating capacity to 2035

(MWe gross capacity)

2011	2012	2013		2015		2020		2025		2030		2035	
1 005	1 005	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		1 010	1 010	1 449	1 449	2 353	2 353	4 665	5 865	4 815	7 215	6 165	8 565

Note: In 2013, there is a 5 MW increase as a result of modifications in Atucha I. In 2014, Atucha II starts operating and Embalse starts its lifetime extension programme and repowering. In 2019, Atucha I starts with the lifetime extension programme.

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
120	120	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		120	120	142	142	283	283	633	849	660	876	903	1 119

Armenia

Uranium exploration

On 23 April 2007, the Director General of Rosatom (a state corporation of the Russian Federation) and the Armenian Minister of Ecology Protection signed a Protocol on the realisation of uranium exploration work in Armenia.

Based on this protocol, an Armenian-Russian joint venture CJ-SC Armenian-Russian Mining Company (ARMC) was established in April 2008 for geological exploration, mining and processing of uranium. The founders of ARMC are the Government of the Republic of Armenia and Atomredmetzoloto of the Russian Federation.

In the frame of this project, the collection and analysis of the archival material relevant to uranium mining has been completed. The document *Geologic Exploration Activity for 2009-2010* aimed at the uranium ore exploration in the Republic of Armenia was developed and approved. According to this document, in the spring of 2009 field work related to uranium ore exploration was started in the province of Syunik.

The geologic prospecting works were carried out on the 1st Voghchi zone of the Pkhrut-Lernadzor licensed area in 2011. Geologic prospecting identified some anomalies. All plans for geologic prospecting in 2011 were fulfilled by January 2012. In 2012, legislated works were implemented.

Exploration of the block 1st Voghchi zone identified reserves of uranium ores classified in category C2. Calculations of inferred resources of the Voghchi zone of the Pkhrut deposit indicate that the deposit is prospective.

Uranium production

In 2007, the Armenian government decided that the Republic of Armenia would enter into an agreement with the governments of Kazakhstan and the Russian Federation to establish an international uranium enrichment centre (IUEC) at the Angarsk electrolytic chemical combine in the Russian Federation. The Republic of Armenia completed the legal registration of accession and in 2010 joined the IUEC.

Uranium requirements

There have been no changes in Armenia's nuclear energy programme during the past two years. The country's short-term uranium requirements remain the same and are based on the operation of one VVER-440 unit (Armenian-2). A detailed uranium requirements forecast was done, taking into account the designed lifetime for this reactor, which has an installed capacity of about 407.5 MW(e).

The long-term requirements depend on the country's policy in the nuclear energy sector. According to the Armenian energy sector development plan to 2025, construction of a new nuclear unit with the capacity of about 1 000 MW(e) and a second unit of the same capacity is envisaged in 2030-2035, according to the high-level energy forecast option. The Ministry of Energy and Natural Resources released in April 2011 the *Armenia New Nuclear Unit Environmental Report*.

Supply and procurement strategy

Nuclear fuel for the reactor of the Armenian NPP is supplied by the Russian Federation. Armenia's nuclear fuel requirements during the past two years remain unchanged. The procurement strategy has remained the same and country's uranium supply position continues to be based on the fuel procurement from the Russian Federation.

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	2.55	2.31

Installed nuclear generating capacity to 2035

(MW(e) net)

2010	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
375	375	375	375	375	375	375	375	1 000	1 000	1 000	2 000	2 000	2 000

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
64	64	64	64	64	64	64	64	315	154	154	469	308	308

Australia

Uranium exploration

Historical review

A review of the history of uranium exploration and mine development in Australia is provided in *Australia's Uranium: Resources, Geology and Development of Deposits*, available at www.ga.gov.au/image_cache/GA9508.pdf.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration expenditure in Australia declined from AUD 189.6 million in 2011 to AUD 98.3 in 2012. Uranium exploration was carried out in Western Australia, South Australia, Northern Territory and Queensland.

Western Australia (WA): Several companies explored for sandstone-hosted uranium deposits in sands and lignite of the Gunbarrel Basin. In mid-2012, Energy and Minerals Australia Ltd discovered a new uranium deposit, **Princess** within the Mulga Rock Project area 250 km east-northeast of Kalgoorlie. The Princess deposit is a tabular body 1.4 km long and ranges from 100 m to 500 m wide. It contains mineralised intervals up to 8.22 m thick with the top of the mineralisation 40 m below the surface. The best intersection to date is 8.33 m averaging 1 360 ppm U_3O_8 (0.115% U) at a depth of 38.4 m.

Toro Energy continued exploration at the **Theseus** prospect, in the Lake Mackay region of North East WA adjacent to the Northern Territory (NT) border. Drilling intersected significant mineralisation in Cainozoic paleochannel sands adjacent to uranium-rich rocks of the Amadeus Basin.

Companies explored for calcrete-hosted deposits in palaeochannels overlying the Yilgarn Craton. Toro Energy intersected significant mineralisation in palaeochannels in the Lake Way region adjacent to the company's Wiluna Project.

South Australia (SA): In 2011, the Australian government agency, Geoscience Australia released the results of a regional airborne electromagnetic survey over the Frome Embayment. The results of this survey outlined the extent of paleochannel sands within the Eyre Formation. There has been increased exploration for sandstone-hosted uranium deposits in the Frome Embayment. Quasar Resources continued exploration drilling at the **Pepegoona**, **Pannikan** and **North Mulga** deposits, which are between 8 to 12 km north of the Beverley mine. Cauldron Energy discovered uranium mineralisation in paleochannel sands at its **Macdonnell Creek** prospect, north of Mount Babbage Inlier.

Several companies explored for sandstone-hosted deposits along the northern portion of the Ngalia Basin, 200 km north-west of Alice Springs. Drilling during 2011 intersected mineralisation at **Anomalies 15** and **4** (near the Bigrlyi deposit) and at the **Camel Flat** prospect (35 km south-east of Bigrlyi).

Northern Territory (NT): In 2011, high-grade unconformity-related mineralisation was discovered at the **Angularli** prospect in western Arnhem Land. The mineralisation is within a major breccia zone and occurs in both the basement rocks and the overlying Kombolgie Sandstone. The best intersection at Angularli prospect to date has been 20.2 m averaging 5.2% U_3O_8 (4.4% U). Angularli is the first discovery in Alligator Rivers region of significant high-grade uranium mineralisation above the unconformity in the Kombolgie Sandstone.

Exploration also intersected high-grade unconformity-related mineralisation in the **Ranger 3 Deeps** area, east of the Ranger open cut, and the **Caramal** prospect in western Arnhem Land.

Queensland (Qld): Paladin Energy Ltd continued exploration drilling for metasomatite deposits in an area extending from 10 km to 110 km north of Mount Isa in North West Qld. There are more than 14 uranium deposits within these tenements, 8 of which contain significant resources. During 2011 and 2012, drilling at the **Odin** prospect and **Skal** deposit intersected extensions to these deposits in a down-dip direction.

Uranium exploration and development expenditures – abroad

During 2011 and 2012, several Australian companies explored for uranium in Namibia and Malawi.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2013, Australia's total identified resources of uranium recoverable at costs of less than USD 130/kg U amounted to 1 706 100 tU, an increase of 3% compared with the estimates for 1 January 2011. Over this two-year period, additional resources were defined at known deposits; however the increase in total resources was partly offset by the transfer of resources for some deposits into higher cost categories as a result of increases in the costs of mining and milling uranium ores in recent years. Capital costs have risen and labour costs in the mining industry increased at a higher rate than for other sectors of the economy as a result of the mining boom.

Mining and processing losses are deducted from company estimates of uranium resources for individual deposits reported under the Joint Ore Reserves Committee (JORC) Code. Mining losses are from company reports and are generally 5-10% for open-cut mines and 15% for underground mining methods.

Metallurgical recovery rates achieved by operating uranium plants are reported in company annual reports and these deductions are applied to JORC reserve and resource figures. These losses range from 14-28%. For ISR operations, 25% losses are applied for acid leach and 35% for alkaline leach.

Although there are more than 35 deposits with identified resources recoverable at costs of less than USD 130/kg U, the vast majority of Australia's resources are within the following 5 deposits:

- Olympic Dam (SA), which is the world's largest uranium deposit;
- Ranger and Jabiluka in the Alligator Rivers region (NT);
- Kintyre and Yeelirrie (WA).

At Olympic Dam mine, uranium is a co-product of copper mining, in addition gold and silver are also recovered.

Approximately 80% of Australia's identified resources recoverable at costs of <USD 130/kg U (and 78% of identified resources recoverable at costs of <USD 260/kg U) are tributary to existing and committed production centres.

Undiscovered conventional resources (prognosticated and speculative resources)

Estimates are not made of Australia's undiscovered resources.

Unconventional resources and other materials

Estimates are not made for Australia.

Uranium production

Historical review

A review of the history of uranium production in Australia is given in *Australia's Uranium Resources, Geology and Development of Deposits*, available at www.ga.gov.au/image_cache/GA9508.pdf

Status of production capability and recent and ongoing activities

During 2012, Australia had four operating uranium mines: Ranger (NT), Olympic Dam, Beverley/Beverley North and Honeymoon (SA) – total mine production for 2012 was 8 265 tU_3O_8 (7 009 tU), 17% greater than for 2011.

Olympic Dam

Olympic Dam production for 2012 was 3 993 tU_3O_8 (3 386 tU), virtually unchanged from the previous year. BHP Billiton continued investigations into the Olympic Dam Expansion Project based on a large open pit to mine the south-eastern portion of the deposit. The project was formally approved by the Australian and South Australian governments in October 2011.

In August 2012, the company announced that it would delay the project and investigate an alternative, less capital-intensive design of the open-pit expansion, involving new technologies, which would substantially improve the economics of the project. Heap leach and other technological solutions were being studied. Market conditions, including subdued commodity prices and higher capital costs led to the decision to delay the expansion project.

Ranger

In 2012, Ranger open cut produced 3 710 tU_3O_8 (3 146 tU), compared with 2 240 tU in 2011. Ore was processed at the main metallurgical plant (2.4 Mt) and the laterite treatment plant (0.24 Mt).

Very high rainfall resulted in flooding of the pit and disruptions to mine production and ore processing in 2010 and 2011. However in 2012 rainfall was much less which enabled mining access to ore in the bottom of the open cut. The open cut (Pit 3) reached the end of its operational life in November 2012 which marked the completion of 31 years of open-cut mining at Ranger.

Construction of an underground decline commenced in 2012 to access the Ranger 3 Deeps orebody, a zone of contiguous high-grade ore east of Pit 3.

Beverley/Beverley North

Production from Beverley *in situ* recovery (ISR) operation for 2012 was 422 tU_3O_8 (358 tU), 2% higher than for 2011. ISR operations continued at Beverley to mine the remaining resources and during the last few years production was mainly from old wellfields that were reopened after having been previously shut down.

At Beverley North, commercial ISR operations commenced at the Pepegoona (12 km north of Beverley) and Pannikan deposits (10 km north-west of Beverley) in 2011. Uranium-bearing solutions are pumped to satellite ion exchange plants at each site. Uranium was captured on resins within ion exchange columns. The resin loaded with uranium was transferred into a road tanker and transported to the Beverley plant for elution and processing to recover uranium.

Honeymoon

Pilot production at the Honeymoon ISR mine commenced in September 2011 and commissioning of the plant continued through 2012. In its first full year of operation in 2012, Honeymoon produced 140 tU_3O_8 (119 tU). Drilling and installation of wellfields continued with more than 30 production wells in operation by the end of 2012. Uranium-bearing solutions are processed using solvent extraction technology at the processing facility which has a designed capacity of 340 tU per year.

Ownership of uranium production

Australia's uranium mines are owned and operated by a range of domestic and international companies:

- The Ranger uranium mine is owned by Energy Resources of Australia Ltd ("ERA") which is owned by Rio Tinto (68.4%) with the remaining capital held publicly.
- The Olympic Dam mine is fully owned by BHP Billiton.
- The Beverley mine is fully owned by Heathgate Resources Pty Ltd ("Heathgate"), a wholly owned subsidiary of General Atomics (United States).
- The Four Mile Project is a joint venture between Quasar Resources Pty Ltd (75%, an affiliate of Heathgate) and Alliance Resources Ltd (25%). There are ongoing discussions to commence development of the project subject to final statutory approvals.

- The Honeymoon mine is wholly owned by Uranium One, following Mitsui Corporation's withdrawal from the joint venture arrangements in 2012. Uranium One's major shareholder is JSC Atomredmetzoloto (ARMZ), a wholly owned subsidiary of Rosatom, the Russian State Corporation for Nuclear Energy.

Employment in existing production centres

Total employment at Australia's uranium mines increased from 4 888 employees in 2011 to 5 574 employees in 2012. It is anticipated that employment may increase to around 5 620 employees in 2013.

Future production centres

Four Mile (SA)

Four Mile comprises two large sandstone-hosted uranium deposits, Four Mile West and Four Mile East, and is 75% owned by Quasar Resources (affiliate of Heathgate Resources) and 25% by Alliance Resources. In October 2012, the companies decided to recommence development of the project. For the initial phase of operations, it is proposed to pump uranium-bearing solutions to the nearby satellite ion exchange plant at Pannikan deposit. The resin produced will be trucked to Beverley processing plant for elution, precipitation and drying the uranium concentrates.

The initial phase of ISR mining operations will allow actual production rates to be considered before full-scale production facilities are constructed. Full-scale ISR operations are planned to commence at Four Mile in late 2013 or 2014.

Wiluna (WA)

The Wiluna Project comprises two shallow (less than 8 m deep) calcrete-hosted deposits, Lake Way and Centipede, which are 15 km and 30 km south (respectively) of Wiluna, WA. It is proposed to use alkaline agitated leaching in tanks at elevated temperatures to process the ore. Production is estimated to be 820 tU_3O_8 (695 tU) per year in concentrates.

Toro Energy also owns three other calcrete-hosted deposits in the Wiluna region – the Millipede, Dawson Hinkler Well and Nowthanna deposits.

In October 2012, the company received environmental approval for the project from the WA government Minister for Environment and in April 2013, the Australian Minister for the Environment formally granted environmental approval. The company is completing detailed engineering design and commercial studies as part of a definitive feasibility study for the project.

Yeelirrie (WA)

The Yeelirrie deposit, 70 km south-west of Wiluna (WA) is Australia's second largest undeveloped uranium deposit. It occurs in calcretes within a paleochannel and is at shallow depths down to 15 m below the surface. BHP Billiton carried out a drilling programme to upgrade the resource estimate and commenced a feasibility study for development of the deposit. In December 2012, Cameco Corporation purchased the deposit from BHP Billiton for USD 430 million. For 2013, Cameco proposes to review the drillhole data (gamma logs and the grade-radiometry relationship) and recalculate the resources.

Kintyre (WA)

In July 2012, Cameco completed a pre-feasibility study of Kintyre and reported that the study "… highlighted the project's challenging economics caused by low uranium prices and escalating costs in Western Australia". The pre-feasibility study was based on a seven-year open-pit mine to produce around six million pounds of U_3O_8 a year (2 300 tU). The study found that to break even, the project would need an average realised uranium price of USD 67/lb for 62 million pounds (23 850 tU) of production over its 7-year life, as opposed to 40 million pounds (15 380 tU) of currently defined resources.

The company plans to carry out further drilling aimed at discovering more resources at Kintyre and other projects in the region. Cameco stated that the project was unlikely to start construction in 2014 as previously envisaged.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4
Name of production centre	Ranger	Olympic Dam	Beverley/Beverley North	Honeymoon
Production centre classification	Existing	Existing	Existing	Existing
Date of first production	1981	1988	2000	2011
Source of ore:				
Deposit name(s)	Ranger No.3	Olympic Dam	Beverley, Pepegoona, Pannikan	Honeymoon, East Kalkaroo
Deposit type(s)	Proterozoic unconformity	Polymetallic Fe-oxide Breccia Complex	Sandstone	Sandstone
Recoverable resources (tU)	58 200	1 109 500	Beverley small res. Pepegoona 630	2 667
Grade (% U)	0.06	0.023	0.10	0.17
Mining operation:				
Type (OP/UG/ISL)	OP(a)	UG	ISL	ISL
Size (t ore/year)	4.5 Mt	12 Mt	NA	NA
Average mining recovery (%)	90	85	65(d)	65(d)
Processing plant:				
Acid/alkaline	Acid	Acid	Acid	Acid
Type (IX/SX)	SX	FLOT, SX	IX	SX
Size (t ore/year); for ISL (litre/hour)	2.5 Mt/yr	12 Mt/yr	1.62 ML/h	Not reported
Average process recovery (%)	88	72	(d)	(d)
Nominal production capacity (tU/year)	4 660	3 820	850	340
Plans for expansion	No	Yes(c)	Yes(e)	No
Other remarks	(b)	NA	(f)	

(a) Open-cut mining ceased December 2012. ERA are investigating the feasibility of underground mining of the Ranger 3 Deeps deposit.

(b) Processing of lateritic ores in a separate plant with capacity to produce 400 tU_3O_8 (340 tU) per annum.

(c) BHP Billiton plans to expand Olympic Dam operations to produce 19 000 tU_3O_8 (16 100 tU) per year. It is proposed to mine the southern portion of the deposit by a large open pit. In August 2012, the company announced it would delay the expansion and investigate an alternative, less capital intensive option for the project.

(d) Recovery includes combined losses due to ISL mining and hydro-metallurgical processing.

(e) Approval has been granted to extend the capacity of the Beverley plant to produce 1 500 tU_3O_8 (1 270 tU) per year when the company decides it is commercially viable to do so.

(f) Satellite ISL operations at the Pepegoona and Pannikan deposits. Uranium resins from satellite ion exchange plants are trucked to Beverley for further processing.

Uranium production centre technical details *(continued)*

(as of 1 January 2013)

	Centre #5	Centre #6	Centre #7
Name of production centre	Four Mile	Yeelirrie	Wiluna
Production centre classification	Planned	Planned	Planned
Date of first production	Late 2013	Not known	2015
Source of ore:			
Deposit name(s)	Four Mile	Yeelirrie	Centipede, Lake Way
Deposit type(s)	Sandstone	Calcrete	Calcrete
Recoverable resources (tU)	9 800(g)	44 500	6 700
Grade (% U)	0.26	0.13	0.053
Mining operation:			
Type (OP/UG/ISL)	ISL	OP	OP
Size (tonnes ore/year)	NA	NA	2 Mt per year
Average mining recovery (%)	65	NA	90
Processing plant:			
Acid/alkaline	Acid	Alkaline	Alkaline
Type (IX/SX)	(h)	(j)	IX
Size (t ore/year); for ISL (litre/hour)	NA	NA	NA
Average process recovery (%)	NA	NA	85
Nominal production capacity (tU/year)	(h)	NA	850(k)
Plans for expansion	No	No	No
Other remarks	(i)		

(g) Four Mile West Indicated and inferred resources total 19 000 tU_3O_8 (16 100 tU) at an average grade of 0.29% U. Four Mile East inferred resources total 13 000 tU_3O_8 (11 000 tU) at 0.26% U.

(h) Uranium-bearing resin from Four Mile will be treated at the Beverley plant to recover uranium.

(i) Uranium will be captured at Heathgates' Pannikan satellite IX plant. Resin will be trucked to the Beverley plant for elution and precipitation.

(j) The company is investigating several options for processing the ores including tank leaching with ion exchange and heap leaching with ion exchange.

(k) Planned production of 1 200 t per year of $UO_4.2H_2O$ which equates to 850 tU per year.

Secondary sources of uranium

Australia does not produce or use mixed oxide fuels, re-enriched tails or reprocessed uranium.

Environmental activities and socio-cultural issues

Environmental impact statement

All new uranium projects and expansions of existing uranium mines are required to go through environmental assessments. In addition to state or territory government environmental assessment, the Australian government assessment is conducted under the Environmental Protection and Biodiversity Conservation Act 1999 ("EPBC"). An EPBC assessment is often undertaken bilaterally with the state and territory jurisdictions.

Recent environmental assessments include the proposed Olympic Dam mine expansion which obtained Australian and state governments' environmental approval in October 2011, but in August 2012 BHP Billiton decided to not proceed with the approved expansion; rather BHP Billiton is examining a range of less capital intensive options for expansion. Toro Energy Limited's Wiluna Project (WA) obtained environmental approval from WA and the Australian government in October 2012 and April 2013 respectively. Toro is targeting an investment decision in the second half of 2013, with first production and uranium sales during 2015. ERA's Ranger 3 Deeps underground mine is currently undergoing an environmental assessment with the intent to transition from open-pit to underground mining.

In January 2013, a suite of agreements covering the Ranger Project Area were signed by the Australian government, Northern Land Council, the Mirarr Traditional Owners and ERA. The new arrangements provide greater benefits to traditional owners, including intergenerational benefits through the establishment of the Kakadu West Arnhem Social Trust. Other key features of the agreements include an agreed approach to increasing opportunities for local Aboriginal participation in business development, training and employment.

Regulatory activities

The Uranium Council (UC), formerly the Uranium Industry Framework, was established by the government in 2009 to develop a sustainable Australian uranium mining sector in line with world's best practice in environmental and safety standards. The attendees at the UC comprise representatives of: the Australian and state/territory government agencies; industry; industry associations and the Northern Land Council.

Projects and initiatives of the UC, since 2011, have included:

- production of a report on the state of play and outlook for the Australian uranium industry, presented to ministers at the December 2012 meeting of the Standing Council on Energy and Resources;
- development of a transport strategy to address impediments to the transport of uranium oxide concentrate (UOC), domestically and internationally;
- development of the handbook Guide to Safe Transport of UOC;
- a project led by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) on radiological protection of non-human biota;
- participation in the development and implementation of the Australian National Radiation Dose Register (ANRDR).

An Australian government initiative in co-operation with industry launched the development of the ANRDR. Officially launched on 9 June 2011, the ANRDR is a centralised database designed for the collection and long-term storage of radiation dose records for workers who are occupationally exposed to radiation in the Australian uranium mining and milling industry.

The UC is currently focusing on three broad strategic themes: transport, environmental regulation and radiation protection. These themes aim to progress initiatives which are consistent with the priorities of industry. Further information on the UC is available at www.ret.gov.au/uranium.council.

Radiological protection matters arising from uranium mining in Australia are principally the responsibility of the states and territories. ARPANSA is responsible for developing Australia's national radiation protection framework as laid out in the Radiation Protection Series and which are implemented through jurisdictional legislation and licence conditions.

ARPANSA's Radiation Protection Series currently includes the following Codes of Practice and Safety Guides which relate to uranium mining and associated processes: RPS 2 Code of Practice for the Safe Transport of Radioactive Material (2008); RPS 2.1 Safety Guide for the Safe Transport of Radioactive Material (2008); RPS 2.2 Safety Guide for Approval Processes for the Safe Transport of Radioactive Materials (2012); RPS 9 Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005); RPS 9.1 Safety Guide for Monitoring, Assessing and Recording Occupational Radiation Doses in Mining and Mineral Processing (2011); RPS 15 Safety Guide for the Management of Naturally Occurring Radioactive Material (NORM) (2008); RPS 16 Safety Guide for the Predisposal Management of Radioactive Waste (2008); and RPS 20 Safety Guide for Classification of Radioactive Waste (2010).

In addition, ARPANSA has begun planning or preparation of several new Radiation Protection Series documents which take into account the latest international guidance. Those of interest to the uranium industry include a Fundamentals document (in preparation), a Planned Exposure Situations Code of Practice, a Near Surface Disposal Code of Practice, an Environmental Protection Safety Guide and a Site Closure Safety Guide. In each case, there will be a public consultation process.

A Radon Progeny Technical Coordination Group has been set up with representation from the uranium mining industry, state regulators and ARPANSA to develop a national approach to radon progeny dose assessment, including a programme of measurements in Australian uranium mines, to address proposed changes in international recommendations.

The Leading Practice Sustainable Development Program for the Mining Industry (LPSDP) previously developed a number of handbooks to address key issues affecting sustainable development. The Department of Resources, Energy and Tourism, assisted by the LPSDP Steering Committee, has commenced a review of the handbooks to ensure that they remain current in sharing leading practices in sustainable development of the mining industry globally. Further information of the Leading Practice handbooks can be found at www.ret.gov.au/resources/resources_programs/lpsdpmining/handbooks/Pages/default.aspx.

Uranium requirements

Australia has no commercial nuclear power plants and thus has no uranium requirements.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The Australian government supports the development of a sustainable Australian uranium mining sector in line with world's best practice environmental and safety standards. In September 2012, the New South Wales government passed legislation to overturn the ban on uranium exploration; uranium mining is still prohibited by state legislation. In October 2012, the Queensland government overturned the ban on uranium mining put in place by the previous state government, and allows uranium exploration and mining along with South Australia, Western Australia and the Northern Territory.

The Australian government's control over uranium exports reflects both national interest considerations and international obligations. The government is committed to ensuring that Australian uranium is only used for peaceful purposes by enforcing a strict safeguards policy. Australia's uranium export policy requires recipient states to have concluded a bilateral nuclear co-operation agreement (NCA) with Australia and to have in place an Additional Protocol with the IAEA. Since 2011, Australia has negotiated an NCA for the export of uranium to the United Arab Emirates; that agreement is yet to be ratified. The Australian government has commenced negotiations with India on an NCA.

Uranium stocks

For reasons of confidentiality, information on producer stocks is not available.

Uranium prices

The average price of uranium exported from Australia in 2012 was USD 45.03/lb U_3O_8. Average export prices for the last five years are as follows:

	2012	2011	2010	2009	2008	2007
Average export value (AUD/lb U_3O_8)	43.36	40.10	35.12	50.43	35.17	39.07
(USD/lb U_3O_8)	45.03	40.73	32.30	39.97	29.98	32.77

Uranium exploration and development expenditures and drilling effort – domestic

(AUD millions)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	190.0	189.6	98.3	90
Government exploration expenditures	0	0	0	0
Industry* development expenditures	NA	NA	NA	NA
Government development expenditures	0	0	0	0
Total expenditures	NA	NA	NA	NA
Industry* exploration drilling (m)	NA	NA	NA	NA
Industry* exploration holes drilled	NA	NA	NA	NA
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	NA	NA	NA	NA
Industry* development holes drilled	NA	NA	NA	NA
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	NA	NA	NA	NA
Subtotal exploration holes drilled	NA	NA	NA	NA
Subtotal development drilling (m)	NA	NA	NA	NA
Subtotal development holes drilled	NA	NA	NA	NA
Total drilling (m)	NA	NA	NA	NA
Total number of holes drilled	NA	NA	NA	NA

* Non-government.

Uranium exploration and development expenditures – non-domestic

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	NA	NA	NA	NA
Government exploration expenditures	0	0	0	0
Industry* development expenditures	NA	NA	NA	NA
Government development expenditures	0	0	0	0
Total expenditures	**NA**	**NA**	**NA**	**NA**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	NA	NA	119 300	139 600
Sandstone	NA	NA	28 800	34 300
Polymetallic Fe-oxide breccia complex	NA	NA	942 300	943 000
Granite-related	NA	NA	0	200
Intrusive	NA	NA	1 100	5 000
Volcanic-related	NA	NA	2 700	6 100
Metasomatite	NA	NA	21 300	21 300
Surficial	NA	NA	58 500	58 500
Total	**NA**	**NA**	**1 174 000**	**1 208 000**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	NA	NA	83 000	83 600
Open-pit mining (OP)	NA	NA	133 500	166 100
In situ leaching acid	NA	NA	16 600	17 400
Co-product and by-product	NA	NA	940 900	940 900
Total	**NA**	**NA**	**1 174 000**	**1 208 000**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	NA	NA	1 023 900	1 024 500
Conventional from OP	NA	NA	133 500	166 100
In situ leaching acid	NA	NA	16 600	17 400
Total	**NA**	**NA**	**1 174 000**	**1 208 000**

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	NA	NA	44 600	49 200
Sandstone	NA	NA	53 600	73 700
Polymetallic Fe-oxide breccia complex	NA	NA	403 400	408 900
Intrusive	NA	NA	800	5 000
Volcanic-related	NA	NA	1 000	1 500
Metasomatite	NA	NA	14 600	16 900
Surficial	NA	NA	14 100	35 100
Total	**NA**	**NA**	**532 100**	**590 300**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	NA	NA	53 300	55 600
Open-pit mining (OP)	NA	NA	70 700	103 800
In situ leaching acid	NA	NA	19 100	36 400
Co-product and by-product	NA	NA	389 000	394 500
Total	**NA**	**NA**	**532 100**	**590 300**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	NA	NA	442 300	450 100
Conventional from OP	NA	NA	70 700	103 800
In situ leaching acid	NA	NA	19 100	36 400
Total	**NA**	**NA**	**532 100**	**590 300**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
NA	NA	NA

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
NA	NA	NA

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Proterozoic unconformity	102 841	3 216	2 240	3 146	111 443	3 000
Sandstone	5 848	354	374	477	7 053	400
Polymetallic Fe-oxide breccia complex	47 422	2 330	3 353	3 386	56 491	3 300
Metamorphite	7 531	0	0	0	7 531	0
Intrusive	721	0	0	0	721	0
Total	**164 363**	**5 900**	**5 967**	**7 009**	**183 239**	**6 700**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	110 255	3 216	2 240	3 146	118 857	3 000
Underground mining*	838	0	0	0	838	0
In situ leaching	5 848	354	374	477	7 053	400
Co-product/by-product	47 422	2 330	3 353	3 386	56 491	3 300
Total	**164 363**	**5 900**	**5 967**	**7 009**	**183 239**	**6 700**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	164 363	5 900	5 967	7 009	183 239	6 700
Total	**164 363**	**5 900**	**5 967**	**7 009**	**183 239**	**6 700**

Ownership of uranium production in 2012*

Domestic		Foreign		Totals	
Government/private		Government/private			
(tU)	(%)	(tU)	(%)	(tU)	(%)
1 888	26.9	5 121	73.1	7 009	100

* These figures are estimated based on public ownership information. For reasons of confidentiality, government vs private ownership information is not available.

Uranium industry employment at existing production centres

(person-years)*

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	4 813	4 888	5 574	5 620
Employment directly related to uranium production	4 514	4 590	3 720	3 661

* These figures are estimated and take into account total employment at BHP Billiton's Olympic Dam polymetallic operations also including contractors employed at the mine. A breakdown of employees working for BHP's uranium mining operations was not available.

Short-term production capability

(tonnes U/year)

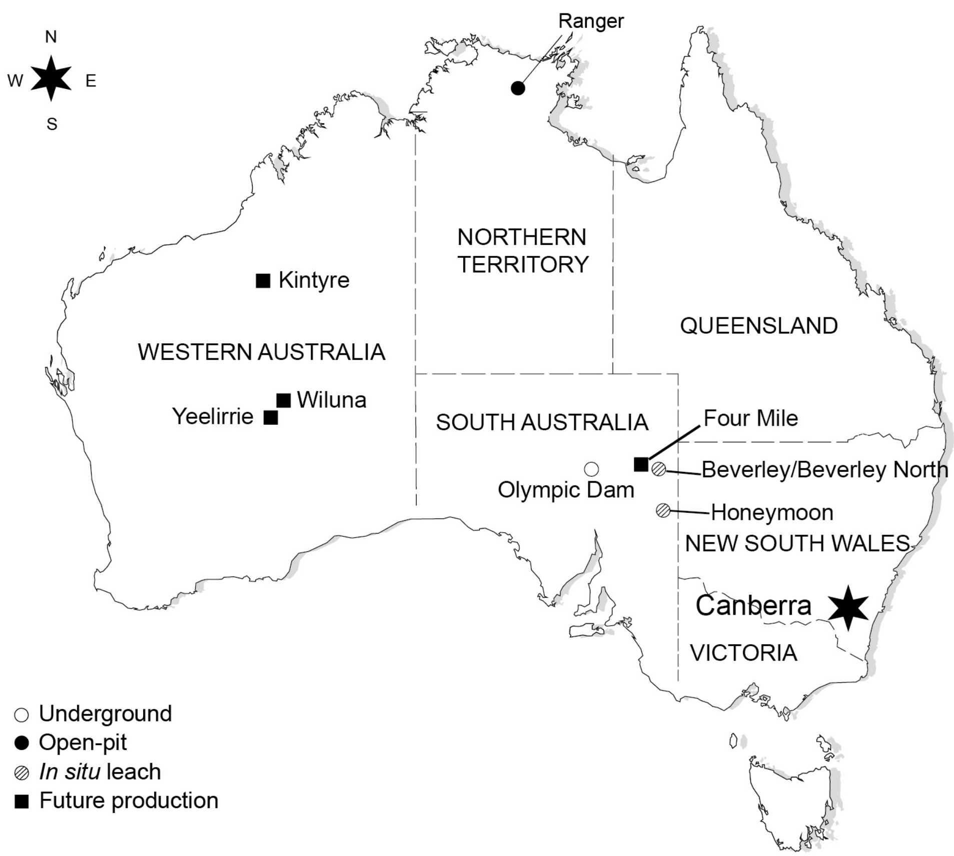
2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	9 700	9 700	NA	NA	9 700	10 200	NA	NA	10 100	20 800

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	10 100	28 400	NA	NA	9 800	28 100	NA	NA	9 800	28 100

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	Nil	Nil	Nil	Nil	Nil
Producer	NA	Nil	Nil	Nil	NA
Utility	Nil	Nil	Nil	Nil	Nil
Total	**Nil**	**Nil**	**Nil**	**Nil**	**Nil**



Botswana*

Uranium exploration and mine development

Historical review

The surge in the uranium price in the 1970s led to exploration activities in Botswana by various foreign and local companies. Large airborne radiometric surveys were followed by ground surveys, soil sampling, trenching and drilling. However, the thick sand cover in many parts of the country hindered exploration activities. Exploration work effectively ceased in the early 1980s with the slump in uranium prices. No deposits of economic interest were discovered in this early phase of exploration but significant mineralisation was shown to occur in the Karoo sandstones and surficial calcretes, particularly in the east-central part of the country.

Rising uranium prices in 2005 renewed interest in uranium exploration by junior Australian companies and by 2011 there were 168 uranium prospecting licences registered in Botswana.

A-Cap Resources has been exploring in Botswana since 2004, following up on mineralisation discovered by Falconbridge in the 1970s in the Serowe area and discovering significant mineralisation at the Letlhakane Project. Intensive drilling resulted in A-Cap reporting Botswana's first JORC compliant uranium resource in 2008 of just over 100 000 tU at an average grade of 129 ppm U (0.0129% U).

Recent and ongoing uranium exploration and mine development activities

The Letlhakane uranium deposit has been the focus of detailed technical work for A-Cap since 2010, resulting in the February 2013 release of a positive scoping study. A thorough examination of all aspects of the resource has led to a greater understanding of the framework and grade distribution of uranium mineralisation and the use of appropriate mining techniques to maximise the economics of the deposit.

The uranium mineralisation, hosted predominately in carbonaceous mudstones and siltstones, occurs in relatively thin (0.5-5 m), laterally extensive lenses with lower-grade material separating higher-grade ore horizons. The nature of the ore combined with shallow, flat-lying and soft strata lends itself well to open-pit extraction methods. This information has resulted in a resource determination that is less than previously reported, but with higher grades. The current resource estimate is 118 615 tU at 0.018% U.

Impact Minerals Ltd, another Australian junior company, acquired permits around A-Cap's areas in early 2008. Exploration activities in 2009 began with airborne radiometric surveys, followed by field reconnaissance, mapping and drilling, leading to the discovery of four prospects in Karoo siltstones and sandstones. In addition to sandstone-hosted mineralisation, uranium-bearing alaskitic rocks similar to those found at Rossing in Namibia and mineralisation related to Proterozoic sedimentary and basement rocks with similarities to the unconformity-related deposits in Canada and Australia were discovered. Further work is needed to assess the validity of the model and the potential

* Report prepared by the Secretariat, based on previous Red Books and company reports.

of this unconformity style of mineralisation. Impact Minerals Ltd is actively searching for an experienced joint venture partner.

At the end of 2012, A-Cap's prospecting licences for uranium totalled 5 000 km^2 while Impact Minerals Ltd controlled 26 000 km^2. The two companies drilled a total of 12 462 m in 95 reverse circulation holes during 2011 but no drilling was reported in 2012. Both companies completed regional ground gravity surveys and Impact Minerals Ltd completed a soil geochemical survey over an area of 250 km^2 at the Ikongwe prospect.

Australia-based Bannerman Resources held three prospecting licences for uranium exploration in the Foley and Sua Pan regions of Botswana. However, the Serule South, Serule North and Dukwe licences were not renewed in 2011 and Bannerman is no longer active in Botswana.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

In June 2012, A-Cap Resources upgraded the global JORC Resource of the Letlhakane Uranium Project by 35%. Letlhakane hosts a global resource of 1.04 billion tonnes at 130 ppm uranium (0.013% U) for 351.8 million pounds of contained uranium (135 269 tU), based on an 85 ppm U cut-off grade. Within this resource, A-Cap has defined a higher-grade resource of 143.2 million tonnes at 241 ppm uranium (0.0241% U) for 89.7 million pounds of uranium contained (34 500 tU), based on 170 ppm U cut-off grade.

However, in early 2013, A-Cap Resources released the results of a scoping study on the Letlhakane uranium deposit and in June 2013, released new updated resources based on results of the scoping study. The global resource has been reduced from the 2012 resource of 135 269 tU to 118 615 tU using a cut-off grade of 85 ppm U. Although the size of the uranium resource has been reduced, the grade has increased from 0.013 to 0.018% U. Using a recovery factor of 58%, the total inferred recoverable resource is 68 797 tU in the <USD 260/kgU category.

Undiscovered conventional resources (prognosticated and speculative resources)

The key feature for uranium mineralisation in Botswana is the presence of highly radiogenic granitoid suites, most relating to the Pan African (~500 Ma [million years ago]) magmatic event, which introduced uranium-rich source material into the upper crust. The uranium mineralisation is highly mobile and through leaching, uranium-bearing solutions became concentrated in reduced environments in sandstones, mudstones and carbonaceous materials in the overlying lower Karoo system.

Most calcareous sediments in the Gojwane and the Foley area, which lies on top of the Karoo and the Karoo-aged sediments are considered to host widespread and continuous uranium mineralisation. These areas are considered to have the same geology as the Letlhakane area, which host one of the biggest undeveloped uranium deposits in Botswana.

Impact Minerals Ltd reports "target conceptual" undiscovered resources of less than 2 000 tU. However, the uncertainty of the term and small amounts reported do not warrant inclusion as undiscovered resources at this time. Although undiscovered resources no doubt exist, further work is required to develop the estimates.

Uranium production

Uranium has never been produced in Botswana.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2
Name of production centre	Letlhakane	Letlhakane
Production centre classification	Planned	Planned
Date of first production	2016	2016
Source of ore:		
Deposit name(s)	Letlhakane	Gorgon West
Deposit type(s)	Secondary/calcrete	Secondary/calcrete
Recoverable resources (tU)	56 912	12 754
Grade (% U)	0.0197	0.0196
Mining operation:		
Type (OP/UG/ISL)	OP	OP
Size (tonnes ore/day)	24 000	
Average mining recovery (%)	75	
Processing plant:		
Acid/alkaline	Acid	Acid
Type (IX/SX)	HL	HL
Size (tonnes ore/day)		
Average process recovery (%)	77	77
Nominal production capacity (tU/year)	1 350	

Environmental activities and socio-cultural issues

A-Cap has established the Safety, Health, Radiation, Environment and Community Group aimed at informing, educating and involving local communities with regard to their activities. Meetings are held on a regular basis. The company submitted an environmental and social impact assessment study of the Letlhakane Project to the Botswana government in 2011. The scoping study indicates potential for a mine life in excess of 20 years subject to world market prices for uranium. A-Cap Resources anticipates starting production at its uranium mine by in 2016, at an average operating cost of USD 42/lb at Letlhakane in the first five years and USD 4/lb in the first ten years.

A detailed water exploration programme by A-Cap has confirmed that a well field located 30 km west of Letlhakane, could supply water of sufficient quality and quantity to meet the project's requirements. A-Cap submitted water rights applications which were subsequently granted by Botswana's Water Apportionment Board in 2012.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

National policies regarding uranium exploitation and production are under development and no regulations for uranium mining and milling are currently in place. However, the government is committed to encouraging private investment in exploration and new mine development and the fiscal, legal and policy framework for mineral exploration, mining and mineral processing in Botswana is continuously being reviewed to make it more competitive. Amendments made to the Mines and Minerals Act in 1999 and the Income Tax Act in 2006 streamlined licensing, enhanced security of tenure and reduced royalty payments and tax rates.

Uranium exploration and development expenditures and drilling effort – domestic

(AUD [Australian dollar] thousands for 2010; BWP [Botswana pula] for 2011, 2012, 2013)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	6 202	7 920 000	8 129 000	7 851 000
Total expenditures	**6 202**	**7 920 000**	**8 129 000**	**7 851 000**
Industry* exploration drilling (m)	26 475	10 493	16 875	12 514
Industry* exploration holes drilled	589	111	129	27
Subtotal exploration drilling (m)	26 475	10 493	16 875	12 514
Subtotal exploration holes drilled	589	111	129	27
Total drilling (m)	**26 475**	**10 493**	**16 875**	**12 514**
Total number of holes drilled	**589**	**111**	**129**	**27**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	12 827	12 827
Total	**0**	**0**	**12 827**	**12 827**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	0	0	12 827	12 827	58
Total	**0**	**0**	**12 827**	**12 827**	**58**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Heap leaching* from OP	0	0	12 827	12 827	58
Total	**0**	**0**	**12 827**	**12 827**	**58**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	55 970	55 970
Total	**0**	**0**	**55 970**	**55 970**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	0	0	55 970	55 970	58
Total	**0**	**0**	**55 970**	**55 970**	**58**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Heap leaching* from OP	0	0	55 970	55 970	58
Total	**0**	**0**	**55 970**	**55 970**	**58**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Brazil

Uranium exploration and mine development

Historical review

Systematic prospecting for radioactive minerals by the Brazilian National Research Council began in 1952. These efforts led to the discovery of the first uranium occurrences at Poços de Caldas (State of Minas Gerais) and Jacobina (State of Bahia). In 1955, a technical co-operation agreement was signed with the United States to assess the uranium potential of Brazil. After the creation of the National Nuclear Energy Commission (CNEN) a mineral exploration department was organised with the support of the French Alternative Energies and Atomic Energy Commission (CEA) in 1962.

In the 1970s, CNEN exploration for radioactive minerals increased due to increased financial resources. Additional incentive for exploration was provided in 1974 when the government opened NUCLEBRAS, an organisation with the exclusive purpose of uranium exploration and production. One of the early achievements of the government organisations was the discovery and development of the Osamu Utsumi deposit on the Poços de Caldas plateau.

In late 1975, Brazil and Germany signed a co-operation agreement for the peaceful use of nuclear energy. It was the beginning of an ambitious nuclear development programme that required NUCLEBRAS to increase its exploration activities. This led to the discovery of eight areas hosting uranium resources including the Poços de Caldas plateau, Figueira, the Quadrilátero Ferrífero, Amorinópolis, Rio Preto/Campos Belos, Itataia, Lagoa Real and Espinharas (discovered and evaluated by NUCLAM, a Brazilian-German joint venture).

In 1991, *Industrias Núcleares do Brasil* S.A (INB) uranium exploration activities were brought to a halt according to the Brazilian nuclear development programme reorganisation of 1988. Planned exploration activities in 2009 and 2010 were delayed due to regulatory requirements.

Recent and ongoing uranium exploration and mine development activities

During 2011/2012 exploration efforts were focused on favourable albititic areas in the north part of the Lagoa Real province. A geophysical survey in 2011 and surface drillings in 2012 were used to identify and define the extension of the uranium deposits. Expenditures totalled BRL 200 000 (Brazilian reals) in 2011 and BRL 2 500 000 in 2012, with 5 200 m drilled. For 2013, expected expenditures are BRL 3 500 000 corresponding to 7 300 m of drilling.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Brazil's conventional identified uranium resources are hosted in the following deposits:

- Poços de Caldas (Osamu Utsumi mine) with the orebodies A, B, E and Agostinho (collapse breccia pipe-type).
- Figueira and Amorinópolis (sandstone).
- Itataia, including the adjoining deposits of Alcantil and Serrotes Baixos (phosphate).
- Lagoa Real, Espinharas (metasomatite).
- Campos Belos (metamorphite).
- Others including the Quadrilátero Ferrifero with the Gandarela and Serra des Gaivotas deposits (paleo-quartz-pebble conglomerate).

No additional resources were identified during the 2011-2012 period.

Undiscovered conventional resources (prognosticated and speculative resources)

Based on exploration activities in the Rio Cristalino (Proterozoic unconformity) area and additional resources at the Pitinga site (granite-related), *in situ* prognosticated resources are estimated to amount to 300 000 tU.

Uranium production

Historical review

The Poços de Caldas uranium production facility, which started production in 1982 with a design capacity of 425 tU/year, was owned by the state-owned company NUCLEBRAS until 1988. At that time Brazil's nuclear activities were restructured. NUCLEBRAS was succeeded by INB and its mineral assets transferred to *Urânio do Brasil S.A.* With the dissolution of Urânio do Brasil in 1994, ownership of uranium production is 100% controlled by INB, a state-owned company.

Between 1990 and 1992, the production centre at Poços de Caldas was on stand-by because of increasing production costs and reduced demand. Production restarted in late 1993 and continued until October 1995. After two years on stand-by the Poços de Caldas production centre was shut down in 1997. A decommissioning programme started in 1998. This industrial facility was used to produce rare earth compounds from monazite treatment until 2006, but is now closed for market reasons. The Caetité unit (Lagoa Real) is currently the only uranium production facility in operation in Brazil.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3
Name of production centre	Caetite	Santa Quitéria	Engenho
Production centre classification	Existing	Committed	Planned
Date of first production	1999	2016	2016
Source of ore:			
Deposit name(s)	Cachoeira	Santa Quitéria	Engenho
Deposit type(s)	Metasomatite	Phosphate	Metasomatite
Recoverable resources (tU)	10 100	76 100	6 500
Grade (% U)	0.3	0.08	0.2
Mining operation:			
Type (OP/UG/ISL)	OP/UG	OP	OP
Size (tonnes ore/day)	1 000	6 000	1 000
Average mining recovery (%)	90	90	90
Processing plant:			
Acid/alkaline	Acid	Acid	Acid
Type (IX/SX)	HL/SX	SX	SX
Size (tonnes ore/day)			
Average process recovery (%)	80	75	90
Nominal production capacity (tU/year)	340	970	300
Plans for expansion (yes/no)	Yes	Yes	Yes
Other remarks		By-product phosphoric acid	To be sent to Caetite mill

Status of production facilities, production capability, recent and ongoing activities and other issues

The expansion of Lagoa Real, Caetité unit to 670 tU/year is progressing but the operation has been delayed somewhat to around 2016. The expansion involves replacement of the current heap leaching (HL) process by conventional agitated leaching. The overall investment in this expansion is estimated to amount to USD 90 million.

The production in the period 2010 and 2012 was 265 and 326 tU, respectively.

Ownership structure of the uranium industry

The Brazilian uranium industry is 100% government-owned through INB.

Employment in the uranium industry

See table.

Future production centres

The phosphate/uranium project of Santa Quitéria, an INB-Brazilian fertiliser producer partnership agreement, is under development. In 2012, the project applied for a construction licence, expected to be granted by the end of 2013. The operation is now scheduled for 2016.

The Engenho deposit, located 2 km from the currently mined Cachoeira deposit is under study and is expected to provide additional feed for the Caetité mill after 2016.

Environmental activities and socio-cultural issues

Licences in Brazil are issued by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) and also by CNEN.

The closure of Poços de Caldas in 1997 brought to an end the exploitation of this low-grade ore deposit that produced vast amounts of waste rock. Several studies have been carried out to characterise geochemical and hydrochemical aspects of the waste rock and tailings dam in order to better establish the impact they may have had on the environment and to develop the necessary mitigation measures. A remediation/restoration plan, considering several alternatives, was submitted to the regulatory body at the end of 2012. Depending on the option adopted, the costs of implementing the remediation/restoration plan could reach USD 300 million.

The licensing of Santa Quitéria Uranium/Phosphate Project is split into a non-nuclear part involving milling and phosphate production and a nuclear part involving uranium concentrate production. INB has applied for local construction licences under the guidelines established by IBAMA and CNEN.

Regulatory regime

Licences are issued by IBAMA, according to Brazilian environment law and CNEN regulations.

Government policies and regulations established by CNEN include basic radiation protection directives (NE-3.01 – *Diretrizes Básicas de Radioproteção*), standards for licensing of uranium mines and mills (NE-1.13 – *Licenciamento de Minas e Usinas de Beneficiamento de Minérios de Urânio ou Tório*) and decommissioning of tailings ponds (NE-1.10 – *Segurança de Sistema de Barragem de Rejeito Contendo Radionuclídeos*), as well as standards for conventional U and Th mining and milling (NORM and TENORM NM 4.01 – *Requisitos de Segurança e Proteção Radiológica para Instalações Mínero-Industriais*). In the absence of specific norms, the International Commission on Radiological Protection (ICRP) and IAEA recommendations are used.

CNEN is in charge of nuclear research and regulation and currently controls INB as a major stakeholder. Due to the future growth of the Brazilian nuclear programme, the creation of a separate independent nuclear regulatory agency is under study by the federal government.

Uranium requirements

Brazil’s present uranium requirements for the Angra 1 nuclear power plant, a 630 MWe PWR, are about 130 tU/yr. The Angra 2 nuclear power plant, a 1 245 MWe PWR, requires 220 tU/yr. The start-up of the Angra 3 nuclear power plant (a similar design to Angra 2), scheduled in 2016, will add another 220 U/yr to annual domestic demand.

The long-term electricity energy supply plan includes 4 000 MW generated from nuclear sources by 2030. The first unit of this longer-term plan is expected to be in operation in 2022. Siting studies for this unit are under way.

Supply and procurement strategy

All domestic production is destined for internal requirements. The shortfall between demand and production is met through market purchases. The planned production increases are intended to meet all reactor requirements, including the Angra 3 unit and all units foreseen in the long-term planned expansion of nuclear energy for electricity generation.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

INB, a 100% government-owned company, is in charge of fuel cycle activities which are conducted under state monopoly. Currently INB is working on the increase of uranium concentrate production and toward full implementation of the fuel cycle activities to meet domestic demand.

Uranium stocks

The Brazilian government does not maintain stocks of uranium concentrate or enriched uranium product.

Uranium exploration and development expenditures and drilling effort – domestic

(in BRL [Brazilian real])

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	0	0	0	0
Government exploration expenditures	400	200 000	2 500 000	3 500 000
Total expenditures	**400**	**200 000**	**2 500 000**	**3 500 000**
Government exploration drilling (m)	0	0	5 200	7 300
Government exploration holes drilled	0	0	41	47
Total drilling (m)	**0**	**0**	**5 200**	**7 300**
Total number of holes drilled	**0**	**0**	**41**	**47**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related	17 800	35 600	35 600	35 600
Collapse breccia-type	400	400	400	400
Metasomatite	65 900	65 900	65 900	65 900
Phosphate	53 200	53 200	53 200	53 200
Total	**137 300**	**155 100**	**155 100**	**155 100**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	58 300	58 300	58 300	58 300	80
Open-pit mining (OP)	7 900	7 900	7 900	7 900	80
Co-product and by-product	71 100	88 900	88 900	88 900	70
Total	**137 300**	**155 100**	**155 100**	**155 100**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	58 300	58 300	58 300	58 300	80
Conventional from OP	6 500	6 500	6 500	6 500	80
Heap leaching* from OP	1 400	1 400	1 400	1 400	80
Unspecified	71 100	88 900	88 900	88 900	70
Total	**137 300**	**155 100**	**155 100**	**155 100**	

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		9 100	9 100	9 100
Paleo-quartz-pebble conglomerate		10 500	10 500	10 500
Granite-related		0	47 400	47 400
Metamorphite		700	700	700
Collapse breccia-type		18 600	18 600	18 600
Metasomatite		3 500	3 500	3 500
Phosphate		31 200	31 200	31 200
Total		**73 600**	**121 000**	**121 000**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)		2 400	2 400	2 400	70
Co-product and by-product		31 200	78 600	78 600	70
Unspecified		40 000	40 000	40 000	70
Total		**73 600**	**121 000**	**121 000**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP		2 400	2 400	2 400	70
Unspecified		71 200	118 600	118 600	70
Total		**73 600**	**121 000**	**121 000**	

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
300 000	300 000	300 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
NA	NA	500 000

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Collapse breccia-type	1 097	0	0	0	1 097	0
Metasomatite	2 089	148	265	326	2 828	340
Total	**3 186**	**148**	**265**	**326**	**3 925**	**340**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	3 186	148	265	326	3 925	340
Total	**3 186**	**148**	**265**	**326**	**3 925**	**340**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	1 097				1 097	0
Heap leaching*	2 089	148	265	326	2 828	340
Total	**3 186**	**148**	**265**	**326**	**3 925**	**340**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
326	100	0	0	0	0	0	0	326	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	620	620	620	650
Employment directly related to uranium production	340	340	340	370

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
340	340	340	340	340	340	340	340	1 600	2 000	1 600	2 000

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 600	2 000	1 600	2 000	NA	NA	NA	NA	NA	NA	NA	NA

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	15 644	16 041

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
1875	1 875	1 875	1 875	1 875	1 875	3 120	3 120	3 120	5 120	3 120	7 120	NA	NA

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
400	400	650	650	600	600	550	550	550	1 000	550	1 400	NA	NA

Canada

Uranium exploration

Historical review

Uranium exploration in Canada began in 1942, with the focus of activity first at Great Bear Lake, Northwest Territories where pitchblende ore had been mined since the 1930s to extract radium. Exploration soon expanded to other areas of Canada, resulting in the development of mines in northern Saskatchewan and in the Elliot Lake and Bancroft regions of Ontario during the 1950s. In the late 1960s, exploration returned to northern Saskatchewan where large high-grade deposits were discovered in the Athabasca Basin and later developed. Saskatchewan is now the sole producer of uranium in Canada.

Recent and ongoing uranium exploration and mine development activities

During 2011 and 2012, exploration efforts continued to focus on areas favourable for the occurrence of deposits associated with Proterozoic unconformities in the Athabasca Basin of Saskatchewan, and to a lesser extent, similar geologic settings in the Thelon Basin of Nunavut and the Northwest Territories. Uranium exploration also remained active in Quebec in 2011 and 2012. Uranium exploration activities increased in Newfoundland and Labrador after a temporary moratorium on uranium mining was lifted by the Nunatsiavut government in March 2012. Very little exploration activity occurred in other areas of Canada in 2011 and 2012.

Surface drilling, geophysical and geochemical surveys continued to be the main tools used to identify new uranium occurrences, define extensions of known mineralised zones and to reassess deposits which were last examined in the 1970s and 1980s.

Exploration activity has led to new uranium discoveries in the Athabasca Basin. Notable recent high-grade uranium mineralisation discoveries include Centennial (UEM Inc.), Shea Creek (AREVA Resources Canada Inc.), Wheeler River (Denison Mines Inc.), Midwest A (AREVA Resources Canada Inc.) and Roughrider (Rio Tinto).

Domestic uranium exploration expenditures were CAD 205 million in 2012, up 3.5% from 2011 exploration expenditures of CAD 198 million. In 2012, overall Canadian uranium exploration and development expenditures amounted to CAD 874 million. Less than one-quarter of the overall exploration and development expenditures in 2012 can be attributed to advanced underground exploration, deposit appraisal activities and care and maintenance expenditures associated with projects awaiting production approvals.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2013, Canada's total identified conventional uranium resources recoverable at a cost of <USD 80/kgU amounted to 418 300 tU, an increase of 0.4% from the 2011 estimate of 416 800 tU. Canada's total identified uranium resources recoverable at a cost of <USD 130/kgU were 493 900 tU as of 1 January 2013, an increase of 5.4% compared to the 2011 estimate of 468 600 tU. These increases are primarily due to new resources being identified as a result of recent exploration activities. Most of Canada's identified uranium resources are re-evaluated annually by the uranium mining companies.

The bulk of Canada's identified conventional uranium resources occur in Proterozoic unconformity-related deposits in the Athabasca Basin of Saskatchewan and the Thelon Basin of Nunavut. These deposits host their mineralisation near the unconformity boundary in either monometallic or polymetallic mineral assemblages. Pitchblende prevails in the monometallic deposits, whereas uranium-nickel-cobalt assemblages prevail in the polymetallic assemblages. The average grade varies from 1% U to over 15% U. None of the uranium resources referred to or quantified herein are a co-product or by-product output of any other mineral of economic importance. Mining losses (~20%) and ore processing losses (~3%) were used to calculate known conventional resources.

About 92% of Canada's identified conventional uranium resources recoverable at <USD 40/kgU are in existing or committed production centres. The percentage of identified conventional uranium resources in existing or committed production centres that are recoverable at <USD 80/kgU, <USD 130/kgU and <USD 260/kgU are 80%, 62% and 48%, respectively.

Undiscovered conventional resources (prognosticated and speculated resources)

Prognosticated and speculated resources have not been a part of recent resource assessments; hence there are no changes to report in these categories since 1 January 2001.

Uranium production

Historical review

Canada's uranium industry began in the Northwest Territories with the 1930 discovery of the Port Radium pitchblende deposit. Exploited from 1933 to 1940 for radium, the deposit was reopened in 1942 in response to uranium demand by British and United States defence programmes. A ban on private exploration and development was lifted in 1947, and by the late 1950s some 20 uranium production centres had started up in Ontario, Saskatchewan and the Northwest Territories. Production peaked in 1959 at 12 200 tU. No further defence contracts were signed after 1959 and production began to decline. Despite government stockpiling programmes, output fell rapidly to less than 3 000 tU in 1966, by which time only four producers remained. While the first commercial sales to electric utilities were signed in 1966, it was not until the mid-1970s that prices and demand had increased sufficiently to promote expansions in exploration and development activity. By the late 1970s, with the industry firmly re-established, several new facilities were under development in Saskatchewan and Ontario. Annual output grew steadily throughout the 1980s, as Canada's focus of uranium production shifted increasingly to Saskatchewan. The last remaining Ontario uranium mine closed in mid-1996.

Status of production capability and recent and ongoing activities

Overview

Since the last Elliot Lake production facility closed in 1996, all active uranium production centres are located in northern Saskatchewan. Current Canadian uranium production remains below full production capability. Production in 2012 was 8 998 tU, 1.6% below 2011 production of 9 145 tU. Canadian uranium production is forecast to decrease to 9 000 tU in 2013 but will increase significantly in 2014 when the Cigar Lake mine begins production.

Cameco Corporation is the operator of the McArthur River mine, a Cameco (70%), AREVA (30%) joint venture. Production at this, the world's largest high-grade uranium mine, was 7 626 tU and 7 460 tU in 2011 and 2012, respectively. After raise bore mining of the high-grade ore behind a freeze curtain created to control groundwater inflow, high-grade ore slurry is produced by underground crushing, grinding and mixing. The slurry is then pumped to the surface and loaded on specially designed containers that are trucked 80 km to Key Lake, where all McArthur River ore is milled. Remaining identified resources for McArthur River mine are currently 170 000 tU with a grade of 11.5% U.

The Key Lake mill is a Cameco (83%) and AREVA (17%) joint venture operated by Cameco. Although mining at Key Lake was completed in 1997, the mill maintained its standing as the world's largest uranium production centre by producing 7 686 tU and 7 520 tU in 2011 and 2012, respectively. These totals represent a combination of high-grade McArthur River ore slurry and stockpiled, mineralised Key Lake special waste rock that is blended to produce a mill feed grade of about 3.4% U.

The McClean Lake production centre, operated by AREVA, is a joint venture between AREVA (70%), Denison Mines Inc. (22.5%) and OURD (Canada) Co. Ltd, a subsidiary of Overseas Uranium Resources Development Corporation of Japan (7.5%). Open-pit mining was completed in 2008 and ore containing 2 500 tU was stockpiled to provide mill feed.

Production in 2009 and 2010 amounted to 2 045 tU and was obtained from processing the higher-grade ore from the stockpile. The 500 tU of ore remaining in the stockpile was not economic to process so the mill was placed into care and maintenance in July 2010. Production from the mill is expected to resume in 2014 when high-grade ore from Cigar Lake becomes available for processing. Modifications to the mill to increase capacity to 4 615 tU/yr and to process ore from the Cigar Lake mine have been completed. The environmental assessment of a proposal to mine the Caribou deposit was completed in April 2010, however, AREVA has decided to postpone mining the deposit until market conditions improve.

The Rabbit Lake production centre, wholly owned and operated by Cameco, produced 1 459 tU and 1 479 tU in 2011 and 2012, respectively. Exploratory drilling in the Eagle Point mine during the last several years has increased identified resources to 14 700 tU, extending the life of the mine to at least 2017. Cameco conducted underground exploratory drilling at the Eagle Point mine in 2012 to evaluate an orebody that was discovered by the latest phase of surface drilling.

Cigar Lake, with identified resources of 120 000 tU at an average grade of approximately 12.6% U, is the world's second-largest high-grade uranium deposit. The mine is a Cameco (50.025%), AREVA (37.1%), Idemitsu (7.875%) and TEPCO (5%) joint venture operated by Cameco. When completed, the mine is expected to have a full annual production capacity of 5 000 tU. Cigar Lake ore will be shipped to the McClean Lake mill for processing. Construction of the Cigar Lake mine, which began on 1 January 2005, has now been completed and testing of the jet-bore mining method is currently underway. Production from the mine is expected in 2014.

Ownership structure of the uranium industry

Cameco Corporation and AREVA Canada Resources Inc. (AREVA) are the operators of the current uranium production centres in Canada. Cameco is the owner and operator of the Rabbit Lake production centre which includes the Eagle Point mine and the Rabbit Lake mill. Cameco is also the operator of the McArthur River mine and the Key Lake mill which are joint ventures with AREVA. AREVA is the majority owner and operator of the McClean Lake production centre in which Denison Mines Inc. and OURD (Canada) Co. Ltd have minority ownership.

Employment in the uranium industry

Direct employment in Canada's uranium industry totalled 1 316 in 2011 and 1 361 in 2012. Total employment, including head office and contract employees, was 2 060 in 2011 and 2 109 in 2012.

Future production centres

Three uranium mining projects in Saskatchewan could enter into production within a few years, extending the lives of existing production centres. The Cigar Lake mine, which is scheduled to begin production in 2014, will provide feed for the McClean Lake mill. Ore from the proposed Midwest mine would also provide additional feed for the McClean Lake mill. Ore from the proposed Millennium mine would be processed at the Key Lake mill. There are several other exploration projects in the Athabasca Basin which have identified significant high-grade uranium mineralisation that may develop into proposals for new mines. There is also the possibility of mines being developed outside of Saskatchewan. A proposal by AREVA to develop the Kiggavik and Sissons deposits in Nunavut is currently undergoing an environmental assessment as well as a feasibility study. Strateco Resources Inc. has obtained a licence from the Canadian Nuclear Safety Commission to conduct underground exploration at the Matoush deposit in Quebec but has not obtained approval from the province. There is also a proposal to develop the Michelin and Jacques Lake deposits in Labrador.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6	Centre #7
Name of production centre	McArthur River /Key Lake	McClean Lake	Rabbit Lake	Cigar Lake	Midwest	Millennium	Kiggavik
Production centre classification	Existing	Existing	Existing	Committed	Planned	Planned	Planned
Start-up date	1999/1983	1999	1975	2014	NA	NA	NA
Source of ore:							
Deposit name(s)	P2N et al.	JEB, McClean, Sue A-E, Caribou	Eagle Point	Cigar Lake	Midwest	Millennium	Kiggavik, Andrew Lake, End Grid
Deposit type(s)	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity
Resources	170 000 tU	4 400 tU	14 700 tU	120 000 tU	3 700 tU	34 800 tU	44 000 tU
Grade (% U)	11.5	1.96	0.61	14.0	0.78	3.8	0.47
Mining operation:							
Type (OP/UG/ISL)	UG	OP/UG	UG	UG	OP	UG	OP/UG
Size (tonnes ore/day)	NA	NA	NA	~200	NA	~500	~1 500
Average mining recovery (%)	NA	NA	NA	NA	NA	NA	NA
Processing plant:							
Acid/alkaline	Acid	Acid	Acid	To be processed at McClean Lake	To be processed at McClean Lake	To be processed at Key Lake	Acid
Type (IX/SX)	SX	SX	SX				SX
Size (tonnes ore/day)	750	300	2 300				NA
Average process recovery (%)	98	97	97				NA
Nominal production capacity (tU/year)	7 200*	4 615	6 500	~5 000	~2 300	~2 750	~3 000
Plans for expansion	Relates to Millennium	Relates to Cigar Lake					

* Licence with flexible capacity to 8 075 tU to recover any shortfalls in annual production.

Secondary sources of uranium

Canada reported that there was no production or use of mixed acid fuels nor any production or use of re-enriched tailings.

Environmental activities and socio-cultural issues

Environmental impact assessments

The environmental assessment for the Midwest Project was approved on 25 July 2013. The Midwest Project is a joint venture between AREVA (69.16%), Denison Mines Inc. (25.17%) and OURD (Canada) Co. Ltd (5.67%). The proposal is to mine the Midwest deposit (13 300 tU averaging 4.68% U) by open-pit methods over a period of two years and to transport the ore to McClean Lake for milling. Although the project has received environmental approval, development of the project has been postponed due to low uranium prices.

On 3 December 2007, AREVA Resources Canada Inc. announced a decision to proceed with an economic feasibility study and to commence the regulatory process to obtain approval for the development of the Kiggavik Project in Nunavut. The deposits have an estimated 44 000 tU with an average grade of 0.47% U. An environmental impact statement was submitted to the Nunavut Impact Review Board in May 2012 as part of the Canadian Nuclear Safety Commission (CNSC) licensing process.

The environmental assessment for the Matoush Exploration Project, located in the Otish Mountains of Quebec, was approved in February 2012. The project would allow Strateco Resources Inc. to conduct underground exploration on the Matoush deposit which has identified resources of 6 500 tU with an average grade of 0.42% U. In March 2013, the Quebec government announced a moratorium on uranium projects. This moratorium will be in effect while the Quebec environmental assessment agency studies the impacts of uranium exploration and mining in the province. The project has therefore been delayed.

In August 2009, Cameco submitted a proposal to the CNSC to develop the Millennium deposit which is located 35 km north of Key Lake. The proposed underground mine would produce 150 000 to 200 000 tonnes of ore annually for 6-7 years. Ore and associated waste materials, other than clean waste rock, would be transported to the Key Lake mill along a new 21 km access road. Due to lower than expected uranium demand, Cameco has postponed plans to develop the mine, although the environmental assessment process will continue.

A proposal to extend the lifespan and increase the annual production capacity of the Key Lake milling operation by 33% (from 7 200 tU/yr to 9 600 tU/yr) was submitted to the federal nuclear regulator, the CNSC in May 2010. The proposal includes increasing the storage capacity of the Deilmann Tailings Management Facility and modifications to the mill to allow treatment of a wider range of ore and waste rock from other deposits.

Effluent management

Water treatment and minor engineering works continued to be the main activities at the closed Elliot Lake area uranium mine and mill sites in 2011 and 2012. Water quality within the Serpent River Watershed has improved since the closure and decommissioning of the mines and currently meets Ontario Drinking Water Standards.

Site rehabilitation

The Cluff Lake mine, located in the western Athabasca Basin of Saskatchewan, ceased mining and milling operations in May 2002. A two-year decommissioning programme was initiated in 2004, following a five-year comprehensive environmental assessment study. Decommissioning was essentially completed by 2006 and AREVA continues to work on site restoration activities such as the planting of over 800 000 tree seedlings. A follow-up monitoring programme is in place to confirm that the objectives of the decommissioning plan are met.

On 2 April 2007, the Canadian government and the Saskatchewan government announced funding for the first phase of the clean-up of uranium mining sites (principally the Gunnar and Lorado mines) that operated in northern Saskatchewan from the late 1950s to early 1960s. The private sector companies that operated these facilities no longer exist. When the sites were closed, there was no regulatory framework in place to appropriately contain and treat the waste, which has led to environmental impacts on local soils and lakes. The projects to decommission the Gunnar and Lorado sites are currently undergoing environmental assessments.

In Elliot Lake, Ontario, the major uranium mining centre in Canada for over 40 years, uranium mining companies have committed well over CAD 75 million to decommission all mines, mills and waste management areas. These companies continue to commit some CAD 2 million each year for treatment and monitoring activities.

Uranium requirements

Nuclear energy represents an important component of Canada's electricity sources. In 2012, nuclear energy provided close to 15% of Canada's total electricity needs (over 50% in Ontario) and should continue to play an important role in supplying Canada with power in the future. Canada has a fleet of 22 CANDU reactors, of which 19 are currently in full commercial operation, in Ontario (18) and New Brunswick (1). One unit in Quebec was shut down at the end of December 2012 and two units in Ontario have been placed in guaranteed safe shutdown state.

In Canada, the responsibility for deciding on energy supply mix and investments in electricity generation capacity, including the planning, construction and operation of nuclear power plants, resides with the provinces and their provincial power utilities. In 2012 the environmental assessment associated with the development of new nuclear power at the Darlington NPP in Ontario was approved by the Canadian government. The CNSC issued a site preparation licence for Darlington, which is the first of three licences required to build and operate a new nuclear facility in Canada. In June 2013, detailed analyses were submitted to Ontario Power Generation by the two prospective vendors. However, on 10 October 2013, the Ontario government announced that plans to build two new nuclear reactors at Darlington will be shelved due to the lack of growth in power demand in the province. Plans for refurbishing existing reactors will proceed. Details from the Ontario government on its future plans for nuclear new builds and refurbishments are expected with the release of its updated Long-Term Energy Plan in late 2013.

Refurbishment projects in New Brunswick (Point Lepreau) and Ontario (Bruce A units 1 and 2) have been successfully completed and the reactors returned to service in the fall of 2012. Ontario's 2010 Long-Term Energy Plan, currently under review, foresees the refurbishment of up to ten nuclear reactors (four at Darlington, two at Bruce A and four at Bruce B) by 2025 and the decommissioning of the Pickering nuclear station to start in 2020. The CNSC announced the approval of the environmental assessment of the proposed Darlington refurbishment project on 14 March 2013. Before the refurbishment project can proceed, Ontario Power Generation will need to submit a licence application to the CNSC to be considered in a public hearing.

Supply and procurement strategy

Ontario Power Generation fills its uranium requirements through long-term contracts with a variety of suppliers, as well as periodic spot market purchases. Since becoming a partner in Bruce Power in 2001, Cameco provides all uranium and uranium conversion services and contracts all required fuel fabrication services for all of Bruce Power's fuel procurement needs.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The Nuclear Fuel Waste Act (NFWA), which came into force on 15 November 2002, requires nuclear energy corporations to establish a Nuclear Waste Management Organization (NWMO) to safely and securely manage nuclear fuel waste over the long term. Under the NFWA, the NWMO is required to submit a study to the government on the options for the long-term management of nuclear fuel waste.

On 3 November 2005, the NWMO submitted its report to the federal government for review and consideration. The NWMO recommended adaptive phased management (APM) which involves centralised containment and isolation of nuclear fuel waste in a deep geological repository. On 14 June 2007, the federal government announced its acceptance of the recommendation of the NWMO and selected APM as the preferred approach. Pursuant to the NFWA, the NWMO is responsible for implementing the approach, with government oversight. In May 2011, the NWMO initiated a site selection process to find a suitable site in a community willing to host a nuclear fuel waste facility. It is expected to take a decade or more before a site is identified.

The Nuclear Liability Act (NLA) sets out a comprehensive scheme of liability for civil injury and damage arising from nuclear accidents and a compensation system for victims. It embodies the principles of absolute and exclusive liability of the operator, mandatory insurance and limitations on the operator's liability in both time and amount. Under the act, operators of nuclear installations are absolutely and exclusively liable for civil nuclear damage to a limit of CAD 75 million. All other contractors or suppliers are thereby indemnified. Previous parliaments have considered, but not passed bills, to update the NLA in order to better addresses public interests and reflect international standards. Key among the proposed amendments was an increase in the operator liability limit to CAD 650 million. The current session of Parliament will provide an opportunity for the government to make a renewed attempt to modernise Canada's nuclear civil liability regime.

Uranium stocks

The Canadian government does not maintain any stocks of natural uranium and data for producers and utilities are not available. Since Canada has no enrichment or reprocessing facilities, there are no stocks of enriched or reprocessed material in Canada. Although Canadian reactors use natural uranium fuel, small amounts of enriched uranium are used for experimental purposes and in booster rods in certain CANDU reactors.

Uranium prices

In 2002, Natural Resources Canada suspended the publication of the average price of deliveries under export contracts for uranium.

Uranium exploration and development expenditures and drilling effort – domestic

(CAD millions)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	181	198	205	169
Government exploration expenditures	0	0	0	0
Industry* development expenditures	595	736	669	698
Government development expenditures	0	0	0	0
Total expenditures	**776**	**934**	**874**	**867**
Industry* exploration drilling (m)	317 200	486 095	357 450	NA
Industry* exploration holes drilled	NA	NA	NA	NA
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	56 700	30 833	154 745	NA
Industry* development holes drilled	NA	NA	NA	NA
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	317 200	486 095	357 450	NA
Subtotal exploration holes drilled	NA	NA	NA	NA
Subtotal development drilling (m)	56 700	30 833	154 745	NA
Subtotal development holes drilled	NA	NA	NA	NA
Total drilling (m)	**373 900**	**516 928**	**512 195**	**NA**
Total number of holes drilled	NA	NA	NA	NA

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	256 160	318 917	343 972	414 466
Sandstone			2 992	2 992
Paleo-quartz-pebble conglomerate				5 255
Volcanic-related			10 540	31 818
Total	**256 160**	**318 917**	**357 504**	**454 531**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	255 900	318 657	326 878	403 471	~77
Open-pit mining (OP)	260	260	30 626	51 060	~77
Total	**256 160**	**318 917**	**357 504**	**454 531**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	255 900	318 657	326 878	398 216
Conventional from OP	260	260	30 626	51 060
In-place leaching*				3 153
Heap leaching** from UG				2 102
Total	**256 160**	**318 917**	**357 504**	**454 531**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	65 614	92 150	122 273	146 407
Sandstone		7 244	10 084	10 084
Paleo-quartz-pebble conglomerate				18 947
Volcanic-related			3 993	20 531
Total	**65 614**	**99 394**	**136 350**	**195 969**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	65 614	99 394	116 691	171 414	~77
Open-pit mining (OP)			19 659	24 555	~77
Total	**65 614**	**99 394**	**136 350**	**195 969**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	65 614	99 394	116 691	152 467
Conventional from OP			19 659	24 555
In-place leaching*				11 368
Heap leaching** from UG				7 579
Total	**65 614**	**99 394**	**136 350**	**195 969**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
50 000	150 000	150 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
700 000	700 000	0

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Proterozoic unconformity	262 203	9 775	9 145	8 998	290 121	9 000
Paleo-quartz-pebble conglomerate	144 182				144 182	
Intrusive	6 088				6 088	
Metasomatite	25 098				25 098	
Total	**437 571**	**9 775**	**9 145**	**8 998**	**465 489**	**9 000**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	118 328	716	0	0	119 044	0
Underground mining*	319 243	9 059	9 145	8 998	346 455	9 000
Total	**437 571**	**9 775**	**9 145**	**8 998**	**465 489**	**9 000**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	436 571	9 775	9 145	8 998	464 489	9 000
In-place leaching*	1 000				1 000	
Total	**437 571**	**9 775**	**9 145**	**8 998**	**465 489**	**9 000**

* Also known as stope leaching or block leaching.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
0	0	6 737	75	2 261	25	0	0	8 998	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	2 399	2 060	2 109	2 400
Employment directly related to uranium production	1 305	1 316	1 361	1 500

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
16 430	16 430	16 430	16 430	17 730	17 730	17 730	17 730	17 730	19 000	17 730	19 000

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
17 730	19 000	17 730	19 000	17 730	19 000	17 730	19 000	17 730	19 000	17 730	19 000

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	88.3	91

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
12 000	13 500	13 500	13 500	13 500	NA	10 100	NA	NA	NA	NA	NA	NA	NA

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
1 600	1 600	1 500	1 650	1 500	1 650	1 500	NA	NA	NA	NA	NA	NA	NA

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	0	0	0	0	0
Producer	NA	0	0	0	NA
Utility	NA	0	0	0	NA
Total	**NA**	**0**	**0**	**0**	**NA**

Chad*

Uranium exploration and mine development

Historical review

Beginning in 1946, the French Alternative Energies and Atomic Energy Commission sent several missions to countries in Africa, including Chad. A preliminary reconnaissance of the north-western part of Chad did not produce positive results.

From 1972–1980 the United Nations Development Programme (UNDP) assisted the government in exploring for metallic and non-metallic mineral resources in the Mayo-Kebbi area of south-western Chad. An area of about 10 000 km² was covered by an aerial radiometric and magnetic survey and several anomalies were found in granitic and sedimentary terrain. As a result of this survey, vein uranium mineralisation was found in the Lere alkaline granite, although the anomalies were not particularly favourable.

In 1978, Phase II of the UNDP supported project resulted in the discovery of uranium mineralisation in the Mayo-Kebbi area near the border with Cameroon. The uranium minerals (pitchblende and coffinite) were found as disseminations and in veinlets in syenitic rocks. Following a wide-spaced airborne radiometric survey, uranium mineralisation was discovered at Mandagzang and confirmed by diamond drilling. However, exploration drilling had to be discontinued in 1980 due to political instability.

In early 2008, the London-based Brinkley Exploration SA was granted three exploration permits for uranium, gold and base metals in the Mayo-Kebbi area in south-western Chad. The Mayo-Kebbi region covers an area of approximately 8 000 km² of exposed basement complex with syntectonic alkaline intrusions and a Cretaceous platform cover. Despite conducting a detailed airborne survey that delineated a number of radiometric anomalies, Brinkley Exploration SA ended all uranium exploration activities in Chad in 2008.

Recent and ongoing uranium exploration and mine development activities

Signet Mining Services Ltd (Signet), a European-based mining company that has been active in Africa since 2005, has 6 concessions comprising 841 km² that include the Lere Project in south-western Chad near the towns of Lere and Pala.

The Lere deposit has uranium hosted near vertical shear zones and secondary foliation in albitised and silicified granite in a mixed terrain of Precambrian units. Exploration activities have included an airborne geophysical survey, a geological survey and a surface radiometric survey. Uranium anomalies and potentially significant structures have been identified. Anomaly A and B have been drilled by percussion drilling (18 541 m) and core drilling (2 676 m), enabling the development of a geological model and providing sufficient data for resource estimation.

* Report prepared by the Secretariat, based on company reports and government data.

Resources compliant with the South African code for the reporting of exploration results, mineral resources and minerals reserves (The South African Mineral Resource Committee [SAMREC] Code) have been evaluated to amount to 3 190 tU, at an average grade of 200 ppm U (0.020% U). At a uranium price of less than USD 50/lb U_3O_8, the identified deposit is considered uneconomic. Further structures will need to be identified to increase the resources in order to move the project to a development stage.

At Pala, exploration activities included an airborne geophysical survey and percussion drilling (72 m). Uranium anomalies have been identified associated with surficial laterite, underlain by unweathered granite.

Total exploration expenditures for all projects from 2006 to 2011 amount to USD 26 million, including USD 10.9 million for exploration costs, USD 6.8 million of operating expenditure and USD 8.3 million of corporate expenditure.

Uranium resources

Identified conventional resources

At Lere, uranium resources have been estimated amount to 3 190 tU at an average grade of 0.020% U. These resources have been classified as inferred resources in the USD 130-260/kgU cost category.

Uranium production

No uranium has been produced in Chad.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related	0	0	0	3 190
Total	**0**	**0**	**0**	**3 190**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	3 190	NA
Total	**0**	**0**	**0**	**3 190**	**NA**

* *In situ* resources.

Chile

Uranium exploration and mine development

Historical review

Uranium exploration was initiated in the 1950s with a review of uranium potential in mining districts with Cu, Co, Mo, Ag mineralisation conducted by the United States Atomic Energy Commission. Following a delay of about ten years, activities were renewed in 1970 by the Spanish Nuclear Energy Organization (JEN), focusing for four years on Region IV of the Tambillos mining district.

Between 1976 and 1990, regional prospecting encompassing an area of 150 000 km^2 was conducted in co-operation with the IAEA using geochemical drainage surveys, aerial radiometry, ground-based geology and radiometry. This work led to the detection of 1 800 aerial anomalies, 2 000 geochemical and radiometric anomalies and the definition of 120 sectors of interest. Subsequent investigation of 84 of these sectors of interest led to the detection of 80 uranium occurrences, stimulating further study of the 12 most promising uranium prospects, preliminary exploration of these prospects and eventually the evaluation of uranium resources as a by-product of copper and phosphate mining.

From 1980 to 1984, *Cía Minera Pudahuel* (the Pudahuel Mining Company), in co-operation with the Chilean Nuclear Energy Commission (CCHEN), conducted drilling of the Sagasca Cu-U deposit, Region I (Tarapacá), leading to a technical and economic evaluation of the Huinquintipa copper deposit, Region I. The Production Development Corporation (*Corporación de Fomento de la Producción* – CORFO) and CCHEN conducted exploration and technical-economic evaluation of the Bahía Inglesa phosphorite deposit, Region III (Atacama) in 1986 and 1987.

Between 1990 and 1996 CCHEN undertook geological and metallogenic uranium research, mainly in the north of the country. From 1996 to 1999, CCHEN and the National Mining Company (ENAMI) investigated rare earth elements in relation to radioactive minerals in the Atacama and Coquimbo regions. Dozens of primary occurrences were studied, with the “Diego de Almagro” Anomaly-2 chosen as a priority. The study of this 180 km^2 sector found disseminations and veins of davidite, ilmenite, magnetite, sphene, rutile and anatase, with 3.5 to 4.0 kg/t of rare earth oxides (REO), 0.3 to 0.4 kg/t of U and 20 to 80 kg/t of Ti. The geological resources of the ore contained in this prospect were estimated at 12 000 000 t. The metallurgical recovery of REOs from these minerals was also investigated with a purpose of investigating mining resources with economic potential in the medium term.

In 1998 and 1999, CCHEN created the National Uranium Potential Evaluation Project, encompassing the activities of uranium metallogeny research and development of a geological database. The aim of this project was to set up a portfolio of research projects to improve the evaluation of national uranium ore potential. Between 2000 and 2002, a preliminary geological evaluation for uranium and rare earth oxides of the Cerro Carmen prospect (2000-2002), located in Region III (Atacama), was completed as part of the specific co-operation agreement between CCHEN and ENAMI. Geophysical exploration work was undertaken (magnetometry, resistivity and chargeability), defining targets with metallic sulphur minerals with uranium and associated rare earths.

In 2001, a project portfolio document was developed that updated the metallogeny and geological favourability for uranium in Chile. A total of 166 research projects were proposed, ranging from regional activities to detailed scientific studies, to be undertaken sequentially in accordance with CCHEN capacities. In the extractive metallurgy area, work has been ongoing since 1996, through a co-operation agreement between CCHEN and ENAMI, to develop processes to produce commercial concentrates of rare earths. High-purity concentrates of light rare earths as well as yttrium have been obtained.

In 2003, regional reconnaissance was undertaken for uranium and rare earths in Region I of the country, after which the CCHEN-ENAMI co-operation agreement was terminated. Through 2004, database work was continued by CCHEN and commercial services were provided to the mining industry through 2010.

Recent and ongoing uranium exploration and mine development activities

From 2008 to 2012, CCHEN completed a broad scope co-operation agreement with the National Copper Corporation (CODELCO Norte) for geological and metallurgical investigation of natural atomic material occurrences. From 2009 to 2012, CCHEN and CODELCO Norte completed an agreement on activities to investigate recovery of uranium and molybdenum from copper ore leaching solutions.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

No new uranium resources have been identified since the 2011 edition of the Red Book. Using a recovery factor of 75%, total identified recoverable resources are 1 447 tU in the <USD 260kg/U category.

Surface deposits

(tonnes U)

Surface deposits	RAR	IR	PR	SR	% U_3O_8	Minerals
Boca Negra		3.0			0.02-0.600	Silica, yellow minerals
Manuel Jesús		2.5			0.10-0.190	Silica, yellow minerals
Casualidad					0.018	Silica, yellow minerals
San Agustín					0.20-0.250	Silica, yellow minerals
Poconchile					0.028	Silica, yellow minerals
Quebrada Vítor					0.028	Autunite
Pampa Chaca		2.0			0.028	Autunite
Pampa Camarones		3.5	3.5		0.030	Autunite, shronquingierite
Salar Grande	28.0		100.0		0.023	Carnotite
Quebrada Amarga		2.0			0.117	Carnotite
Quillagua		22.0			0.165	Carnotite
Chiu Chiu		5.0	5.0	15.0	0.04-0.140	Yellow minerals
Total	**28.0**	**40.0**	**108.5**	**15.0**		

Uranium resources by deposit type

(tonnes U)

Deposits, areas and other resources	RAR + IR	PR + SR	SR*
Surface deposits	68.0	123.5	
Metasomatic deposits	1 762.8	4 060.0	
Cenozoic volcanogenic deposits	100.0	5 000.0	
Unconventional deposits and resources	1 798.0	5 458.0	1 000
Deposit areas	--	--	500
1 - Surface deposits, Cenozoic	--	--	500
2 - Metasomatic deposits, Cretaceous	--	--	250
3 - Magmatic deposits, Cenozoic			
4 - Polymtallic deposits, Cretaceous	--	--	100
Favourable areas			
A - Acid volcanism, Tertiary	--	--	500
B - Jurassic-cretaceous intrusives	--	--	500
C - Volc. acid-sedimentary, Cretaceous	--	--	200
D - Palaeozoic magmatism. Main Cordillera	--	--	50
E - Sedimentary-volcanic, Middle Cretaceous	--	--	100
F - Palaeozoic plutonism, Nahuelbuta	--	--	300
G - Clastic sedimentary, Cretaceous-Tertiary	--	--	300
Total	**3 728.8**	**10 141.5**	**4 300**

* Undiscovered resources are expected to exist remotely from the known occurrences, either in the aforementioned uranium deposit areas or in favourable areas. In the case of unconventional resources, the figures correspond to uranium that could be recovered from the copper leaching plant solutions of the country's medium and large-scale mining activities. The latter could be several orders of magnitude greater, considering that large-scale national mining, both state-owned and private, produces large reserves of minerals in projects lasting up to 20 years. CCHEN has not updated its studies on this subject.

Metasomatic deposits

(tonnes U)

Metasomatic and hydrothermal deposits	RAR	IR	PR	SR	% U_3O_8	Minerals
Anomaly-2, Diego de Almagro (Cerro Carmen prospect)	595.3	796.5	1 400.0	1 500.0	0.03-0.10	Davidite, sphene, Ilmenite, anatase
Agua del Sol	15.0			50.0	0.02-0.06	Davidite
Sierra Indiana			15.0	15.0	0.02-0.08	Davidite
Estación Romero						
Carmen	20.0	10.0		50.0	0.01-0.12	Davidite
Producer	60.0	236.0	300.0	500.0	0.01-0.28	Autunite, torbernite
Tambillos	10.0			100.0	0.01-0.20	Uraninite, pitchblende
Pejerreyes – Los Mantos	20.0			130.0	0.01-0.05	Davidite, aut., torbernite
Total	**720.3**	**1 042.5**	**1 715.0**	**2 345.0**		

Unconventional resources and other materials

(tonnes U)

Mines, prospects, materials	RAR	IR	PR	SR	% U_3O_8	Minerals
Copper-uranium paleochannels						
Sagasca – Cascada(1)	164				0.0046	Crisocola, U
Huinquintipa(2)	46				0.0030	Crisocola, U
Chuquicamata Sur(3)	950				0.0007	Crisocola, U
Quebrada Ichuno(4)				25	0.0060	Crisocola, U
El Tesoro(5)				50	0.0070	Crisocola, U
North Chuquicamata (oxides zone)(6)				1 000	0.0008	Oxides Cu, U
Gravel from Chuquicamata oxides plant(7)				2 000	0.0008	Oxides Cu, U
Seams of high-temperature copper						
Algarrobo – El Roble(8)			513		0.0400	Sulph., Cu, U
Carrizal Alto(8)				500	0.0250	Sulph., Cu, U
Tourmaline breccias(8)						
Campanani(8)						
Sierra Gorda(8)				60	0.0020	Sulph., Cu, U
Los Azules(8)			5			
Cabeza de Vaca(8)				5		
Uranium-bearing phosphorites						
Mejillones			1 300		0.0026	Colophane - U
Bahía Inglesa(9)	638				0.0062	Colophane - U
Total	**1 798**		**1 818**	**3 640**		

Note: The figures shown in this table represent historical data and are of little current value. Studies need to be done to validate or eliminate these figures.

(1) The Sagasca deposit is exhausted, the Cascada deposit (continuation of the mineralised body) is practically exhausted; however, new explorations in the area have found new mineralised bodies, so the figure could vary substantially.

(2) Huinquintipa currently forms part of the Collahuasi Project, a contractual mining company belonging to Anglo American PLC and Xstrata Copper, a division of the Swiss mining company Xstrata Plc, each of which has a 44% stake. The remaining 12% belongs to JCR, a consortium of Japanese companies led by Mitsui & Co., Ltd. The oxidised mineral reserves amount to 53 million tonnes, for which copper extraction and production began in 2000 and will last for 20 years. The figures shown in the foregoing table could rise by a factor of between 10 and 20.

(3) Chuqui Sur: Although this deposit is not exhausted, the surcharge makes it expensive to operate, so the uranium resources contributed to the Chuquicamata division oxides plant could be zero. Accordingly, the figures indicated above could decrease significantly.

(4) Quebrada Ichuno, has not been studied and there are only preliminary works, so the figure mentioned above is maintained.

(5) The uranium resources assigned to the El Tesoro mine correspond to preliminary geological reconnaissance data obtained in 1983. This deposit is currently a nationally important mining centre, 70% owned by Antofagasta Minerals S.A., which belongs to Antofagasta Plc, and 30% owned by the Marubeni Corporation of Japan. Its mineral reserves amount to 186 million tonnes, with a useful life of 21 years. Preliminary samples suggest uranium contents of between 5 and 200 ppm, with an average of between 15 and 20 ppm. Investigating this uranium source could change the figure indicated above substantially.

(6) The "Chuquicamata Norte" prospect currently corresponds to the Radomiro Tomic mining centre, with reserves of 970 million tonnes of minerals that could be leached from copper and a useful life of 22 years. A programme of activities is currently being developed to recover uranium and molybdenum.

(7) Estimations performed in the 1970s assigned a potential of 1 000 tU that could be recovered from copper leaching solutions obtained from the gravels of the old oxides plant of the Chuquicamata copper mine. This project began its activities in 1998 and will be active for 12 years. By the end of the period it will produce 467 000 t of fine copper. Recovery of uranium from these leaching solutions has not been researched.

In addition to the uranium resources present in the leaching solutions from the aforementioned mines, there are other large copper deposits in the large-scale mining sector, whose leaching solutions have not been researched. An example is El Abra. This deposit, owned by Phelps Dodge Mining Co (51%) and CODELCO Chile (49%), started production of 800 million tonnes of is copper minerals for a 17-year period.

(8) These figures have historical value only and as geological background data. The low copper content of these districts and the small volume of their reserves makes it difficult to recover their uranium content.

(9) No experiments have been done to recover uranium from the uranium content in marine phosphorites. The only deposit currently being exploited is Bahía Inglesa, in Region III (Atacama), which produces a solid phosphate concentrate of direct use as fertiliser. In 2001, *Compañía Minera de Fosfatos Naturales Ltda*., (BIFOX LTDA.), which operates the aforementioned mine, began producing phosphoric acid, which would make it possible to recover uranium from the mother solutions.

Volcanogenic deposits

(tonnes U)

Volcanogenic deposits	RAR	IR	PR	SR	% U_3O_8	Minerals
Acid and intermediate volcanism, Regions I to III						Not investigated
El Laco sector, Region II		100	500			Aut., torbernite, REE
El Perro sector, Region III						Not investigated
Total		**100**	**500**			

REE = rare earth elements.

Unconventional resources and other materials

Deposit	RAR	IR	PR	SR	% U	Mineral
Unconventional	1 798	0	1 818	3 640	0.0008-0.1	Leaching solution 7 to 15 g/m^3 Oxide plants gravel Cu silicate and oxides, 20-70 ppm Sulphur oxide veins of 500-1 000 ppm
Total	**1 798**	**0**	**1 818**	**3 640**		

The uranium present in copper oxide ores could be recovered from the leaching solutions. These processes were trialled at the pilot level in the Chuquicamata Division between 1976 and 1979, obtaining 0.5 t of yellow cake from copper-rich solutions containing 10 to 15 ppm U (0.001 to 0.0015% U), which was sent for purification at the CCHEN metallurgy pilot plant at the Lo Aguirre nuclear centre. The production of copper oxide minerals has quadrupled in Chile over the last decade.

The copper mining industry, particularly large-scale mining, has strategic (sub-economic) uranium potential in the large volumes of copper oxide leaching solutions. These resources are assigned a potential of 1 000 tU in mining centres not included in the previous table. However, no background studies have been performed to confirm these figures, either as mining resources or in terms of the volumes of solutions treated annually, so the information should be treated as unofficial. Over the last decade, private firms, both domestic and foreign, have explored 12 "exotic copper" deposits in Chile, which correspond to paleochannels filled with gravel, mineralised with copper silicates, oxides and sulphates as a result of the natural leaching of porphyry copper deposits or other contribution areas. These mineralisations contain variable uranium contents ranging between 7 to 116 ppm (0.007 to 0.016% U). The leaching solutions in the plants that treat these copper oxide minerals display uranium levels of up to 10 ppm. This uranium content is technically recoverable using ion-exchange resins, at a likely production cost of over USD 80/kgU.

There has been no experience in recovering uranium from phosphorites in Chile. The only deposit currently being worked is Bahía Inglesa in Region III (Atacama), which produces a solid phosphate concentrate used directly as fertiliser. In 2001, *Compañía Minera de Fosfatos Naturales Ltda.*, (Bifox Ltda.) began producing phosphoric acid from this deposit, opening the potential of recovering uranium from the acid.

Speculative resources in uranium geological favourable areas

Growing knowledge of the distribution of uranium mineralisation in Chile has made it possible to define four areas of uranium occurrence and seven favourable areas, five of which have occurrences of uranium.

Areas of uranium occurrence:

1. Upper Cenozoic surface deposits – potential in SR: 500 tU.
2. Upper Cretaceous metasomatic deposits – potential in SR: 500 tU.
3. Upper Cenozoic magmatic and hydrothermal deposits – potential in SR: 250 tU.
4. Upper Cretaceous polymetallic and uranium deposits – potential in SR: 100 tU.
5. Tertiary volcanogenic deposits – potential not investigated.

Areas favourable for uranium occurrences (only minimum potential is indicated owing to a lack of research):

A. Acid volcanism and tertiary-quaternary alluvial deposits, Main Cordillera, Regions I and II – potential: 500 tU.

B. Intrusive Jurassic and Cretaceous rocks, Coastal Range, Regions I and II – potential: 500 tU.

C. Acid volcanism and upper Cretaceous clastic sedimentary rocks; Central Valley, Regions II and III – potential: 200 tU.

D. Paleozoic magmatism, Main Cordillera, Region IV – potential: 50 tU.

E Sedimentary-volcanic rocks of the Middle Cretaceous period, neogenic intrusives, Main Cordillera, Regions VI, VII and Metropolitan Region – potential: 100 tU.

F. Paleozoic plutonism, Nahuelbuta Range, Regions VIII and IX – potential: 300 tU.

G. Acid and intermediate sedimentary clastic volcanism, tertiary and tertiary [sic], Main Cordillera, Regions VII, VIII and IX – potential: 300 tU.

Uranium production

Outside of trial production mentioned above, no uranium has been produced in Chile.

Environmental activities and socio-cultural issues

The CHEN runs a permanent programme to disseminate information on peaceful uses of nuclear energy, attached to the Office of Dissemination and Public Relations (*Oficina de Difusión y Relaciones Públicas*).

Uranium requirements

Chile has achieved significant technological development in the manufacture of MTR-type (materials test reactor) combustible elements, based on U_3Si_2 (uranium silicide). In March 1998, the manufacture of 47 combustible elements began at the CCHEN combustible elements plant, ending in 2004. For this work, 60 kg of metallic uranium was purchased from the Russian Federation, enriched to 19.75% in ^{235}U, covering uranium requirements up to the indicated date. At the present time, 47 combustible elements have been manufactured, 16 of which are operating in the RECH-1 reactor, and another was sent to the Petten Research Centre in the Netherlands, to be classified under radiation in the high-flow reactor (HFR), which ended in November 2004.

Supply and procurement strategy

Should other loads of combustible elements be required, consideration will be given to purchasing enriched metallic uranium.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

There have been no changes in legislation relating to uranium in Chile.

Uranium stocks

There are no uranium stocks.

Undiscovered conventional resources (prognosticated and speculative resources)

Deposit	Type	Prognosticated tonnes U	Speculative tonnes U	Grade % U	Rocks hosting age
Cenozoic surface Deposits[1]	Surface	108.5	15.0		Diatomite, volcanic ash with organic material. PLIO – Pleistocene.
Cretaceous metasomatics[2]	Metasomatics	1 715	2 345	0.025-0.17	Intrusive, volcanic and metasomatic rocks. Upper cretaceous.
Cenozoic volcanogenics[3]	Volcanic	500	0	0.085-0.15%	Tuffs with high magnetite and haematite content. Mineralisation of secondary REE minerals observed. Oligocene pleistocene.
Total		**2 323.5**	**2 360**		

REE = rare earth elements.

1. Salar Grande (100 t), Pampa Camarones (4 t), Prosperidad - Quillagua (24 t).

   No new uranium prospecting has been done in the area of Cenozoic surface deposits.

2. Diego de Almagro Anomaly-2 (1 400 t); Diego de Almagro Alignment (1 500 t); Agua del Sol (50 t), Sierra Indiana (30 t), Sector Estación Romero: Carmen Prospect (50 t) and Productora Prospect (800 t), Tambillos district (100 t), Sector Pejerreyes - Los Mantos (130 t).

   In 1999-2000 at the Diego de Almagro Anomaly-2 (Cerro Carmen prospect), 1 400 tU was assigned as prognosticated and speculative undiscovered resources. The regional alignment that controls the mineralisation of this prospect extends 60 km to the north-west. This structure, visible in satellite images, involves other mining districts for which a potential of 1 500 tU of speculative resources is assigned.

3. In 1999-2000, data held by CCHEN was reviewed as part of the National Uranium Potential Evaluation Project. It was concluded that the acidic and intermediate volcanism present in a broad area of the Main Cordillera stretching from Regions I to III constituted an inclined plane dipping towards the west, ending in a lagoon environment situated in a central depression, with a similar conditions occurring to the east. This volcanism covered the pre-volcanic landscape, preserving the surface drainage courses (now paleochannels). The leaching of these volcanic rocks contributed large amounts of uranium into the lagoon systems, paleochannels and other structures in which solutions circulate. This process is represented by extensive layers of calcilutites, diatomites (Pampa Camarones), layers of salt (Salar Grande), argillites, limestones, limolites and volcanic ash (Quillagua, Prosperidad, Quebrada Amarga, Chiu Chiu), with uranium contents ranging between 100 and 1 000 ppm. These uranium occurrences and mineralisations have been classified historically as “surface deposits”. There are also paleochannels with copper and associated uranium (the Sagasca, Cascada, Huinquintipa, Quebrada Ichuno, Chuqui Sur, El Tesoro deposits and others). Within the volcanic area, uranium mineralisation (torbernite and autunite) has been discovered in volcanic structures containing iron (El Laco and El Perro). This environment is considered to have great potential and requires further research. In structures associated with the U mineralisation indicated above, 500 tU is assigned as EAR-II (now prognosticated).

Identified conventional resources (reasonably assured and inferred resources)

Deposit	Type	RAR tonnes U	IR tonnes U	Grade % U_3O_8	Rocks, hosting age
Cenozoic surface deposits(1)	Surface	28	40	0.023	Diatomite, volcanic ash with organic material (PLIO – Pleistocene)
Cretaceous metasomatics(2)	Metasomatics	720	1 043	0.028-0.20	Intrusive, volcanic and metasomatic rocks (Upper Cretaceous)
Cenozoic volcanogenics(3)	Volcanic	0	100	0.01-0.18	Magnetite and haematite tuffs. Secondary U-REE mineralisation (Oligocene Pleistocene)
Total		**748**	**1 183**		

Surface deposits:

1. Salar Grande (28 t), Mina Neverman (?), Boca Negra (3 t), Manuel Jesús (2.5 t), Mina Casualidad (?), Mina San Agustín (?), Quebrada Vítor (?), Pampa Chaca (2 t), Pampa Camarones (3.5 t), Quebrada Amarga (2 t), Quillagua (22 t), Prosperidad (?), Chiu Chiu (5 t).

Metasomatic deposits:

2. Estación Romero 326 t (Carmen and Productora prospects), Cerro Carmen prospect (1 391.8 t), Agua del Sol (15 t), Sector Pejerreyes - Los Mantos (20 t), Tambillos district (10 t). The following estimates were produced at the prospect of the Diego de Almagro Anomaly-2 (Cerro Carmen prospect) in 1999-2000, as a result of detailed geological and radiometry work, together with magnetometry, excavation and sampling of exploration trenches, undertaken as part of the activities of the co-operation agreement between ENAMI and CCHEN: Calculations indicate that the deposit hosts a total of 595.3 tU as indicated resources, 796.5 tU as inferred resources, making a total *in situ* of 1 391.8 tU as identified resources (RAR + inferred). The cost of extracting these resources was not estimated.

Volcanogenic deposits:

3. In the El Laco iron ore deposit, produced during Cenozoic volcanism on the "altiplano" of Region II (Antofagasta), a total of 100 tU (*in situ*) was identified as inferred.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related	0	0	0	540
Surficial	0	0	0	21
Total	**0**	**0**	**0**	**561**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	561	75
Total	**0**	**0**	**0**	**561**	**75**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	561	75
Total	**0**	**0**	**0**	**561**	**75**

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related	0	0	0	75
Metasomatite	0	0	0	782
Surficial	0	0	0	30
Total	**0**	**0**	**0**	**887**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	887	75
Total	**0**	**0**	**0**	**887**	**75**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	887	75
Total	**0**	**0**	**0**	**887**	**75**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	2 324

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	NA	2 360

Reasonably assured unconventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Copper deposit	0	0	0	754
Phosphorite	0	0	0	415
Total	**0**	**0**	**0**	**1 169**

Reasonably assured unconventional resources by mining method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	1 169	65
Total	**0**	**0**	**0**	**1 169**	**65**

Reasonably assured unconventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Co-product/by-product	0	0	0	1 169	65
Total	**0**	**0**	**0**	**1 169**	**65**

Prognosticated unconventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	1 818

Speculative unconventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	3 640

China, People's Republic of

Uranium exploration and mine development

Historical review

Before 1990s, China's uranium resource exploration activities were mainly carried out on hydrothermal-related granite-type and volcanic-type uranium deposits in the Jiangxi, Hunan and Guangdong provinces and the Guangxi Autonomous Region of southern China. With decades of exploration experience, the Bureau of Geology (BOG), China National Nuclear Corporation (CNNC), had been successful in discovering some significant uranium deposits such as the Xiangshan and Xiazhuang ore fields and the Chengxian deposit in the Southern China Fold Belt. These deposits mainly occur in intermediate to acid magmatic rocks (such as granitoid) and volcanic rocks. As a number of these deposits are of relatively small size, low to middle grade and their transportation and power supply are not easily accessible, the mining cost turned out to be much higher than those that could be accepted by the commercial nuclear reactor operators. At the beginning of 1990s, when China initiated its nuclear energy programme, the demand for uranium from China's NPPs was not so urgent. In the mid-1990s, China experienced relatively high currency inflation, resulting in a decrease in uranium exploration activities in China from the mid to the end of 1990s.

Facing financial difficulties, as well as the challenge of meeting demand for economic uranium resources for China's mid-term and long-term nuclear energy development plan, the BOG made the decision of changing its prospecting direction from "hard rock" types to *in situ* leach amenable deposits in northern and north-west China. From the mid-1990s, the pace of construction of NPPs in coastal areas increased, and accordingly the demand of uranium increased steadily. As the low-cost identified uranium resources declined, the BOG initiated in the early 1990s with limited funding some regional geological reconnaissance projects and drilling survey projects in the Yili, Turpan-Hami, Junggar, Er'lian and Songliao basins in northern and north-west China. Due to limited funding from the government, the average annual drilling footage was just maintained at about 40 000 m. In 1999, the government conducted a significant structural reform in China's mineral exploration sector, during which a large part of the personnel who had been involved in geological exploration were transferred to local governments. After the transfer of most of the geological organisations, the staff of BOG was reduced from more than 45 000 to near 5 500. At the end of 1990s, the government gradually became aware of the importance of increasing uranium resources of economic interest to meet rising demand from the domestic nuclear power industry. Beginning in 2000, investment in uranium exploration steadily increased and drilling rebounded from 40 000 m to 70 000 m in 2000, gradually increasing to 130 000 m in 2003 and 140 000 m in 2004. All this drilling was directed at identifying ISL amenable sandstone-type uranium deposits in northern China, with important target areas including the Yili, Erdos, Turpan-Hami, Er'lian, Junggar and Songliao basins.

Since 2008, CGNPC Uranium Resources Co., Ltd (renamed CGNPC Nuclear Fuel Co., Ltd in 2012), a subsidiary of China General Nuclear Power Group (CGNPC), has carried out domestic uranium resources exploration, including several uranium exploration projects in the northern edge of Tarim basin in Xinjiang Uygur Autonomous Region and the northern part of Guangdong province.

Recent and ongoing uranium exploration and mine development activities

Domestic uranium prospecting and exploration have intensified and increased due to additional financial input. The scope of work has also been expanded to potential prospects selected after regional prognosis and assessment has been completed, apart from the continued prospecting and exploration on areas within previously discovered metallogenic regions/belts.

The exploration, including regional uranium potential assessment and further works on previously discovered mineralisation and deposits in northern China has principally been focused on the Yili, Turpan-Hami, Junggar and Tarim basins of the Xinjiang Autonomous Region; the Erdos, Erlian, Songliao, Badanjili and Bayingebi basins of Inner Mongolia; the Caidaum basin in Qinghai province and the Jiuquan basin in Gansu province.

Different geophysical methods, such as audio magnetotellurics (AMT), controlled source audio magnetotellurics (CSAMT), combined with some drilling and shallow seismic methods were used in these assessments, followed by further drilling in mineralised areas in order to identify ISL amenable sandstone-type deposits, conventional mining mudstone-type deposits and shallow sandstone-type deposits.

The exploration work in southern China is directed at identifying metallogenic belts relating to volcanic-type and granite-type deposits, distributed in the Xiangshan and Taoshan uranium fields in Jiangxi province; the Xiazhuang and Zhuguang uranium fields in Guangdong province; the Miaoershan uranium field in the Guangxi Autonomous Region; the Lujing field in Hunan province; the Daqiaowu field in Zhejiang province and the Ruoergai area of Sichuan province. Potential deposits in Carbonaceous siliceous mudstones are secondary targets in this exploration campaign.

The total drilling footage completed in the last two years amounted to over 1 700 000 m (820 000 m in 2011 and 920 000 m in 2012). As a result, uranium resources in northern China such as those contained in the Yili, Tarim, Erdos, Erlian, Songliao basins have been dramatically increased, especially the large Daying deposit which was discovered in the Erdos basin. In addition, important progress has been achieved in old mining areas of southern China, such as the Xiangshan, Taoshan, Xiazhuang, Zhuguangnanbu and Dazhou uranium fields.

Referring to the CNNC's overseas uranium development, the Azelik Uranium Project in Niger entered the pilot production stage in 2011 and produced 300 tons of uranium by the end of 2012. The Semizbay and Irkol mines in Kazakhstan, which were invested together with CGNPC, had produced 4 200 tons of uranium by the end of 2012. CGNPC acquired the Husab Project in Namibia in 2012 and the project is under construction and with operation expected to begin in 2015.

In addition, the above-mentioned Chinese companies have also carried out exploration activities in Australia, Mongolia, Namibia, Uzbekistan and Zimbabwe completing over 140 000 m drilling in two years. In Namibia, a new deposit (No. 18) was discovered in Happy Valley. In addition, the resources and confidence level of other projects have also been improved.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As a result of the exploration in 2011 and 2012, a total of about 44 000 tU, categorised RAR and IR, have been added to China's uranium resource base. These additional resources are distributed in northern China (a total of 28 000 tU in the Yili, Erlian, Erdos, Songliao and Benxi basins) and in southern China (a total of 16 000 tU in the Xiangshan, Taoshan, Zhuguangnanbu and Dazhou uranium fields). As of 1 January 2013, uranium resources in China totalled 265 500 tU according to this latest data, as listed in the following table.

No.	Location (province + place/name)		tU
1	Jiangxi	Xiangshan	32 000
		Ganzhou	12 000
		Taoshan	12 500
2	Guangdong	Xiazhuang	15 000
		Zhuguangnanbu	25 000
		Heyuan	4 000
3	Hunan	Lujin	9 000
4	Guangxi	Ziyuan	11 000
5	Xinjiang	Yili	33 000
		Tuha	10 000
6	Inner Mongolia	Erdos	35 000
		Erlian	40 000
		Tongliao	4 000
7	Hebei	Qinglong	8 000
8	Yunnan	Tengchong	6 000
9	Shanxi	Lantian	2 000
10	Zhejiang	Dazhou	5 000
11	Liaoning	Benxi	2 000
Total			**265 500**

Undiscovered conventional resources (prognosticated and speculative resources)

China has great potential for uranium resources. According to statistical studies conducted by several institutes in China, 2 million tonnes of potential uranium resources are predicted. Favourable areas in the Erlian basin of the Inner Mongolia Autonomous Region have been identified in the last few years and other areas such as the Tarim and Junggar basins in the Xinjiang Autonomous Region and the Songliao basin in north-east China are regarded as favourable target areas. More uranium resources may also be added to the known uranium deposits in southern China as prospecting and exploration works continue.

Unconventional resources and other materials

No systematic appraisal of unconventional uranium resources has been conducted in China.

Uranium production

Historical review

The more than 50-year history of China's uranium industry has included both a boom in activities during the first two decades and a decline in late 1980s to 1990s. In the early 2000s, a surge in activities took place, driven principally by the ambitious new NPP construction programme announced by the Chinese government and the increased uranium spot price. As a result, uranium production became a focus again.

As uranium demand from NPPs is increasing rapidly in the coming decade, China has accelerated the pace of domestic uranium exploitation. Several uranium production centres such as Fuzhou and Yining are being developed and put into construction to keep pace with the uranium mining production in those regions. On the other hand, in order to promote uranium production, the development of other uranium deposits with potential reserves if appropriate technology is available, such as Tongliao uranium deposit, has been accelerated. Finally some new sandstone uranium deposits with abundant reserves that are suitable for ISL mining, such as Erduos and Erlian, are undergoing pilot tests and feasibility studies.

Status of production capability

There are currently a total of six production centres in China: Fuzhou and Chongyi in Jiangxi province, east China; Lantian in Shaanxi province, central China; Benxi in Liaoning province, north-east China; Shaoguan in Guangdong province, south China; and Yining in the Xinjiang Autonomous Region of north-west China. The Fuzhou production centre is an underground mine, which exploits Xiangshan volcanic uranium resources with conventional ion-exchange processing. Currently exploited ore zones have steady capacity and primary preparation and sampling of potential new ore zones is in progress.

The Chongyi production centre in the Jiangxi province, is an underground mine, which exploits Ganzhou and Taoshan granite uranium resources with a hydro-metallurgical process using heap leaching and ion-exchange. Production capacity of this centre has been steady in recent years and a previously closed pit is now under remediation.

The Yining facility in the Xinjiang Autonomous Region is an ISL production centre, which exploits Yili and Tuha sandstone-hosted uranium resources using ion-exchange. This centre supports development of sandstone-hosted uranium resources in the Kujieertai deposit and its neighbouring areas, such that expansion plans and increased production capacity are expected to occur relatively rapidly.

The Benxi production centre in the Liaoning province is an underground mine, which exploits Benxi granite-type and Qinglong volcanic-type uranium resources with heap leaching and solvent extraction. The Shaoguan production centre in the Guangdong province is an underground mine, which exploits Xiazhuang and Zhuguang granite-type uranium resources using heap leaching and solvent extraction. Shaogun is now developing uranium resources of the Guangxi Region and will gradually increase production capacity.

Uranium production in China amounted to 1 400 tU in 2011 and 1 450 tU in 2012. It is expected to remain steady at 1 450 tU in 2013.

Ownership structure of the uranium industry

The uranium industry is owned by state companies in China.

Employment in the uranium industry

With a few new mines and uranium production centres undertaking and preparing for pilot tests, new employees are required. Hence, employment in the industry will increase slightly.

Future production centres

Industry tests have been launched on the sandstone-hosted uranium deposit in the Tongliao area and a corresponding expansion at the associated production centre is planned. ISL tests are being carried out in some parts of the Erdos and Erlian uranium deposits in order to obtain relative technical parameters and economic indicators of these two deposits and provide reliable technical support for the development of sandstone-hosted uranium deposits in Inner Mongolia. Driven by the active nuclear power development strategy in China, some of the current sub-economic uranium mines are expected to be put into operation again.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5		Centre #6
Name of production centre	Fuzhou	Chongyi	Yining	Lantian	Benxi		Shaoguan
Production centre classification	Existing	Existing	Existing	Existing	Existing	Existing	Existing
Date of first production	1966	1979	1993	1993	1996	2007	NA
Source of ore:							
Deposit name(s)			Kujieertai	Lantian	Benxi	Qinglong	
Deposit type(s)	Volcanic	Granite	Sandstone	Granite	Granite	Volcanic	Granite
Resources (tU)	NA	NA	NA	NA	NA	NA	NA
Grade (% U)	NA	NA	NA	NA	NA	NA	NA
Mining operation:							
Type (OP/UG/ISL)	UG	UG	ISL	UG	UG	UG	UG
Size (tonnes ore/day)	700	500	NA	200	100	200	500
Average mining recovery (%)	92	90	NA	80	85	85	90
Processing plant:							
Acid/alkaline	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Type (IX/SX)	IX	IX	IX	IX	SX	IX	SX
Size (tonnes ore/day); for ISL (l/day or l/h)	700	500	NA	NA	NA	NA	NA
Average process recovery (%)	90	84	NA	90	90	96	90
Nominal production capacity (tU/year)	350	200	380	100	120	100	200
Plans for expansion	Up to 500	Up to 300	Up to 500	NA	NA	Up to 200	Up to 300
Other remarks	NA	NA	NA	NA	NA	NA	NA

Uranium requirements

As of 1 January 2011, the total installed capacity of NPPs is 12 500 MWe (gross). Annual uranium requirements amount to about 4 200 tU. According to the government's nuclear power programme, the total capacity of NPPs will reach between 40 GWe and 58 GWe by the end of 2020. Based on preliminary calculations, uranium requirements will amount to between 6 450 tU and 8 200 tU in 2015 and 2020, then rise to between 12 300 and 16 200 tU in 2025 and 2030, then increase to 14 400 and 20 500 tU in 2035.

Supply and procurement strategy

In order to meet the demand of NPPs planned within the development programme approved by the central government, the policy "Facing Two Markets and Using of Two Kinds of Resources" has been adopted. This means that China will actively develop domestic uranium resources and make full use of non-domestic resources and mine development in advance of requirements. Uranium supply will be guaranteed through a combination of domestic production, development of non-domestic resources and international trade to ensure a stable supply of nuclear fuel. As a supplement to national supply and to balance uranium supply, international supply will be acquired through different channels in order to reduce market risks, ensure stable supply and to realise reasonable prices.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

In order to meet the demand driven by increasing domestic nuclear power development, the Chinese government has given greater importance to uranium fuel supply. Measures taken by the central government include intensification of uranium exploration in China, promotion of domestic production, introduction of regulations to allow non-government organisations to explore for uranium in China, and further development of the "two markets and two resources" policy, including overseas purchases and production.

Uranium stocks

NA.

Uranium prices

The uranium price has been gradually streamlined with the international market price in order to follow the global trend of uranium prices. Accordingly, it is priced in China following the fluctuations in the international market.

CNNC uranium exploration and development expenditures – non-domestic

(USD millions)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	9.18	14.05	8.62	8.62
Government exploration expenditures				
Industry* development expenditures	85.77	80.69	73.07	554.75
Government development expenditures				
Total expenditures	**94.95**	**94.74**	**81.69**	**563.37**

* Non-government.

Uranium exploration and development expenditures and drilling effort – domestic

(USD millions)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	12	29	35	31
Government exploration expenditures	69	79	85	85
Industry* development expenditures	8	10	11	12
Government development expenditures	0	0	0	0
Total expenditures	**89**	**118**	**131**	**128**
Industry* exploration drilling (m)	94 400	222 600	272 600	250 700
Industry* exploration holes drilled	216	509	692	643
Government exploration drilling (m)	530 000	600 000	650 000	650 000
Government exploration holes drilled	1 600	1 710	1 800	1 800
Industry* development drilling (m)	NA	NA	NA	NA
Industry* development holes drilled	NA	NA	NA	NA
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	624 400	822 600	922 600	900 700
Subtotal exploration holes drilled	1 816	2 219	2 492	2 443
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**624 400**	**822 600**	**922 600**	**900 700**
Total number of holes drilled	**1 816**	**2 219**	**2 492**	**2 443**

* Non-government.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	23 000	52 000	74 000	NA
Open-pit mining (OP)	0	0	0	NA
In situ leaching acid	46 000	73 000	86 000	NA
In situ leaching alkaline	0	0	0	NA
Co-product and by-product	0	0	0	NA
Unspecified	0	0	0	NA
Total	**69 000**	**125 000**	**160 000**	**NA**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	23 000	52 000	74 000	NA
Conventional from OP	0	0	0	NA
In situ leaching acid	46 000	73 000	86 000	NA
In situ leaching alkaline	0	0	0	NA
In-place leaching**	0	0	0	NA
Heap leaching*** from UG	0	0	0	NA
Heap leaching*** from OP	0	0	0	NA
Unspecified	0	0	0	NA
Total	**69 000**	**125 000**	**160 000**	**NA**

* *In situ* resources.

** Also known as stope leaching or block leaching.

*** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	5 600	46 000	62 500	NA
Open-pit mining (OP)	0	0	0	NA
In situ leaching acid	12 900	27 000	43 000	NA
In situ leaching alkaline	0	0	0	NA
Co-product and by-product	0	0	0	NA
Unspecified	0	0	0	NA
Total	**18 500**	**73 000**	**105 500**	**NA**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	5 600	46 000	62 500	NA
Conventional from OP	0	0	0	NA
In situ leaching acid	12 900	27 000	43 000	NA
In situ leaching alkaline	0	0	0	NA
In-place leaching**	0	0	0	NA
Heap leaching*** from UG	0	0	0	NA
Heap leaching*** from OP	0	0	0	NA
Unspecified	0	0	0	NA
Total	**18 500**	**73 000**	**105 500**	**NA**

* *In situ* resources.

** Also known as stope leaching or block leaching.

*** A subset of open-pit and underground mining, since it is used in conjunction with them.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Proterozoic unconformity	NA	0	0	0	NA	0
Sandstone	NA	330	330	380	NA	380
Polymetallic Fe-oxide breccia complex	NA	0	0	0	NA	0
Paleo-quartz-pebble conglomerate	NA	0	0	0	NA	0
Granite-related	NA	570	620	620	NA	620
Metamorphite	NA	0	0	0	NA	0
Intrusive	NA	0	0	0	NA	0
Volcanic-related	NA	450	450	450	NA	450
Metasomatite	NA	0	0	0	NA	0
Surficial	NA	0	0	0	NA	0
Carbonate	NA	0	0	0	NA	0
Phosphate	NA	0	0	0	NA	0
Collapse-breccia type	NA	0	0	0	NA	0
Lignite and coal	NA	0	0	0	NA	0
Black shale	NA	0	0	0	NA	0
Other/unspecified	NA	0	0	0	NA	0
Total	**NA**	**1 350**	**1 400**	**1 450**	**NA**	**1 450**

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	NA	350	350	350	NA	350
In-place leaching*	NA	100	120	120	NA	120
In situ leaching	NA	330	330	380	NA	380
Heap leaching**	NA	570	600	600	NA	600
U recovered from phosphate rocks	NA	0	0	0	NA	0
Other methods***	NA	0	0	0	NA	0
Total	**NA**	**1 350**	**1 400**	**1 450**	**NA**	**1 450**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	NA	0	0	0	NA	0
Underground mining[1]	NA	1 020	1 070	1 070	NA	1 170
In situ leaching	NA	330	330	380	NA	380
Co-product/by-product	NA	0	0	0	NA	0
Total	**NA**	**1 350**	**1 400**	**1 450**	**NA**	**1 450**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
1 450	100								

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	7 560	7 650	7 660	7 670
Employment directly related to uranium production	6 860	6 950	6 960	6 970

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	82.6	92.7

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Installed nuclear generating capacity to 2035*

(MWe net)

2011	2012	2013**		2015		2020		2025		2030		2035	
11 816	12 860	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		16 000	18 000	25 000	35 000	40 000	58 000	58 000	71 300	71 300	83 800	83 800	108 800

* 2015-2035 capacity projections from 2011 Red Book.

** Secretariat estimate.

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
3 900*	4 200*	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		4 600*	5 000*	6 450	8 200	6 450	8 200	12 300	16 200	12 300	16 200	14 400	20 500

* Secretariat estimate.

Czech Republic

Uranium exploration and mine development

Historical review

Following its start in 1946, uranium exploration in Czechoslovakia grew rapidly and developed into a large-scale programme in support of the country's uranium mining industry. A systematic exploration programme including geological, geophysical and geochemical surveys and related research was carried out to assess the uranium potential of the entire country. Areas with identified potential were explored in detail using drilling and underground exploration methods.

Exploration continued in a systematic manner until 1989, with annual exploration expenditures in the range of USD 10-20 million and an annual drilling effort in the range of 70-120 km. Exploration was traditionally centred around vein deposits located in metamorphic complexes (Jáchymov, Horní Slavkov, Príbram, Zadní Chodov, Rozná, Olsí and other deposits), granitoids (Vítkov deposit) of the Bohemian massif and around the sandstone-hosted deposits in northern and north-western Bohemia (Hamr, Stráz, Brevniste, Osecná-Kotel, Hvezdov, Vnitrosudetská pánev, Hájek and other deposits).

In 1989, the decision was made to reduce all uranium-related activities. Following this decision, in 1990, expenditures decreased to about USD 7 million and have declined since. No field exploration has been carried out since the beginning of 1994.

Recent and ongoing uranium exploration and mine development activities

Recent uranium exploration activities have been focused on the conservation and processing of previously collected exploration data from Czech uranium deposits. Advance processing of the exploration data and building the exploration database will continue in 2013.

Uranium resources

Historically, most of the known uranium resources of the Czech Republic occurred in 23 deposits, of which 20 have been mined out or closed. Of the three remaining deposits, only Rozná and Stráz are being mined. Resources at the Stráz deposit are, however, limited due to remediation process. Other deposits (the Osecná-Kotel part of the Stráz bloc and Brzkov) have resources that are not mineable because of environmental protection.

In 2012, in preparation of the new State Energy Concept as well as the Concept of the Raw Materials and Energy Security of the Czech Republic, technical and economic re-evaluation of remaining uranium resources was undertaken. This has resulted in an increase of uranium resources in some cost categories.

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2013, total identified conventional resources (RAR and IR) amounted to 119 256 tU, an increase of 118 882 tU from estimates as of 1 January 2011. This significant increase was due to the re-evaluation and reclassification of uranium resources that have not been reported until now because of high mining costs, unfavourable uranium resource development policies and environmental protection legislation.

In detail, the reasonably assured resources recoverable at a cost of <USD 130/kgU amounted to 1 255 tU, an increase of 951 tU compared with the previous estimates. These are recoverable resources in existing production centres at the Rozná and Stráz deposits. The reasonably assured resources recoverable at a cost of <USD 260/kgU amounted to 50 955 tU, an increase of 100% compared to the estimates as of 1 January 2011.

Inferred resources at a cost of <USD 130/kgU amounted to 101 tU, an increase of 31 tU compared with the previous estimates. These additional resources are tributary to the Rozná and Stráz deposits. Inferred resources recoverable at a cost of <USD 260/kgU amounted to 68 301 tU, an increase of 100% compared the estimations as of 1 January 2011. These high cost resources are located in the Stráz bloc (the Stráz, Hamr, Osecná-Kotel and Brevniste deposits) and remain strictly protected due to environmental concerns.

Undiscovered conventional resources (prognosticated and speculative resources)

As of 1 January 2013, total undiscovered conventional resources (PR and SR) have been increased to a total of 240 060 tU. Prognosticated resources at a cost <USD 130/kgU totalling 180 tU, unchanged from previous estimates, are located at the Rozná deposit only. Prognosticated resources at a cost <USD 260/kgU amounted to 222 880 tU, an increase of 222 700 tU from estimates as of 1 January 2011 due to re-evaluation and general reclassification of uranium resources in the Czech Republic. These resources occur mainly (98%) in the sandstone deposits of the Northern Bohemian Cretaceous basin (Stráz block, Tlustec block and Hermanky deposits) and to a lesser extent (2%) in the metamorphic complex of Western Moravia (Rozná and Brzkov deposits).

Speculative resources at a cost about or more than USD 260/kgU are estimated to amount to 17 000 tU and are reported in the unassigned cost category. Since these resources occur in Northern Bohemian Cretaceous sandstone deposits in a groundwater source protection zone, further exploration and evaluation is not permitted.

Uranium production

Historical review

Industrial development of uranium production in Czechoslovakia began in 1946. Between 1946 and the dissolution of the Soviet Union, all uranium produced in Czechoslovakia was exported to the Soviet Union.

The first production came from Jáchymov and Horní Slavkov mines, which completed operations in the mid-1960s. Príbram, the main vein deposit, operated from 1950 to 1991. The Hamr and Stráz production centres, supported by sandstone deposits, started operation in 1967. Peak annual national production of about 3 000 tU was reached around 1960 and production remained between 2 500 and 3 000 tU/yr from 1960 until 1989/1990 and declined thereafter. A cumulative total of 111 396 tU was produced in the Czech Republic during the period 1946-2012, of which about 85% was produced by underground and open-pit mining methods and the remainder was recovered by ISL.

Status of production facilities, production capability, recent and ongoing activities and other issues

Two production centres remain in the Czech Republic. One is a conventional deep mine and mill (Rozná) in the Dolni Rozinka uranium production centre (Western Moravia) and the second is a chemical mining centre in Stráz pod Ralskem (Northern Bohemia). Both the Dolni Rozinka and Stráz pod Ralskem production centres are wholly operated by the state-owned enterprise DIAMO.

The Dolni Rozinka centre (Rozná metamorphite deposit, resources of 311 tU, stoping at 1 100 m underground) produced 202 tU in 2011 and 203 tU in 2012. Expected production in 2013 is 188 tU (these figures do not include U recovered from water treatment). Because the remaining resources are located in the deepest boundary parts of the mine, they are expected to be recovered at a higher cost and will result in a gradual decrease in production.

At the Stráz pod Ralskem chemical mining centre (Stráz sandstone deposit, with resources of 1 045 tU recoverable at cost <USD 260/kgU), the former acid ISL (c. 180 m underground) production centre, produced 12 tU and 15 tU in 2011 and 2012, respectively. Uranium production at this centre results from environmental remediation activities that began in 1996. Production capability during remediation (without acid) has decreased due to lower uranium concentration in solutions. Production in 2013 is expected to amount to 15 tU in 2013 and is anticipated to decrease thereafter.

Uranium is also obtained from mine water treatment (at existing and former facilities), with a total recovery of 15 tU expected in 2013 (not including U recovery from ISL mining restoration activities).

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2
Name of production centre	Dolni Rozinka	Stráz pod Ralskem
Production centre classification	Existing	Existing
Date of first production	1957	1967
Source of ore:		
Deposit name(s)	Rozna	Stráz
Deposit type(s)	Metamorphite	Sandstone
Recoverable resources (tU)	311	1 045
Grade (% U)	0.251	0.030
Mining operation:		
Type (OP/UG/ISL)	UG	ISL
Size (tonnes ore/day)	550	-
Average mining recovery (%)	91.5	60.0 (estimated)
Processing plant:		
Acid/alkaline	Alkaline	Acid
Type (IX/SX)	IX, CWG	IX
Size (tonnes ore/day) For ISL (mega or kilolitre/day or litre/hour, specify)	530 -	- 540
Average process recovery (%)	90.4	92
Nominal production capacity (tU/year)	300	100
Plans for expansion	No	No
Other remarks	-	Production under remediation process

CWG = carburetted water gas.

Ownership structure of the uranium industry

All uranium activities, including exploration, production and related environmental activities are being carried out by the state-owned enterprise, DIAMO, a mining and environmental engineering company, based in Stráz pod Ralskem.

Employment in the uranium industry

Total employment in the Czech uranium production centres was 2 118 workers in 2011 and 2 126 workers in 2012 (i.e. employment related to production including head office, auxiliary divisions, mining emergency services).

Employment directly related to uranium production at Dolni Rozinka and Stráz pod Ralskem centres was 1 149 in 2011 and 1 147 in 2012, however some uranium production is associated with remediation.

Future production centres

No other production centres are committed or planned in the near future.

Secondary resources of uranium

Production and/or use of mixed oxide fuels

The Czech power utility ČEZ, a.s., as the sole owner and operator of NPPs in the Czech Republic, does not use MOX fuels in its reactors.

Production and/or use of re-enriched tails

ČEZ, a.s. does not use re-enriched tails in its reactors.

Production and/or use of reprocessed uranium

ČEZ, a.s. does not use RepU in its reactors.

Environmental activities and socio-cultural issues

Both the environmental activities and the resolution of social issues are the responsibility of the government contraction programme of the Czech uranium mining industry. These activities began in 1989. Although this programme was formally terminated in 2009, extensive environmental remediation projects and projects with a focus on associated social issues continue to be funded by the state budget and EU.

These projects aim to gradually decrease employment related to declining uranium production and develop alternative (mainly environmental) projects to address social issues.

In general, the environmental activities include project preparation, environmental impact assessment, decommissioning, tailings impoundments and waste rock management, site rehabilitation and maintenance, water treatment and long-term monitoring.

The key environmental remediation projects are as follows:

- Remediation of the after-effects of the ISL used in Stráz pod Ralskem that impacted a total 266 million m^3 groundwater and an enclosure of 600 ha surface area.
- Rehabilitation of the tailings impoundments in Mydlovary, Pribram, Stráz pod Ralskem and Rozná (a total of 19 ponds with a total area 589 ha).

- Rehabilitation (incl. reprocessing) of the waste rock dumps in Pribram, Hamr, Rozná, Western Bohemia and other sites (a total of 67 dumps with a capacity 38.2 million m^3).
- Mine water treatment from former uranium facilities in Pribram, Stráz, Horní Slavkov, Licomerice, Olsi and others, amounting to a total of approximately 15.8 million m^3/yr which, results in the recovery of about 14 tU annually).

The major part of environmental expenses (about 85%) is being funded by the state budget, with the remainder financed by the EU (9-12%) and DIAMO (3-6%). Since 1989, CZK 36.766 million (Czech koruna – about USD 1.8 million) has been spent on the environmental remediation projects. The projects, expected to continue until approximately 2040, are expected to cost in total more than CZK 60 000 million (about USD 3 billion).

The social part of the programme (obligatory spending, compensation, damages, rent) is financed entirely by the state budget.

Expenditures related to environmental activities and social issues

(CZK millions)

	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Uranium environmental remediation	28 820	2 460	3 110	2 376	36 766	2 728
Social programme and social security	7 799	408	383	328	8 918	297
Total	**36 619**	**2 868**	**3 493**	**2 704**	**45 684**	**3 025**

Uranium requirements

There are two NPPs with a total of six units in operation in the Czech Republic. The older Dukovany NPP with four VVER-440 reactors, upgraded up to 510 MWe (gross) in the period of 2009-2012, and the younger Temelin NPP with two VVER 1 000 MWe (gross) reactors. The sole owner and operator of these NPPs is the Czech power company ČEZ, a.s. Both NPPs proved a good operational performance in 2011 and 2012, which resulted in record amounts of electricity generated in both years.

Transition to a new fuel supplier (TVEL Russian Fuel Company) at the Temelin NPP was carried out via the replacement of the entire fuel cores in both reactors, which meant higher uranium needs in 2010 and 2011. After finalising the transition period to balanced fuel reloads in 2013/2014, further fuel reloads will be designed to uprate power generation by 4%. At the Dukovany NPP, improved fuel with a higher content of enriched uranium product (EUP) in the fuel assemblies will be deployed from 2016. These improvements will lead to a 35 tU increase in annual uranium needs after 2015 (from the current 640 tU to about 675 tU).

In 2012, ČEZ, a.s. received bids for the construction of two additional units at the Temelin site (Temelin 3 and 4) within the framework of an open tender for new nuclear build. A contract for the construction of two new units was to be signed by the end of 2013, but the unexpected fall of the government in June has delayed this process, in turn likely pushing back the original schedule of construction beginning in 2016-17 and operation beginning in 2023-2025.

The following additional assumptions were considered in the projection of the long-term Czech nuclear generation capacities and uranium needs:

- fifty years of the Dukovany reactors lifetime instead of the previously considered forty years;

- new lead-times and higher uranium needs for the new Temelin unit 3 and unit 4 in comparison with previous assumptions (uranium supplies for the first fuel cores are scheduled already in about 2020);
- for 2025, only the first new Temelin unit 3 is to be in full production, generation from unit 4 which shall start in 2025 is considered as not substantial for that year;
- launching of one additional reactor at the Dukovany site was delayed for two years from 2030 to about 2032.

Supply and procurement strategy

ČEZ, a.s. has been procuring uranium on the basis of long-term contracts. About one third of its uranium needs has been currently covered from domestic production of DIAMO, s.p. Some uranium has been purchased in the form of already fabricated fuel, delivered from the Russian fabricator TVEL as a package. ČEZ, a.s. has been exploiting such a supply opportunity within the framework of so-called "grandfathered" fuel contract under the EURATOM supply policy.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The reduction programme of the Czech uranium industry from the end of the 1980s has already been formally terminated.

On the basis of the last government decision (Government Decree No. 548/2012 Coll.), the existing Rozná uranium deposit will be mined by DIAMO as long as it can be done profitably with no government financial assistance. According to the government's Concept of the Raw Materials and Energy Security of the Czech Republic, a feasibility study of early development at Brzkov uranium deposits will be undertaken, as well as new technological possibilities of uranium mining that strictly respect environmental protection. The results should be known after 2014.

The government of the Czech Republic maintains a positive nuclear policy. Political support for the completion of the Temelin NPP is an important, ground-breaking decision for possible future development of nuclear power.

Uranium stocks

The Czech power company ČEZ, a.s. does not publish data concerning its uranium stocks. It is assumed that it holds total stockpiles that amount to a minimum of two years of its needs in all forms of processed uranium. A substantial portion of the stocks is held as already fabricated fuel at the Dukovany NPP.

Uranium prices

Uranium prices are not available as they are commercially confidential. In general, uranium prices in supply contracts between the domestic producer DIAMO, s.p. and ČEZ, a.s. reflect price indicators of the world market incorporated according to agreed formulas.

Uranium exploration and development expenditures and drilling effort – domestic

(CZK millions)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	0.1	0.2	0.2	0.2
Government exploration expenditures	0	0	4.0	4.0
Industry* development expenditures	0	0	0	0
Government development expenditures	0	0	0	0
Total expenditures	0.1	0.2	4.2	4.2
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	0	0	0	0
Subtotal exploration holes drilled	0	0	0	0
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	0	0	0	0
Total number of holes drilled	0	0	0	0

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	1 045	49 245
Metamorphite	0	0	210	1 710
Total	**0**	**0**	**1 255**	**50 955**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	210	1 710	92
In situ leaching acid	0	0	1 045	49 245	60
Total	**0**	**0**	**1 255**	**50 955**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	210	1 710	90
In situ leaching acid	0	0	1 045	49 245	92
Total	**0**	**0**	**1 255**	**50 955**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	0	67 800
Metamorphite	0	0	101	501
Total	**0**	**0**	**101**	**68 301**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	101	501	92
In situ leaching acid	0	0	0	67 800	60
Total	**0**	**0**	**101**	**68 301**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	101	501	90
In situ leaching acid	0	0	0	67 800	92
Total	**0**	**0**	**101**	**68 301**	

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	180	222 880

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	17 000

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Proterozoic unconformity	NA	0	0	0	NA	0
Sandstone	32 809	13	12	15	32 849	15
Granite-related	NA	0	0	0	NA	0
Metamorphite*	NA	241	217	213	NA	198
Metasomatite	NA	0	0	0	NA	0
Lignite and coal	NA	0	0	0	NA	0
Other/unspecified	NA	0	0	0	NA	0
Total	**110 685**	**254**	**229**	**228**	**111 396**	**213**

* Includes uranium recovered from mine water treatment; 17 tU in 2010, 15 tU in 2011 and 10 tU in 2012

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Underground mining*	93 210	241	217	213	93 881	198
In situ leaching	17 475	13	12	15	17 515	15
Total	**110 685**	**254**	**229**	**228**	**111 396**	**213**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	108 084	224	202	203	108 713	188
In-place leaching*	3	0	0	0	3	0
Heap leaching**	125	0	0	0	125	0
Other methods***	2 473	30	27	25	2 555	25
Total	**110 685**	**254**	**229**	**228**	**111 396**	**213**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
228	100	0	0	0	0	0	0	228	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	2 164	2 118	2 126	2 141
Employment directly related to uranium production	1 118	1 139	1 147	1 150

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	500	500	0	0	500	500	0	0	50	50

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	50	50	0	0	50	50	0	0	30	30

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
3 760	3 820	3 820	3 850	3 850	3 880	3 900	3 920	5 900	6 100	5 900	6 100	7 100	7 200

Annual reactor-related uranium requirements to 2035 (excluding MOX)

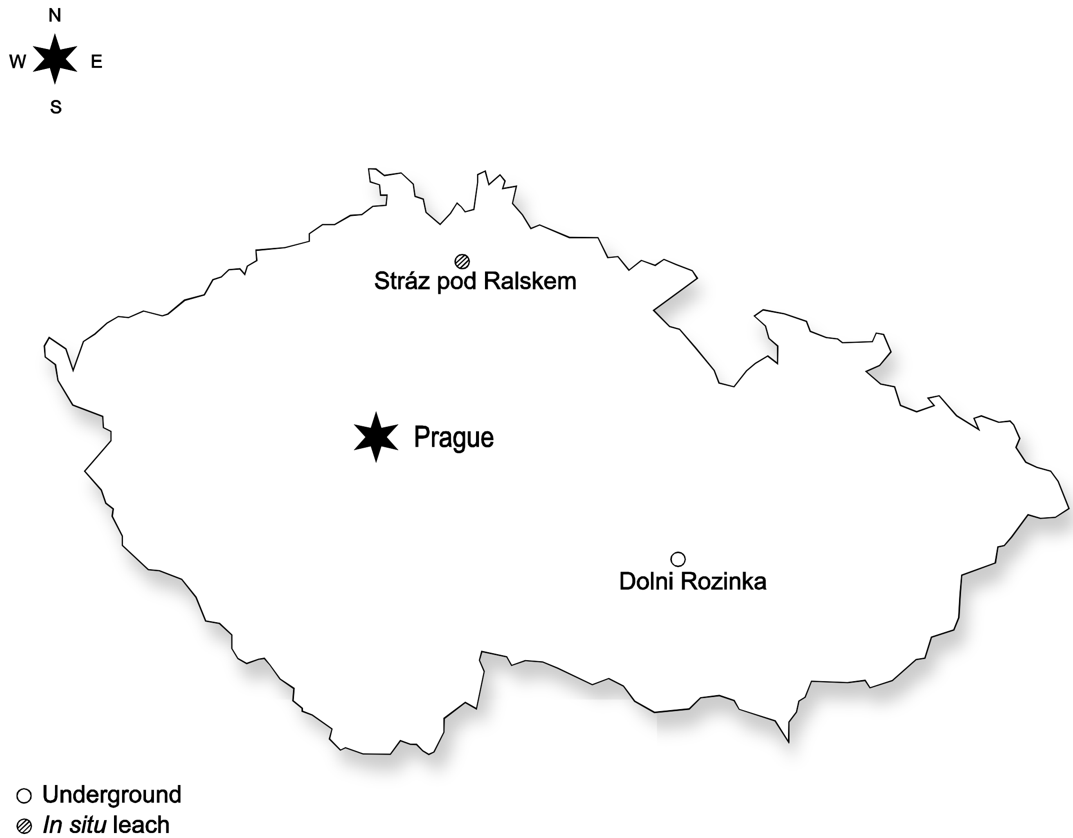
(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
867	670	635	640	650	655	955	970	885	890	1 090	1 100	1 100	1 500

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	0	0	0	0	0
Producer		0	0	0	
Utility	NA	NA	0.25	0	0.25
Total		0	0.25	0	



Finland

Uranium exploration and mine development

Historical review

Uranium exploration was carried out in Finland from 1955 to 1989 by several organisations: Atomienergia Oy, Imatran Voima Oy, Outokumpu Oy and Geological Survey of Finland. Since the early 1970s, the regional aero-geophysical and geochemical mapping programmes have played an important role in uranium exploration. The distribution of uranium provinces and the geological settings of uranium deposits can be summarised as follows; the grades (% U) and tonnages of (*in situ*) uranium of the deposits are given in brackets:

- The Kolari-Kittilä province in western Lapland, including the Kesänkitunturi sandstone deposit (0.06% U; 950 tU) and the Pahtavuoma-U vein deposit (0.19% U; 500 tU) in Paleoproterozoic quartzite and greenstone-associated graphitic schists, respectively.

- The Kuusamo province in north-eastern Finland, with metasomatite uranium occurrences associated with mineralisations of gold and cobalt (e.g. Juomasuo deposit) in a sequence of Paleoproterozoic quartzites and mafic volcanics.
- The historical Koli province in eastern Finland, with several small sandstone (Ipatti, Martinmonttu and Ruunaniemi: 0.08-0.14% U; 250 tU) and epigenetic uranium deposits (the former Paukkajanvaara mine) and occurrences of uranium and thorium-bearing quartz-pebble-conglomerate in Paleoproterozoic quartzites, with an additional prospect of unconformity-related deposits in a Paleoproterozoic regolith.
- The Uusimaa province of intrusive uranium occurrences in Paleoproterozoic granitic migmatites of southern Finland, represented by the Palmottu deposit (0.1% U; 1 000 tU) and the Askola area.

The geological settings further include:

- Uraniferous phosphorites associated with sedimentary carbonates of the Paleoproterozoic sequences, e.g., the Vihanti-U (Lampinsaari) deposit (0.03% U; 700 tU) and the Nuottijärvi deposit (0.04% U; 1 000 tU).
- Uranium mineralisation and uraniferous carbonate veins in Paleoproterozoic albitite and albite diabase dykes, mostly in northern Finland.
- Uranium- and thorium-bearing dykes and veins of Paleoproterozoic pegmatite granites.
- Surficial concentrations of young uranium in recent peat.

Exploration began again in the 2000s by AREVA and junior companies. AREVA NC decided to run its subsidiary AREVA Resources Finland down and sold the Finnish uranium exploration projects to Mawson Resources Ltd in 2010.

Recent and ongoing uranium exploration and mine development activities

Mawson Resources Ltd has been the most active company in uranium exploration the past three years. The company is focused on the Rompas-Rajapalot gold and uranium exploration project in Paleoproterozoic Peräpohja Schist Belt in northern Finland. Structurally hosted hydrothermal-style gold and uranium mineralisations occur in metamorphic supracrustal rocks. The initial discovery area, Rompas is defined over a 6 km strike and 200-250 m width. In September 2012, Mawson announced a new discovery at the Rajapalot area located 8 km to the east of the Rompas trend. At this early stage of exploration, Mawson has indications of a mineral system that has deposited high-grade gold within an area approaching 10 km by 10 km.

The Rompas exploration licence was granted for a period of three years in October 2011, but the licence was initially not in legal force due to five appeals. However, Mawson signed a contract with a private landholder to diamond drill in February 2012. Although the Finnish Mining Act allows for private agreements to be reached between explorers and landholders (without an exploration licence), this is not allowed for uranium exploration. In early 2012, Mawson announced that the company specifically drills for and targets gold. The first drilling programme in early 2012 was completed for a total of 39 diamond holes for 4 178 m. Drill hole results from South Rompas released in May 2012 comprised 6 m at 617 g/t Au from 7 m depth including 1 m at 3 540 g/t Au from 11 m depth in drill hole ROM0011.

The Rompas exploration licence came into legal force in October 2012 following the completion of an appeal process. Rompas is partly within a Natura 2000 protected area and the licence allows Mawson to drill only outside the Natura 2000 areas. The best intersection of the winter 2013 drilling programme at the North Rompas prospect was 0.4 m at 395 g/t Au and 0.41% U_3O_8 from 41 m depth in drill hole ROM0052.

In early 2012, European Uranium Resources Ltd acquired a portfolio of exploration licences and applications for uranium projects in Finland from Mawson. The transaction involved three uranium exploration projects in Finland (Riutta, Asento and Nuottijärvi). In March 2013, the company was awarded a three-year exploration licence for the Asento Project in north-central Finland. Asento was discovered by AREVA Resources Finland in 2007. Mineralised boulders have been identified and the project area is considered prospective for vein-style hydrothermal uranium deposits within Archean granites. European Uranium Resources is planning a summer 2013 exploration programme for the Asento Project.

In Riutta and Nuottijärvi, exploration licences are expired and applications for an extended time are pending at the mining authority. AREVA had a small drilling programme in Riutta in 2008 and the best drill result intersected 11.3 m at 0.68% U_3O_8 (3.7 m at 1.53% U_3O_8).

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Finland reports a total of 1 500 tU of reasonably assured conventional resources recoverable at costs of USD 80-130/kgU in the Palmottu and Pahtavuoma U deposits. No inferred conventional resources are reported.

Undiscovered conventional resources (prognosticated and speculative resources)

None reported.

Unconventional resources and other materials

Since the IUREP (International Uranium Resources Evaluation Project) mission's first estimate 30 years ago, Finland has reported Talvivaara as a potential unconventional resource. Unconventional by-product uranium resources of Talvivaara are approximately 22 000 tU (measured and indicated) in the total mineral resources of 2 053 Mt. Uranium grade in the black schist-hosted ore is 17 ppm on average, a grade typical of Paleoproterozoic black schists in Finland. Uranium occurs uniformly in the ore and the main U-bearing mineral is uraninite which is mostly enclosed in carbonaceous nodules. Talvivaara is included in the black shale uranium deposit type in the new IAEA classification system.

Another potential by-product uranium target is the Sokli carbonatite in northern Finland, presently under development by Yara International for the beneficiation of the regolith phosphate ore on top of the magmatic carbonatite. In the hardrock carbonatite, uranium pyrochlore occurs in specific zones at a grade of 0.01% U which have been evaluated to contain 2 500 tU.

Finland previously reported a total of 2 900 tU of reasonably assured resources from several deposits in the cost range USD 130/kgU or more. This cost category was not used in the Red Book for several editions and these resources were therefore not included in the estimates. Extensions of national parks, mine closure and other reasons still exclude most of these resources from being considered mineable deposits.

Uranium production

Historical review

Uranium production in Finland has been confined only to the now restored Paukkajanvaara mine that operated as a pilot plant between 1958 and 1961. A total of 40 000 tonnes of ore was hoisted and the concentrates produced amounted to about 30 tU.

As reported in the "Red Book Retrospective", the total historical production calculated from the mining register statistics is no more than 41 tU from 1958 to 1961.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1
Name of production centre	Talvivaara
Production centre classification	Planned
Date of first production	2014
Source of ore:	
Deposit name(s)	Kuusilampi and Kolmisoppi
Deposit type(s)	Black schist
Recoverable resources (tU)*	15 800*
Grade (% U)	0.0017
Mining operation:	
Type (OP/UG/ISL)	OP
Size (tonnes ore/day)	NA
Average mining recovery (%)	80
Processing plant:	
Acid/alkaline	Acid (heap leaching)
Type (IX/SX)	SX
Size (tonnes ore/day)	NA
Average process recovery (%)	90
Nominal production capacity (tU/year)	350
Plans for expansion	Yes
Other remarks	Heap leaching by-product

* Overall recovery factor of 72% used in the estimate.

Future production centres

On 1 March 2012, the Finnish government granted a licence for the extraction of uranium as a by-product from the Talvivaara nickel mine operated by Talvivaara Sotkamo Ltd in Sotkamo, eastern Finland with plans to begin uranium production sometime in 2013-2014. The licence is valid until the end of 2054.

The Talvivaara open-pit Ni-Zn-Cu-Co mine began production in 2008. The company applies heap leaching to extract metals from low-grade, black schist-hosted ore which contains 0.0017% U on average. Uranium recovery in Talvivaara is possible due to high-volume mining and heap leach conditions which favour uranium dissolution from easily leachable uraninite. In heap leaching, uranium dissolves in the pregnant leach solution (PLS) along with the main base metals (Ni, Zn). Uranium concentration in the PLS is 10-30 mg/l U and uranium will be recovered using a solvent extraction process. Annual uranium production is expected to be 350 tU. After uranium extraction, the solution will be directed to pre-neutralisation and then, to Ni-Co precipitation.

At present, dissolved uranium mostly ends up in the gypsum pond (tailings) and partly in the Ni-Co sulphide concentrate (product). Ni-Co sulphide concentrate is upgraded and processed by the Norilsk Nickel Harjavalta refinery. As an impurity in Ni-Co sulphide product, uranium disturbs processes at the Harjavalta refinery. Harjavalta is licensed to extract uranium below a limit of 10 tU/yr.

Construction of the uranium recovery circuit in Talvivaara is expected to be completed in 2013. Cameco Corporation is providing technical assistance to Talvivaara in the design, construction, commissioning and operation of the uranium extraction circuit. Uranium concentrate will be sold to Cameco until 2027.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Finland does not produce or use mixed oxide fuels.

Production and/or use of re-enriched tails

Re-enriched tails have not been used in 2011 and 2012.

Environmental activities and socio-cultural issues

In Talvivaara, an EIA process of uranium recovery was completed in March 2011 and the local environmental authority declared the EIA sufficient. An environmental permit application for uranium recovery was submitted to the regional environmental permitting agency in March 2011. Before uranium production begins, an environmental permit from the Northern Finland Regional State Administrative Agency and a start-up permit from the Radiation and Nuclear Safety Authority are required. A decision on the uranium recovery environmental permit is connected to the general update of the mine's environmental permit.

Talvivaara's uranium off-take agreement with Cameco has been approved by the Euratom Supply Agency under the Euratom Treaty. In addition, the company has received ratification of the uranium recovery process from the European Commission under the Euratom Treaty.

As a result of the uranium recovery in Talvivaara, the amount of uranium in the gypsum pond tailings will be reduced. In addition, uranium-related problems in Ni-Co concentrate processing will be reduced at the Harjavalta refinery.

On 31 October 2011, the Finnish Safety and Chemical Agency (TUKES) granted Mawson the Rompas exploration licence for a period of three years. In November 2011, five appeals were filed against the decision made by TUKES. The Rovaniemi Administrative Court examined the appeals and on 14 September 2012, a decision was taken to reject all appeals against the granting decision. As no further appeals were filed to the Supreme Administrative Court within 30 days, the exploration licence took legal effect from 15 October 2012.

The Rompas exploration licence outlines limitations on exploration methods that can be completed in the Natura 2000 areas, including no drilling or trenching due to the presence of specific flora until Mawson applies for a modification of the licence decision by conducting an environmental programme (a Natura 2000 assessment). Golder Associates of Finland is conducting the environmental study. Approximately 30% of the 6 km Rompas trend lies outside the Natura 2000 areas and is available for drilling.

Regulatory regime

The Mining Act regulates exploration and mining activities in Finland. TUKES is the mining authority and all licences under the Mining Act are granted by TUKES. The mine closure process is regulated in Finland by mining and environmental legislation as well as a number of EU and other specifications.

The Radiation and Nuclear Safety Authority (STUK) is the regulatory body for uranium extraction, as specified in the Nuclear Energy Act and the Radiation Act. Production of uranium or thorium needs a licence from the government according to the Nuclear Energy Act. The Ministry of Employment and the Economy (MEE) prepares the licence based on statements from different ministries and authorities (including STUK) and the licence is granted by the government.

STUK's regulatory control covers radiation exposure of workers and public, environmental monitoring, waste management, emergency preparedness, nuclear material accountancy, physical protection and inspections to verify the safety and security of the facility and compliance with licence conditions over the plant lifetime. Radioactive tailings are regarded as nuclear waste and are subject to funding for the future costs of waste management. Uranium concentrate export, controlled by the Ministry for Foreign Affairs, is also subject to national and international safeguards control.

Mining also needs an environmental permit from the Regional State Administrative Agencies (AVI) and a permit is regulated by the Centres for Economic Development, Transport and the Environment (ELY).

The environmental impact assessment procedure is applied to all uranium mining projects, without any limitations on the annual amount of the extracted resource or on the area of an opencast mine. In addition to the licensing based on the Mining Act, other legislation to be applied includes Environmental Protection, Nature Conservation, Protection of Wilderness Reserves, Reindeer Herding, Land Use and Building, Occupational Safety and Health.

Uranium requirements

At the beginning of 2013, four reactors were in operation: Olkiluoto 1 and 2, owned by the Finnish private utility Teollisuuden Voima Oyj (TVO) and Loviisa 1 and Loviisa 2, owned by Fortum Power and Heat Oy. The total installed capacity was about 2.7 GWe net. Uranium requirements have been averaged approximately 490 tU/yr over the past seven years.

Finland's fifth nuclear power plant unit, Olkiluoto 3 (a European pressurised reactor, or EPR) is under construction. The net electrical output of the unit will be approximately 1 600 MW. The uranium requirements for this new unit will range from 200 to 300 tU/year. Based on the recent progress reports received from the plant supplier, AREVA-Siemens Consortium, TVO is preparing for the possibility that the start of the regular electricity production of Olkiluoto 3 may be postponed until 2016.

Despite repeated challenges with the project scheduling, work is proceeding at the Olkiluoto 3 site with approximately 75% of the installation works completed and all major components installed. The first systems at the turbine plant have also been commissioned. The supplier is constructing the unit under a fixed-price turnkey contract.

In 2010, the Finnish Parliament ratified the decision-in-principle approving the construction of Finland's sixth and seventh nuclear power plants by the companies TVO (Olkiluoto 4) and Fennovoima. Construction licences and operating licences submitted in due course will be considered by the government following the broad-based comment and hearing procedure required under law. At the earliest, the new units will be ready for commissioning in early 2020s.

In early 2013, TVO received bids related to the new Olkiluoto 4 nuclear power plant. After bid evaluation and negotiations, the plant supplier will be selected based on a technical and economic review. TVO invited bids for Olkiluoto 4 specifying an electric output of approximately 1 450 MW to 1 750 MW. The construction licence application is expected to be submitted to the Finnish government by mid-2015. Construction of Olkiluoto 4 can begin after the investment decision has been made and a construction licence granted. The supplier candidates for Olkiluoto 4 include AREVA (EPR), GE-Hitachi (economic simplified boiling water reactor, or ESBWR), Korea Hydro & Nuclear Power (advanced pressurised reactor, or APR-1400), Mitsubishi Heavy Industries (advanced pressurised water reactor, or APWR) and Toshiba (advanced boiling water reactor, or ABWR).

Finland's third nuclear power company Fennovoima, founded in 2007, plans to build a new nuclear power plant (Hanhikivi 1) on a greenfield site in Pyhäjoki, northern Finland. Fennovoima is owned by a large group of Finnish companies who want to secure their own electricity supply. Fennovoima will produce electricity for its owners' needs at production cost in proportion to their ownership share. In October 2012, E.ON announced that it was divesting all its operations in Finland, including its ownership in Fennovoima, and in early 2013 Fennovoima's majority owner Voimaosakeyhtiö SF purchased E.ON's 34% share.

In January 2012, Fennovoima received bids for a nuclear power plant from AREVA and Toshiba. As a result of an overall evaluation, Fennovoima decided to terminate the bidding process and proceeded with a new supplier selection process. Accordingly, Fennovoima invited Toshiba to direct negotiations in February 2013. Toshiba's proposal for Hanhikivi 1 is a 1 600 MW advanced boiling water reactor (EU-ABWR). In addition, with changes to its ownership structure, Fennovoima decided to start assessing whether a mid-sized plant option would be feasible, with Toshiba, AREVA and Rosatom offering potentially suitable alternatives. Fennovoima's target is to select the plant supplier during 2013.

Supply and procurement strategy

TVO procures natural uranium, enrichment services and fuel fabrication from several countries. Fortum Power and Heat Oy purchases uranium from the Russian Federation.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

No significant changes to Finnish uranium policy are reported. The MEE promotes the use of mineral resources by securing a favourable operating environment for mineral exploration and mining activities. The ministry has been responsible for the revisions to the mining legislation in recent years.

Licences for mining, enrichment, possession, fabrication, production, transfer, handling, use and transport of nuclear materials and nuclear wastes may be granted only to natural persons, corporations or authorities under the jurisdiction of a member state of the European Union. However, under special circumstances, foreign organisations or authorities may be granted a licence to transport nuclear material or nuclear waste within Finland.

An environmental impact assessment procedure is applied to all uranium mining projects, without any limitations on the annual amount of the extracted resource or on the area of an opencast mine. In addition to the licensing based on the Mining Act and on other legislation (Environmental Protection Act, Nature Conservation Act, Protection of

Wilderness Reserves Act, Land Use and Building Act, Occupational Safety and Health Act and Radiation Act), production of uranium or thorium also needs a licence from the government according to the Nuclear Energy Act.

The new Mining Act (621/2011) came into force 1 July 2011, including an amendment of the Nuclear Energy Act. One of the most important changes brought in by the new Mining Act is the transfer of the mining authority from MEE to TUKES. As of 1 July 2011, all licences under the Mining Act are granted by TUKES, which has offices dealing with mining issues in Helsinki and Rovaniemi.

While securing the preconditions for mining and exploration, the Mining Act of 2011 takes account of environmental issues, citizens' fundamental rights, landowners' rights and municipalities' opportunities to influence decision-making.

According to the Mining Act of 2011, an exploration licence is required for uranium exploration (e.g. drilling, trenching). Permit applications concerning a uranium mine under the Mining Act and Nuclear Energy Act are handled jointly and decided on in a single decision by the government. The granting of a permit for a uranium mine requires that the mining project activities are aligned with the overall interests of the society, the municipality in question has given its consent and safety requirements are being complied with.

The Finnish nuclear waste management is guided by the Nuclear Energy Act and Decree. All nuclear waste generated in Finland must be handled, stored and permanently disposed of in Finland. The act also prohibits the import of nuclear waste. Responsibility for nuclear waste remains with the power companies until final disposal. Contributions are being accumulated annually in the State Nuclear Waste Management Fund by the companies. These contributions also cover the decommissioning of the plants. Low- and intermediate-level waste repositories are in operation at the depth of 60-100 m in bedrock at both Loviisa (Fortum) and Olkiluoto (TVO).

The spent fuel from the nuclear power plants owned and operated by Fortum and TVO will be packed into copper canisters and disposed of in the bedrock of Olkiluoto at a depth of approximately 420 m by Posiva Oy, a company owned by the two power companies. Posiva submitted a construction licence application for a final repository for spent nuclear fuel to the government in December 2012. STUK makes a safety assessment of the application for MEE.

The construction licence application concerns a complex comprising of an above-ground encapsulation plant and an underground final repository. In addition to the spent nuclear fuel final disposal facility construction licence application submitted to MEE, Posiva submitted to STUK the related long-term safety justification documentation.

STUK will submit its statement on the long-term safety of final disposal, based on the safety justification submitted by Posiva, to MEE. Furthermore, the ministry will request statements from several co-operating parties and organise a public hearing on the matter. If Posiva is granted the spent nuclear fuel final disposal facility construction permit as planned, construction of the facility could start in 2015. In this case, Posiva would be ready to submit the facility operating licence application in 2020 and actual disposal at the planned scope could begin in 2022.

The decision-in-principle approved for Fennovoima's new nuclear power plant is conditional. Upon submitting its construction licence application, Fennovoima must also provide a detailed report on its plans for nuclear waste management. Furthermore, the company must develop its plan for the final disposal of spent nuclear fuel. By 2016, Fennovoima is obliged to present to MEE either an agreement on a nuclear waste disposal partnership with TVO and Fortum (Posiva), or, under the Environmental Impact Assessment Act, its own environmental assessment programme on the final disposal repository for nuclear waste to be operated by Fennovoima.

Uranium stocks

The nuclear power utilities maintain reserves of fuel assemblies from seven months to one year's use, although the legislation demands only five months use.

Uranium prices

Due to commercial confidentiality price data are not available.

Uranium exploration and development expenditures and drilling effort – domestic

(EUR)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	1 820 000	1 340 000	2 210 000	NA
Government exploration expenditures	0	0	0	0
Industry* development expenditures	100 000	12 400 000	45 200 000	NA
Government development expenditures	0	0	0	0
Total expenditures	**1 920 000**	**13 740 000**	**47 410 000**	**NA**
Industry* exploration drilling (m)	0	0	5 400	NA
Industry* exploration holes drilled	0	0	51	NA
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	0	0	5 400	NA
Subtotal exploration holes drilled	0	0	51	NA
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**0**	**0**	**5 400**	**NA**
Total number of holes drilled	**0**	**0**	**51**	**NA**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Metamorphite	0	0	500	500
Intrusive	0	0	1 000	1 000
Total	**0**	**0**	**1 500**	**1 500**

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	0	0	500	500
Open-pit mining (OP)	0	0	1 000	1 000
Total	**0**	**0**	**1 500**	**1 500**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	0	0	500	500
Conventional from OP	0	0	1 000	1 000
Total	**0**	**0**	**1 500**	**1 500**

* *In situ* resources.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	30	0	0	0	30	0
Total	**30**	**0**	**0**	**0**	**30**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	15	0	0	0	15	0
Underground mining[1]	15	0	0	0	15	0
Total	**30**	**0**	**0**	**0**	**30**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	30	0	0	0	30	0
Total	**30**	**0**	**0**	**0**	**30**	**0**

Re-enriched tails production and use

(tonnes natural U equivalent)

Re-enriched tails	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	0	0	0	0	0	0
Use	843	0	0	0	843	0

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	22.3	22.1

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
2 700	2 700	2 700	2 700	2 750	4 400	2 750	4 400	5 600	7 800	5 100	7 300	5 600	6 800

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
560	371	370	370	700	760	700	1 360	870	1 250	690	1 050	690	1 050

France

Uranium exploration and mine development

Historical review

Uranium exploration began in 1946, focusing on previously discovered deposits and a few mineralisation occurrences discovered during radium exploration. In 1948, exploration led to the discovery of the La Crouzille deposit, formerly of major importance. By 1955, additional deposits had been identified in the granite areas of Limousin, Forez, Vendée and Morvan. Prospecting activities were subsequently extended to sedimentary formations in small intra-granitic basins and terrigeneous formations, arising from eroded granite mountains and mainly located north and south of the Massif Central.

Recent and ongoing uranium exploration and mine development activities

No domestic activities have been carried out in France since 1999.

During 2011 and 2012, AREVA and its subsidiaries have been working outside France focusing on targets aimed at the discovery of exploitable resources in Australia, Canada, Central Africa Republic, Finland, Gabon, Jordan, Kazakhstan, Mongolia, Namibia, Niger and South Africa. In Canada, Kazakhstan, Namibia and Niger, AREVA is involved in uranium mining operations and projects. In addition, without being an operator, it holds shares in several mining operations and research projects in different countries.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

AREVA no longer reports resources or reserves in France since the historic data on which these estimates are based do not conform to modern international standards.

Undiscovered conventional resources (prognosticated and speculative resources)

No systematic appraisal is made of undiscovered resources.

Uranium production

Status of production facilities, production capability, recent and ongoing activities and other issues

Following the closure of all uranium mines in 2001, all ore processing plants were shut down, dismantled and the sites reclaimed. Only a few tonnes of uranium per year are recovered from resins during the water cleaning process at the outflow of the former Lodève mine in the south of France. The resins are eluted at the Malvesi refinery, where the uranium is recovered.

In France, a total of 244 sites, ranging from exploration sites to mines of various sizes, 8 mills and 17 tailings deposits (containing a total of 52 Mt of tailings) resulted from the production of more than 80 000 tU. All of these sites have been remediated. Monitoring continues at only the most important sites and 14 water treatment plants were installed to clean drainage from the sites. AREVA is responsible for the management of 234 of these sites.

The targets of remediation are to:

- ensure public health and safety;
- limit the residual impact of previous activities;
- integrate the industrial sites into landscape;
- maintain a dialogue and consultation with local populations.

Future production centres

There are no plans to develop new production centres in France in the near future.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

The annual licensed capacity of MOX fuel production in France is about 195 tHM, roughly corresponding to 1 560 tU equivalent (tNatU) using the recommended Red Book conversion factor. Actual yearly production of MOX in France varies below this licensed capacity in accordance to contracted quantities. Most of the French MOX production is used to fuel French NPPs (a total of about 120 t/yr, or 960 tNatU) and the remainder is delivered abroad under long-term contract arrangements.

Production and/or use of re-enriched tails

Until 2010, a fraction of the depleted UF_6 flow generated through enrichment activities was sent to the Russian Federation for re-enrichment. This fraction was limited to materials with mining origins that would allow their transfer (in accordance with international and bilateral agreements dealing with the exchange of nuclear materials). The return flow was exclusively used to over-feed the enrichment plant in France at the Georges Besse gaseous diffusion plant run by EURODIF, an AREVA subsidiary.

In addition, in 2008 and 2009 a few thousand tonnes of depleted uranium was removed from storage, converted to UF_6 and enriched to natural uranium grade at the Georges Besse gaseous diffusion plant, thanks to the then prevailing economic conditions (primarily high uranium spot prices).

Production and/or use of reprocessed uranium

In France, reprocessed uranium is produced at the la Hague reprocessing plant. The annual production from EDF (*Électricité de France*) spent fuel is around 1 000 tU. Since 2010, around 600 tNatU equivalent are recycled every year in four reactors (EDF reactors at the Cruas nuclear power plant).

Regulatory regime

In France, mines are nationally regulated according to the Mining Code and processing plants according to regulations specified in legislation governing the operation of installations that present environmental risks (ICPE – *installation classée pour la protection de l'environnement*). These regulations are applied by regional environmental authorities (DREAL – *Directions régionales de l'Environnement, de l'Aménagement et du Logement*) on behalf of the prefect (the state representative in a particular department or region).

In order to open a mine, the mining company must present a report to the regional authorities that will allow them to confirm that the project will be operated in accordance with all regulations. Once this is confirmed, a public enquiry must be held. If these processes are successfully completed, the mining company will be allowed to open the mine according to requirements laid out in an Order of the Prefecte. When mining is completed, the mining company must prepare a report for local authorities who can then give authorisation for decommissioning through an Order of the Prefecte.

In theory, according to Mining Code, after remediation and a period of monitoring to verify that there is no environmental impact, the mining company can transfer the responsibility of the site to the state but, if there is a problem, the state asks mining company to remediate the problem.

After decommissioning, the mining company retains responsibility for the site, including monitoring and maintenance. There has not been a transfer of responsibility for a uranium mine from the mining company to the state because AREVA is always present. However, AREVA is in discussion with authorities on the transfer of responsibility.

The cost of mine remediation is the responsibility of the mining company. In the case of processing plants (mills), local authorities request financial guarantees for the costs of all remediation works and monitoring. A draft revision of the Mining Code is currently under development.

Uranium requirements

As of 31 December 2012, France's installed nuclear capacity consisted of 58 pressurised water reactors (34 x 900 MWe units, 20 x 1 300 MWe units and 4 x 1 450 MWe units), with uprates now totalling 63.13 MWe (net), requiring about 8 000 tU/yr.

A national debate on the French energy transition was launched in late 2012. The current government expressed a policy goal of reducing nuclear electricity generation to a 50% share of total generation, from the current share of about 75%. The debate is a way of gathering the views of citizens on energy policy to address four key questions:

- How can demand be reduced through improvements in energy efficiency and energy conservation?
- What is the most effective path to reach the desired energy mix in 2025? What would moving to this path do in terms of 2030 and 2050 scenarios with respect to current national climate change commitments (i.e. reducing greenhouse gas emissions)?
- What realistic choices exist for renewable energy and new energy technologies? What strategy of industrial and regional development should be adopted to achieve the introduction of these technologies?
- What costs are involved in the energy transition and what sources of transitional funding could be used?

Legislation is expected to be presented to the government in late 2014 after a national debate on energy policy came to a close in September 2013.

The current government also wants to shut down the oldest reactors in France, the Fessenheim nuclear power plant (2 units with a combined capacity of 1.76 GWe that entered into service in 1978), by the end of the current term of President Hollande's government in 2016. An inter-ministerial delegate has been appointed on this issue with the mission of clarifying the timing and manner of closing.

Construction of the 1.6 GWe Flamanville 3 EPR began in late 2007. By the end of 2012, 94% of the civil engineering work and 39% of the electromechanical assembly work had been completed. The reactor is due to enter into service in 2016. There are currently no plans for additional nuclear generating capacity in France after Flamanville 3 is brought into service.

In 2006, AREVA began work at the Tricastin site on construction of the Georges Besse II uranium centrifuge enrichment plant to replace the Eurodif gaseous diffusion plant that has been in service since 1978. In 2012, production at the Eurodif plant was stopped and the facility will be dismantled in the coming years. The Georges Besse II facility will have a current production capacity of 5.5 million SWU by the end of 2013. The project is currently on track to reach a nominal capacity 7.5 million SWU in 2016.

Supply and procurement strategy

Since France is a net importer of uranium, its policy towards procurement is one of supply diversification. French entities participate in uranium exploration and production outside France within the regulatory framework of the host countries. Uranium is also purchased under short- or long-term contracts, either from mines in which French entities have shareholdings or from mines operated by third parties.

Uranium policies, uranium stocks and uranium prices

Uranium stocks

EDF possesses strategic uranium inventories, the minimum level of which has been fixed at the equivalent of a few years' forward consumption to offset possible supply interruptions.

Uranium prices

Information on uranium prices is not available.

Uranium exploration and development expenditures – non-domestic

(EUR millions)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	50	48	52	55
Government exploration expenditures				
Industry* development expenditures	NA	NA	NA	NA
Government development expenditures				
Total expenditures	50	48	52	55

* Non-government.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	16 781	0	0	0	16 781	0
Granite-related	63 683	0	0	0	63 683	0
Metamorphite	395	0	0	0	395	0
Volcanic-related	1	0	0	0	1	0
Black Shale	3	0	0	0	3	0
Other/unspecified	82	9	6	3	100	3
Total	80 945*	9	6	3	80 963	3

* Pre-2010 total updated from Red Book 2011 after review of historic records.

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	5 427	0	0	0	5 427	0
Underground mining*	1 511	0	0	0	1 511	0
Open-pit + Underground**	73 925	0	0	0	73 925	0
Co-product/by-product	82	9	6	3	100	3
Total	80 945	9	6	3	80 963	3

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

** Not possible to separate in historic records.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	80 863	0	0	0	80 863	0
Other methods*	82	9	6	3	100	3
Total	80 945	9	6	3	80 963	3

* Includes mine water treatment and environmental restoration.

Mixed oxide fuel production and use

(tonnes natural U equivalent)

Mixed oxide (MOX) fuel	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	15 598	1 560	1 160	1 200	19 518	NA
Use	NA	880	880	880	NA	NA
Number of commercial reactors using MOX		21	21	22		NA

Reprocessed uranium use

(tonnes natural U equivalent)

Reprocessed uranium	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	13 900	1 000	1 000	1 000	16 900	1 000
Use	3 500	600	600	600	5 300	600

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	405	421

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
63 130	63 130	63 130	63 130	63 130	63 130	62 900	62 900	NA	NA	NA	NA	NA	NA

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
8 000	8 000	8 000	8 000	8 000	9 000	8 000	9 000	NA	NA	NA	NA	NA	NA

Germany

Uranium exploration and mine development

Historical review

After World War II, exploration for uranium in Germany occurred in the two separate countries prior to reunification in 1990. A summary of the activities is provided below.

Former German Democratic Republic before 1990

Uranium exploration and mining was undertaken from 1946 to 1953 by the Soviet stock company, SAG Wismut. These activities were centred around old mining locations of silver, cobalt, nickel and other metals in the Erzgebirge (Ore Mountains) and in Vogtland, Saxony, where uranium had first been discovered in 1789.

Uranium exploration had started in 1950 in the vicinity of the radium spa at Ronneburg. Using a variety of ground-based and aerial techniques the activities covered an extensive area of about 55 000 km^2 in the southern part of the former German Democratic Republic (GDR). About 36 000 holes in total were drilled in an area covering approximately 26 000 km^2. Total expenditures for uranium exploration over the life of the GDR programme were on the order of GDR Mark 5.6 billion.

Uranium mining first began shortly after World War II in cobalt and bismuth mines near Schneeberg and Oberschlema (a former famous radium spa). During this early period more than 100 000 people were engaged in exploration and mining activities. The rich uraninite and pitchblende ore from the vein deposits was hand-picked and shipped to the USSR for further processing. Lower-grade ore was treated locally in small processing plants. In 1950, the central mill at Crossen near Zwickau, Saxony was brought into operation.

In 1954, a new joint Soviet-German stock company was created, Sowjetisch-Deutsche Aktiengesellschaft Wismut (SDAG Wismut). The joint company was held equally by both governments. All production was shipped to the USSR for further treatment. The price for the final product was simply agreed upon by the two partners. Profits were used for further exploration.

At the end of the 1950s, uranium mining was concentrated in the region of Eastern Thuringia. From the beginning of the 1970s, the mines in Eastern Thuringia provided about two-thirds of SDAG Wismut's annual production.

Between the mid-1960s and the mid-1980s, about 45 000 people were employed by SDAG Wismut. In the mid-1980s, Wismut's employment decreased to about 30 000. In 1990, only 18 000 people worked in uranium mining and milling and the number of employees has declined since as remediation activities are completed.

Federal Republic of Germany before 1990

Starting in 1956, exploration was carried out in several areas of geological interest: the Hercynian Massifs of the Black Forest, Odenwald, Frankenwald, Fichtelgebirge, Oberpfalz, Bayerischer Wald, Harz, the Paleozoic sediments of the Rheinisches Schiefergebirge, the Permian volcanics and continental sediments of the Saar-Nahe region and other areas with favourable sedimentary formations.

The initial phase included hydro-geochemical surveys, car borne surveys, field surveys, and, to a lesser extent, airborne prospecting. Follow-up geochemical stream sediment surveys, radon surveys and detailed radiometric work, followed by drilling and trenching, were carried out in promising areas. During the reconnaissance and detailed exploration phases both the federal and state geological surveys were involved, whereas the actual work was carried out mainly by industrial companies.

Three deposits of economic interest were found: the partly high-grade hydrothermal deposit near Menzenschwand in the southern Black Forest, the sedimentary Müllenbach deposit in the northern Black Forest and in the Grossschloppen deposit in north-eastern Bavaria. Uranium exploration ceased in Western Germany in 1988 but by then about 24 800 holes had been drilled, totalling about 354 500 m. Total expenditures were on the order of USD 111 million.

Recent and ongoing uranium exploration and mine development activities

There have been no exploration activities in Germany since the end of 1990. Several German mining companies did perform exploration abroad (mainly in Canada) through 1997.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Identified conventional resources were last assessed in 1993. These identified conventional resources occur mainly in the closed mines that are in the process of being decommissioned. Their future availability remains uncertain.

Undiscovered conventional resources (prognosticated and speculative resources)

All undiscovered conventional resources are reported as speculative resources in the cost category above USD 260/kgU.

Unconventional resources and other materials

None reported.

Uranium production

Historical review

Federal Republic of Germany before 1990

In the Federal Republic of Germany, a small (125 tonnes per year) uranium processing centre in Ellweiler, Baden-Württemberg began operating in 1960 as a test mill. It was closed on 31 May 1989 after producing a total of about 700 tU.

Former German Democratic Republic before 1990

Two processing plants were operated by SDAG Wismut in the territories of the former GDR. A plant at Crossen, near Zwickau in Saxony, started processing ore in 1950. The ore was transported by road and rail from numerous mines in the Erzgebirge. The composition of the ore from the hydrothermal deposits required carbonate pressure leaching. The plant had a maximum capacity of 2.5 million tonnes of ore per year. Crossen was permanently closed on 31 December 1989.

The second plant at Seelingstadt, near Gera, Thuringia, started ore processing operations in 1960 using the nearby black shale deposits. The maximum capacity of this plant was 4.6 million tonnes of ore per year. Silicate ore was treated by acid leaching until the end of 1989. Carbonate-rich ores were treated using the carbonate pressure leaching technique. After 1989, Seelingstadt's operations were limited to the treatment of slurry produced at the Königstein mine using the carbonate method.

A total of over 200 000 tU was produced in the GDR between 1950 and 1989.

Status of production facilities, production capability, recent and ongoing activities and other issues

There is no commercial production of uranium in Germany today. Decommissioning of the historic German production facilities started in 1989 (former Federal Republic of Germany) and 1990 (former GDR). Between 1991 and 2012, uranium recovery from mine water treatment and environmental restoration amounted to a total of 2 540 tU. Since 1992, all uranium production in Germany has been derived from the clean-up operations at the Königstein mine.

Ownership structure of the uranium industry

The production facilities in the former GDR were owned by the Soviet-German company Wismut (SDAG Wismut). After reunification, the German Ministry of Economy inherited the ownership from SDAG Wismut. The German federal government through Wismut GmbH took responsibility for the decommissioning and remediation of all production facilities. The government retains ownership of all uranium recovered in clean-up operations.

In August 1998, Cameco completed its acquisition of Uranerz Exploration and Mining Ltd (UEM), Canada, and Uranerz USA Inc. (UUS), from their German parent company Uranerzbergbau GmbH (Preussag and Rheinbraun, 50% each). As a result, there remains no commercial uranium industry in Germany.

Employment in the uranium industry

All employment is engaged in decommissioning and rehabilitation of former production facilities. Employment decreased within the last 4 years from 1 770 (2008) to 1 372 (2012).

Future production centres

None reported.

Uranium policies, uranium stocks and uranium prices

According to the energy concept 2010, the federal government decided to phase-out use of nuclear power for commercial electricity generation on a staggered schedule. With the adoption of the Thirteenth Act amending the Atomic Energy Act (*Dreizehntes Gesetz zur Änderung des Atomgesetzes*), all reactors will be shut down by no later than the end of 2022. The German Bundestag (parliament) passed the amendment on 30 June 2011 and it came into force on 6 August 2011. For the first time in the history of the Federal Republic of Germany, a fixed deadline has been laid down in law for the end of the use of nuclear power in the country. The withdrawal is to be undertaken in stages with specific shutdown dates.

The country's seven nuclear power stations commissioned prior 1980, along with the Krümmel nuclear power plant, were shut down during a provisional three-month operational shutdown period in 2011 and will remain permanently closed. The final shutdown dates for the nine remaining nuclear power plants are determined according to the following schedule: 2015, Grafenrheinfeld; 2017, Gundremmingen B; 2019, Philippsburg 2; 2021, Grohnde, Gundremmingen C and Brokdorf; and 2022, the three youngest nuclear power stations, Isar 2, Emsland and Neckarwestheim 2.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified				3 000	
Total				**3 000**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified				3 000	
Total				**3 000**	

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified				4 000	
Total				**4 000**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified				4 000	
Total				**4 000**	

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	NA				NA	0
Underground mining*	NA				NA	0
Total	**219 517**				**219 626**	**0**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Other methods*	2 431	8	51	50	2 540	30
Total	**219 517**	**8**	**51**	**50**	**219 626**	

* Includes mine water treatment and environmental restoration.

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
		74 000

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
50	100							50	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	1 489	1 452	1 372	1 204
Employment directly related to uranium production	NA	NA	NA	NA

Mixed oxide fuel production and use

(tonnes natural U equivalent)

Mixed oxide (MOX) fuel	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	0					
Use	6 530	100	100	100	6 830	260
Number of commercial reactors using MOX		2*	2*	2*		5*

* Reactors loading fresh MOX.

Re-enriched tails production and use

(tonnes natural U equivalent)

Re-enriched tails	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	NA	NA	NA	NA	NA	NA
Use	NA	0	0	0	0	0

Reprocessed uranium use

(tonnes natural U equivalent)

Reprocessed uranium	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	NA	0	0	0	0	0
Use	NA	NA	NA	NA	NA	NA

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	102	94.5

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
20 500	12 100	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
			12 100		12 100		8 100		0		0		0

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
2 900	2 000	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
			2 000		2 000		1 200		0		0		0

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	NA	NA	NA	NA	NA
Producer	NA	NA	NA	NA	NA
Utility	NA	NA	NA	NA	NA
Total	**NA**	**NA**	**NA**	**NA**	**NA**

Greenland

Uranium exploration and mine development

Historical review

From 1955 to 1984, uranium exploration activities were undertaken in south, east and west Greenland, including exploration of the Kvanefjeld U-Th deposit in south Greenland, a large rare earth element (REE) deposit associated with alkaline intrusive rocks.

Additional activities in south Greenland included a regional exploration programme during the 1979-1986 period. Three prospects were found: *i)* uraninite in mineralised fractures and veins; *ii)* uranium-rich pyrochlore mineralisation in alkaline rocks; and, *iii)* uraninite in hydrothermally mineralised metasediments.

In east Greenland, additional exploration activities were undertaken between 1972 and 1977. The exploration programme concluded with no major discovery. Reconnaissance airborne gamma spectrometry with ground follow-up performed in west Greenland also resulted in no major discovery.

In 1995, a stream sediment survey including analysis for uranium and thorium, with scintillometer readings, covered 7 000 km^2 in north-west Greenland, but no prospects were recorded.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration is no longer permitted in Greenland. Companies which have found and demarcated mineral resources containing radioactive elements can however apply for a licence to prepare assessments of the environmental impact and social sustainability to better inform government.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

An inferred resource has been determined at the Kvanefjeld REE-deposit in south Greenland. As the REE-resource has been re-evaluated, so has the uranium resource. The complex composition and processing of the ore results in the resource being placed in the high cost category (<USD 260/kg U). The deposit is of 956 Mt ore at a cut-off grade of 150 ppm U_3O_8 (0.015% U) equivalent to an inferred uranium resource of 260 815 tU_3O_8 (221 172 tU).

Undiscovered conventional resources (prognosticated and speculative resources)

Not evaluated.

Unconventional resources and other materials

Unknown.

Uranium production

Historical review

No uranium has been produced in Greenland.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

In Greenland there is a zero-tolerance policy regarding exploration and exploitation of uranium and other radioactive elements.

An addition to the rules which regulate exploration for mineral resources was made on 9 September 2010. The addition was a clarification of the rules and statutes that companies which have found and demarcated mineral resources containing radioactive elements can apply for a licence to prepare assessments of the environmental impact and social sustainability. The addition to the rules also explicitly states that a licence to complete such environmental impact assessments does not give right to a licence to explore for or exploit radioactive elements.

In making this addition to the standard terms, the hope is to increase knowledge about health and safety issues regarding radioactive elements in occurrences where the actual goal is the production of other, non-radioactive metals.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Intrusive	0	0	0	221 172
Total	**0**	**0**	**0**	**221 172**

Inferred conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Co-product and by-product	0	0	0	221 172	65
Total	**0**	**0**	**0**	**221 172**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Unspecified	0	0	0	221 172	65
Total	**0**	**0**	**0**	**221 172**	

Hungary

Uranium exploration

Historical review

The first reconnaissance for uranium started in 1952 when, with Soviet participation, material from Hungarian coal deposits was checked for radioactivity. The results of this work led in 1953 to a geophysical exploration programme (airborne and surface radiometry) over the western part of the Mecsek Mountains. The discovery of the Mecsek deposit was made in 1954 and further work was aimed at the evaluation of the deposit and its development. The first shafts were placed in 1955 and 1956 for the mining of sections I and II. In 1956, the Soviet-Hungarian uranium joint venture was dissolved and the project became the sole responsibility of the Hungarian state. That same year, uranium production began.

Recent and ongoing uranium exploration and mine development activities

Since 2006, four uranium ore exploration project areas were covered by seven exploration licences, namely: *i)* Mecsek, *ii)* Bátaszék, *iii)* Dinnyeberki and *iv)* Máriakéménd. However, the Bátaszék, Dinnyeberki and Máriakéménd programmes were completed without noteworthy success.

The Mecsek Exploration Project, covering an area of 42.9 km^2 that includes some non-mined parts of the Upper Permian Mecsek sandstone-type deposit that was the subject of historic mining activities, remains active. Digitisation and computer-based processing of the data from historic exploration activities has been completed and a new geological model of the deposit was established. In 2011, a 2-D seismic survey (2.8 km in length) was conducted in the uranium exploration area near the city of Pécs. In accordance with the expectation of the Hungarian Office for Mining and Geology, the resource estimate was re-evaluated in 2012.

Uranium resources

Hungary's reported uranium resources are limited to those of the Mecsek deposit. The ore occurs in Upper Permian sandstones that may be as thick as 600 m. The sandstones were folded into the Permian-Triassic anticline of the Mecsek Mountains. The ore-bearing sandstone in the upper 200 m of the unit is underlain by a very thick Permian siltstone and covered by Lower Triassic sandstone. The thickness of the green-grey ore-bearing sandstone, locally referred to as the productive complex, varies from 15 to 90 m. The ore minerals include uranium oxides and silicates associated with pyrite and marcasite.

Identified conventional resources (reasonably assured and inferred resources)

Following the recent resource estimate re-evaluation, 17 946 tU are now reported as *in situ* high-cost inferred resources, an increase of over 6 000 tU from the previous estimate.

Undiscovered conventional resources (prognosticated and speculative resources)

Prognosticated resources amount to a total of 13 427 tU recoverable at costs of USD 130-260/kgU, an increase of more than 500 tU from the previous estimate. These resources are tributary to the former Mecsek production centre. Speculative resources are not estimated.

Uranium production

Historical review

The Mecsek underground mine and mill situated near the city of Pécs was the only uranium production centre in Hungary. Prior to 1 April 1992, it was operated as the state-owned Mecsek Ore Mining Company (MÉV). It began operation in 1956 and was producing ore from a depth of 100-1 100 m until it was definitively shut down in 1997. During operation, it produced about 500 000-600 000 tonnes ore/year with an average mining recovery of 50-60%. The ore processing plant had a capacity of 1 300 to 2 000 tonnes ore/day and employed radiometric sorting, agitation acid leach (and alkaline heap leaching) with ion exchange recovery. The nominal production capacity of the plant was about 700 t/year.

The Mecsek mine consisted of five sections with the following history:

- section I: operating from 1956 to 1971;
- section II: operating from 1956 to 1988;
- section III: operating from 1961 to 1993;
- section IV: operating from 1971 to 1997;
- section V: operating from 1988 to 1997.

The ore processing plant became operational in 1963. Prior to its operation, 1.2 million tonnes of raw ore was shipped to the Sillimae metallurgy plant in Estonia. After 1963, processed uranium concentrates were shipped directly to the Soviet Union.

Mining and milling operations were closed down at the end of 1997 because changes in market conditions made the operation uneconomic. Throughout its operational history, total production from the Mecsek mine and mill, including heap leaching, amounted to a total of about 21 000 tU.

Status of production capability

Since the closure of the Mecsek mine in late 1997, the only uranium production in Hungary has been recovered as a by-product of water treatment activities, amounting to a total of about 1-6 tU/yr.

Environmental activities and socio-cultural issues

Closure and large-scale site remediation activities at the Mecsek uranium production centre were carried out between 1998 and 2008. The remediation consisted of: removing several hundred thousand tonnes of contaminated soil from various areas around the site to an on-site disposal facility; remediation of tailings ponds and waste rock piles through the placement of protective earthen covers; abandonment and closure of underground mine workings as well as groundwater extraction and treatment. Although the large-scale remediation programme was completed by the end of 2008, long-term care activities – such as groundwater remediation, environmental monitoring and maintenance of the engineered disposal systems – will have to continue for some years to come.

The legal successor of the former Mecsek mine (a state-owned company) is also responsible for paying compensation including damages for occupational disease, income and pension supplements, reimbursements of certified costs and dependent expenses to people formerly engaged in uranium mining. Costs associated with the environmental remediation of the Mecsek mine are provided in the following table.

Costs of environmental management

(HUF thousands [Hungarian forints])

	Pre-1998	1998 to 2008
Closing of underground spaces	NA	2 343 050
Reclamation of surficial establishments and areas	NA	2 008 403
Reclamation of waste rock piles and their environment	NA	1 002 062
Reclamation of heap leaching piles and their environment	NA	1 898 967
Reclamation of tailings ponds and their environment	NA	8 236 914
Water treatment	NA	1 578 040
Reconstruction of electric network	NA	125 918
Reconstruction of water and sewage system	NA	100 043
Other infrastructural service	NA	518 002
Other activities including monitoring, staff, etc.	NA	2 245 217
Total	**5 406 408**	**20 056 616**

NA = Not available.

After remediation of the uranium mining and ore-processing legacy site, the annual cost of long-term activities amounts to some HUF 450-600 million (about USD 2.3-2.7 million).

In 2010, the Hungarian Atomic Energy Authority asked the IAEA to organise an international peer review to examine whether remediation actions to date and ongoing activities are consistent with IAEA international safety standards and will ensure protection of the public and the environment in the long term. The IAEA team of five international experts and two staff members experienced in groundwater and uranium mill tailings remediation and associated radiation protection conducted the review according to the agreed upon terms of reference under four headings considered to be of fundamental importance in the remediation programme:

- the legal and regulatory framework;
- site remediation activities;
- long-term care activities;
- strategic planning.

The observations and conclusions in the final report were based on the extent to which the programme elements met international good practice. Recommendations were made in areas where improvements were needed to meet safety requirements. The main findings and recommendations of the peer review programme were, with few exceptions, incorporated into the Strategic Plan developed in 2012 for future long-term (30-year) activities.

Uranium requirements

The Hungarian Energy Strategy, adopted by the Parliament in October 2011, includes a roadmap to 2030 and a vision to 2050, aims to ensure the optimal balance of security of supply, competitiveness and sustainability. The government considers energy production as a way out of the economic crisis, noting that energy imports should be decreased by diversifying resources and/or origins. The main elements of the strategy include the increased use of renewable energy sources, maintenance of the existing nuclear capacity through lifetime extension along with consideration of adding new capacity, development of regional energy infrastructure and a new organisational system as well as increased effectiveness and efficiency in energy use. The National Energy Strategy can be found on the website of the Ministry of National Development (www.nfm.gov.hu).

In 2012, 15 793.0 GWh of electricity was generated at the Paks NPP, representing 45.89% of gross domestic electricity production in Hungary. The amount generated by each of the four units was: unit 1: 3 988.2 GWh; unit 2: 3 770.9 GWh; unit 3: 4 035.4 GWh; unit 4: 3 998.5 GWh. This is an outstanding result because the largest energy production was achieved in 2012 in the history of the NPP. The total of all electricity generated by the Paks NPP since the date of the first connection of unit 1 to the grid was greater than 382.6 TWh as of the end of 2012.

On 14 November 2008, an application was submitted for the Service Life Extension Programme (SLEP) of the Paks NPP to the nuclear regulator. In June 2009, the Nuclear Safety Directorate of the Hungarian Atomic Energy Authority (HAEA) approved the conditions, additional actions and tasks required for the implementation of the SLEP. In accordance with the provisions specified by the HAEA, preparations for 20-year life extension beyond of the design service life (30 years) of the NPP were undertaken. Documentation and the licence application required for the operation of unit 1 beyond the design service life was submitted for approval on 5 December 2011. The Nuclear Safety Directorate of the HAEA assessed the licence application and, on 18 December 2012, issued a licence to unit 1 for a further 20-year period of operation. SLEPs for the remaining three units of the Paks NPP are in progress and are expected to be completed in 2014, 2016 and 2017, respectively.

In compliance with the request of the European Commission, the Targeted Safety Reassessment of the Paks NPP ("stress tests") took place in 2012. The HAEA submitted the national report on the results of the reassessment to the European Commission by the end of 2011. The report identified a number of options and measures to enhance plant safety even further. On 25 April 2012, the European Nuclear Safety Regulators Group (ENSREG) and the European Commission approved the report. In line with a joint declaration issued by the commission and ENSREG, an action plan was agreed to in July 2012 that aims to ensure that the recommendations from the peer review process are implemented in a consistent and transparent manner.

A WANO (World Association of Nuclear Operators) peer review was held at the Paks NPP in the spring of 2012. Ten professional fields were reviewed by the WANO expert team, including for the first time nuclear emergency response preparedness in light of lessons learned from the Fukushima Daiichi accident.

The MVM Hungarian Power Companies Ltd established the MVM Paks II Nuclear Power Plant Development Ltd project company on 3 August 2012 to deal with preparatory work for the possible construction of new unit(s) at the Paks NPP.

On 5 December 2012, the first underground chamber of the final repository for low- and intermediate-level radioactive waste in Bátaapáti was inaugurated, an important developmental step for the nuclear industry. This facility is operated by the Public Agency for Radioactive Waste Management (www.rhk.hu).

National policies relating to uranium

Since the shutdown of the Hungarian uranium mining industry in 1997, there are no uranium-related policies.

Uranium stocks

The by-product (UO_4 $2H_2O$) of the water treatment activities on the former uranium mining and ore-processing site is stored at the mine water treatment facility until export. At the end of 2012, the inventory amounted to 2 970 kg.

Uranium prices

Uranium prices are not available as they are commercially confidential.

Uranium exploration and development expenditures and drilling effort – domestic

(HUF)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	NA			
Total expenditures	**NA**			
Industry* exploration drilling (m)	2 422			
Industry* exploration holes drilled	5			
Subtotal exploration drilling (m)	2 422			
Subtotal exploration holes drilled	5			
Total drilling (m)	**2 422**			
Total number of holes drilled	**5**			

* Non-government.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone				17 946
Total				**17 946**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)				17 946	
Total				**17 946**	

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG				17 946	
Total				**17 946**	

* *In situ* resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
		13 427

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	21 053	6	2	1	21 062	3
Total	**21 053**	**6**	**2**	**1**	**21 062**	**3**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Underground mining*	21 000				21 000	
Co-product/by-product	53	6	2	1	62	
Total	**21 053**	**6**	**2**	**1**	**21 062**	

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	20 475				20 475	
Heap leaching*	525				525	
Other methods**	53	6	2	1	62	3
Total	**21 053**	**6**	**2**	**1**	**21 062**	**3**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

** Includes mine water treatment and environmental restoration.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
1	100							1	100

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
1 890	1 890			1 890	1 890	1 890	1 890	1 890	3 000	1 890	4 000	950	3 000

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government					
Producer	3				3
Utility					
Total	**3**				**3**

India

Uranium exploration and mine development

Historical review

The history of uranium exploration in India dates from 1949. Until the mid-1970s, uranium exploration was mainly confined to uranium provinces in the Singhbhum, Jharkhand and Umra-Udaisagar belt in Rajasthan where vein-type mineralisation was already known. One deposit (Jaduguda in Singhbhum, Jharkhand) has been exploited since 1967 and many other deposits in nearby areas were earmarked for future exploitation. Subsequently, investigations were expanded to other geologically favourable areas, based on conceptual models and an integrated exploration approach, resulting in the discovery of two main types of deposits:

- a relatively high-grade, medium-tonnage deposit in the Cretaceous sandstones of Meghalaya in north-eastern India;
- a low-grade, large-tonnage, stratabound deposit in the Middle Proterozoic dolostones of Cuddapah Basin in Andhra Pradesh.

Other small, moderately low-grade deposits discovered during this phase of exploration include:

- Lower Proterozoic amphibolites at Bodal, Chhattisgarh.
- Lower Proterozoic sheared migmatites of Chhotanagpur gneiss complex at Jajawal, Chhattisgarh.
- Basal quartz-pebble conglomerates at Walkunji, Western Karnataka and Singhbhum, Jharkhand.

During the early 1990s, a near-surface deposit was discovered adjacent to the unconformity contact between basement granites and overlying Proterozoic Srisailam Quartzite at Lambapur in the Nalgonda district, Andhra Pradesh. These and others showings were further investigated and by 1996 a number of areas had been identified on the basis of favourable geological criteria and promising exploration results. These areas were consequently selected for intensive investigations: Cuddapah Basin, Andhra Pradesh; Cretaceous sandstones of Meghalaya; Son Valley, Madhya Pradesh and Uttar Pradesh; Singhbhum Shear Zone, Jharkhand and Orissa; and Aravallis, Rajasthan.

Exploration drilling in the Lambapur Peddagattu area subsequently confirmed the potential of the north-west part of the Cuddapah Basin. Cretaceous sandstones in Meghalaya have been identified as a potential horizon for uranium concentration. Surveys and prospection in the areas around the Domiasiat uranium deposit have revealed further promising areas.

Another important province along the southern part of the Cuddapah Basin has emerged in the recent years, in which uranium mineralisation is hosted by carbonates. Intensive exploration is ongoing in this sector.

Recent and ongoing uranium exploration and mine development activities

In recent years, exploration activities have been concentrated in the following areas:

- Proterozoic Cuddapah Basin, Andhra Pradesh.
- Mesoproterozoic Singhbhum Shear Zone, Jharkhand.
- Mesoproterozoic North Delhi Fold Belt, Rajasthan and Haryana.
- Cretaceous sedimentary basin, Meghalaya.
- Neoproterozoic Bhima Basin, Karnataka.
- Neoproterozoic alkaline complexes in the Southern Granulite Terrain, Tamil Nadu.

Proterozoic Cuddapah Basin, Andhra Pradesh

The Cuddapah Basin (Paleo to Neoproterozoic) of Dharwar Craton of Southern Peninsular India is one of the major uranium provinces of India hosting uranium mineralisation at various stratigraphic levels. Three types of uranium mineralisation/deposits have been established in the Cuddapah Basin: carbonate-hosted stratabound-type; unconformity-related; and fracture controlled.

▪ Carbonate-hosted stratabound uranium deposit

The southern part of the Cuddapah Basin hosts a unique, low-grade and large-tonnage uranium deposit hosted by dolostone of Vempalle Formation of Papaghni Group in the Tummalapalle-Rachakuntapalle sector. This formation occurs in the lower stratigraphic sequence of the Cuddapah Basin. Uranium mineralisation has been traced over a strike length of 160 km from Reddipalle in the north to Maddimadugu in the south-east. The vast extent of the deposit – its stratabound nature hosted by dolostone, along with point-to-point correlation with uniform grade and thickness of the mineralisation over considerable lengths along the strike and dip – makes the deposit unique. Sustained exploration activities over the 15 km segment within the 160-km-long belt has added additional uranium resources. Intensive exploration activities continue in various sectors of the 160-km-long belt, substantially increasing the uranium potential of this geological domain.

▪ Unconformity-related uranium deposits

The north-western margin of the Cuddapah Basin comprising Meso to Neoproterozoic Srisailam and Palnad Sub-basins are known for their potential to host unconformity-related uranium deposits. Past exploration in the northern part of Srisailam Sub-basin resulted in establishing three low-tonnage, low-grade uranium deposits: Lambapur, Peddagattu and Chitrial. Exploration efforts along the northern margin of Palnad Sub-basin have resulted in the discovery of a low-grade and low-tonnage deposit at Koppunuru. Further exploration continued in the other parts of the Srisailam and Palnad Sub-basins with similar litho-structural settings.

- Fracture controlled uranium mineralisation

The Gulcheru quartzite overlying the basement granitoid in the southern parts of Cuddapah Basin is intensely fractured, faulted and intruded by E-W trending basic dykes. Uranium mineralisation associated with the quartz-chlorite-breccia along the contact between the Gulcheru quartzite and the basic dykes both in the northern and southern contacts is currently being explored in the Gandi-Madyalabodu area. The fracture systems within the crystalline basement (comprised mostly of granitoids) close to the southern margin of Cuddapah Basin also host uranium mineralisation.

Mesoproterozoic Singbhum Shear Zone, Jharkhand

The Singhbhum Shear Zone, a 200-km-long arcuate belt of tectonised rocks fringing the northern boundary of the Singhbhum craton along its contact with the Singhbhum Group, is a well-known uranium province of India. The known uranium deposits are mostly located in the central and eastern sector of this shear zone. During the last few years focus has shifted to the western sector, where exploration has resulted in the identification of additional uranium resources, notably in the Bangurdih and Narwapahar, Singridungri and Banadungri-Geradih sectors.

Mesoproterozoic North Delhi Fold Belt of Rajasthan and Haryana

The metasediments of North Delhi Fold Belt comprising Khetri, Alwar and Bayana-Lalsot Sub-basins in the states of Rajasthan and Haryana host a number of uranium occurrences. The 170-km-long north-northeast to south-southwest trending Kaliguman lineament that passes through the Delhi Supergroup and Banded Gneissic Complex hosts extensive soda metasomatism that holds potential for vein-type uranium mineralisation. An integrated exploration approach (litho-structural, ground geophysical and drilling inputs) resulted in the discovery of a fracture-controlled vein-type uranium deposit near Rohil, Rajasthan. Extensive ground and airborne geophysical surveys and drilling has been deployed in the contiguous sectors near Rohil, resulting in the establishment of promising new sectors in a similar geological setting along Gumansingh-Ki-Dhani, Narsinghpuri, Hurra-Ki-Dhani, Jahaj-Maota and others.

Cretaceous sedimentary basin, Meghalaya

The Upper Cretaceous Mahadek sandstone exposed along the southern fringes of the Shillong plateau, Meghalaya, is a potential host for uranium mineralisation. This geological domain has been under exploration since the late 1970s. Substantial exploration over the years established five low- to medium-grade and low- to medium-tonnage deposits at Domiasiat, Wahkyn, Gomaghat, Tyrnai and Umthongkut. Exploration efforts continue in contiguous sectors with similar geology.

Neoproterozoic Bhima Basin, Karnataka

The Bhima Basin, comprised of calcareous sediments with minor arenaceous lithological units of Bhima Group which were deposited over basement granite, has been affected by a number of east-west trending faults. A small-sized, medium-grade uranium deposit has been established along the Gogi-Kurlagare fault. Present exploration efforts are concentrated along contiguous sectors of the Gogi-Kurlagare fault and similar structures that cut across the basement and sediments along the basin margin.

Neoproterozoic Alkaline complexes in Southern Granulite Terrain, Tamil Nadu.

The Dharmapuri Shear Zone (DSZ) of Tamil Nadu is emerging as a potential province for multi-metal deposits, including uranium. The north-northeast to south-southwest trending shear zone forms part of the Southern Granulite Terrain. Exploration for uranium, Nb-Ta and rare earth elements in the northern part of the granulite terrain dates back to mid-1960s and has resulted in the discovery of significant uranium anomalies in quartz-barite veins at several places along the DSZ. A series of prospecting ventures during the past two decades led to the discovery of a number of uranium anomalies in the alkaline emplacements within the DSZ. The Sevattur alkaline-carbonatite complex has been explored for uranium and rare earth elements in the past and the alkaline intrusions near Rasimalai and Pakkanadu along the DSZ are actively being explored.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

India's known conventional uranium resources (RAR and IR), estimated to amount to 158 282 tU, are hosted in the following deposit types:

Carbonate deposits	38.67%
Metamorphite	32.26%
Sandstone-type	11.46%
Unconformity-type	11.42%
Metasomatite	3.68%
Granite-related	2.29%
Quartz-pebble conglomerates	0.22%

As of 1 January 2013, the known conventional *in situ* resources established so far include 129 012 tU of RAR and 29 270 tU of IR. This amounts to a substantial increase in RAR and a marginal decrease in IR, compared to figures in the 2011 Red Book. These changes are mainly due to resource additions in the contiguous area of the stratabound deposit in the southern part of the Cuddapah Basin and in extension of known deposits in the Singhbhum Shear Zone and Mahadek basin. Furthermore, part of the IR reported in 2011 has been converted to RAR.

Undiscovered conventional resources (prognosticated and speculative resources)

In parts of Andhra Pradesh, Meghalaya, Rajasthan, Jharkhand and Karnataka, potential areas for uranium resources were firmed-up with higher degree of confidence. As of 1 January 2013, undiscovered resources amounted to 84 800 tU under the prognosticated category and 42 400 tU under the speculative category.

Uranium production

Historical review

The Uranium Corporation of India Limited (UCIL) was formed in October 1967 under the administrative control of the Department of Atomic Energy, Government of India. The UCIL operates six underground uranium mines (Jaduguda, Bhatin, Narwapahar, Turamdih, Bagjata and Mohuldih) and one opencast (open-pit) mine (Banduhurang in Singhbhum East district of Jharkhand State). The ore produced from mines is processed in two processing plants located at Jaduguda and Turamdih. All these facilities are located in a multi-metal mineralised sector – the Singhbhum Shear Zone in the eastern part of India. Besides these, UCIL has also constructed a uranium mine and a processing plant in YSR district (formerly Kadapa) of Andhra Pradesh.

Status of production facilities, production capability, recent and ongoing activities and other issues

The total installed capacity of UCIL's three operating plants is as follows:

- Jaduguda Plant: 2 500 t ore/day.
- Turamdih Plant: 3 000 t ore/day.
- Tummalapalle Plant: 3 000 t ore/day.

Recent and ongoing activities

Jaduguda mine: The Jaduguda uranium deposit lies within meta-sediments of Singhbhum Shear Zone. The host rocks are of Proterozoic age. There are two prominent parallel ore lenses – the Footwall lode (FWL) and the Hangwall lode (HWL). These lodes are separated by a 100 m barren zone. The FWL extends over a strike length of about 600 m in a south-east to north-west direction. The strike length of HWL (about 250 m) is confined to the eastern part of the deposit. Both the lodes have an average dip of 40 degrees towards the north-east. Of the two lodes, the FWL is better mineralised. The Jaduguda deposit has been explored up to a depth of 880 m.

Entry to the mine is through a 640-metre-deep vertical shaft. An underground auxiliary vertical shaft, sunk from 555 m to 905 m, provides access to deeper levels. The cut-and-fill stoping method is practiced, giving about 80 % ore recovery. De-slimed mill tailings are used as backfill material. Ore is hoisted by the skip in stages through shafts to surface and sent to the Jaduguda mill by conveyor for further processing.

Bhatin mine: The Bhatin uranium deposit is located 4 km north-west of Jaduguda. A major strike-slip fault lies between the Jaduguda and Bhatin deposits, both of which lie in similar geological settings. The Bhatin mine began production in 1986. The ore lens has a thickness of 2 to 10 m with an average dip of 35 degrees and entry to the mine is through an adit, with deeper levels accessed by inclines. Cut-and-fill stoping is practised and deslimed mill tailings from the Jaduguda mill are used as backfill. Broken ore is trucked to the Jaduguda mill. UCIL is evaluating possibilities for increasing underground productivity by introducing further mechanisation in its working methods.

Narwapahar mine: The Narwapahar deposit, (about 12 km west of Jaduguda) has been operating since 1995. In this deposit, discrete uraninite grains occur within chlorite-quartz schist with associated magnetite with several lenticular-shaped ore lenses extending over a strike length of about 2 100 m, each with an average north-easterly dip of 30 to 40 degrees. The thickness of the individual ore lenses varies from 2.5 to 20 m. The deposit is accessed by a 355-metre-deep vertical shaft and a 7 degree decline from the surface. Cut-and-fill stoping is also practiced using deslimed mill tailings of the Jaduguda plant as backfill. Ore is trucked to the Jaduguda plant for processing.

Turamdih mine: The Turamdih deposit is located about 12 km west of Narwapahar. Discrete uraninite grains within feldspathic-chlorite schist form a number of ore lenses with very erratic configuration. The mine was commissioned in 2003 and two levels (70 m and 100 m depth) have been opened by access through an 8 degree decline from the surface and a vertical shaft is being sunk to provide access to deeper levels. Ore from this mine is processed at the Turamdih plant. As the deposit has irregular ore geometry, possibilities of adopting a mining method with higher productivity in specific segments of the orebody is being explored. Trial stoping in one such area has been undertaken.

Bagjata mine: The Bagjata deposit, situated about 26 km east of Jaduguda, has been developed as an underground mine with a 7 degree decline for entry and a vertical shaft to access deeper levels. This mine was commissioned in 2008. Ore from the Bagjata mine is transported by road to the Jaduguda plant for processing.

Banduhurang mine: The Banduhurang deposit has been developed as a large opencast mine. The orebody is the westernmost extension of ore lenses at Turamdih. The mine was commissioned in 2009 and ore is transported by road to the Turamdih plant for processing.

Mohuldih mine: The deposit is located in the Seraikela-Kharswan district of Jharkhand, about 2.5 km west of Banduhurang. The mine was commissioned in 2012. The ore from the mine is treated at the Turamdih plant.

Tummalapalle mine: Hosted in carbonate rock, this deposit is located in the YSR district (formerly Kadapa) of Andhra Pradesh. It is the first uranium production centre in the country located outside Jharkhand. This underground mine is accessible by three declines along the apparent dip of the orebody. The central decline is equipped with a conveyor for ore transport and the other two declines are used as service paths. The ore is treated in a pressurised alkali leaching plant. The mine processes 2 000 t ore/day and expansion of the mine and processing plant at Tummalapalle has been planned to augment uranium production.

Jaduguda mill: Ore produced at the Jaduguda, Bhatin, Narwapahar and Bagjata mines is processed in the mill located at Jaduguda. Commissioned in 1968, the mill is capable of treating about 2 500 t/day of dry ore. Following crushing and grinding to 60% (passing 200 mesh), the ore is leached in pachuca tanks using sulphuric acid under controlled pH and temperature. After filtration of the pulp, an ion exchange resin is used to recover the uranium. After elution, the product is precipitated using magnesia to produce magnesium di-uranate containing 70% U_3O_8 (59% U). The final product of the Jaduguda mill is uranium peroxide. The treatment of mine water and reclaiming tailings water has resulted in reduced fresh water requirements, as well as increasing the purity of the final effluent. A magnetite recovery plant is also in operation at Jaduguda producing very fine grained magnetite as a by-product.

Turamdih mill: Uranium ore from the Turamdih and Banduhurang mines is being processed in the Turamdih mill. The mill, commissioned in 2009, is capable of treating about 3 000 t/day dry ore. An expansion of this plant to process 4 500 t/day dry ore has been taken up.

Tummalapalle mill: The Tummalapalle uranium deposit in the Kadapa district of Andhra Pradesh was established in 1992 and taken up for development in 2007. In order to process ore produced from the Tummalapalle mine, UCIL has recently set up a process plant with a 3 000 t ore/day capacity.

Ownership structure of the uranium industry

The uranium industry is wholly owned by the Department of Atomic Energy, Government of India. The Atomic Minerals Directorate for Exploration and Research (AMD) under the Department of Atomic Energy is responsible for uranium exploration programmes in India. Following the discovery and deposit delineation, the economic viability is evaluated. The evaluation stage may also include exploratory mining. Once a deposit of sufficient tonnage and grade is established, UCIL initiates activities for commercial mining and production of uranium concentrates.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6	Centre #7	Centre #8
Name of production centre	Jaduguda	Bhatin	Narwapahar	Bagjata	Turamdih	Banduhurang	Mohuldih	Tummalapalle
Production centre classification	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Existing
Start-up date	1967	1986	1995	2008	2003	2007	2011	2012
Source of ore:	Uranium ore	Uranium ore	Uranium ore	Uranium ore	Uranium ore	Uranium ore	Uranium ore	Uranium ore
Deposit name(s)	Jaduguda	Bhatin	Narwapahar	Bagjata	Turamdih	Banduhurang	Mohuldih	Tummalapalle
Deposit type(s)	Vein	Vein	Vein	Vein	Vein	Vein	Vein	Strata bound
Resources (tU)	-	-	-	-	-	-	-	-
Grade (% U)	-	-	-	-	-	-	-	-
Mining operation:								
Type (OP/UG/ISL)	UG	UG	UG	UG	UG	OP	UG	UG
Size (tonnes ore/day)	650	150	1 500	500	750	3 500	500	3 000
Average mining recovery (%)	80	75	80	80	75	65	80	60
Processing plant:	Jaduguda				Turamdih			Tummalapalle
Type (IX/SX/AL)	IX/AL				IX/AL			ALKPL*
Size (tonnes ore/day)	2 500				3 000			3 000
Average process recovery (%)	80				80			70
Nominal production capacity (tU/year)	200				190			220
Plans for expansion	-				Turamdih mine (1 000 TPD) and Turamdih plant (4 500 TPD) are under expansion			Tummalapalle mine (4 500 TPD) and Tummalapalle plant (4 500 TPD) are under expansion
Other remarks	Ore being processed in Jaduguda plant				Ore being processed in Turamdih plant			

* Pressurised alkali leach. TPD = tons per day.

Uranium production centre technical details *(continued)*

(as of 1 January 2013)

	Centre # 9	Centre # 10	Centre # 11
Name of production centre	Gogi	Lambapur-Peddagattu	Kylleng-Pyndengsohiong Mawthabah (KPM)
Production centre classification	Committed	Planned	Planned
Start-up date	2014	2016	2017
Source of ore:	Uranium ore	Uranium ore	Uranium ore
Deposit name(s)	Gogi	Lambapur-Peddagattu	KPM
Deposit type(s)	Vein	Unconformity	Sandstone
Resources (tU)	-	-	-
Grade (% U)	-	-	-
Mining operation:			
Type (OP/UG/ISL)	UG	UG/OP	OP
Size (tonnes ore/day)	500	1 250	2 000 (250 days/yr working)
Average mining recovery (%)	60	75	90
Processing plant:	Gogi	Seripally	KPM
Type (IX/SX/AL)	AL	IX/AL	IX/AL
Size (tonnes ore/day)	500	1 250	2 000 (275 days/yr working)
Average processing ore recovery (%)	88	77	87
Nominal production capacity (tU/year)	130	130	340
Plans for expansion	-	-	-
Other remarks	Ore to be processed in the plant at Saidapur	Ore to be processed in the plant at Seripally	

Employment in the uranium industry

About 4 962 people are engaged in uranium mining and milling activities.

Future production centres

The uranium deposit located at Gogi in the Yadgir (former name Gulbarga) district, Karnataka, is planned for development as an underground mine. Exploratory mining work is in progress to establish the configuration of the orebody. The plant at Gogi will utilise alkali leaching technology.

A sandstone-hosted uranium deposit in the north-eastern part of the country at Kylleng-Pyndengsohiong, Mawthabah (formerly Domiasiat) in West Khasi Hills District, Meghalaya State, is planned for development by open-pit mining, with a processing plant to be situated near the mine.

Uranium deposits located at Lambapur-Peddagattu in the Nalgonda district, Andhra Pradesh are also slated for development, with an open-pit and three underground mines proposed. An ore processing plant is being proposed at Seripally, 50 km from the mine site. Pre-project activities are in progress.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

NA.

Production and/or use of re-enriched tails

NA.

Production and/or use of reprocessed uranium

NA.

Environmental activities and socio-cultural issues

There are no environmental issues related to the existing uranium mines and processing plants operated by UCIL. However, provisions are made for the management of environmental impacts. The organisation responsible for this task is the Health Physics Group of the Bhabha Atomic Research Centre, located in Mumbai. It carries out environmental health monitoring for radiation, radon and dust at uranium production facilities. The Health Physics Unit operates an Environmental Survey Laboratory at Jadugudaand and has establishments at all operating facilities.

Regulatory regime

In India all nuclear activities, including mining of uranium or other atomic minerals, falls within the purview of the central government and are governed by the Atomic Energy Act, 1962 (AE Act) and regulations made thereunder. The Department of Atomic Energy (DAE) oversees the development and mining of uranium and other atomic minerals. Accordingly, policies of DAE and provisions of the AE Act and regulations framed thereunder play a key role in the prospecting, exploration and mining of uranium. Relevant provisions of the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act) and the Mines Act, 1952 are also applicable in the case of mining of uranium. In addition, all mining activities must comply with environmental regulations. The mining, milling and processing of uranium ore requires a licence under the AE Act. The Atomic Energy (Radiation Protection) Rules (2004) and the Atomic Energy (Working of Mines and Minerals and Handling of Prescribed Substances) Rules (1984) provide procedural details for obtaining a licence and specify conditions required to carry out these activities.

A mining lease for uranium is granted by the state government after the mining plan is approved by AMD as per the provisions of MMDR Act. The Atomic Energy Regulatory Board (AERB), an independent authority, regulates safety and other regulatory provisions under the AE Act and ensures the safety of workers, the public and the environment. The AERB oversees various aspects of a mining plan that are required to conform to radiological safety, siting of the mill, disposal of tailings and other waste rocks, as well as decommissioning the facility. Opening, operation and decommissioning of uranium mines require compliance with the various provisions under different legislation and regulations.

In India, uranium exploration/prospecting and mining are carried out exclusively by the central government.

Uranium requirements

As of 1 January 2013, the total installed nuclear capacity in India was 4 780 MWe (gross) which is comprised of 18 pressurised heavy water reactors and two boiling water reactors. Construction of 4 pressurised heavy water reactors (KAPP 3 and 4 – 2 x 700 MWe and RAPP 7 and 8 – 2 x 700 MWe), 2 light water reactors; KKNPP 1 and 2 – 2 x 1 000 MWe) and 1 prototype fast breeder (500 MWe) is in progress. Total nuclear power generating capacity is expected to grow to about 7 280 MWe (gross; 6 700 MWe net) by 2015 as projects under construction are progressively completed.

The present plan is to increase nuclear installed capacity to about 35 000 MWe by the year 2022 which will be comprised of 11 460 MWe by pressurised heavy water reactors, 22 320 MWe by light water reactors, 1 500 MWe by fast breeder reactors and 300 MWe by advanced heavy water reactor.

Annual uranium requirements in 2011 amounted to about 930 tU and this would increase in tandem with increases in installed nuclear capacity. Identified conventional uranium resources are sufficient to support 10-15 GWe installed capacity of pressurised heavy water reactors operating at a lifetime capacity factor of 80% for 40 years

With international co-operation in peaceful nuclear energy being opened to India, installed nuclear generating capacity is expected to grow significantly as more international projects are envisaged. However, the exact size of the programme based on technical co-operation with other countries is yet to be finalised.

Supply and procurement strategy

Uranium requirements for pressurised heavy water reactors are being met with a combination of indigenous and imported sources. Two operating boiling water reactors and two light water reactors (VVER-type) under construction require enriched uranium and are fuelled by imported uranium. Future light water reactors will also be fuelled by imported uranium.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Uranium exploration, mining, production, fuel fabrication and the operation of nuclear power reactors are controlled by the government of India. National policies relating to uranium are governed by the Atomic Energy Act 1962 and the provisions made thereunder.

Imported light water reactors to be built in the future are to be purchased with an assured fuel supply for the lifetime of the reactor.

Uranium stocks

NA.

Uranium prices

NA.

Uranium exploration and development expenditures and drilling effort – domestic

(Indian rupee millions)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	0	0	0	0
Government exploration expenditures	2 581.40	2 526.30	2 827.00	2 359.00
Industry* development expenditures	0	0	0	0
Government development expenditures	0	0	0	0
Total expenditures	**2 581.40**	**2 526.30**	**2 827.00**	**2 359.00**
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Government exploration drilling (m)	217 548	203 799	188 140	186 950
Government exploration holes drilled	NA	NA	NA	NA
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	217 548	203 799	188 140	186 950
Subtotal exploration holes drilled	NA	NA	NA	NA
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**217 548**	**203 799**	**188 140**	**186 950**
Total number of holes drilled	**NA**	**NA**	**NA**	**NA**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Proterozoic unconformity	NA	NA	NA	18 072
Sandstone	NA	NA	NA	15 337
Granite-related	NA	NA	NA	3 618
Metamorphite	NA	NA	NA	33 396
Metasomatite	NA	NA	NA	5 159
Carbonate	NA	NA	NA	53 430
Total				**129 012**

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Underground mining (UG)	NA	NA	NA	109 046
Open-pit mining (OP)	NA	NA	NA	19 966
Unspecified	0	0	0	0
Total				**129 012**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Conventional from UG	NA	NA	NA	109 046
Conventional from OP	NA	NA	NA	19 966
Total				**129 012**

* *In situ* resources.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Sandstone	NA	NA	NA	2 807
Paleo-quartz-pebble conglomerate	NA	NA	NA	352
Metamorphite	NA	NA	NA	17 665
Metasomatite	NA	NA	NA	666
Carbonate	NA	NA	NA	7 780
Total	**NA**	**NA**	**NA**	**29 270**

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Underground mining (UG)	NA	NA	NA	26 463
Open-pit mining (OP)	NA	NA	NA	2 807
Total	**NA**	**NA**	**NA**	**29 270**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Conventional from UG	NA	NA	NA	26 463
Conventional from OP	NA	NA	NA	2 807
Total	**NA**	**NA**	**NA**	**29 270**

* *In situ* resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	Cost range unassigned
NA	NA	84 800

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
NA	NA	42 400

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
NA	100	NA	NA	NA	NA	NA	NA	NA	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	4 917	4 917	4 962	4 962
Employment directly related to uranium production				

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA				NA				NA			

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA				NA				NA			

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	32.400	33.170

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
4 780	4 780	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		NA	5 780	NA	7 280	10 080	11 480	NA	25 000	NA	NA	NA	NA

Annual reactor-related uranium requirements to 2035 (excluding MOX)

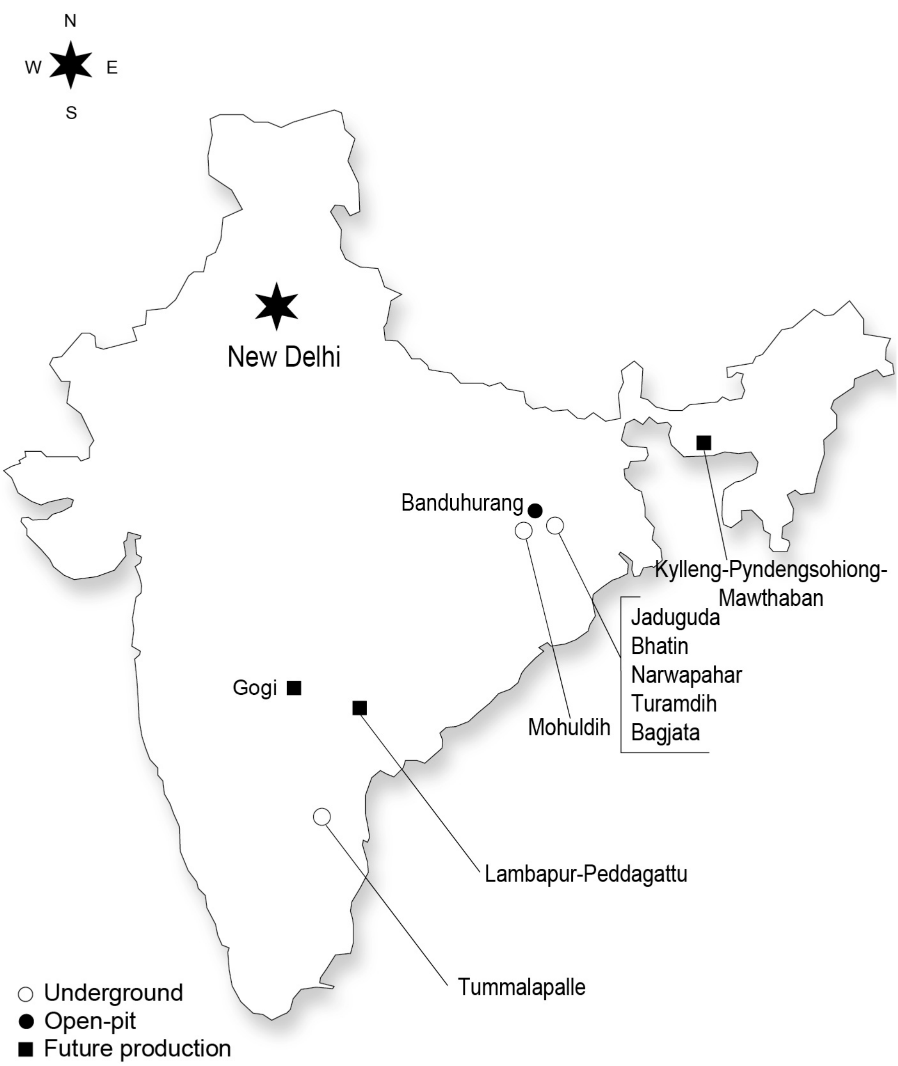
(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
NA	NA	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		NA	1 400	NA	1 300	1 800	2 050	NA	4 400	NA	NA	NA	NA

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government					
Producer					
Utility					
Total	**NA**	**NA**	**NA**	**NA**	**NA**



Indonesia

Uranium exploration and mine development

Historical review

Uranium exploration by the Centre for Development of Nuclear Ore and Geology of the National Nuclear Energy Agency of Indonesia (BATAN) started in the 1960s. Up to 1996 reconnaissance surveys had covered 79% of a total of 533 000 km^2 identified for survey on the basis of favourable geological criteria and promising exploration results. Since that year the exploration activities have been focused on the Kalan, Kalimantan, in which the most significant indications of uranium mineralisation have been found. During 1998-1999, exploration consisted of systematic geological and radiometric mapping, including a radon survey carried out at Tanah Merah and Mentawa, Kalimantan in order to delineate the mineralised zone. The results of those activities increased speculative resource estimates by 4 090 tU to 12 481 tU. From 2000 up to 2002, exploration drilling was carried out at upper Rirang (178 m), Rabau (115 m) and Tanah Merah (181 m) in west Kalimantan.

In 2003-2004, additional exploration drilling was conducted at Jumbang 1 (186 m) and Jumbang 2 (227 m). In 2005, exploration drilling was carried out at Jumbang 3 (45 m) and at Mentawa (45 m), in 2006 at Semut (454 m) and Mentawa (45 m) and 2007 at Semut (174 m). In 2008, no exploration drilling was undertaken.

In 2009, exploration drilling was continued in the Kalan Sector and detailed, systematic prospection in the Kawat area and its surroundings was carried out. General prospection in Bangka Belitung Province was also undertaken. Plans to extend exploration in Kalimantan and Sumatera by prospecting from general reconnaissance to systematic stages in order to discover new uranium deposits have been adopted. In 2010, efforts were devoted to evaluating drilling data from the Kawat sector to re-evaluate estimates of speculative resources.

Recent and ongoing uranium exploration and mine development activities

In 2011, exploration drilling was carried out at Sarana (Kalan Sector) to a total depth of 116 m, targeting uranium mineralisation hosted in metasiltstone and metapelite schistose. A general survey was completed in the eastern part of the central mountain of Papua Island (Nalca District, Yahukimo Region), covering an area of 300 km^2. The exploration target is Proterozoic unconformity-type mineralisation in Paleozoic – middle Proterozoic rocks. No significant radiometric anomaly has been found. Results of geochemical stream sediment samples range between 0.3-3.8 ppm U (0.00003-0.00038% U).

In 2012, the general survey of Papua continued in the central area of the central mountain, targeting sandstone-type deposits hosted in the Paleozoic Aiduna Formation that contains carbonaceous material. No significant radiometric anomaly was found at the surface. Uranium content in the rocks ranges between 4.3-32 ppm U (0.00043-0.0032% U).

In 2013, a general survey was conducted over an area of 80 km^2 in Miocene age potassic volcanic rocks in West Sulawesi. A general survey will also be conducted in Biak Island, Papua where a uranium anomaly from an environmental survey has been reported. Exploration drilling is also planned with a total of 1 500 m in the Lemajung sector and a total of 600 m in Lembah Hitam, Kalan.

No mining activity is currently under consideration.

Uranium exploration and development expenditures and drilling effort – domestic

(Indonesian rupiah [IDR])

	2010	2011	2012	2013 (expected)
Government exploration expenditures	2 925 000 000	3 907 357 400	2 610 215 235	5 881 000 000
Total expenditures	**2 925 000 000**	**3 907 357 400**	**2 610 215 235**	**5 881 000 000**
Government exploration drilling (m)	84	116		2 100
Government exploration holes drilled	2	2		7
Subtotal exploration drilling (m)	84	116		2 100
Subtotal exploration holes drilled	2	2		7
Total drilling (m)	**84**	**116**		**2 100**
Total number of holes drilled	**2**	**2**		**7**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Metamorphite	0	2 005	8 417	8 417
Total	**0**	**2 005**	**8 417**	**8 417**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	2 005	8 417	8 417	75
Total	**0**	**2 005**	**8 417**	**8 417**	**75**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	2 005	8 417	8 417	75
Total	**0**	**2 005**	**8 417**	**8 417**	**75**

* *In situ* resources.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Metamorphite	0	0	0	2 244
Total	**0**	**0**	**0**	**2 244**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	0	2 244	75
Total	**0**	**0**	**0**	**2 244**	**75**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	0	2 244	75
Total	**0**	**0**	**0**	**2 244**	**75**

* *In situ* resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	23 472

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	22 020

Iran, Islamic Republic of

Uranium exploration and mine development

Historical review

Exploration

In 1935, the first occurrence of radioactive minerals was detected in the Anarak mining region. In 1959 and 1960, through co-operation between the Geologic Survey of Iran (GSI) and a French company, preliminary studies were carried out in Anarak and Khorassan (central Iran and Azarbaijan regions) in order to evaluate the uranium mineralisation potential. Systematic uranium exploration in Iran began in the early 1970s in order to provide uranium ore for planned processing facilities. Between 1977 and the end of 1978, one-third of Iran (650 000 km^2) was covered by terrain clearance airborne geophysical surveys. Many surficial uranium anomalies were identified and follow-up field surveys have continued to the present. The airborne coverage is mainly over the central, south-eastern, eastern and north-western parts of Iran. The favourable regions studied by this procedure are the Bafq-Robateh Posht e Badam region (Saghand, Narigan, Khoshumi), Maksan and Hudian in south-eastern Iran and Dechan, Mianeh and Guvarchin in Azarbaijan. Outside of the airborne geophysics coverage area, uranium mineralisation at Talmesi, Meskani, Kelardasht and the Salt Plugs of south Iran are also worthy of mention.

Mine development

Feasibility studies and basic engineering designs (1994-1995) and mining preparation reports (1996) led to construction of administration and industrial buildings and equipment supply (1997-1998). Shafts No.1 and No. 2 were sunk (1999 to 2002) and underground development of the Saghand mine began in 2003.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration activities

According to comprehensive planning, exploration activities within recognised favourable areas are being performed in different phases (i.e. reconnaissance to detailed phase). The reconnaissance and prospecting phases are being accomplished in central, southern, eastern, north-eastern and north-western provinces of the country. Since uranium mineralisation with positive indications has been found in various geological environments, uranium exploration activities are being conducted for a number of different types of deposits, such as granite-related, intrusive and surficial types, and an extensive part of the country has been explored as part of a reconnaissance phase with many favourable areas suited for the prospecting phase. At present, the general and detailed exploration phases are done in different parts of the country, particularly central and southern parts.

Mine development activities

At present, the development of mines No. 1 and 2 is being carried out in the Saghand ore field. In mine No. 1, based on the basic and detailed design, open-pit method is being used to access orebodies to a specified level, through overburden stripping. Ore at mine No. 2 is being extracted by an underground method. For this purpose two shafts (main and ventilation shafts) have been sunk and the adits are being drilled. Also some stopes are being developed at different levels for ore production.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Based on exploration activities completed during 2011 and 2012 in different parts of the country, a total of 2 880 tU has been added to RAR and inferred resources.

Saghand ore field

Exploration activities have been expanded to many other parts of the Saghand mining district, including both surface and subsurface studies. Extensive exploration has been performed in areas of metasomatic mineralisation. Considering the extensiveness of these areas, despite low-grade uranium values, the presence of valuable associated elements bring about a suitable outlook for resources.

Gachin deposit

Many indications of mineralised outcrops and blind deposits have been recognised in central and marginal parts of the salt plug. At present, detailed exploration including geological and geophysical studies, shallow drilling and logging is being completed in this area. The recognised deposits are of surficial type and relatively high grade. Up to now, many positive indicators have been recognised and it is expected to find some other deposits in undiscovered parts and also at depth of the plug.

Narigan deposit

Exploration operations are being terminated in this deposit. The mineralisation is of granite-related type. The recognised resources are in RAR and inferred categories. Further exploration is planned in other more favourable parts of this area.

Champeh and Moghuyeh salt plugs

The general and detailed exploration has been performed in these plugs through surface and subsurface studies and the recognised deposits are of surficial type.

Undiscovered conventional resources (prognosticated and speculative resources)

Kerman-Sistan mineralisation trend

The uranium mineralisation potential in this trend is of volcanic-related, metasomatic and granite-related type and at present, exploration studies are being conducted on favourable areas. Considering the potential of these areas, some of them are expected to be selected for further exploration.

Naiin-Jandagh mineralisation trend

The uranium mineralisation potential is of granite-related and volcanic-related type and is polymetallic. The surficial studies are being undertaken on favourable areas. If results are positive, further exploration will be performed on subsurface.

Birjand-Kashmar mineralisation trend

The uranium mineralisation potential is of sedimentary, granite-related and volcanic-related type. The surficial studies are being conducted on favourable areas. If favourable results are obtained, further exploration, including borehole drilling and logging will be undertaken.

Salt plugs in south of Iran

Exploration of many salt plugs have been performed in south of Iran, favourable findings have resulted in the selection of favourable plugs for further exploration activities. In Band-e Moallem salt plug, the general exploration via geological, geophysical surveys and trenching is being done. In case of obtaining good results from surficial studies, further exploration including shallow borehole drilling and logging will be done.

Uranium production

Historical review

Uranium ore recovered by open-pit mining of the Gachin salt plug has been processed at Bandar Abbas uranium plant (BUP) since 2006.

Status of production facilities, production capability, recent and ongoing activities and other issues

Iran's first operating production centre (BUP) began operating in 2006. Considering a decrease of ore grade and in order to increase production, daily feed of the plant has been increased to 70 tonnes.

Uranium production centre technical details
(as of 1 January 2013)

	Centre #1	Centre #2
Name of production centre	Gachin	Ardakan
Production centre classification	Existing	Committed
Date of first production	2006	2013
Source of ore:		
Deposit name(s)	Gachin	Saghand
Deposit type(s)	Salt plug	Metasomatite
Recoverable resources (tU)	100	900
Grade (% U)	0.08	0.0553
Mining operation:		
Type (OP/UG/ISL)	OP	10% OP, 90% UG
Size (tonnes ore/day)	70	400
Average mining recovery (%)	80	80
Processing plant:		
Acid/alkaline	Acid	Acid
Type (IX/SX)	SX	IX
Size (tonnes ore/day)	70	400
Average process recovery (%)	90	90
Nominal production capacity (tU/year)	21	50
Plans for expansion	Yes	No

Ownership structure of the uranium industry

The owner of uranium industry is the Government of the Islamic Republic of Iran and the operator is the Atomic Energy Organisation of Iran (AEOI).

Future production centres

In addition to the currently operating BUP production centre, a production centre in Ardakan is at pre-commissioning stage and it is to be expected that comes into operation in 2013. In addition, bench scale processing studies are being carried out for the Narigan deposit. At present, the Ardakan plant is in pre-commissioning stage and it is expected to come into operation in 2013. It will be supplied with ore from the Saghand uranium mine. Parallel to the detailed exploration phase in the Narigan deposit, bench scale processing studies are being carried out.

Uranium exploration and development expenditures and drilling effort – domestic

(IRR millions [Iranian rial])

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	0	0	0	0
Government exploration expenditures	146 156	321 952	635 700	680 000
Industry* development expenditures	0	0	0	0
Government development expenditures	186 676	256 064	369 989	215 000
Total expenditures	**332 832**	**578 016**	**1 005 689**	**895 000**
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Government exploration drilling (m)	45 230	46 730	47 010	80 000
Government exploration holes drilled	328	400	420	615
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	45 230	46 730	47 010	80 000
Subtotal exploration holes drilled	328	400	420	615
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**45 230**	**46 730**	**47 010**	**80 000**
Total number of holes drilled	**328**	**400**	**420**	**615**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Proterozoic unconformity	0	0	0	0
Sandstone	0	0	0	0
Polymetallic Fe-oxide breccia complex	0	0	0	0
Paleo-quartz-pebble conglomerate	0	0	0	0
Granite-related	0	0	285	285
Metamorphite	0	0	136	136
Intrusive	0	0	0	0
Volcanic-related	0	0	0	0
Metasomatite	0	0	491	491
Surficial	0	0	110	110
Carbonate	0	0	0	0
Total	**0**	**0**	**1 022**	**1 022**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	491	491	85-90
Open-pit mining (OP)	0	0	110	110	85-90
In situ leaching acid	0	0	0	0	
In situ leaching alkaline	0	0	0	0	
Co-product and by-product	0	0	0	0	
Unspecified	0	0	421	421	85-90
Total	**0**	**0**	**1 022**	**1 022**	**85-90**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	491	491	85-90
Conventional from OP	0	0	110	110	85-90
In situ leaching acid	0	0	0	0	
In situ leaching alkaline	0	0	0	0	
In-place leaching*	0	0	0	0	
Heap leaching** from UG	0	0	0	0	
Heap leaching** from OP	0	0	0	0	
Unspecified	0	0	421	421	85-90
Total	**0**	**0**	**1 022**	**1 022**	**85-90**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	0	0	0	0
Sandstone	0	0	0	0
Polymetallic Fe-oxide breccia complex	0	0	0	0
Paleo-quartz-pebble conglomerate	0	0	0	0
Granite-related	0	0	752	752
Metamorphite	0	0	24	24
Intrusive	0	0	0	0
Volcanic-related	0	0	100	100
Metasomatite	0	0	2 510	2 510
Surficial	0	0	0	0
Total	**0**	**0**	**3 386**	**3 386**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	876	876	85-90
Open-pit mining (OP)	0	0	0	0	85-90
In situ leaching acid	0	0	0	0	
In situ leaching alkaline	0	0	0	0	
Co-product and by-product	0	0	0	0	
Unspecified	0	0	2 510	2 510	85-90
Total	**0**	**0**	**3 386**	**3 386**	**85-90**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	876	876	85-90
Conventional from OP	0	0	0	0	
In situ leaching acid	0	0	0	0	
In situ leaching alkaline	0	0	0	0	
In-place leaching*	0	0	0	0	
Heap leaching** from UG	0	0	0	0	
Heap leaching** from OP	0	0	0	0	
Unspecified	0	0	2 510	2 510	85-90
Total	**0**	**0**	**3 386**	**3 386**	**85-90**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	12 400	12 400

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	32 700

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Proterozoic unconformity	0	0	0	0	0	0
Sandstone	0	0	0	0	0	0
Polymetallic Fe-oxide breccia complex	0	0	0	0	0	0
Paleo-quartz-pebble conglomerate	0	0	0	0	0	0
Granite-related	0	0	0	0	0	0
Metamorphite	0	0	0	0	0	0
Intrusive	0	0	0	0	0	0
Volcanic-related	0	0	0	0	0	0
Metasomatite	0	0	0	0	0	25
Surficial	25.5	7.3	12	15	59.8	15
Carbonate	0	0	0	0	0	0
Phosphate	0	0	0	0	0	0
Collapse-breccia type	0	0	0	0	0	0
Lignite and coal	0	0	0	0	0	0
Black shale	0	0	0	0	0	0
Other/unspecified	0	0	0	0	0	0
Total	**25.5**	**7.3**	**12**	**15**	**59.8**	**40**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	25.5	7.3	12	15	59.8	15
Underground mining[1]	0	0	0	0	0	25
In situ leaching	0	0	0	0	0	0
Co-product/by-product	0	0	0	0	0	0
Total	**25.5**	**7.3**	**12**	**15**	**59.8**	**40**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	25.5	7.3	12	15	59.8	40
In-place leaching*	0	0	0	0	0	0
Heap leaching**	0	0	0	0	0	0
U recovered from phosphate rocks	0	0	0	0	0	0
Other methods***						
Total	**25.5**	**7.3**	**12**	**15**	**59.8**	**40**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
15	100	0	0	0	0	0	0	15	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	325	340	350	600
Employment directly related to uranium production				

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	71	0	0	0	87	0	NA	NA	90	118

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	0.1	1.33

Installed nuclear generating capacity to 2035

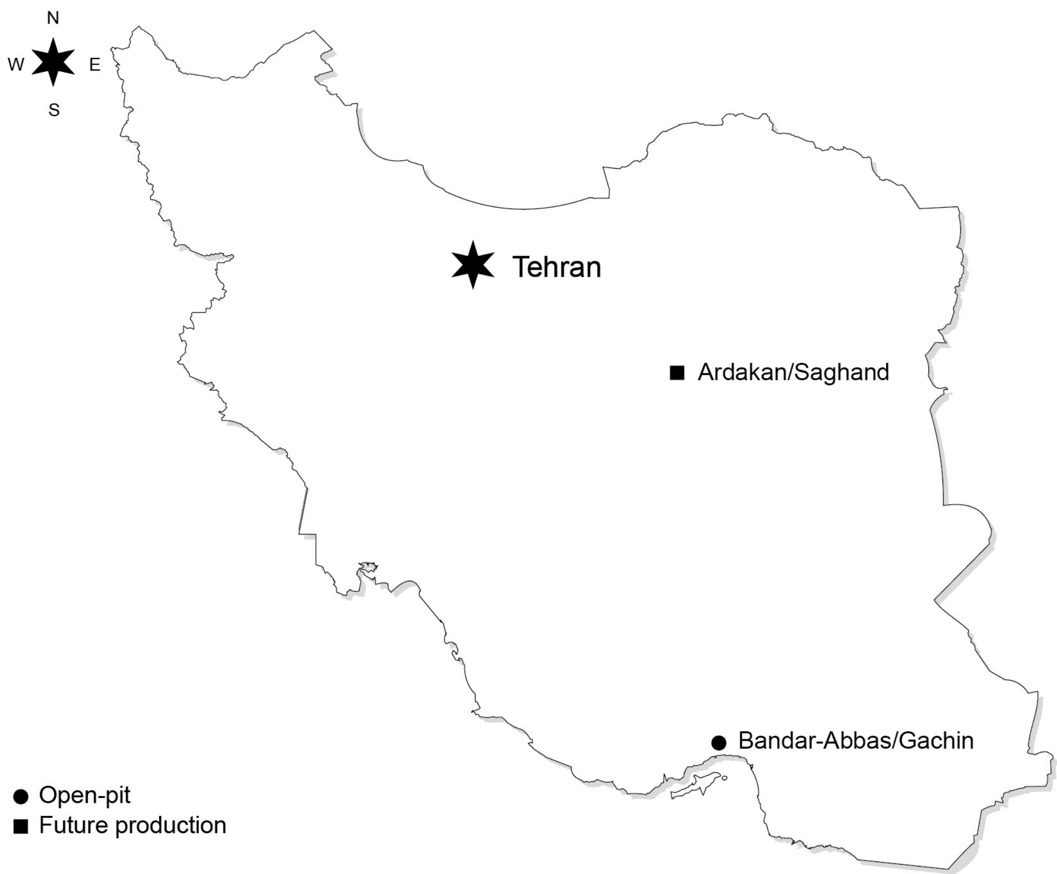
(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
915	915	915	915	915	915	3 175	5 075	6 975	7 925	NA	NA	NA	NA

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
8	40	160	160	160	160	590	910	1 230	1 390	NA	NA	NA	NA



Italy

Uranium exploration and mine development

Historical review

The first uranium deposit, the volcanogenic permian Novazza, was discovered in the Orobic Alps (Lombardia region, province of Bergamo) as a result of exploration from 1954 to 1962. A second deposit, Val Vedello, was also discovered in the same general area (Lombardia region, province of Sondrio) as a result of exploration from 1975 to 1983. Between 1985 and 1987, very limited exploration also took place on three uranium projects over a total area of 25.7 km^2. Agip Miniere also carried out joint venture exploration projects in Australia, Canada, the United States and Zambia prior to 1990. Since then, no exploration has taken place in Italy. Efforts by the Australian company Metex in 2006 to restart exploration of the Novazza deposit were unsuccessful due to local public resistance.

Plans to construct the Valvenova uranium production centre (260 tU/yr) in the 1980s were never realised. No uranium exploration and/or mine development activity is currently underway either domestically or abroad.

Recent and ongoing uranium exploration and mine development activities

Renewed interest in exploration of deposits in the Orobic Alps has been reported by Australian-Italian companies.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

There are no changes to the uranium resource figures presented in the 1991 edition of this publication. These estimates were made in 1987.

Unconventional resources and other materials

None reported.

Uranium requirements

Requirements had been estimated to comply with the national nuclear programme objective of 25% electricity generation from nuclear at 2030, corresponding to some 13 GWe net nuclear power fleet to be installed (reference case). However, following the March 2011 nuclear accident at the Fukushima Daiichi NPP in Japan, the Italian government established a one-year moratorium for the nuclear national programme. In a referendum held on 13-14 June 2011, voters strongly rejected all of the four initiatives promoted by the government, including the 2009 legislation that set up arrangements to build and operate new NPPs in the country. While excluding demand for uranium from the Italian market, the referendum results do not prevent exploration and development of uranium extraction projects.

Supply and procurement strategy

Not defined.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Italy currently has no operating NPPs, having shut down three operational reactors by 1990 following the results of a referendum in 1987. However, in 2004 the government made the first step toward reconsidering nuclear power by issuing a new energy law that opened up the possibility of making joint ventures with foreign companies in relation to NPPs abroad and importing electricity from them.

A second more decisive step was set in May 2008 when the then pro-nuclear Italian government confirmed that it would start building new NPPs within five years in order to diversify the energy mix, reduce the country's great dependence on oil, gas and imported electricity and to curb greenhouse gas emissions. At that time nuclear power was foreseen as a key component of the new energy policy which by 2030 aimed to have 25% of electricity generated by nuclear power together with 50% by fossil fuels and 25% by renewable energy sources.

Comprehensive economic development legislation was passed in July 2009 when the government introduced a complete package of legislation for nuclear power, a fundamental step in the revival of the technology. This package included measures to set up a national nuclear regulatory agency, expedite the licensing of new reactors at existing NPPs and new greenfield sites and to reorganise the national nuclear research and development entity.

In January 2010, provisions for public consultation were announced and the draft decree set out financial benefits for cities and regions hosting NPPs (EUR 3 000/MWe/yr during construction and 40 centimes/MWh during operation). Further legislation in February 2010 set out a framework for siting of NPPs, involving local governments. For NPPs and fuel cycle facilities, a so-called "unique authorisation" would be required for construction, as well as an environmental permit. In November 2010, the Constitutional Court had overturned a bid by three regions (Puglia, Campania and Basilicata) to ban nuclear plants from their territory due to strong public opposition.

In January 2011, the Constitutional Court ruled that Italy could hold a referendum on the planned reintroduction of nuclear power, as proposed by an opposition party – www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Italy/#. The question posed in the referendum, held later in the year, was whether voters wanted to cancel most of the legislative and regulatory measures which had been taken by the government over the previous three years to make possible the construction and operation of new NPPs in the country.

Immediately following the Fukushima Daiichi accident, the government declared a one-year moratorium on nuclear development plans and through a law decree stated the abrogation of some specific articles of the nuclear legislation package (approved by parliament at the end of May), with the intent of carrying out a reconsideration of the national energy strategy on the basis of the results from the stress test programme established by the EU and other input from competent international institutions. The referendum was held on 13-14 June 2011 and voters strongly rejected all four initiatives promoted by the government, including the 2009 legislation that set up arrangements to build and operate new NPPs. Although a strong majority voted to cancel plans for building new NPPs, the results of the referendum do not affect plans for the development of a national waste repository, the so-called "Technological Park", the national nuclear research and development entity, the nuclear regulatory agency and mineral exploration activities. The referendum result is binding for five years. This situation is similar to the one following the 1987 referendum that was held in the aftermath of the Chernobyl accident.

A National Energy Strategy (SEN) was submitted for public consultation in 2012, mostly relying on fossil fuels, especially gas, as well as renewable energy sources and enhanced energy efficiency.

While a national nuclear programme is not required for uranium exploration and extraction projects, concerns about impacts on mountain ecosystems have to be taken into account.

A R&D presidium on "new nuclear fission" was maintained within a three-year 2012 to 2014 ENEA-MSE (Ministry for Economic Development) programme agreement on electrical system research. This is aimed at knowledge development in system safety and innovations, emphasising lessons learned from Fukushima Daiichi and co-operation in international programmes for Generation IV closed-cycle systems (mostly lead-cooled fast reactor systems).

Uranium stocks

None to report. A total of 1 641 tHM of spent fuel from shutdown NPPs has been sent abroad for reprocessing under the national decommissioning programme led by the Sogin management company (963.2 tHM up to 1978 + 678 tHM after 1978).

Uranium prices

None to report.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Volcanic-related		4 800	4 800	4 800	72
Total		**4 800**	**4 800**	**4 800**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Volcanic-related		1 300	1 300	1 300	72
Total		**1 300**	**1 300**	**1 300**	

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
10 000	10 000	

Installed nuclear generating capacity to 2035*

(MWe net)

2009	2010	2011		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		-	-	-	-	1 600	1 600	6 400	6 400	13 000	13 000	13 000	13 000

* Estimates based on nuclear development plans of the previous government that were rejected in a referendum in 2011.

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2009	2010	2011		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		-	-	-	-	212	212	1 908	1 908	7 844	7 844	16 324	16 324

Note: Figures are cumulated amounts at end of the reference year in the table. Estimations are based on the following assumptions:

– 13 GWe net online by 2030, of which 1.6 GWe net online by 2020 and 6.4 GWe net online by 2025.

– Fuel burn-up: 60 GWd/t UO_2; fuel enrichment: 4.1% U-235, tails assay: 0.3% U-235; efficiency: 34.2%; capacity factor: 0.9.

Japan

Uranium exploration and mine development

Historical review

Domestic uranium exploration has been carried out by the Power Reactor and Nuclear Fuel Development Corporation (PNC) and its predecessor since 1956. About 6 600 tU of uranium resources were discovered in Japan before domestic uranium exploration activities were terminated in 1988. Overseas uranium exploration began in 1966 with activities carried out mainly in Australia and Canada, as well as other countries such as Niger, the People's Republic of China, the United States and Zimbabwe.

In October 1998, PNC was reorganised into the Japan Nuclear Cycle Development Institute (JNC). The Atomic Energy Commission decided in February 1998 to terminate uranium exploration activities in 2000 and JNC's mining interests and technologies were transferred to the private sector. In October 2005, the Japan Atomic Energy Agency (JAEA) was established by integrating the Japan Atomic Energy Research Institute and JNC.

In April 2007, the Japanese government decided to resume overseas uranium exploration activities with financial support provided by Japanese companies through Japan Oil, Gas and Metals National Corporation (JOGMEC). JOGMEC is carrying out exploration activities in Australia, Canada and other countries.

Recent and ongoing uranium exploration and mine development activities

Japan-Canada Uranium Co. Ltd, which took over JNC's Canadian mining interests, is continuing exploration activities in Canada while JOGMEC continues exploration activities in Australia, Canada and elsewhere. Japanese private companies hold shares in companies developing uranium mines and also with those operating mines in Australia, Canada, Kazakhstan and Niger.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

About 6 600 tU of reasonably assured resources recoverable at <USD 130/kgU have been identified in Japan.

Uranium production

Historical review

A test pilot plant with a capacity of 50 t ore/day was established at the Ningyo-toge mine in 1969 by PNC. The operation was ended in 1982 with total production amounting to 84 tU. In 1978, a leaching test consisting of three, 500 t ore vats with a maximum capacity of 12 000 t ore/year was initiated to process Ningyo-toge ore on a small scale. The vat leaching test was terminated at the end of 1987.

Secondary sources of uranium

Production of mixed oxide fuels

Production facilities

The JAEA plutonium fuel plant consists of three facilities, the Plutonium Fuel Development Facility (PFDF), the Plutonium Fuel Fabrication Facility (PFFF) and the Plutonium Fuel Production Facility (PFPF).

The PFDF, constructed for basic research and the fabrication of test fuels, started operation in 1966. As of December 2012, approximately two tonnes of MOX fuel had been fabricated in the PFDF.

The PFFF has two MOX fuel fabrication lines, one for the experimental Jōyō fast breeder reactor (FBR line) with a capability of one tonne MOX/yr and the second for the prototype advanced thermal reactor Fugen (ATR line) with ten tonnes MOX/yr fabrication capability. The FBR line started operations in 1973, producing the initial fuel load for the experimental Jōyō sodium cooled fast reactor. FBR line fuel fabrication ended in 1988 and Jōyō fuel fabrication was switched to the PFPF. The ATR line started operations in 1972 with MOX fuel fabrication for the Deuterium Critical Assembly in JAEA's O-arai Research and Development Center. Fuel fabrication for ATR Fugen was started in 1975 and ended in 2001. MOX fuel fabrication in both lines amounted to a total of approximately 155 tonnes.

The PFPF FBR line, constructed to supply MOX fuels for the prototype Monju FBR and the experimental Jōyō FBR, has a production capability of five tonnes MOX/yr. The PFPF FBR line began operating in 1988 fabricating Jōyō fuel reloads. Fuel fabrication for the FBR Monju was started in 1989. As of December 2012, approximately 16 tonnes of MOX fuels had been fabricated in the PFPF.

Use of mixed oxide fuels

Monju prototype fast breeder reactor

Monju achieved initial criticality in April 1994 and began supplying electricity to the grid in August 1995. However during a 40% power operation test of the plant, a sodium leak accident in the secondary heat transport system in December 1995 interrupted operation. After carrying out an investigation to determine the cause, a two-year comprehensive safety review and the required licensing procedure, the permit for plant modification (including countermeasures to reduce the likelihood of sodium leak accidents) was issued in December 2002 by the Ministry of Energy, Trade and Industry. JAEA completed a series of countermeasure modifications in May 2007, implemented a modified system function test until August 2007 and then conducted an entire system function test. The existing 78 slightly used and 6 newly fabricated fuel assemblies were loaded by 27 July 2009. Following the system start-up test, Monju was restarted on 6 May 2010. The core confirmation test was completed on 22 July 2010 and 33 freshly fabricated fuel assemblies were loaded by 18 August 2010. However, after refuelling, the in-vessel fuel transfer machine was dropped on 26 August 2010 and removed by 24 June 2011. JAEA is working on countermeasures against tsunami, station black-out and severe accidents on the basis of the severe Fukushima Daiichi accident. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has also been reviewing the Monju research plan.

Experimental fast reactor Jōyō

The experimental fast reactor Jōyō attained criticality in April 1977 with the MK-I breeder core. As an irradiation test bed, the Jōyō MK-II core achieved maximum design output of 100 MW in March 1983. Thirty-five duty cycle operations and thirteen special tests with the MK-II core had been completed by June 2000. The MK-III high performance irradiation core, with design output increased to 140 MW, achieved initial criticality in July 2003. Six duty cycle operations and four special tests with MK-III core had been completed by December 2012. The Jōyō net operation time reached around 70 000 hours and 588 fuel subassemblies were irradiated during MK-I, MK-II and MK-III core operations.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Japan has relatively scarce domestic uranium resources and therefore relies on overseas uranium supply. A stable supply of uranium resources is to be ensured through long-term purchase contracts with overseas uranium suppliers, direct participation in mining development and diversification of suppliers and countries.

With the exception of two reactors that have operated periodically since the severe accident at the Fukushima Daiichi NPP in March 2011, all remaining operational reactors in Japan that normally provide about 30% of electricity production have been progressively taken out of service during scheduled refuelling and maintenance outages. The number of reactor restarts, as well as the timing of the restarts, is uncertain. The establishment of a new, independent regulatory agency, regulations governing the safe operation of reactors and requirements for restart were established by mid-2013, prompting utilities to apply to restart a number of reactors, the first of which are expected to resume operations in 2014. Until the number of reactors to be restarted is better defined, Japanese uranium requirements remain uncertain.

Uranium exploration and development expenditures – non-domestic

(JPY million [Japanese yen])

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	NA	NA	NA	NA
Government exploration expenditures	288	245	426	345
Industry* development expenditures	NA	NA	NA	NA
Government development expenditures	0	0	0	0
Total expenditures	**NA**	**NA**	**NA**	**NA**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	6 600	6 600
Total	**0**	**0**	**6 600**	**6 600**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	6 600	6 600	85
Total	**0**	**0**	**6 600**	**6 600**	**85**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	6 600	6 600	85
Total	**0**	**0**	**6 600**	**6 600**	**85**

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	84	0	0	0	84	0
Total	**84**	**0**	**0**	**0**	**84**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	39	0	0	0	39	0
Underground mining[1]	45	0	0	0	45	0
Total	**84**	**0**	**0**	**0**	**84**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	45	0	0	0	45	0
Heap leaching*	39	0	0	0	39	0
Total	**84**	**0**	**0**	**0**	**84**	**0**

*A subset of open-pit and underground mining, since it is used in conjunction with them.

Mixed oxide fuel production and use

(tonnes natural U equivalent)

Mixed oxide (MOX) fuel	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	645	37	2	0	684	0
Use	702	146	64	0	912	0
Number of commercial reactors using MOX		1	3	0		0

Reprocessed uranium use

(tonnes natural U equivalent)

Reprocessed uranium	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	645	0	0	0	645	0
Use	207	8	0	0	215	0

Net nuclear electricity generation*

	2011	2012
Nuclear electricity generated (TWh net)	96.7	15.1

* Data from the 2013 edition of *OECD Nuclear Energy Data*.

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
47 025	44 269	44 269	44 269	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Jordan

Uranium exploration and mine development

Historical review

In 1980 an airborne spectrometric survey covering the entire country was completed and by 1988 ground-based radiometric surveys of anomalies identified in the airborne survey were completed. From 1988 to 1990, Precambrian basement and Ordovician sandstone target areas were evaluated using geological, geochemical and radiometric mapping and/or surveys.

During the 1990s reconnaissance and exploration studies revealed surficial uranium deposits distributed in several areas of the country, as described below:

- Central Jordan: exploration, including 1 700 trenches and over 2 000 samples were analysed for uranium using a fluorometer, revealed the occurrence of uranium deposits as minute mineral grains disseminated within fine calcareous Pleistocene sediments and as yellowish films of carnotite and other uranium minerals coating fractures of fragmented chalk or marl of Mastrichtian-Paleocene age. Results of channel sampling in three areas indicate uranium contents ranging from 140 to 2 200 ppm U_3O_8 (0.014% to 0.22% U_3O_8) over an average thickness of about 1.3 m, with overburden of about 0.5 m.

- Three uranium anomalous areas (Mafraq, Wadi Al-Bahiyyah and Wadi-Sahab Alabyad) with promise for hosting uranium deposits were also covered by the reconnaissance studies.

In 2008, the Jordan Atomic Energy Commission (JAEC) was established, in accordance with the Nuclear Energy Law (Law No. 42) of 2007 and amendments of 2008. The JAEC is the official entity entrusted with the development and execution of the Jordanian nuclear power programme. The exploration, extraction and mining of all nuclear materials; including uranium, thorium, zirconium and vanadium is under the authority of JAEC.

The Nuclear Fuel Cycle Commission of JAEC is in charge of developing and managing all aspects of the nuclear fuel cycle; including uranium exploration, extraction, production, securing fuel supply and services, nuclear fuel management and radioactive waste management. The JAEC uranium policy is to maximise sovereignty while creating value from resources and to avoid concessions to foreign companies. To attract investors and operate on a commercial basis, JAEC created Jordan Energy Resources Inc. (JERI) as its commercial arm.

In September 2008, JAEC signed an exploration agreement with AREVA and created the Jordanian French Uranium Mining Company (JFUMC), a joint venture created to carry out all exploration activities leading to a feasibility study of developing resources in the central Jordan area. In January 2009, JAEC signed a Memorandum of Understanding (MoU) entitling RioTinto to carry out reconnaissance and prospecting in three areas (north of Al-Bahiyyah, Wadi SahbAlabiadh and Rewashid). Exploration activities by Jordanian teams in co-operation with the Chinese SinoU were carried out in two other areas (Mafraq and Wadi Al-Bahiyyah).

During 2009-2010, JFUMC started the first phase of the exploration programme in the northern part of the central Jordan licence area that included geological mapping, a carborne radiometric survey, drilling, trenching, sampling, chemical analyses, development of an environmental impact assessment and a hydrogeological study and building a database inventory.

Recent and ongoing uranium exploration and mine development activities

During 2011-2012, JFUMC started the second phase of the exploration programme in the southern part of the central Jordan licence area. The second phase of the exploration programme included geological mapping; a carborne radiometric survey; borehole drilling and trenching; limited sampling and chemical analysis; and a preliminary resource evaluation using the radiometric data collected from the gamma logging of the boreholes.

The JFUMC did not meet the timelines of the agreement signed in 2008. As a result, the Jordanian government did not agree to the extension of the longstop date of the agreement and cancelled the joint venture activities.

During 2011-2012, JERI continued the same prospecting programme in other areas with a similar geological setting, located to the north of the three anomalous areas mentioned above. The prospecting programme included geological studies; carborne radiometric surveys; a trenching programme (443 trenches); sampling programme (1 951 samples); chemical analyses (X-ray fluorescence, inductively coupled plasma and gamma spectrometry); delineation of mineralised zones (four areas); and a preliminary resource estimate of 15 265 tU (18 000 tU_3O_8). An additional three areas were delineated during 2009-2010 resulting in a preliminary resource estimation of the seven areas of 28 000 tons U.

Summary of exploration plan for 2013

In January 2013, JAEC formed the Jordan Uranium Mining Company (JUMCO) for the purpose of:

- uranium exploration in the central Jordan area in accordance with international standards, enabling derivation of JORC compliant uranium resource estimates;
- development of optimised uranium ore processing leading to the development of a pilot-scale processing plant;
- securing the financing required to launch full-scale mining plant(s) capable of ultimately producing up to 1 400 metric tons of yellow cake (U_3O_8) annually (1 185 tU/yr).

JUMCO and JERI jointly started an exploration programme to evaluate the surficial uranium resources in central Jordan. The exploration programme includes a trenching programme (4-5 m deep); channel sampling (quality assurance/quality control); chemical analyses utilising X-ray fluorescence; inductively coupled plasma; and gamma spectrometry and JORC compliant resource estimates.

Uranium production

Historical review

Jordan does not currently produce uranium. In 1982, a feasibility study for uranium extraction from phosphoric acid was completed by an engineering company (LURGI A.G. of Frankfurt, Germany) on behalf of the Jordan Fertiliser Industry Company, as company subsequently purchased by the Jordan Phosphate Mines Company. One of the extraction processes evaluated was originally found to be economically feasible, but as uranium prices dropped in the 1990s, the process became uneconomic and development of an extraction plant construction was deferred.

In 2009, SNC-Lavalin performed a technological and economic feasibility study, for the recovery of uranium from the phosphoric acid produced at the Aqaba Fertilizer Complex. This study has been performed jointly with Prayon Technologies SA. The profitability was evaluated to be 6.8% in terms of internal rate of return.

Status of production capability

Jordan does not have firm plans in place to produce uranium.

Uranium requirements

In 2010, Jordan announced plans to pursue the development of civil nuclear power, stating its intention to have four units in operation by 2040. A number of nuclear co-operation agreements have been signed with a number of countries, including Canada, China, France, Japan, the Republic of Korea, the Russian Federation and the United Kingdom. In 2011, it was reported that Jordan would be receiving bids from nuclear power plant vendors. Currently, the kingdom imports over 95% of its energy needs and disruptions in natural gas supply from Egypt have reportedly cost Jordanians more than USD 1 million a day.

Despite the need to generate electricity by other means, the accident at the Fukushima Daiichi nuclear power plant has created some local resistance to the plan to have one 700-1 200 MWe reactor operating by 2020 and a second unit of similar size by 2025. This has created some issues in site selection for the planned reactor construction. In mid-2013, it was reported that JAEC had chosen a preferred reactor technology for construction and that the winning bid would be announced later in the year.

National policies related to uranium

With Jordan's intention to develop a peaceful atomic energy programme for generating electricity and water desalination, JAEC reactivated uranium exploration in the country with the goal of achieving a degree of energy self-sufficiency.

Uranium exploration and development expenditures and drilling effort – domestic

(JOD [Jordanian dinars])

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	7 435 000	4 285 000	1 022 000	0
Government exploration expenditures	660 000	505 000	280 000	1 700 000
Industry* development expenditures	0	0	0	0
Government development expenditures	0	0	0	0
Total expenditures	**8 095 000**	**4 790 000**	**1 302 000**	**1 700 000**
Industry* exploration drilling (m)	29 058	28 136	0	0
Industry* exploration holes drilled	2 422	2 096	0	0
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	29 058	28 136	0	0
Subtotal exploration holes drilled	2 422	2 096	0	0
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**29 058**	**28 136**	**0**	**0**
Total number of holes drilled	**2 422**	**2 096**	**0**	**0**

* Non-government.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Surficial			50 000
Total			**50 000**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)			50 000	50 000
Total			**50 000**	**50 000**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified			50 000	50 000
Total			**50 000**	**50 000**

* *In situ* resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	0

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	50 000	NR

Kazakhstan

Uranium exploration

Historical review

In 1944, the USSR State Defence Committee ordered the Committee for Geological Affairs to conduct exploration of uranium deposits using all "geology" organisations. This regulation is the reference point of the so-called "mass" uranium exploration in the USSR. In 1948, the "Volkovskaya Expedition" (now Volkovgeology JSC [joint-stock company]) was established and in 1951 the Kurdai deposit was discovered, the first in Kazakhstan.

By early 1960, due to the efforts of the geological organisations "Volkovgeology", "Krasnoholmskgeology", "Steppegeology" and "Koltzovskgeology", the first stage of the establishment of a uranium mineral and raw materials resource base was completed in order to provide stable operation of the Tselinnyi (later TsMCC), Prikaspian ("Kaskor") and Kara-Balty ("KMPP") refineries in Kazakhstan.

By late 1970, unique deposits suitable for uranium mining by ISL, such as Inkai, Mynkuduk, Moinkum, Kanzhugan and North and South Karamurun, were discovered.

Recent and ongoing uranium exploration and mine development activities

During 2011 and 2012, exploration of deposits was performed at Moinkum, Inkai, Budenovskoye in the Shu-Saysu uranium province and the Northern Kharassan and South Zarechnoe deposits in the Syrdaria uranium province.

Joint venture (JV) Katco continues exploration at site No. 3 (central) and detailed exploration at site No. 2 (Tortkuduk) of the Moinkum deposit and JV Inkai continues exploration at site No. 3 of the Inkai deposit. The Akbastau JSC started exploration at sites No. 1, 3 and 4 of the Budenovskoye deposit. ISL pilot production is ongoing at sites No. 1 and 3. The Kyzylkum LLP and the Baiken-U LLP are performing exploration at the Northern Kharassan deposit and the Karatau LLP finished exploration on site No. 2 of the Budenovskoye deposit.

In 2011, GRK LLP began exploration and ISL pilot production at the new Moinkum site No. 3 (central) deposit and exploration of the Zhalpak deposit was postponed. Zarechnoe LLP also postponed exploration on the South Zarechnoe deposit.

Exploration in 2011-2012 resulted in an increase of identified resources by 110 940 tU, including an increase of reasonably assured resources by 10 058 tU and of inferred resources by 100 882 tU because of reclassification of some prognosticated resources. These resource increases have occurred at Budenovskoe (sites 2, 3) and Inkai (sites 3, 4).

The Volkovgeology JSC renewed geological prospecting of sandstone-type deposits amenable for ISL mining in new perspective areas of the Shu-Sarysu uranium provinces, with funding from the NAK Kazatomprom JSC budget.

No new deposits were discovered during the reporting period. No uranium exploration and development was performed by Kazakh enterprises outside of the Republic of Kazakhstan.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2013, identified uranium resources recoverable at <USD 260/kgU amounted to a total of 998 809 tU, including 687 520 tU of resources amenable for ISL recovery. In 2011-2012, a total of 40 690 tU were mined. Considering losses during mining (5 096 tU or 11%), 45 786 tU of resources were depleted. While 40 050 tU (98.4%) were produced by ISL, 640 tU were produced by underground mining at the Vostok and Zvezdnoye deposits (depleting resources by 702 tU). Reasonably assured resources increased by 10 058 tU as a result of geological exploration. A total of 100 882 tU in sandstone deposits were transferred from prognosticated resources to inferred resources.

Although significant changes in cost categories are not specified, an increase on lower cost resources indicates that production costs in sandstone resources are expected to remain low.

All of Kazakhstan's RAR plus IR recoverable at <USD 40/kgU are associated with existing and committed production centres, whereas 93% recoverable at <USD 80/kgU are in existing and committed production centres, 82% recoverable at <USD 130/kgU are in existing and committed production centres and 65% recoverable at <USD 260/kgU are in existing and committed production centres.

Undiscovered conventional resources (prognosticated and speculative resources)

Re-evaluation of prognosticated and speculative resources was done in the reporting period resulting in 100 882 tU being transferred from prognosticated resources to inferred resources. The majority (402 980 tU) of the total of 404 890 tU of prognosticated resources are related to sandstone deposits, while the remaining 2 000 tU are metasomatite deposits. Of the 300 000 tU of speculative resources, 90% are related to sandstone deposits and 10% to unconformity-related or metasomatite deposits.

Unconventional resources and other materials

Estimates are not made of Kazakhstan's unconventional uranium resources and other materials.

Uranium production

Historical review

Uranium mining began in 1957 with open-pit mining of the Kurdai deposit in southern Kazakhstan. Until 1978, 4 companies belonging to the USSR Ministry of Middle Machine Construction (Kyrgyzski Mining Combine, Leninabadski Mining and Chemical Combine in the south, Tselinny Mining and Chemical in the north and Prikaspiiski Mining and Chemical Combine in the west) mined some 15 deposits by underground and open-pit methods, extracting a total of about 5 000 tU.

ISL production from sandstone deposits was initiated in 1978. By the early 1990s, production amounted to about 2 800 tU/yr, but declined until 2002. From 2002 on, uranium production in Kazakhstan (principally by ISL) has been increased dramatically, passing 5 000 tU/yr in 2006. In 2009, production amounted to 14 020 tU and the Republic of Kazakhstan became the world's leading producer of uranium, a position it maintains today.

Production capability and recent and ongoing activities

In 2011-2012 uranium was mined at the Kanzhugan, Moinkum, Akdala, Uvanas, Mynkuduk, Inkai, Budenovskoye, North Karamurun, South Karamurun, Irkol, Zarechnoye, Semizbay, North Kharasan, Vostok and Zvezdnoye deposits. All except Vostok and Zvezdnoye, where underground mining is being practiced, extract uranium by ISL.

The Uvanas, Mynkuduk (eastern site), Kanzhugan, Moinkum (southern part of site No. 1), North Karamurun, South Karamurun deposits are operated by the Mining Company LLP. The Akdala and Inkai (site No. 4) deposits are operated by JV Betpak Dala LLP. JV Katco LLP takes part in the operation of the Moinkum deposit (northern part of site No. 1 and 2). The Inkai deposit (sites No. 1 and 2) is operated by JV Inkai LLP; the Budenovskoye deposit (site No. 2) by Karatau LLP; Irkol and Semizbay deposits operated by Semizbay-U LLP; the Zarechnoye deposit by JV Zarechnoye JSC; the central site of the Mynkuduk deposit by NAC Kazatomprom JSC and the western site of the Mynkuduk deposit by Appak LLP. The Vostok and Zvezdnoye deposits are operated by Stepnogorskiy Mining and Chemical Complex LLP.

In the Syrdaria uranium province, Kyzylkum LLP has undertaken ISL pilot production of the North Kharasan deposit (Kharasan-1), working toward commercial production of 1 000 tU/yr starting from 2015, with a further expansion to 3 000 tU/yr in 2021. The Baiken-U LLP started ISL pilot production at the North Kharasan deposit (Kharasan-2) in 2009, working toward a design capacity of 2 000 tU/yr by 2017.

In 2009, JV Akbastau JSC started pilot production by ISL at the Budenovskoye deposit (sites No. 1 and 3). In 2013, the Mining Company LLP plans to start pilot production on the Moinkun deposit (site No. 3 (central); JV Akbastau JSC will start pilot production at the Budenovskoye deposit (site No. 4).

In 2011-2012, uranium production in Kazakhstan amounted to a total 40 960 tU, of which 640 tU were produced by traditional underground mining methods (including 74 tU by heap leaching), and 40 050 tU by ISL (98.4% of total production). As of 1 January 2011, the total capacity of uranium production centres in Kazakhstan is 23 000 tU/yr.

Uranium production at ISL mines in Kazakhstan is carried out using sulphuric acid to produce pregnant uraniferous solutions. Further processing of pregnant solutions using ion-exchange sorption-elution technologies produces a uranyl salts precipitate that, with further extraction refining results in the production of natural uranium concentrate. A number of mining enterprises (Appak LLP, Karatau LLP, JV Betpak-Dala LLP, Inkai LLP) obtain natural uranium concentrate by sedimentation of uranium using hydrogen peroxide and further calcination without an extraction stage. Production of natural uranium concentrates from the Vostok and Zvezdnoye deposits uses autoclave soda leaching at the hydrometallurgical plant.

Ownership structure of the uranium industry

In 2012, the state share of uranium production in Kazakhstan was 56.2% (11 931 tU), including 33% from NAC Kazatomprom owing to its partnership in joint ventures and 23.2% from the Mining Company LLP, which is wholly owned by NAC Kazatomprom, a 100% state-owned company, and through the Samruk-Kazyna JSC which is a national wealth fund.

As of 10 March 2010, ownership of the Mynkuduk deposit (central site) was transferred to NAC Kazatomprom.

The Mining Company LLP includes the following production centres: Taukent Mining and Chemical Plant LLP, the Stepnoye Mining Group LLP and Mining Group-6 LLP, all of which produce uranium by ISL.

In 2012, NAC Kazatomprom held shares in nine joint ventures with private companies from Canada, Japan and Kyrgyzstan (JV Betpak Dala LLP, JV Inkai LLP, Appak LLP, Kyzylkum LLP, Baiken-U LLP, JV Zarechnoe JSC, JV Akbastau JSC and Karatau LLP) and with foreign state companies from China and France (Semizbai-U LLP and JV Katko LLP).

All of the shares of the Stepnogorsk Mining-Chemical Complex LLP (SMCC LLP) belong to a foreign private company. The Mining-Chemical Complex mines deposits by the underground method.

In 2012, the production share of private foreign companies in Kazakhstan amounted to 32.1%, while the share of state foreign companies of France and China in Kazakhstan amounted to 11.7% of total production.

Employment in the uranium industry

Owing to the expansion of uranium production in 2011-2012, Kazakhstan experienced a shortage of qualified staff. As a result training was conducted in two educational centres to prepare qualified personnel, drawing on local residents of the Kyzylorda (Shieli) and southern Kazakhstan regions (Taukent) in the vicinity of the production centres. The Kazakhstan Nuclear University, founded by NAC Kazatomprom JSC, was involved in retraining and raising skill levels of new personnel. New uranium production centres also create educational opportunities for students of higher and secondary technical institutes in Kazakhstan. According to the subsoil use contracts, annual obligatory training expenses amount to about 1% of annual exploration expenses and 1% of annual expenses for uranium production during the production period.

Future production centres

In 2011-2012, no new centres for uranium exploration and production were established. However, once prospecting of promising areas of the Shu-Sarysu and Syrdaria uranium provinces is completed, new ISL production centres may be established.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6	Centre #7	Centre #8
Name of production centre	Taukent Mining Chemical Plant LLP	Stepnoye Mining Group LLP	Mining group-6 LLP	Betpak-Dala JV LLP	Katko JV LLP	Inkai JV LLP	Stepnogorsk Mining Chemical Complex LLP	Zarechnoe JV JSC
Production centre classification	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Existing
Start-up date	1982	1978	1985	2001	2004	2004	1958	2007
Source of ore:								
Deposit name(s)	Kanzhugan, Moinkum (sites 1, 3)	Mynkuduk (eastern site), Uvanas	North and South Karamurun	Akdala, Inkai (site 4)	Moinkum (sites 1, 2, 3)	Inkai (sites 1, 2, 3)	Vostok, Zvezdnoe	Zarechnoye, South Zarechnoye
Deposit type(s)	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Vein-stockwork	Sandstone
Recoverable resources (tU)	NA	NA	NA	NA	NA	NA	NA	NA
Grade (% U)	NA	NA	NA	NA	NA	NA	NA	NA
Mining operation:								
Type (OP/UG/ISL)	ISL	ISL	ISL	ISL	ISL	ISL	UG	ISL
Size (tonnes ore/day)							1 000	
Average mining recovery (%)	87	90	91	90	87	80	90	94
Processing plant:								
Acid/alkaline	Acid	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Type (IX/SX/AL)	IX, SX	IX	IX	IX	IX	IX	SX, AL	IX
Size (kilolitre/day)	50 000	45 000	40 000	80 000	100 000	80 000	1 000	60 000
Average process recovery (%)	98.9	98.7	98.7	98.9	98.9	98.9	92.5	98.5
Nominal production capacity (tU/year)	1 200	1 300	1 000	3 000	4 000	2 000	500	1 000
Plans for expansion	Yes	No	No	No	No	Yes	No	Yes
Other remarks								

Uranium production centre technical details *(continued)*

(as of 1 January 2013)

	Centre #9	Centre #10	Centre #11	Centre #12	Centre #13	Centre #14	Centre #15	Centre #16
Name of production centre	Karatau LLP	Ortalyk LLP	Appak LLP	Kyzylkum LLP	Bayken-U LLP	Akbastau JV JSC	Semyzbai-U LLP	NAC Kazatomprom JSC
Production centre classification	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Committed
Start-up date	2007	2007	2008	2008	2009	2009	2007	2016
Source of ore:								
Deposit name(s)	Budenovskoe (site 2)	Mynkuduk (central site)	Mynkuduk (western site)	North Kharasan (site 1)	North Kharasan (site 2)	Budenovskoe (sites 1, 3, 4)	Semyzbai, Irkol	Zhalpak
Deposit type(s)	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Recoverable resources (tU)	NA	NA	NA	NA	NA	NA	NA	NA
Grade (% U)	NA	NA	NA	NA	NA	NA	NA	NA
Mining operation:								
Type (OP/UG/ISL)	ISL	ISL	ISL	ISL	ISL	ISL	ISL	ISL
Size (tonnes ore/day)								
Average mining recovery (%)	90	90	90	90	90	90	87	90
Processing plant:								
Acid/alkaline	Acid	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Type (IX/SX/AL)	IX	IX	IX	IX	IX	NA	IX	IX
Size (kilolitre/day)	80 000	60 000	40 000	40 000	40 000	20 000	50 000	0
Average process recovery (%)	98.9	98.5	98.9	98.5	98.5	98.9	98.6	NA
Nominal production capacity (tU/year)	3 000	1 600	1 000	1 000	1 000	500	1 250	0
Plans for expansion	No	Yes	No	Yes	Yes	Yes	No	Yes
Other remarks								

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Mixed oxide fuel is neither produced nor used in Kazakhstan.

Production and/or use of re-enriched tails

Uranium obtained through re-enrichment of depleted uranium tails is neither produced nor used in Kazakhstan.

Environmental activities and social cultural issues

Environmental activities

In the framework of ecological policy in Kazakhstan a number of measures to improve environmental protection and encourage rational use of natural resources have been implemented in recent years. Environmental protection activities of enterprises and organisations within the Holding corporate management are being fulfilled in accordance with legislation, other by-laws and regulatory documents. Statutory acts regulating negative impacts on the environment were developed; including requirements for documenting emission and pollutant discharges. In the reporting period a significant reduction in emissions and pollutant discharges were achieved at major enterprises due to the implementation of environmental activities. Production of waste volumes and consumption of material inputs are being minimised. Remediation of the west and central site of the Uvanas deposit has been completed and the second stage of remediation is being designed. In 2013, remediation works were scheduled to start on the Kanzhugan deposit.

Social and/or cultural issues

All contracts for uranium exploration and mining provided by the government require financial contributions to local social and cultural improvements. All subsoil users are obliged to finance the establishment, development, maintenance and support of the regional social sphere, including health care facilities for employees and local citizens, education, sport, recreation and other activities in accordance with the strategy of JSC NAC Kazatomprom and by an agreement with local authorities.

Expenditures on environmental activities and social cultural issues in 2011-2012

(KZT million)

	2011	2012	Total
Environmental impact assessments	38.0	42.6	80.6
Monitoring	162.5	222.7	385.2
Tailings impoundment	132.8	118.2	251.0
Waste rock management	121.2	160.8	282.0
Effluent management	31.7	92.5	124.2
Site rehabilitation	0.0	0.0	0.0
Regulatory activities	34.3	12.6	46.9
Social and/or cultural issues	2 707	2 775	5 479

Contributions from each operator amount to:

- USD 30 000 to 100 000 per year (during the exploration period);
- up to 15% of annual operational expenses or USD 50 000 to 350 000 per year (during the mining period).

Demeu-Kazatomprom LLP, established at the end of 2004, is responsible for social and cultural issues related to uranium production in Kazakhstan.

Uranium demands

Internal demand for natural and enriched uranium is not expected in Kazakhstan until 2020. Construction of an NPP is under consideration.

Supply and procurement strategy

At present the entire volume of uranium produced in Kazakhstan is exported to the world market.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

National policy in the area of atomic energy use target:

- creation of a basis for the development of nuclear power;
- further development of uranium production and processing enterprises, development of related industry sectors;
- development of nuclear science to assist development of nuclear energy and uranium production;
- protecting the health of the population, environment and the remediation of radioactive contaminated territories;
- improvement of education and build-up of qualified personnel in the nuclear industry;
- improving regulations in nuclear area;
- assurance of radiation, nuclear and industrial safety and the security of nuclear sites;
- assurance of non-proliferation of nuclear weapons;
- development of international co-operation in field of atomic energy use.

In accordance with the Law of RK No 535-IV from 9 January 2012, additions in paragraph 1 of Article 76 of the Law on "Mineral Recources and Subsoil Use" introduce the obligations of subsoil users to deduct 1% of the total annual revenue for research and development activities. This provision will significantly increase funding for R&D subsoil.

In 2010, a new programme for the development of the nuclear industry was launched in the Republic of Kazakhstan for the period 2011-2014 with a view to developments to 2020. The objective is the priority development of the nuclear industry and the creation of a civil nuclear programme as a platform for accelerating industrial innovation and country development. Implementation of this programme will allow the optimal use of available resources, increase the country's export capacity, assure environmental protection and the safety of energy technologies, development of nuclear technologies, as well as social and economic development of regions in Kazakhstan and developments in other areas.

Kazakhstan has also offered to host an IAEA fuel bank of low-enriched uranium in the country.

Uranium exploration and development expenditures and drilling effort – domestic

(KZT million)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	7 324	9 261	13 697	16 300
Government exploration expenditures	0	0	0	0
Industry* development expenditures	1 112	1 080	373	437
Government development expenditures	0	0	0	0
Total expenditures	**8 436**	**10 341**	**14 070**	**16 737**
Industry* exploration drilling (m)	1 231 684	1 104 124	1 002 656	1 181 610
Industry* exploration holes drilled	2 670	2 374	2 056	2 383
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	505 758	332 405	61 519	84 150
Industry* development holes drilled	1 451	907	213	224
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	1 231 684	1 104 124	1 002 656	1 181 610
Subtotal exploration holes	2 670	2 374	2 056	2 383
Subtotal development drilling (m)	505 758	332 405	61 519	84 150
Subtotal development holes	1 451	907	213	224
Total drilling (m)	**1 737 442**	**1 436 529**	**1 264 175**	**1 265 760**
Total number of holes drilled	**4 121**	**3 281**	**2 269**	**2 607**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Proterozoic unconformity	0	0	0	0
Sandstone	22 891	224 416	311 183	340 616
Metasomatite	0	0	8 997	84 857
Total	**22 891**	**224 416**	**320 180**	**425 473**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	4 294	109 587	83
Open-pit mining (OP)	0	0	47 237	47 237	91
In situ leaching acid	22 891	224 416	268 649	268 649	89
Total	**22 891**	**224 416**	**320 180**	**425 473**	**88**

* *In situ* resources reported with recovery factors provided.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	4 294	109 587	83
Conventional from OP	0	0	47 237	47 237	91
In situ leaching acid	22 891	224 416	268 649	268 649	89
In-place leaching**	0	0	NA	NA	NA
Heap leaching*** from UG	0	0	NA	NA	NA
Heap leaching*** from OP	0	0	NA	NA	NA
Unspecified	NA	NA	NA	NA	NA
Total	**22 891**	**224 416**	**320 180**	**425 473**	**88**

* *In situ* resources reported with recovery factors provided.

** Also known as stope leaching or block leaching.

*** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	0	0	0	0
Sandstone	77 360	355 077	418 871	429 074
Metasomatite	0	0	23 367	144 262
Total	**77 360**	**355 077**	**442 238**	**573 336**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	4 896	135 994	83
Open-pit mining (OP)	0	0	18 471	18 471	91
In situ leaching acid	77 360	355 077	418 871	418 871	89
Total	**77 360**	**355 077**	**442 238**	**573 336**	**88**

* *In situ* resources reported with recovery factors provided.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	4 896	135 994	83
Conventional from OP	0	0	18 471	18 471	91
In situ leaching acid	77 360	355 077	418 871	418 871	89
In-place leaching**	0	0	NA	NA	NA
Heap leaching*** from UG	0	0	NA	NA	NA
Heap leaching*** from OP	0	0	NA	NA	NA
Unspecified	NA	NA	NA	NA	NA
Total	**77 360**	**355 077**	**442 238**	**573 336**	**88**

* *In situ* resources reported with recovery factors provided.

** Also known as stope leaching or block leaching.

*** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
217 543	403 360	404 890

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
270 500	300 000	NA

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	77 775	17 451	19 069	20 981	135 276	22 500
Metasomatite	41 527	352	381	259	42 519	0
Phosphate	21 618	0	0	0	21 618	0
Total	**140 920**	**17 803**	**19 450**	**21 240**	**199 413**	**22 500**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	21 618	0	0	0	21 618	0
Underground mining[1]	41 527	352	381	259	42 519	0
In situ leaching	77 775	17 451	19 069	20 981	135 276	22 500
Total	**140 920**	**17 803**	**19 450**	**21 240**	**199 413**	**22 500**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	62 819	342	355	21 211	199 003	22 470
In situ leaching	77 775	17 451	19 069	20 981	0	0
Heap leaching*	326	10	26	48	410	30
Total	**140 920**	**17 803**	**19 450**	**21 240**	**199 413**	**22 500**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
11 931	56	0	0	2 481	12	6 828	32	21 240	100

Uranium industry employment at existing production centres

(person-years)

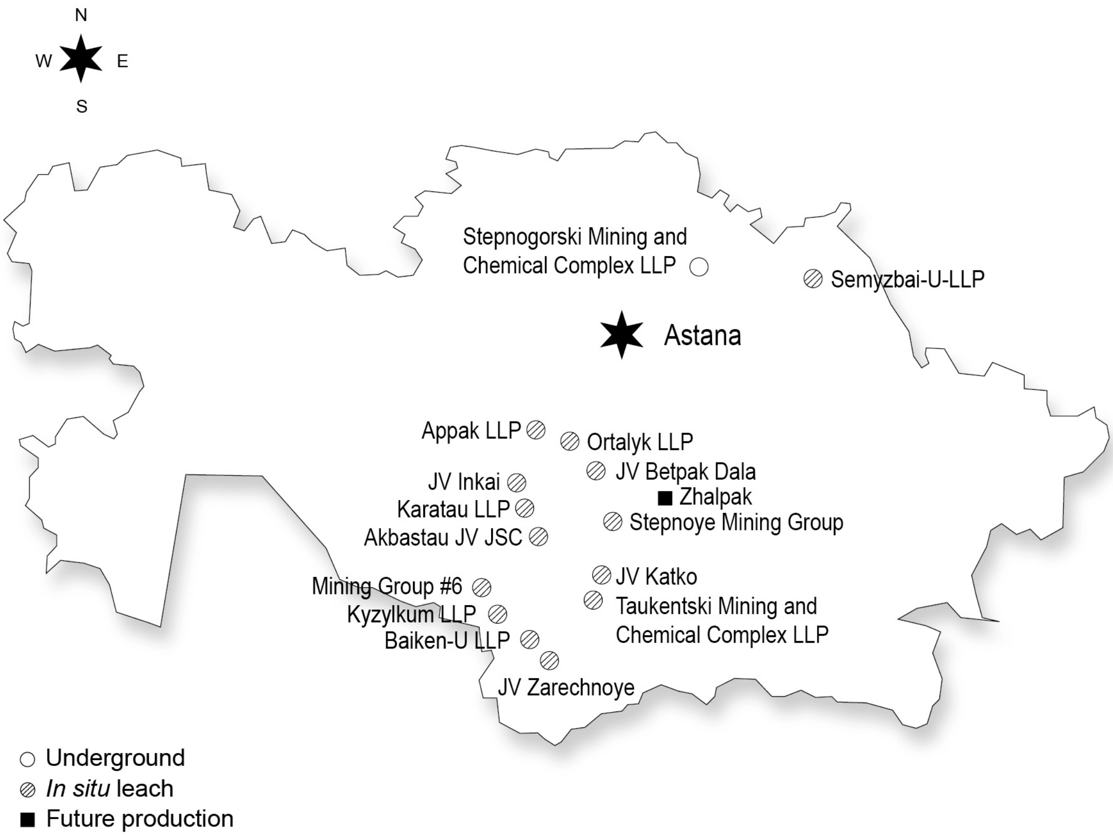
	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	8 828	8 550	9 760	10 232
Employment directly related to uranium production	6 718	6 792	5 809	8 946

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
18 000	18 000	22 000	22 000	19 000	20 000	24 000	25 000	20 000	21 000	24 000	25 000

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
12 000	13 000	14 000	15 000	10 000	11 000	12 000	13 000	4 000	5 000	5 000	6 000



Malawi*

Uranium exploration and mine development

Historical review

In the early 1980s, the Central Electricity Generating Board of Great Britain (CEGB) discovered mineralisation in the sandstones of Kayelekera. Extensive drilling from 1982 to 1988 defined an initial inferred resource of 9 800 tU at an average grade of 0.13% U.

From 1989 to 1992, geotechnical, metallurgical, hydrological and environmental works were conducted, as well as a feasibility study to assess the viability of a conventional open-pit mining operation. This work was completed in 1991 at a total cost of USD 9 million. The CEGB study concluded that the project was uneconomic using the mining model adopted and the low uranium prices of that time and the project was abandoned in 1992.

* Report prepared by the Secretariat, based on previous Red Books and company reports.

In 1998, Paladin Resources Ltd (Paladin Energy Ltd as of 1 February 2000) acquired an interest in the Kayelekera Project through a joint venture with Balmain Resources Ltd which then held exploration rights over the project area. Engineering and financial evaluation work indicated a positive outcome for the project. In 2004, additional drilling was completed to improve confidence in resource estimates, and the pre-feasibility study was updated. Resource drilling and bulk sample drilling for metallurgical test works were completed in 2005 and a bankable feasibility study was then undertaken. Paladin purchased Balmain's remaining stake in the project in 2005 and became the sole owner. The Kayelekera uranium deposit is a sandstone-hosted uranium deposit, located close to the north tip of the North Rukuru basin. This basin contains a thick (at least 1 500 m) sequence of Permian Karoo sandstones preserved in a semi-graben about 35 km to the west of and broadly parallel to the Lake Malawi section of the East African Rift System.

The Kayelekera mineralisation lies within the uppermost 150 m of the Muswanga Member, which is the upper part of the Karoo formation. The Muswanga Member consists of a total of eight separate arkose units with intervening silty mudstones in an approximate 1:1 ratio. Such a succession is indicative of cyclic sedimentation within a broad, shallow, intermittently subsiding basin. The arkose units contain most of the uranium mineralisation. They are on average about 8 m thick, are generally coarse grained and poorly sorted, and contain a high percentage of fresh, pink feldspar clasts. The basal layer of arkose units is usually a quartz-feldspar pebble conglomerate.

Coffinite has been identified as the principal uranium-bearing species and it occurs together with minor uraninite. Near-surface weathering of primary ore has produced a zone of oxide ore characterised by yellow and green secondary uranium minerals (meta-autunite and boltwoodite). Approximately 40% of the total ore is reduced arkose, 30% oxidised arkose, 10% mixed arkose and 20% of the mudstone-type.

Historical studies indicate that economically recoverable resources of uranium and coal only occur within the Kayelekera area. Coal is present in the project tenement area in two deposits: the Nkhachira deposit (850 000 tonnes, recoverable by open-pit and underground mining) and in association with the Kayelekera deposit. Coal in the Kayelekera deposit is contained within the uranium resources and is therefore unavailable for commercial extraction. Moreover, this coal is of very low quality.

In Malawi uranium exploration has increased in recent years due to expanding resources at the Kayelekera mine and the potential for discovery of additional deposits in a similar geological setting in the Karoo Group sedimentary rocks. In 2010, Paladin Energy completed exploration drilling in areas to the north-west and south of the mine area with objectives of extending the existing orebody as well as identifying and evaluating new orebodies.

The Livingstonia Uranium Project is a joint venture between two Australian companies, Resource Star and Globe Metals and Mining. The geological setting is very similar to that of Kayelekera. In 2006, Globe drilled 94 holes totalling 11 533 m. In July 2010, Resource Star did an additional 1 502 m of drilling in 13 holes to prove up a JORC compliant inferred resource of 7.7 million tonnes ore grading 0.0229% U.

Another potential uranium resource is the Kanyika Niobium Project held by Globe Metals. Uranium is an important by-product in the complex polymetallic ore in a pegmatite quartz vein, hosted in Proterozoic felsic schists. Niobium and tantalum products would be produced with uranium and zircon as by-products.

Recent and ongoing uranium exploration and mine development activities

Paladin continues to explore around Kayelekera. The orebody remains open to the west where exploration drilling continued in 2011 and 2012 and additionally, drilling was undertaken on nearby leases including Mpata to the east and Juma to the south.

Resource Star, the operator of the Livingstonia Project, has reported that thickened zones of mineralisation are open to the north-east, and the sparse drilling in the southern zone increases potential for additional mineralisation being defined. The mineralisation is also open to the north where the project adjoins tenements owned by Paladin Energy Ltd.

In 2011-2012, Globe Metals and Mining continued the development of the Kanyiba deposit. Total drilling, reverse circulation and diamond drilling, amounted to 40 540 m. As of December 2012, total resources amount to 68.3 Mt of ore at average grade of 0.28% Nb_2O_5, 0.0135% Ta_2O_5 and 0.0666% U (4 550 tU). Globe Metals and Mining submitted the environmental impact assessment for the Kanyika Niobium Project for public review in May 2012.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Malawi's total *in situ* identified resource is 19 910 tU. This is based on resources at three locations; Paladin's Kayelekera operating mine (13 090 tU), Resource Star's Livingstonia deposit (2 270 tU), both sandstone deposits, and Globe Metal's Kanyika niobium deposit (4 550 tU) where uranium will be produced as a by-product.

Uranium production

Historical review

The Kayelekera mine is located in the Karonga district of the northern region of Malawi, about 600 km by road from the capital city of Lilongwe. Transport of the first product to Walvis Bay, Namibia, via Zambia, took place on 17 August 2009. Uranium production is by open-pit with an annual production of 1 270 tU planned with a mine life of nine years.

Uranium is recovered using a solvent extraction process, with sulphuric acid as the lixiviant and sulphur dioxide/air mixture as the oxidant. The plant utilises a resin-in-pulp (RIP) process which is a first in the Western world for uranium production. Expected uranium mill recovery is 90%. Production was hampered in 2009 and 2010 by technical problems with the RIP process. In addition, land slip problems in 2010 resulted in remediation work being implemented and made it necessary to relocate certain parts of the plant and machinery.

Kayalekera is the first mine to have produced uranium in Malawi and is currently the only producer. However, Globe Metals and Mining's Kanyika Niobium Project is planned to come on stream in 2014 and will produce about 60 tU/yr as a by-product.

Status of production facilities, production capability, recent and ongoing activities and other issues

At the Kayelekera operation several technical challenges to production were addressed and solved during 2011. The replacement of the leach launders and improvements to the front end of the plant were successful and resulted in significant increases in throughputs and improved operability for future operation. A major impediment to production was the extended unplanned shutdown that occurred following the planned upgrades in September 2011. Substantial repairs to the acid plant and the relocation of the packaging and drying facility (both damaged by localised land movement) resulted in almost two months of down time for the plant which resulted in a 150 to 200 tU shortfall in production for the year. The issue of land movement has since been managed by remedial measures, which have proved successful. In May 2012, there was a weeklong strike by the national employees that resulted in reduced production of approximately 14 tU.

During 2012 production from the open-pit has resulted in stockpiles that are six months ahead of the processing plant. Feed into the plant has increased with an average recovery of 82.1% resulting in increased production, reduced grades and consistently processing 20% mudstone ores without any difficulties.

Cost optimisation remained a major focus with the continued targeted savings on acid, electric power, reagents, diesel and transport being the main opportunities. A combination of new technologies and ore blend management are seen as the major management tools for reducing costs in the near term.

Paladin commenced installation of the nanofiltration acid recovery plant at the Kayelekera mine that is scheduled to be commissioned by the end of October 2013.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2
Name of production centre	Kayelekera	Kanyika
Production centre classification	Existing	Planned
Date of first production	2009	2017
Source of ore:		
Deposit name(s)	Kayelekera	Kanyika
Deposit type(s)	Sandstone	Intrusive
Recoverable resources (tU)	10 470	2 730
Grade (% U)	0.73	0.08
Mining operation:		
Type (OP/UG/ISL)	OP	OP
Size (tonnes ore/day)	4 000	6 000
Average mining recovery (%)	75	NA
Processing plant:		
Acid/alkaline	Acid	NA
Type (IX/SX)	SX	NA
Average process recovery (%)	80	NA
Nominal production capacity (tU/year)	1 270	60
Plans for expansion	Yes	
Other remarks	Ramp up to 1 460 tU/yr	By-product

Ownership structure of the uranium industry

Two Australian companies, Paladin Energy and Resource Star, are active in Malawi in the primary uranium sector. Paladin holds an 85% interest in the Kayelekera Project through its subsidiary company Paladin (Africa) Limited. The remaining 15% is held by the Republic of Malawi according to terms of the Development Agreement signed in 2007. Paladin supplements ongoing mining with extensive exploration activities aimed at growing its resource base in Malawi.

In 2010, Resource Star signed a joint venture agreement with Globe Metals and Mining over their Livingstonia Project, with Resource Star managing work and earning up to 80% equity. In May 2012, Resource Star announced that it would acquire 100% of the Livingstonia Project from Globe. The Malawi authorities approved the transfer of the exploration licence to Resource Star in November 2012 at which time Resource Star applied to the Malawi authorities for a two-year extension to the term of the Livingstonia tenement.

Global Metals is also involved in rare earth exploration with significant uranium by-product potential.

Employment in the uranium industry

Paladin employed 759 people at the Kayelekera mine in 2012 of which 118 were expatriates and 68 or 9% were female.

Future production centres

Globe Metals and Mining submitted the environmental impact assessment for the Kanyika Niobium Project for public review in May 2012. According to Globe, the aim of the project is to produce niobium and tantalum products with potential production of uranium and zircon. Uranium would be produced as a by-product at a nominal rate of 80 t $Na_2U_2O_7$ (ammonium di-uranate) per year (60 tU/yr). Mining will involve the extraction of ore from a single open-pit at a rate of 1.5 to 3.0 million tonnes per annum using conventional open-pit drill and blast, followed by truck shovel load and haul. The final open-pit dimensions are expected to be in the order of 300 m wide, 2.2 km long (north-south) and 130 m deep. The project will produce approximately 52 million tonnes of solids to tailings over the mine life (estimated in excess of 20 years).

Environmental activities and socio-cultural issues

Paladin continues to fulfil its social development undertakings under the terms of the Kayelekera Mine Development Agreement. A programme to promote local involvement, economic growth and capacity building in communities is in progress. Opportunities are being explored for skills transfer and technical advice from Kayelekera's experienced workforce to local businesses.

Paladin is supporting the UK-based MicroLoan Foundation by funding an expansion of the foundation's activities in the Karonga region to provide micro-loans to 23 groups totalling around 300 local rural women for small-scale co-operative business ventures which will boost farming family incomes by encouraging expansion of small business initiatives.

Paladin engages formally with the Malawi government and with local communities via committees established for that purpose. These committees include the Government Liaison Committee (GLC), Karonga District Assembly and Kayelekera Village Elders.

Paladin continues to provide technical support and assistance to the Northern Region Water Board (NRWB) in the maintenance of the water supply plant in Karonga. This project was constructed by Paladin in 2010 for a cost of approximately USD 10 million as part of its undertaking under the Development Agreement. Paladin funded a 400 m extension of the runway at Karonga Airport, in conjunction with the Malawi Department of Civil Aviation (DCA). This has enabled Paladin's aircraft to operate safely and has upgraded facilities for third party users by enabling larger aircraft to use Karonga Airport. Two reconditioned fire engines have been donated to DCA for use at the airport.

Karonga District Hospital (KDH) was identified as the local public service institution most in need of support under Paladin's Infrastructure Development Programme. The 187-bed hospital services a regional population of 250 775 and is the main referral hospital in the district. Renovations included replacement of ceilings, windows, screens and plumbing fixtures. Responding to a long-standing request of the Karonga Town Planning Department and local public, Paladin upgraded a guardians' compound adjacent to KDH. It is normal practice in Malawi for rural patients' families to camp near a hospital to provide food and support for their relatives. At KDH, an average of 100 patients' guardians at any time camp in a designated area outside the hospital walls, with minimal support services. Paladin constructed a large, sheltered cooking area, toilets and bathing stalls.

In April 2012, Lab Without Walls founder Prof. Tim Inglis handed over a complete field microscope set to Paladin staff for use in Malawi. This was the latest addition to the community health services provided by Paladin and will be used to confirm malaria, tuberculosis and other infectious diseases.

In addition to supporting a number of employees in their external studies, Paladin also continues to support education for children in Kayelekera and nearby villages through paying for nine teachers, supply of materials and teaching initiatives. In 2012 a teacher's house was completed in Viraule village and two new classrooms were completed at Ipiana village. Repairs were carried out on the Kayelekera Primary School. Paladin also sponsors nine volunteer educators who supplement regular teaching staff at schools in villages near the Kayelekera mine.

Friends and Employees of Paladin for African Children (FEPAC) is a charitable foundation established in 2008 by Paladin employees to fund smaller social projects in Malawi that are outside the scope of the company's programmes. The charity supports six projects that assist orphaned children with educational needs and vocational training courses, such as brick laying, carpentry and tailoring. Sixty teenagers have completed these courses and have been provided with tools to enable them to earn money to support their younger siblings. During the year, FEPAC financed construction of a girls' dormitory, a kitchen/dining building and a teacher's house at the School for Deaf Children in Karonga.

Paladin HIV/AIDS awareness programmes continued in local communities. Four new booklets written by the Paladin Social Development Officer have been translated into three local languages and distributed to employees and the community. A total of 22 booklets have been published, covering social topics including HIV/AIDS prevention; malaria and chest infection management; dealing with alcohol abuse; care of the new born; prevention of diarrhoea; combating deforestation; theft and corruption; and wise use of wages.

In the interests of improving access to medical facilities in Kayelekera village, Paladin and the Department of Health entered into discussions to expand upon the Paladin-supported weekly outpatient clinic in the village. The outcome was a commitment from the department to establish a sub-clinic in Kayelekera to provide access to the full range of government programmes. Paladin will facilitate establishing the clinic and provide housing for two clinic staff in the village. Land has been allocated for this purpose.

Uranium requirements

Currently Malawi has no plans for nuclear power.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

All mining activities are under the control of the Department of Mines of the Ministry of Natural Resources with environmental matters falling under the Department of Environmental Affairs in the same ministry. However, in common with many developing countries, Malawi has no specific legislation or a regulation relating to uranium, but it is working in co-operation with the IAEA to develop appropriate legislation. In 2011, the National Assembly passed an atomic energy bill, which is the first step of the introduction of comprehensive legislation to provide for adequate protection of people as well as the environment against harmful effects of radiation, nuclear material and radioactive materials.

Government is committed to putting in place policies that will attract private sector participation in the exploration, exploitation, processing and utilisation of Malawi's mineral resources. To this end in March 2013, the Mines and Mineral Policy of Malawi was developed by the Malawi government. The government recognises that the minerals sector has significant potential to contribute towards the rapid economic growth and development of the country. The policy seeks to stimulate and guide private mining investment by administering, regulating and facilitating the growth of the sector through a well-organised and efficient institutional framework. The government will also intensify provision of extension services to the artisanal and small-scale miners and women miners. The goal of the Mines and Minerals Policy is to enhance the contribution of mineral resources to the economy of the country so as to move from being a agro-based to mineral-based economy.

Uranium exploration and development expenditures and drilling effort – domestic

	2010	2011	2012	2013 (expected)
Industry* exploration drilling (m)		3 867	6 656	
Industry* exploration holes drilled		22	37	
Industry* development drilling (m)		9 554		
Industry* development holes drilled		62		
Total drilling (m)	**NA**	**13 421**	**6 656**	**NA**
Total number of holes drilled	**NA**	**84**	**37**	**NA**

* Non-government (Paladin only).

NA = not available.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone			8 194	8 194
Intrusive				2 205
Total			**8 194**	**10 399**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			8 194	8 194	80
Co-product and by-product				2 205	60
Total			**8 194**	**10 399**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			8 194	8 194	80
Other				2 205	
Total			**8 194**	**10 399**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone			2 277	4 092
Intrusive				525
Total			**2 277**	**4 617**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			2 277	4 092	80
Co-product and by-product				525	60
Total			**2 277**	**4 617**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			2 277	4 092	80
Other				525	60
Total			**2 277**	**4 617**	

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	90	681	842	1 103	2 716	1 200
Total	**90**	**681**	**842**	**1 103**	**2 716**	**1 200**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	90	681	842	1 103	2 716	1 200
Total	**90**	**681**	**842**	**1 103**	**2 716**	**1 200**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	90	681	842	1 103	2 716	1 200
Total	**90**	**681**	**842**	**1 103**	**2 716**	**1 200**

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
165	15	0	0	0	0	938	85	1 103	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres		766	759	750
Employment directly related to uranium production				

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	1 200	1 200	0	0	1 400	1 460	0	0	1 400	1 460

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	1 400	1 460	0	0	1 400	1 460	0	0	1 400	1 460

Mali*

Uranium exploration and mine development

Historical review

Exploration for uranium in Mali was done along the border with Senegal between 1954 and 1956, by the French Alternative Energies and Atomic Energy Commission in the Adrar des Iforas region. Indications of uranothorianite and thorianite were discovered in large pegmatite lenses enclosed in highly metamorphosed hornblende- and pyroxene-schists of the Suggarian sequence. Numerous granites were also studied in this area but only the younger granites showed anomalous radioactivity, probably due to the presence of monazite as an accessory mineral.

Under an agreement with the government of Mali, Krupp carried out a reconnaissance survey in the eastern part of Mali in 1970 with no positive results. In 1971, the Geological Survey of the Federal Republic of Germany carried out a hydrogeochemical and radiometric reconnaissance survey in the western Kayes region of the country. Some anomalies were found but their character did not encourage further activities. In 1974, Japan's Power Reactor and Nuclear Fuel Development Corporation (PNC) initiated an exploration project in the Adrar des Iforas covering parts of the Taoudeni sedimentary basin.

In 1976, the *Compagnie générale des matières nucléaires* (COGEMA) started exploration in the areas of Kenieba, Kayes, Bamako, Sikasso, Hombori, Douentza and Taoudenni. This work included airborne radiometric surveys in Kenieba and Taoudenni, and geophysical exploration (including drilling) in Kenieba (Faléa and Dabora). COGEMA ended its exploration project in 1983 and PNC limited its activities to a small area of 20 km^2. PNC continued work through the first quarter of 1985, using emanometry and VLF over an area of 14 km^2, and then ended its activities in the second quarter of 1985.

Recent and ongoing uranium exploration and mine development activities

Since 2007-2008, several companies have been conducting uranium exploration in Mali. As of 1 January 2013, seven uranium exploration permits have been granted to five exploration companies. However, due to the rebellion in the north-eastern part of the country, exploration activities are only being undertaken in the western part of the country.

Exploration permits

Western part of Mali

Bala	125 km^2	Delta Exploration Mali Sarl
Madini	67 km^2	Delta Exploration Mali Sarl
Falea	75 km^2	Rockgate Capital Corp. in partnership with Delta Exploration Inc.

* Secretariat report based on company reports and government data.

Eastern part of Mali

Arafat	1 750 km^2	Earthshore Resources Mali Ltd
Diarindi	150 km^2	Merrea Gold
Dombia	254 km^2	Tropical Gold of Mali Sarl
Kidal	3 980 km^2	Oklo Uranium Ltd Mali Sarl
Tessalit	4 000 km^2	Oklo Uranium Ltd Mali Sarl

In 2007-2008, Australia's Oklo Uranium Ltd conducted uranium exploration over the Kidal area, part of the underexplored north-eastern part of Mali. Exploration covered a large crystalline geological province known as the Adrar des Iforas that is considered prospective for palaeochannel-hosted uranium, alaskite/pegmatite and vein-hosted uranium and contains occurrences of uranium, gold, copper-lead-zinc and manganese. Target identification has been undertaken in the project area with 47% of an airborne geophysical survey completed in 2007. In 2008, potential uranium anomalies were located and tested with ground spectrometry, geochemical sampling and drilling.

At Falea, substantial uranium and copper values were first discovered by COGEMA in the late 1970s but the project was not advanced due to the prevailing low commodity prices. Exploration conducted since 2008 by Rockgate and Delta has focused on defining and expanding these initial results.

The mineralisation at the Falea Project occurs within the Neoproterozic to Carboniferous sedimentary sequence of the Taoudeni Basin, a shallow interior sag basin with flat to very shallow dips. Falea is located along the southern edge of the western province of the Taoudeni Basin.

The first event related to ore genesis is believed to have deposited the copper (mostly in the form of chalcopyrite) and silver mineralisation. The copper mineralisation is found to be disseminated primarily within the Kania Sandstones, as halos around the uranium minerals and thus it acts as a trap for uranium mineralisation which occurs mostly as pitchblende and coffinite.

The uranium mineralisation is believed to be a sandstone-type – roll-front – deposit. With a few exceptions, mineralisation has been confined to the flat-lying KS unit, as well as within the units immediately above and below it. The distance from surface to the mineralised horizon varies between 31.5 m to more than 350 m below surface.

In 2011, a heliborne VTEM-magnetics-radiometrics survey was flown over the central Falea area. The survey comprised 933 line-km at a 1 100-metre line spacing covering an area of approximately 90 km^2. Drilling data used for the 2009 mineral resource estimate totalled 149 drill holes, 247 in 2011 and 754 in 2012 (virtually all diamond-type drilling). Further drilling is planned, mainly to test potential extensions of high-grade mineralisation on the north zone structures.

Uranium resources

Identified conventional resources

In December 2012, Minxcon Ltd (Johannesburg, South Africa) developed an NI 43-101 compliant resource estimate of the Falea deposit, at a cut-off grade of 0.03% U_3O_8 (0.025% U).

Total identified resources amounted to 17 412 tU which includes 11 377 tU RAR and 6 035 tU inferred.

Recent metallurgical test work and engineering have confirmed recoveries of uranium, silver and copper on a consistent basis, and hence the contribution of all these metals that may be expected from mining. A pre-feasibility study has begun based upon the results above together with an enhanced understanding of the orebody and possible mining and metallurgical solutions.

Environmental activities and socio-cultural issues

On 26 April 2010, Rockgate Capital Corp. announced that it had commissioned Golder Associates to conduct environmental and social baseline studies on the Faléa Project.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	11 377	11 377
Total	**0**	**0**	**11 377**	**11 377**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	11 377	11 377
Total	**0**	**0**	**11 377**	**11 377**

* *In situ* resources.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	6 035	6 035
Total	**0**	**0**	**6 035**	**6 035**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	6 035	6 035
Total	**0**	**0**	**6 035**	**6 035**

* *In situ* resources.

Mongolia

Uranium exploration and mine development

Historical review

Uranium exploration in Mongolia started immediately after World War II, with investigations directed at the search for uranium contained in other, non-uranium deposits. During the period 1945-1960, numerous uranium occurrences were discovered in the brown coal deposits of eastern Mongolia.

Between 1970 and 1990, under a bilateral agreement between the People's Republic of Mongolia and the Soviet Union, specialised geological surveys were conducted by the Geological Reconnaissance Expedition of the Soviet Ministry of Geology. Full airborne gamma-spectrometric surveys at a scale 1:25 000 and 1:50 000 were conducted over 420 000 km^2, some 27% of Mongolian territory; at a scale 1:200 000 over 450 000 km^2, or 28% of the territory; and at a scale of 1:1 000 000 over 224 000 km^2, or 14% of the Mongolian Altai, Khangai mountains and Gobi Desert region. The territory along the border with China and the central Mongolian mountain area, about 30% of the country, were not included in these surveys.

Metallogenic investigation at the scale of 1:500 000 over a 500 000 km^2 area and more detailed geological exploration at the scale of 1:200 000-1:50 000 over 50 000 km^2 area territory of Mongolia were also completed. This work included 2 684 000 m of surface drilling, 3 179 000 m^3 of surface trenching and 20 800 m of underground exploration.

Based on these surveys, the territory of Mongolia was classified into four uranium-bearing metallogenic provinces: Mongol-Priargun, Gobi-Tamsag, Khentei-Daur and Northern Mongolian. Each of these provinces has different geology and hosts different deposit types. Mineral associations and ages of mineralisation also vary. Within these provinces, 9 uranium deposits, about 100 uranium occurrences and 1 400 showings and radioactive anomalies were identified.

The Mongol-Priargun metallogenic province is located in eastern Mongolia, coinciding with a 70 to 250-km-wide continental volcanic belt tracing along the extension over some 1 200 km, from the Mongolian Altai to the Lower-Priargun. This territory includes mainly deposits and occurrences of fluorite-molybdenum-uranium associations resulting from volcano-tectonic events. Distinct uranium mineralisation districts of the Northern Choibalsan, Berkh, eastern and central Gobi are included in this area. The Dornod ore field of Northern Choibalsan includes the uranium deposits of Dornod, Gurvanbulag, Mardain gol, Nemer, Ulaan (incidental), as well as other polymetallic and fluorite associations. The Choir and Gurvansaikhan basins of the eastern and central Gobi uranium mineralisation district include the Kharaat and Khairkhan uranium deposits, among others.

The Gobi-Tamsag metallogenic province covers a territory 1 400 km long by 60-180 km wide in southern Mongolia. It is characterised by numerous uranium occurrences in grey and motley coloured terriginous sediments related to stratum oxidation and restoration. The district units include a perspective uranium deposit in the south, near the Dulaan uul and Nars deposits and numerous occurrences, as well as perspective uranium-bearing basins, such as Tamsag, Sainshand, Zuunbayan basins and others.

The Henter-Daur metallogenic province (700 km long by 250 km wide) includes the Khangai and Khentii mountains. In this area, uranium occurrences of light coloured granite fragments can be found, such as the Janchivlan ore field, which shows some promise of becoming a deposit of economic interest.

The Northern Mongolian metallogenic province is the largest (1 500 km long by 450 km wide) of the four. This north-western part of Mongolia is a comparatively old geological province characterised by a variety of minerals such as uranium-thorium rare earth elements related to alkaline mineralisation, uranium-thorium in metasomatites, pegmatite, magmatic and quartz schist uranium host rock.

Recent and ongoing uranium exploration and mine development activities

In 2011-2012, most uranium prospecting was performed in the Ulziit, Gurvansaikhan and Zuunbayan basins (south-east Mongolia), with the objective of identifying sandstone-type uranium mineralisation suitable for ISL mining.

Uranium exploration expenditures were MNT 34 842 million (Mongolian tugrik; USD 26.0 million) in 2012, down 8.5% from 2011 exploration expenditures of MNT 38 074 million (USD 30.1 million). Uranium prospecting and exploration drilling totalled 183 476 m in 2012, compared with 202 930 m reported in 2011.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2013, recoverable uranium resources in Mongolia attributable to the category identified resources amounted to 141 521 tU. Compared to 1 January 2011, this is an increase of 67 255 tU. The overall resource increase was primarily due to increased resources at the Gurvansaikhan, Ulziit, Zoovch ovoo sandstone-type deposits located in the Gurvansaikhan, Ulziit and Zuun bayan basins of south-east Mongolia.

RAR amounted to 108 107 tU, a significant increase of over 67 000 tU RAR compared to figures reported in 2011. This increase is even more dramatic if one considers that in 2011 the RAR were reported as *in situ* and for this report the resources are reported as recoverable.

Inferred resources have remained the same at 33 414 tU but have been moved from the <USD 80/kgU to <USD 130/kgU since the last report in 2011. The majority of such resources may be mined by the conventional underground mining method.

Undiscovered conventional resources (prognosticated and speculative resources)

As of 1 January 2013, prognosticated resources amounted to 21 000 tU and speculative resources totalled 1 390 000 tU.

Unconventional resources and other materials

No unconventional resources have been identified.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2				Centre #3	
Name of production centre	Emeelt mines	Gurvansaikhan				Coge-Gobi	
Production centre classification	Planned	Planned				Planned	
Start-up date	2018	2018				2019	
Source of ore:							
Deposit name(s)	Gurvanbulag	Kharaat	Khairkhan	Gurvansaikhan	Ulziit	Dulaan Uul	Zoovch Ovoo
Deposit type(s)	Volcanic	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Resources (tU)	8 580	7 288	8 406	2 479	2 611	6 259	67 706
Grade (% U)	0.162	0.026	0.071	0.034	0.036	0.022	0.022
Mining operation:							
Type (OP/UG/ISL)	UG	ISL	ISL	ISL	ISL	ISL	ISL
Size (tonnes ore/day)	NA	NA	NA	NA	NA	NA	NA
Average mining recovery (%)	NA	NA	NA	NA	NA	NA	NA
Processing plant:							
Acid/alkaline	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Type (IX/SX)	IX	IX	IX	IX	IX	IX	IX
Size (kilolitre/day)	NA	NA	NA	NA	NA	NA	NA
Average process recovery (%)	NA	NA	NA	NA	NA	NA	NA
Nominal production capacity (tU/year)	NA	NA	NA	NA	NA	NA	NA
Plans for expansion							
Other remarks	No	No	No	No	No	No	No

Uranium production

Historical review

Uranium production in Mongolia started with operation of the Dornod open-pit mine in the Mardai-gol district in 1989, based on the known uranium resources at the Dornod and Gurvanbulag deposits. Assuming an ore grade of 0.12%, this equals a mining production capability of 2 400 tU/year. Mongolia has no processing facilities. The ores mined in the Mardai-gol district were transported by rail 484 km to Priargunsky mining and processing combinate in Krasnokamensk, Russian Federation, for processing. Due to the political and economic changes both in Mongolia and neighbouring areas of the Russian Federation, uranium production at Erdes was terminated in 1995.

Status of production facilities, production capability, recent and ongoing activities and other issues

Currently, no uranium is being produced in Mongolia. However, a number of mines are in the planning stage of development.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Mongolia has not produced or used mixed oxide fuels.

Production and/or use of re-enriched tails

Mongolia currently does not have a uranium enrichment industry. Re-enriched tails are not used or produced.

Production and/or use of reprocessed uranium

There is no production or use of reprocessed uranium.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The new Mongolian government is attaching great significance to the mining of uranium deposits that would positively influence and improve the national economy. It has developed a special programme on uranium and is committed to implementing this programme.

The programme covers the following policies and guidelines:

- Geological exploration and the mining of uranium deposits, processing and marketing of uranium ores on the territory of Mongolia; the direction here is to reduce Mongolian government investment and to encourage foreign investment.
- Conducting surveys on the potential hazards of uranium exploration and mining and to protect the environment, people, fauna and flora.
- Developing intensive and effective co-operation with international organisations involved in the prospecting, mining and sale of uranium and other raw materials for nuclear energy.
- Developing all the necessary regulations, instructions and recommendations for activities related to uranium mining.

- Starting uranium geological surveys of sandstone-type deposits or occurrences on the territory of Mongolia.
- Studying possibilities of recovering uranium from phosphate and brown coal deposits and developing alternative extraction techniques.
- Training national personnel for uranium studies and production and to introduce advanced technology, instruments and tools of high precision.
- Setting up a government enterprise responsible for monitoring and co-ordinating uranium exploration and production as well as developing and implementing government policy and strategies in the field of uranium exploration based on mobilising efforts of national uranium specialists.

The programme defines actions and activities necessary for training national personnel in uranium prospecting and production, introducing advanced and efficient technologies and supplying high-capacity equipment, instruments and tools. The programme also lists achievements in this field and highly appreciates the impact of IAEA projects.

Uranium exploration and development expenditures and drilling effort – domestic

(MNT million)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	25 022	38 074	34 842	NA
Government exploration expenditures	0	0	0	0
Industry* development expenditures	0	0	0	0
Government development expenditures	100	0	0	0
Total expenditures	**25 122**	**38 074**	**34 842**	**0**
Industry* exploration drilling (m)	82 925.2	202 930	183 476	0
Industry* exploration holes drilled	670	-	-	0
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	82 925.2	202 930	183 476	0
Subtotal exploration holes drilled	670	-	-	0
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**82 925.2**	**202 930**	**34 842**	**0**
Total number of holes drilled	**670**	**-**	**-**	**0**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	92 837	92 837	92 837
Volcanic-related	0	15 270	15 270	15 270
Total	**0**	**108 107**	**108 107**	**108 107**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	15 270	15 270	15 270	85
In situ leaching acid	0	92 837	92 837	92 837	80
Total	**0**	**108 107**	**108 107**	**108 107**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	15 270	15 270	15 270	85
In situ leaching acid	0	92 837	92 837	92 837	80
Total	**0**	**108 107**	**108 107**	**108 107**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related	0	33 414	33 414	33 414
Total	**0**	**33 414**	**33 414**	**33 414**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	33 414	33 414	85
Total	**0**	**0**	**33 414**	**33 414**	**85**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	33 414	33 414	85
Total	**0**	**0**	**33 414**	**33 414**	**85**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
21 000	21 000	21 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
1 390 000	1 390 000	0

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Volcanic-related	535	0	0	0	535	0
Total	**535**	**0**	**0**	**0**	**535**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	535	0	0	0	535	0
Total	**535**	**0**	**0**	**0**	**535**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Namibia*

Uranium exploration and mine development

Historical review

Uranium was first discovered in the Namib Desert in 1928 by Captain G. Peter Louw in the vicinity of the Rössing Mountains in the Namib Desert. Over many years he tried to promote the prospect, but it was not until the late 1950s that Anglo-American Corporation of South Africa prospected the area by drilling and limited underground exploration. Due to erratic uranium prices and limited economic prospects for uranium, Anglo-American abandoned its work.

As a result of an upswing in the uranium market demand and prices, extensive uranium exploration started in Namibia in the late 1960s. Several airborne radiometric surveys were conducted by the geological survey and numerous uranium anomalies were identified. In 1966, after discovering a number of uranium occurrences, Rio Tinto acquired the rights to the low-grade Rössing deposit, 65 km inland from Swakopmund. During the same exploration period, Trekkopje, a near-surface calcrete deposit, was discovered just north of Rössing and Langer Heinrich, another calcrete deposit, was discovered in 1973 by Gencor, 50 km south-east of Rössing.

Mining commenced in 1976 at Rössing and exploration intensified as uranium prices increased sharply. However, in the early 1980s the combined effects of political uncertainty and the decline of uranium prices caused the rapid curtailment of exploration and development work. This was unfortunate as the refinement of exploration techniques, which had proved to be successful in the Namib Desert, appeared poised to potentially locate a number of new deposits.

The upward trend in uranium prices that began in 2003 once again stimulated extensive exploration activity, mainly in the Namib Desert. Based on earlier successes, two major types of deposits were targeted: the intrusive type associated with alaskite, as at Rössing and the surficial, calcrete-type, as at Langer Heinrich. Exploration activities continue but declining uranium prices since 2011, partly as a result of the Fukushima Daiichi accident, have slowed activities to a certain extent. Despite this recent slowdown, substantial growth in uranium exploration had already taken place in the Erongo area of west-central Namibia, focusing mainly on previously known deposits with considerable historical data. Over 60 exploration licences had been issued up until early 2007, when a moratorium on new licences was imposed by the Namibian government pending development of new policies and legislation given concerns about water and energy requirements for uranium mining.

The state-owned Epangelo Mining Company, created by the Namibian government in 2008, was given exclusive rights to all future uranium exploration and mining licences in April 2011. It was created to effect direct state participation in the Namibian mining

* Report prepared by the Secretariat, based on previous Red Books, government data and company reports.

industry, combining characteristics of an instrument of public policy and those of a business.

To appease concern among companies currently active in Namibia, the government stated that existing licences held by private companies would be honoured and that private companies were welcome to negotiate for a share of interest in ventures. However, Epangelo would maintain a majority shareholding at the outset of new strategic minerals developments, including uranium. Through "earn-in" agreements, joint venture private partners can increase shareholding by achieving key milestone targets as the project develops.

Recent and ongoing uranium exploration and mine development activities

During 2011 and 2012, the two operating uranium mines in Namibia have focused efforts on expanding the resource base and increasing production.

Rössing Uranium Limited

A positive evaluation of extending the mine life to 2016 and later to 2023 has led to efforts to expand the existing pit to expose more of the steeply dipping SJ orebody. The mining rate was increased from an average of 20 Mtpa (million tonnes per year) from the end of 2007 to an average of 50 Mtpa to the end of 2012. The majority of this increase was due to overburden stripping with plant throughput increasing only marginally during this time (average 11 Mtpa to 12 Mtpa respectively). Beginning in 2013, stripping was reduced as more ore is uncovered and the grade improves. Plant throughput and recovery improvements are also underway to restore production back to the 14 Mtpa nameplate capacity.

Between 2007 and 2010, exploration at Rössing focused on extensions of the main SJ orebody as well as the adjacent SK and SH deposits (at the end of 2012 amounting to a total of 71 415 tU *in situ* identified resources at 0.025% U). However, the SK deposit contains largely refractory mineralisation (betafite) for which the existing process plant is not suitable. A small portion known as SK4 with favourable mineralisation was identified and a small satellite pit was excavated between 2009 and 2011 as a means of supplementing ore supply while overburden stripping continued. Since 2010, the main exploration focus has been on the southernmost Z20 deposit that extends across the lease boundary into the adjacent lease held by Swakop Uranium Limited (SUL). A total of 24 000 m of drilling was completed on Z20 to declare an inferred resource by the end of 2012 and an additional 25 000 m of drilling is underway to upgrade this to indicated resources.

After establishing that the Z20 deposit is the northern extension of the Husab orebody, negotiations with SUL were initiated but as of the end of 2012 a joint development agreement involving fixed plant infrastructure had not been finalised. Nonetheless, potential remains for the development of Z20 either as a standalone pit to supply Rössing or as part of a combined pit with Husab.

Expansion studies progressed in parallel with exploration activities and ultimately focused on heap leaching as the preferred process expansion route due to potential lower costs and the ability to treat low-grade ore. Following initial column test work, a pilot plant was commissioned in 2010 that operated until the end of 2012 when a pre-feasibility study was completed. Further development is dependent on increased uranium prices and increases in the resource base required to support the scale of expansion under consideration.

Langer Heinrich

The Langer Heinrich Project (*in situ* identified resources of 66 131 tU at 0.045% U), currently the only other operating uranium mine in Namibia, is located in the western portion of central Namibia about 80 km east from the major deepwater seaport at Walvis

Bay and the coastal town of Swakopmund. An eight-year evaluation period followed the discovery of calcrete-hosted uranium mineralisation in the early 1970s. In 1980, Gencor, now part of BHP Billiton, completed an USD 8.5 million evaluation study but the project was subsequently placed on care and maintenance due to depressed uranium prices.

The initial production level of 2.6 Mlb/yr U_3O_8 (1 040 tU/yr) was achieved in 2008/2009. This was followed by the Stage 2 expansion to 3.7 Mlb/yr U_3O_8 (1 348 tU/yr) in 2010. Stage 3 expansion to 5.2 Mlb/yr U_3O_8 (2 030 tU/yr) was completed in 2012. A Stage 4 expansion feasibility study and EIA were submitted to government but the project was put on hold due to low uranium prices. The Stage 4 expansion plan is aimed at achieving a production level of 10 Mlb/yr U_3O_8 (3 852 tU/yr). Drilling for the Stage 4 mineral resource update was completed in 2010 and a new resource estimate was announced in 2011. The current mine model indicates a life of mine in excess of 18 years.

Proposed developments

Husab (Rössing South)

In April 2012, Taurus Minerals Limited of Hong Kong became the new owner of SUL thereby acquiring rights to the Husab deposit. Taurus is owned by the China General Nuclear Power Company (CGNPC). In November 2012, Epangelo, the Namibian state-owned mining company, finalised an agreement for the purchase of a 10% stake in the Husab deposit. A definitive feasibility study demonstrating the technical and economic viability of mining Zones 1 and 2 has been completed.

The total resource base amounts to identified *in situ* resources of 196 490 tU (averaging about 0.033% U) and remains open along strike and dip. As an extension of the Rössing Z20 deposit, it is an extension of Rössing stratigraphy. The Namibian government awarded a mining licence to SUL in December 2011. Taurus had originally planned to start development of the mine in October 2012, but construction did not begin until February 2013. Mining is expected to commence late in 2015 with a 24-month ramp-up to full production capacity of 5 770 tU/yr in 2017.

Trekkopje

The Trekkopje Uranium Project is located approximately 65 km north-east of the coastal town of Swakopmund, which is approximately 30 km north of the major deep water port of Walvis Bay. The project will exploit the Klein Trekkopje resource (identified *in situ* resources of 40 277 tU at 0.0119% U); a broad, surficial uranium deposit (80% of mineralisation is contained within 15 m of the surface) hosted in calcium carbonate cemented (calcrete) conglomerates of Tertiary age which lie on a peneplaned surface of Precambrian/Cambrian age meta-sedimentary rocks and intrusive granite. The basal channels in the Trekkopje area follow the northeast-trending structural grain of the underlying basement rocks.

In 2009, a geotechnical site investigation and the engineering design were completed for a new 30 million tonne, 2.5 km^2 on-off uranium heap leach pad. Construction of the main production pad began in 2010. A final production level of 3 000 tU_3O_8/yr (2 545 tU/yr) is envisaged. In October 2011, declining uranium prices led to a slowdown in project development to allow more time to optimise the technical and economic drivers of the future operation. Despite the slowdown, AREVA has made significant progress in mine development. The first 250 tU in the form of dried sodium diuranate (SDU), produced locally, was shipped from Walvis Bay to AREVA's conversion and enrichment facilities in France on 25 October 2012. This milestone followed the drying and packaging of the first drum of SDU extracted at the pilot plant on 21 July 2012. The pilot operation has been successful with over 400 tU produced to date and USD 800 million has been invested in building permanent mine facilities. However, AREVA announced in October 2012 that it would postpone the launch of the Trekkopje mine in Namibia until the economics of the project improve.

Etango

In October 2010, Perth-based Bannerman Resources Ltd announced resources of identified *in situ* resources of 81 673 tU at about 0.016% U for the Etango Project (30 km south-west of Rössing and 35 km east of Swakopmund). The alaskite ore is very similar to that at Rössing, and although with extensions continue to 400 m below the surface, two-thirds of the resource base is located less than 200 m below the surface. Open-pit mining and heap leaching appear to be the most cost-effective recovery method. In 2012, environmental approval for project was received complementing environmental approval for associated off-site infrastructure received earlier, but a mining licence has not yet been approved. AMEC Minproc completed the definitive feasibility study in March 2012 that confirmed the viability of the project with a long-term uranium price of about USD 61/lb U_3O_8 (USD 159/kgU) with pre-production capital costs estimated to amount to USD 870 million. As currently planned, Etango has a projected life of 16 years at a production rate of 2 700 tU/yr.

Bannerman, which holds 80% of the Etango Project, is seeking a development partner. In July 2011, China's Sichuan Hanlong group made a conditional takeover offer for Bannerman, but this did not proceed. In April 2012, state-owned Epangelo agreed to buy a 5% stake in the project with an option to buy a further 5% upon commitment to mine development. The agreement would result in Bannerman holding 76% of project ownership, Epangelo 5% and the existing private investor 19%, with funding responsibilities *pro rata*. However the deal was called off when the parties could not agree on terms.

Omahola

Reptile Uranium Namibia Ltd (RUN), the subsidiary of Australia's Deep Yellow Ltd (DYL), has been exploring for paleodrainage (calcrete), metamorphic/metasomatic and alaskite-hosted uranium since 2009. In January 2013, RUN announced *in situ* resources for their Omahola Project of 17 286 tU at 0.036% U, the majority of which will be mineable by open-pit methods. Reverse circulation and diamond drilling during 2012 have increased resources at both the MS7 and Ongolo prospects highlighting both extensive high-grade intercepts and new discoveries. Conceptually the Omahola Project will comprise a processing plant located close to the Ongolo alaskite deposit treating a blend of primary ore mined by open-pit from the Ongolo and MS7 alaskite deposits as well as the Inca uraniferous magnetite deposit.

Tubas Sand and Tubas paleochannel

RUN's Tubas Sand Project (*in situ* resources of 10 895 tU at 0.013% U) consists primarily of low-grade secondary uranium mineralisation (carnotite) in well-sorted aeolian (windblown) sand which occurs immediately south of the Tubas Palaeochannel Project. These deposits, combined with other surficial deposits in the prospecting licence area, have a combined total *in situ* resource of 24 759 tU at 0.014%. Pilot plant test work in the first half or 2011 showed that the Tubas Sand deposit could be upgraded in an economical and chemical-free fashion to increase the uranium content and produce a low-carbonate, uranium-rich concentrate. This upgraded material could be a suitable feedstock for an acid or alkali leach uranium recovery circuit. A strategy seeking to produce a loaded resin which could be sold to one of the two existing uranium producers in Namibia has been developed. This will enable RUN to commence production initially at a smaller scale (about 190 tU/yr). Prior to committing to a planned pre-feasibility study, a drilling programme has been initiated to improve understanding of and confidence in the resource base.

Valencia and Namibplaas (Norasa Project)

In August 2008, Valencia Uranium Pty Ltd, the operating subsidiary of Forsys Metals Corp, was awarded a mining licence for its 735.6 ha Valencia Project. Valencia is now fully permitted and has NI 43-101 compliant measured and indicated *in situ* resources of 23 260 tU at 0.016% U, plus 2 850 tU of inferred resources which together could support a 17-year mine life. The Valencia alaskite deposit is located 25 km north-east of and along strike from Rössing. Forsys is continuing with mine planning test work, including heap leaching. Drilling on the nearby Namibplaas property (7 km north-east), with similar geology allowed Forsys to announce in September 2012 an NI 43-101 indicated *in situ* resource of 12 850 tU at 0.013% U plus 4 230 tU of *in situ* inferred resources at a similar grade with similar mineralisation. The Norasa Project is a proposed development involving both the Valencia and Namibplass deposits to produce 1 900 tU/yr, starting in 2015, and Forsys has started a definitive feasibility study to support its development, including the possibility of heap leaching.

Marenica

The Marenica deposit is owned by Marenica Energy Limited (75%) and Namibian companies, Xanthos Mining Limited (20%) and Millennium Minerals (5%). Marcenica is situated in a paleochannel approximately 40 km north of Trekkopje. Carnotite uranium mineralisation occurs in both the paleochannel and weathered basement rock. In November 2011, Marenica Energy Ltd announced an *in situ* resource (mainly inferred, based on historical and new data) totalling 21 965 tU grading 80 ppm U (0.008% U) and an inferred resource at the adjacent MA7 deposit of 1 556 tU at 68 ppm U (0.0068% U). The Exclusive Prospecting Licence (EPL) 3287 was extended to 30 November 2014, but since the deposit is a relatively well-known, large, low-grade resource, Marenica Energy suspended all drilling activities while metallurgical testing proceeds, focusing on an upgrade process to increase the grade of mined material prior to leaching. The upgrade process has proven successful and has reduced the leach feed to about 1% of the plant feed due to rejection of the major gangue mineral of calcite. Calcite rejection has also enabled the proposed leach circuit to be changed from an alkali leach (with higher operating temperatures and slower kinetics) to acid (at ambient temperature and rapid kinetics), reducing expected capital and operating costs.

Other exploration prospects

Exclusive Prospecting Licence 3602, located in the Happy Valley area some 110 km north-east of Swakopmund just east of Rössing, was granted to Zhonghe Resources on 1 August 2006. Earlier work included a 1:50 000 scale airborne radiometric survey carried out by the South West African Geological Survey in 1975 and a surface radioactivity survey conducted by Rio Tinto. Between 2007 and 2012, Zhonghe Resources resumed exploration work in this area, including geological, radioactivity, geophysical and geochemical surveys, drilling (372 holes for 89 512 m) and trenching, leading to the discovery of deposits No.18, No.2 and No.15. In 2012, JORC compliant resource declarations using an 85 ppm U (0.0085% U) cut-off grade amounted to indicated *in situ* resources of 25 772 tU and inferred *in situ* resources of 15 000 tU for the No.18 deposit, as well as inferred resources of 11 539 tU in associated deposits on the lease. Currently, exploration is being undertaken on other deposits in addition to the process optimisation test, development of a definite feasibility study and preliminary mine development design.

In 2011, Xemplar Energy Corp. subsidiary Namura Minerals Resources (Pty) Ltd drilled 113 holes for 2 336 m in the Cape Cross calcrete-type deposit. While a number of samples recorded values in the region of 100 to 200 ppm U (0.01% to 0.02% U), there was insufficient data to justify a more extensive exploration programme, particularly in the current market. In 2008 and 2009, Xemplar identified a number of sizable zones of uranium mineralisation on its Warmbad Project, which has similar mineralisation as found at Rössing, with potential for a high-tonnage, low-grade uranium deposit. Xemplar is seeking a strategic partner to engage in taking the Warmbad Project to its full potential.

Petunia Investments Three, the Namibian subsidiary of the Russian Federation's Renova plans to explore 13 000 ha of land east of the central coast dune belt between

Swakopmund and Walvis Bay. In 2012 meetings held in Walvis Bay, the public was informed of plans to explore the area for its uranium potential. The area is within the Dorob and Namib Naukluft Parks. Some of the potential impacts of the exploration to be investigated include access routes to field camps and other facilities in an area described as having "archaeological significance". Another issue is that the area apparently forms part of the annual migratory path of the desert ostrich.

Aussinanis is controlled by DYL's wholly owned subsidiary RUN and is located approximately 100 km south-southwest of Swakopmund (EPL3498). Results of a mineral resource estimate indicate that Aussinanis is a very large, low-grade uranium resource. Uranium mineralisation is present from the surface to an average depth of 6 m as carnotite-hosted in sediments and calcrete. The mineral resource estimate includes JORC compliant indicated and inferred *in situ* resources totalling 35 M tonnes at 237 ppm eU_3O_8 (0.02% U) for 8 203 t eU_3O_8 (18.1 Mlb U_3O_8 or 6 960 tU) at cut-off grade of 150 ppm eU_3O_8 (0.0127% U).

Identified conventional resources (reasonably assured and inferred resources)

Identified recoverable conventional resources in Namibia amounted to 455 591 tU in 2013, a decline of 12% from the last report in 2011 due to adjustment of recovery factors, production depletion and updated mine design plans. Recoverable resources for Rössing, Langer Heinrich, Husab, Trekkopje, Etango, Norasa (Valencia-Namibplaas) were calculated using the recovery factor provided by the Ministry of Mines and for other deposits was calculated using an average of reported recovery factors (i.e. 72%).

Deposits in Namibia are typically large and low grade. In 2013, about 84% of the recoverable identified uranium resources are classified in the <USD 130/kgU (USD 50/lb U_3O_8) cost category with no resources reported in the <USD 80kg/U category. In comparison in 2011, 1% of the recoverable identified resources were reported in the <USD 80kg/U category and about 50% in the <USD 130/kgU cost category, the change in categories reflects a re-evaluation of the resources since the last reporting period in light of low uranium prices and increased mining costs.

Undiscovered conventional resources (prognosticated and speculative resources)

Undiscovered resources are estimated in areas adjacent to deposits with identified resources in Happy Valley, Etango, Tumas, Husab and Ida. As of 1 January 2013, prognosticated resources amounted to 57 000 tU and speculative resources totalled 110 700 tU.

Uranium production

Historical review

In August 1966, Rio Tinto Zinc (RTZ) acquired the exploration rights for the Rössing deposit and conducted an extensive exploration programme until March 1973. After a feasibility study that included surveying, mapping, drilling, bulk sampling and metallurgical testing in a 100 t/day pilot plant, a production centre was established.

Rössing Uranium Limited was formed in 1970 to develop the deposit. RTZ was the leading shareholder with 51.3% of the equity at the time of the formation of the company (69% in 2013). Mine development commenced in 1974 and commissioning of the processing plant and initial production took place in July 1976. In 1977, a full design capacity of 5 000 short tons of U_3O_8/yr (3 845 tU/yr) was established, but due to the highly abrasive nature of the ore, an aspect not identified during the pilot plant testing stage, the production target was not reached until 1979 following plant design changes. From the date of first production in July 1976 to 2012, the Rössing mine had produced a cumulative total of over 104 000 tU.

Full-scale development of the Langer Heinrich mine proceeded after licensing and commissioning began in late 2006. A bankable feasibility study had confirmed that a large body of uranium mineralisation could be mined by open-pit with a minimum mine life of 11 years and a process plant life of 15 years. The study showed 1 000 tU/yr could be produced for the first 11 years at a head feed grade of 0.074% U and that an additional 340 tU could be produced over an additional 4 years using the accumulated low-grade (0.027% U) stockpile. Commercial production began at Langer Heinrich in 2007 and as outlined above, the Langer Heinrich Project has been expanded three times in recent years to achieve a production capacity of just over 2 000 tU/yr.

Status of production facilities, production capability, recent and ongoing activities and other issues

Total uranium production in Namibia declined from 4 0503 tU in 2010 to 4 078 tU in 2011, then increased to 4 653 tU in 2012.

Production at Rössing has declined in recent years due in part to above average seasonal rainfall, planned maintenance shutdowns and a focus on the pre-stripping programme to expose higher-grade material for future mining. The Z20 uranium zone has been drilled and has contributed significantly to increased resources and projected mine life.

Langer Heinrich is operating efficiently, however the low uranium price has led to the delay of the Stage 4 expansion.

Future production centres

Low uranium prices have also caused AREVA to delay start-up at the Trekkopje operation. In contrast, the Husab Project is moving ahead toward planned production start-up in 2015.

Taurus Minerals, owned by China General Nuclear Power Company, completed a successful takeover of Extract Resources Ltd and are the new owners of the Husab Project, operated by SUL. At 8 km in length, uranium mineralisation at Husab is the highest-grade, granite-hosted uranium deposit in Namibia and is considered one of the world’s more significant recent discoveries. Based on the positive results of a definitive feasibility study, Husab is being developed as a conventional, large-scale – load and haul – open-pit mine, feeding ore to a conventional agitated acid leach process plant. The mine has a potential life of more than 20 years, although building on promising exploration results additional efforts could increase the resource base and mine life beyond 20 years. The forecast ore grade at Husab Zones 1 and 2 is 518 ppm (0.0518% U). The strip ratio is 6:2:1, which means that just over seven tonnes of waste rock have to be removed to obtain one tonne of ore. Mine development began in February 2013. More than USD 100 million has been invested to bring the project to the construction phase and it is estimated that a further USD 2 billion will be required to bring the facility into production.

Bannerman Resources have received environmental approvals to proceed with development of the Etango mine. AMEC Minproc completed a definitive feasibility study in March 2012 confirming the viability of the project, but further project development is on hold pending a decision on the mining licence application.

Forsys Metals Corp. of Toronto is developing the Valencia Uranium Project along strike from Rössing and 25 km north-east of it, with geology (alaskite) similar to Rössing. Environmental approval for an open-pit mine was granted in June 2008 and a mining licence was granted in August 2008. Additional drilling on their Nambiplaas Project 7 km to the north-east solidified resource estimates. The Norasa Project is a proposed development involving both deposits to produce 1 900 tU/year, starting as early as 2016.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6
Name of production centre	Rössing	Langer Heinrich	Husab	Trekkopje	Norasa	Etango
Production centre classification	Existing	Existing	Committed	Committed	Planned	Planned
Date of first production	1976	2006	2015	2016(?)	2016	2016
Source of ore:						
Deposit name(s)	SJ, SK, SH and N20	Langer Heinrich	Zones 1 and 2	Trekkopje, Klein Trekkopje	Valencia and Namibplaas	Etango
Deposit type(s)	Intrusive	Calcrete	Intrusive	Calcrete	Intrusive	Intrusive
Recoverable resources (tU)	51 633	50 590	152 084	28 999	28 296	54 150
Grade (% U)	0.025	0.045	0.033	0.012	0.011	0.016
Mining operation:						
Type (OP/UG/ISL)	OP	OP	OP	OP	OP	OP
Size (tonnes ore/day)	40 000	20 000	42 000	30 800	32 000	55 000
Average mining recovery (%)	85	90	88	90	77	78
Processing plant:						
Acid/alkaline	Acid	Alkaline	Acid	Alkaline	Acid	Acid
Type (IX/SX/HL)	IX/SX	IX	IX/SX	HL/IX	IX/SX	HL/SX
Size (tonnes ore/day); for ISL (l/day or l/h)						
Average process recovery (%)	85	85	88	80	85	85
Nominal production capacity (tU/year)	4 000	2 000	5 800	1 600	1 900	3 000
Plans for expansion	Yes	Yes		No	No	
Other remarks				On hold		

Employment in the uranium industry

Levels of employment have not changed significantly since 2011. At Rössing, Langer Heinrich and Trekkopje there were just over 2 000 people employed during 2011 and 2012. There has recently been a reduction in employment at the AREVA Trekkopje operation due to the temporary slowdown. Mine development activities at Husab are expected to create 6 000 temporary and 2 000 permanent jobs when the mine goes into production.

Environmental activities and socio-cultural issues

In 2004, the Namibian government launched a partnership known as Vision 2030 that aims to improve the quality of life of all Namibians to be on par with similar nations by 2030. Rössing Uranium's community engagement is geared towards this vision and the mine is supporting the education, science and technology, health and development, sustainable agriculture (through work undertaken by the Rössing Foundation) and the peace and social justice components of this partnership.

The Rössing Foundation was established in 1978 by Rössing Uranium through a deed of trust to implement and facilitate corporate social responsibilities within the communities of Namibia. The Foundation currently has a strong presence in the Erongo region but support has extended to other regions (Oshana, Omahaheke and Khomas).

The Foundation's Deed of Trust stipulates furthering the education of all Namibians in order to achieve greater national productivity and to enhance lifelong learning, creating opportunities for Namibian people to use their education in employment, promoting the advancement of the living standards of all the people in Namibia and doing any act or thing, which in the opinion of the trustees, shall benefit Namibia.

The focus of foundation activities from 2006 to date has been in the Erongo region (75% of the resources) on education, the Arandis sustainable development plan, small-scale miners, community-based natural resource management (CBNRM) and the Erongo development fund. Activities in Oshana include education and CBNRM and in Omaheke, an outreach programme.

Through 2012, Rössing Uranium continued to provide financial and/or technical support to the Uranium Institute, an organisation launched in 2009 to improve the quality of healthcare, environmental management and radiation safety in the uranium industry. It also provides support to the Arandis town council, the Arandis out of school youth skill development programme (youth unemployment is one of the main challenges in Arandis), small-scale mining in the Erongo region, the CBNRM and local biodiversity programmes.

At the end of 2012 the total closure cost projected for the Rössing mine in 2023 stands at just over NAD 1 486 million (Namibian dollars; about USD 175 million). This includes retrenchment and retraining costs, plant demolition and site rehabilitation, long-term seepage control and post-closure monitoring costs. The provision for closure in the independent Rössing Environmental Rehabilitation Trust Fund stood at NAD 256 million (about USD 30 million) at the end of 2012 and will be increased in the coming years to provide fully for the time of mine closure. A new mine plan is being developed to extend the life of mine beyond 2023 and this closure cost projection will be updated in line with the new plan.

During 2011 and 2012 continuous rehabilitation activities were carried out and redundant plant was demolished and historical waste sites rehabilitated. The disturbed area at the Z20 exploration site in the Namib Naukluft National Park was rehabilitated fully. The various rehabilitation programmes will continue into 2013 and beyond. The mine's footprint was extended minimally to amount to a total of 2 531 ha at the end of 2012. This was due to the extensions of the rock disposal facilities.

Paladin Energy, owner and operator of the Langer Heinrich production facility, continued its support and participation in Uranium Institute's activities. It has also established a stakeholder register that was originally developed during an environmental assessment processes in order to maintain contact with interested individuals and organisations. During 2011 and 2012, 45 formal stakeholder meetings were held with communities, environmental organisations, government, indigenous and other groups to discuss project expansion plans and to develop an appropriate focus for its social development programme. The main issues raised by stakeholders in these consultations were education, youth development, community needs, water extraction and use. Biannual environmental reports and annual reports on project-specific issues, such as water are submitted to government. An environmental database has been established to better evaluate and assess accumulating monitoring data (including a comprehensive surface and groundwater monitoring) in order to detect any potential issues that may arise as early as possible. The reuse and recycling of water is maximised as much as possible using water returned from the tailings storage facility and recovery bores and trenches, as well as treated effluent from the sewage treatment plant.

Swakop Uranium, also a contributing member to the Uranium Institute, has committed itself to social aspects such as local procurement, recruitment and employment, involvement in social responsibility programmes, training, education and sound environmental management practices. The Swakop Uranium Foundation has been established to support the Erongo region and Namibia. Since Swakop Uranium will operate within the Namib Naukluft National Park, it is responsible for minimising impacts on this fragile ecosystem and along infrastructure routes to site. Water requirements have been met with the supply of desalinated water via a temporary pipeline through an agreement between Swakop Uranium, NamWater and AREVA.

Projects have been initiated to address some of the research needs of Swakop Uranium's environmental management plan. Groundwater monitoring in both the Khan and Swakop rivers has been undertaken to collect baseline water-level and water-quality data. Groundwater monitoring wells are being established around the planned locations of the open-pits, waste rock dump and the tailings storage facility to measure the effect that pit groundwater drawdown will have in the area. Water quality in drawdown wells will be used as additional baseline data and monitoring throughout the life of the mine will provide an early warning system of potential impacts. As early as 2009, Swakop Uranium began assessing the amount of particulate matter (dust in the air) to contribute to baseline environmental data collection. A dust suppressant will be used at Husab on the pit and dump haul roads and other gravel roads. This will reduce the dust produced to acceptable levels, as well as potentially save up to 90% of the water that would be required to achieve the same level of control if no suppressant is used.

Uranium producers and most of the major exploration companies operating in Namibia created the Namibian Uranium Association to promote industry adherence to sustainable development performance, product stewardship and compliance with the Namibian legislative framework. The association was also created to be the leading contact point in the industry for governments, media and others interested in the positions and policies of the Namibian uranium industry.

In 2009, the South African Institute for Environmental Assessment was contracted by the government to undertake a strategic environmental assessment (SEA) of the so-called central Namibian uranium rush. Funding was also provided by the German government. The report was submitted to the Namibian government in early 2011. In January 2013, the Geological Survey of Namibia released the first annual report produced under the Strategic Environmental Management Plan (SEMP) developed in response to the SEA.

Positive impacts noted in the SEA include stimulating the Namibian economy, skills development and infrastructure development. A number of constraints to development were also identified, such as possible water shortages, lack of skills, capacity of physical infrastructure and environmental protection. The SEA noted that the uranium rush could have a number of negative impacts in the areas of natural physical resources, biodiversity, health, infrastructure and tourism. Good governance will be critical in minimising these impacts.

The SEMP operational plan sets out 12 environmental quality objectives (socio-economic development, employment, infrastructure, water, air quality and radiation, health, effect on tourism, ecological integrity, education, governance, heritage and future, closure and land use) that are to be continuously monitored as a collective proxy for measuring the extent to which uranium mine development activities are moving the Erongo region towards a desired future state. An SEMP office has been establish to administer the programme. The SEMP document notes that Uranium Institute has worked as a contact point with the uranium industry and supplied much of the data used in the first annual report. It is also noted that the uranium industry in Namibia has voluntarily increased its application of the SEA and SEMP to guide mining and exploration plans in order to minimise and manage potential environmental impacts.

One of the key aspects of the SEMP is water supply. Since 2010 water has been supplied to Trekkopje from a coastal desalination plant built by AREVA in the Erongo region. This plant will supply 20 million m^3/yr output, requiring 16 MWe from the grid. Approximately half of the water will be available to other mines and agreements have been signed with Namibian Water Corp. for Rössing, Langer Heinrich and Husab. The plant is jointly owned by AREVA and a local company, the United Africa Group. In 2014, the government plans to start building a second plant with a 60 million m^3/yr capacity. The first report on implementing the SEMP notes that uranium mining, mine development and exploration have not compromised community access to water supplies of acceptable quality.

Regulatory regime

The constitution provides for the protection of the environment and the welfare of humankind. The Minerals Policy of Namibia of 2003 is aimed at attracting investors by creating a conducive environment for mining activities; however one of its objectives is also to ensure compliance with the national environmental policy and legislation in order to develop a sustainable mining industry.

Furthermore, the Minerals (Prospecting and Mining) Act 1992 (No. 33) requires every licence holder to conduct environmental impact assessments before they start exploration. Namibia's Environmental Management Act of 2007 (Act No. 7 of 2007) came into effect in 2012 and stresses the importance of consultation with interested and affected parties. The act promotes the sustainable management of the environment and the use of natural resources by establishing principles for decision making on matters affecting the environment as well as the Environmental Impact Assessment Regulation.

Uranium mining is regulated under the Atomic Energy Act of 2005 and Environmental Management Act of 2007. An Atomic Energy Board has been established along with a National Radiation Protection Authority.

In 2007, the Namibian government instituted a moratorium on uranium exploration licences for an indefinite term. At the time, the price of uranium had reached a level that had stimulated exploration for the mineral worldwide, in particular in Namibia. The government stated that the moratorium would give it time to reconsider national policies towards uranium following an upswing in demand, citing concerns about water and energy. The Geological Survey of Finland (GTK), the Radiation and Nuclear Safety Authority (STUK) and the Ministry of Mines and Energy of Finland have been providing support to the Namibian Ministry of Mines and Energy in the development of a nuclear fuel cycle policy, legislation and regulations as well as the development of a minerals database in a project funded by the Finnish Ministry of Foreign Affairs.

The Epangelo Mining Company was established in July 2008. The Namibian government is the sole shareholder. In April 2011, the government declared uranium, copper, gold, zinc and coal to be strategic minerals and that Epangelo Mining has exclusive exploration and mining rights on these minerals. A new minerals bill and mineral policy will be finalised in the near future to formalise the situation with regard to Epangelo mining and the rights to the strategic minerals. To appease concern among companies currently active in Namibia the government stated that existing licences held by private companies would be honoured and that private companies were welcome to negotiate for a share of interest in ventures but, at the outset of new developments, Epangelo will maintain a majority shareholding.

Uranium requirements

Namibia has no nuclear generating facilities. Namibia's electricity supply of some 3 billion kWh per year is half supplied by South Africa, which faces serious supply constraints itself. A coal-fired plant is planned for Walvis Bay.

The government has articulated a policy position of supplying its own electricity from nuclear power by 2018, but there have been no signs of progress towards this goal.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Uranium is defined as a controlled mineral and Section 102 of the Minerals Act deals with the export, processing, possession and enrichment of uranium. There is no particular policy or set of regulations that deals with uranium production or the nuclear fuel cycle and Namibia is collaborating with Finland to develop appropriate governance. As noted above, Finnish authorities are working with the Namibian government to develop uranium mining policies and regulations. Namibia is party to the Nuclear Non-Proliferation Treaty and has had a comprehensive safeguards agreement in force since 1998 and in 2000 signed the Additional Protocol.

Uranium exploration and development expenditures and drilling effort – domestic

(NAD [Namibian dollars])

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	839 325 716	552 931 140	458 690 351	208 066 536
Industry* development expenditures	45 903 650	25 915 329	185 714 370	4 225 120 605
Total expenditures	**885 229 366**	**578 846 469**	**644 404 721**	**4 433 187 141**
Industry* exploration drilling (m)	133 738	261 029	169 499	76 000
Industry* exploration holes drilled	3 542	1 722	1 187	375
Industry* development drilling (m)	469 582	178 753	205 493	56 693
Industry* development holes drilled	970	2 379	4 334	5 414
Subtotal exploration drilling (m)	133 738	261 029	169 499	76 000
Subtotal exploration holes drilled	53 512	1 722	1 187	375
Subtotal development drilling (m)	469 582	178 753	205 493	56 693
Subtotal development holes drilled	970	2 379	4 334	5 414
Total drilling (m)	**603 320**	**439 782**	**374 992**	**132 693**
Total number of holes drilled	**4 512**	**4 101**	**5 521**	**5 789**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Intrusive			196 979	215 535
Metasomatite			2 004	2 004
Surficial			49 245	78 964
Total			**248 228**	**296 503**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			248 228	296 503	73
Total			**248 228**	**296 503**	**73**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			210 330	229 606	75
Heap leaching* from OP			37 898	66 897	69
Total			**248 228**	**296 503**	**73**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Intrusive			97 944	117 022
Metasomatite			1 711	1 711
Surficial			34 987	40 355
Total			**134 642**	**159 088**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			134 612	159 088	73
Total			**134 612**	**159 088**	**73**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			118 390	142 836	74
Heap leaching* from OP			16 252	16 252	66
Total			**134 642**	**159 088**	**73**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	57 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	110 700

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Intrusive	98 062	3 083	2 641	2 293	106 079	2 720
Surficial	2 027	1 420	1 437	2 360	6 974	2 100
Total	**100 089**	**4 503**	**4 078**	**4 653**	**113 053**	**4 820**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	100 089	4 503	4 078	4 653	113 323	4 820
Total	**100 089**	**4 503**	**4 078**	**4 653**	**113 323**	**4 820**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	100 089	4 503	4 078	4 253	112 923	4 820
Heap leaching*				400	400	
Total	**100 089**	**4 503**	**4 078**	**4 653**	**113 323**	**4 820**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
69	1.48	0	0	973	20.92	3 611	77.60	4 653	100

Uranium industry employment at existing production centres

(person-years)

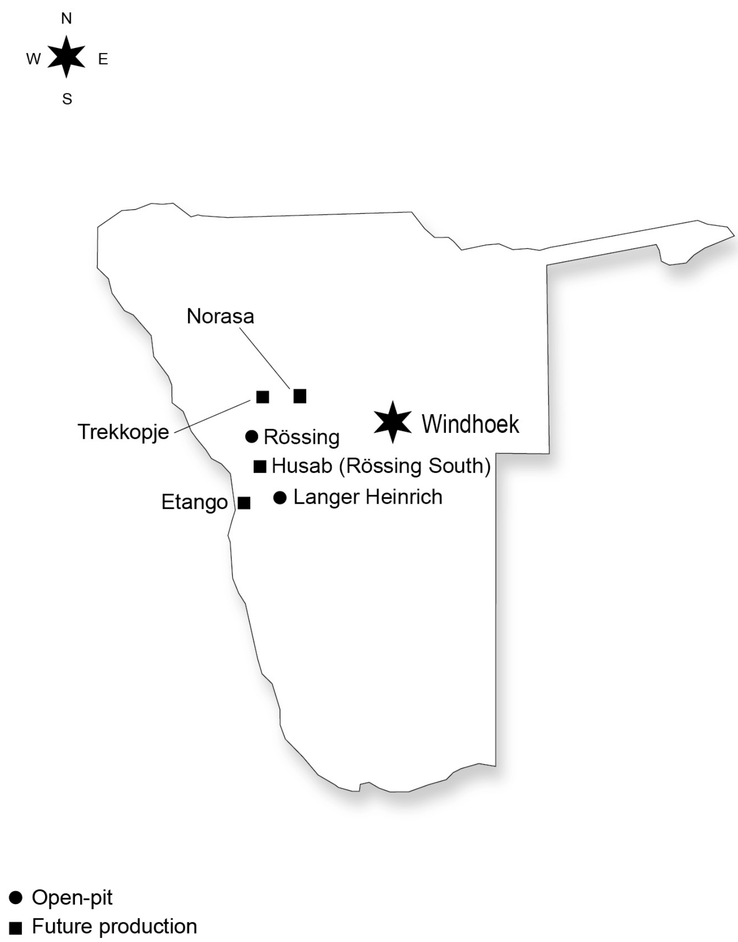
	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	2 554	1 886	2 786	2 340
Employment directly related to uranium production	1 915	1 737	2 628	2 100

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	6 000	6 000	0	0	10 000	10 000	0	0	15 700	15 700

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	16 100	16 100	0	0	16 100	16 100	0	0	12 100	12 100



Niger*

Uranium exploration and mine development

Historical review

Uranium exploration began in 1956 in the Arlit area of Niger within the Tim Mersoï sedimentary basin and uranium was first discovered in sandstone at Azelik in 1957 by the French *Bureau de Recherches Géologiques et Minières* (BRGM). The French Alternative Energies and Atomic Energy Commission initiated further studies of the sandstone which were taken over by COGEMA and resulted in the discoveries of Abokurum (1959), Madaouela (1963), Arlette, Ariege, Artois and Taza (1965), Imouraren (1966) and Akouta (1967).

* Report prepared by the Secretariat based on company reports and government data.

The *Société des mines de l'Aïr* (Somaïr) was formed in 1968 and started production from the Arlette deposit in 1971 by shallow (60 m depth) open-pit mining. From 1971 to 1988, acid heap leaching was used at Arlit, producing 200-600 tU per year, for a total of 5 900 tU over this 17-year period. The uranium recovery rate achieved was low at 50% or less and from 1988 to 2009 more than 10 Mt of low-grade ore (0.08% U average grade) has been stockpiled. In 2009, after conducting tests over several years, Somaïr has restarted heap leaching using an improved process to achieve recovery rates above 65%.

The *Compagnie Miniere d'Akouta* (Cominak) was set up in 1974 and started production from the Akouta and Akola deposits, near the town of Akokan. This is an underground operation at a depth of about 250 m.

In 2004, COGEMA (now AREVA) and the government of Niger signed an agreement to undertake a major exploration programme. In subsequent years, both Somaïr and Cominak were involved in exploration solely for the purpose of better evaluating previously discovered deposits. Somaïr delineated the Taza Nord deposit, while Cominak evaluated a mineralised area south-east of the Akola deposit.

Development of the large Imouraren deposit about 80 km south of Arlit was confirmed in January 2008, after an agreement was signed in 2006 to increase royalty payments by 50%. In 1974, a joint venture agreement was signed to develop Imouraren but it was shelved because of unfavourable economics.

In 2006, the China National Nuclear Corporation (CNNC) signed an agreement to develop the Azelik-Abokurum deposit and a new company, *Société des Mines d'Azelik* (Somina) was created in 2007 for this purpose. First production was announced at the end of December 2010. Total Azelik-Abokurum RAR and inferred recoverable resources amount to 15 900 tU.

All uranium deposits in Niger are located within the Tim Mersoï basin in close proximity to the main Arlit-In-Azaoua fault. Uranium is mined close to the twin mining towns of Arlit and Akokan, 900 km north-east of the capital Niamey (more than 1 200 km by road) on the southern border of the Sahara Desert and the western range of the Aïr Mountains. The concentrates are trucked to ports in Benin and the majority are exported to the Comurhex conversion facility in France.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration in Niger was revitalised in 2006. A total of six new exploration permits were granted that year and by 2011 uranium exploration activities were being carried out on 160 concessions by foreign companies. However since 2011, there have been increasing geopolitical tensions in the region, resulting in foreign companies like Paladin and URU Metals ceasing exploration activities in Niger.

In recent years, production has been focused on the Ebba-Afasto deposit south of Akouta and Akola. Cominak workers staged a three-day strike on 9 July 2012 to press demands for increased wages as the company was engaged in a process to improve competitiveness and retain its rank among the world's top producers.

The Azelik mine produced its first uranium concentrate on 30 December 2010 and its first uranium shipment was sent to China on 22 October 2012.

The Imouraren mine, which is being developed by AREVA, was originally scheduled to begin production in 2012, but has been delayed due to security risks and unfavourable market conditions. Nonetheless, waste rock above the deposits has been removed, dewatering pumping systems have been installed and a 16-hectare acid heap leaching pad has been constructed. This on-off heap leach pad includes a radial stacker, mobile conveyors and an overland conveyor. Equipment for processing chemicals used in ore treatment and a cogeneration system in the sulphuric acid plant have been installed.

Steam generated in the acid plant will be used partly in the chemical plants and partly to produce electricity.

Imouraren construction was suspended in 2010 after seven AREVA workers were kidnapped in the northern area of Arlit. All hostages were later released but mine development has been delayed. Production at Imouraren is expected to begin in mid-2015.

GoviEx holds exploration properties of 2 300 km^2 near the Arlit mine, as well as 2 000 km^2 near Agadez. In August 2008, Cameco bought an 11% share of GoviEX, with options to increase that share to 48%. A conceptualised mine plan has been developed that could begin as early as 2017 with annual production of up to 1 000 tU. Toshiba Corporation completed a convertible debt-financing that provided GoviEx with USD 40 million in exchange for off-take rights to at least 230 tU/yr as of 2020.

URU Metals Limited reported a South African Mineral Resource Committee compliant inferred resource of 1 654 tU on their In Gall deposit and in 2011 continued to drill the Aboye, Akenzigui and Fagochia targets within their Irhazer and In Gall permits. Project commitments elsewhere and security risks in Niger caused URU Metals to take steps to terminate activities in Niger by 2014.

In December 2010, Paladin completed the takeover of NGM Resources Ltd, the owner of the local company Indo Energy Ltd that held concessions in the Agadez region. NGM Resources had announced an inferred mineral resource of 4 320 tU. Paladin indicates that they have developed an exploration programme to identify higher-grade uranium mineralisation in local Lower Carboniferous stratigraphies. In early 2011, Paladin carried out a drilling programme that further defined targets for follow-up and information from the drilling was used to plan a 15 000 m follow-up drilling campaign. However, this was put on hold due to security concerns. All fieldwork has ceased and force majeure has been requested from the government authorities for an indefinite suspension of further expenditures.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The total recoverable identified conventional resources for Niger, as of the end of 2013, amount to 404 914 tU, a decline of 40 585 tU compared to estimates in 2011, owing to the change in processing method and recoveries for the Imouraren deposit. Imouraren was originally planned (2011) to be mined by open-pit by conventional processes with a 95% recovery, but in 2013 the plan was updated – mining will be open-pit with heap leaching process and recoveries of approximately 75%. All uranium deposits in Niger are sandstone-hosted, with average grades of 0.07 to 0.40% U.

Undiscovered conventional resources (prognosticated and speculative resources)

Total speculative and prognosticated resources in Niger, as of the end of 2013, amount to 64 900 tU (unchanged from 2011).

Uranium production

Historical review

Uranium has been produced from sandstone deposits in Niger since 1970 by Somaïr and 1978 by Cominak. In 2007, Société des Mines d'Azelik (Somina) was created to mine the Azelik deposit and first production was achieved at the end of December 2010.

Uranium production has been increasing in recent years as efficiencies have been introduced. In 2010, production amounted to 4 197 tU, then increased to 4 264 tU in 2011 and 4 822 in 2012 as Azelik increasingly added to the national total. However, production is expected to decline in 2013 to 3 859 tU following the attack on the Somaïr mine on 23 May 2013 which forced AREVA to suspend operations for two months while repairs were completed.

Status of production facilities, production capability, recent and ongoing activities and other issues

The two long-standing uranium production centres in Niger are operated by Somaïr and Cominak. In 2009, a facility to process low-grade ores through heap leaching was launched at Somaïr which provides the potential to increase production by an additional 900 tU. The Azelik deposit was reportedly developed with a USD 99 million loan from the China National Nuclear Corporation (CNNC), or SinoU. At full production, the mine has a projected production capability of 700 tU/yr. This will bring the current total production capability of Niger to 5 400 tU/year, up from 4 700 tU/yr in 2011.

Ownership structure of the uranium industry

The Madaouela deposits, wholly owned by GoviEx Niger Holdings Ltd (a wholly owned subsidiary of GoviEx Uranium Inc., Toronto, Canada), have been the subject of a preliminary economic assessment. The government of Niger holds a 10% carried equity interest in the project through state-owned *Société du Patrimoine des Mines du Niger* (SOPAMIN), with an option to purchase an additional 30% share once a mining licence is issued.

The ownership structure of Niger's four uranium production companies are set out in the table below:

Somaïr	Cominak	Somina	Imouraren
36.6% SOPAMIN (Niger)	31% SOPAMIN (Niger)	37.2% CNUC (China)	33.35% SOPAMIN
63.4% AREVA NC	34% AREVA NC (France)	33% SOPAMIN (Niger)	56.65% AREVA
	25% OURD (Japan)	24.8% ZXJOY invest (China)	10% KEPCO
	10% Enusa (Spain)	5% KORES	

SOPAMIN = La Société du Patrimoine des Mines du Niger; OURD = Overseas Uranium Resources Development Corporation; CNUC = China Nuclear Uranium Corporation; ZXJOY invest = Zhongxing Joy Investment Co., Ltd; KORES = Korea Resources Corporation; KEPCO = Kansai Electric Power Company.

Employment in the uranium industry

Approximately 1 175 are employed at the Somaïr mine and 1 140 at the Cominak mine. It is reported that 99% of the workers at these two mines are Nigerien. About 680 are employed at the Azelik mine. The Imouraren Project employs about 300 during the development stage and is expected to create about 1 400 permanent and up to 3 000 indirect jobs when the facility is in full production.

Future production centres

In May 2009, development of the Imouraren mine was launched with an initial investment of more than USD 1.6 billion. Once up to full production capacity, production of 5 000 tU/yr for 35 years is expected. Production, scheduled to start mid-2015, has been delayed owing to security risks and poor market conditions.

GoviEx has completed a preliminary economic assessment and proposed underground mine development at the Madaouela Project, which will go into production as early as 2017 with a capacity to produce 1 040 tU/yr from 39 600 tU in resources and an additional 11 260 tU from the Miriam deposit, which can be mined as an open pit.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1		Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Arilit (Somaïr)		Akouta (Cominak)	Azelik (Somina)	Imouraren	Madaouela
Production centre classification	Existing		Existing	Existing	Committed	Planned
Date of first production	1970	2009	1978	2010	2015	2017
Source of ore:						
Deposit name(s)	Tamou-Artois-Tamgak	Low-grade stockpiles	Akouta-Akola-Ebba	Azelik-Teguidda-Abokurum	Imouraren	Miriam-Marianne-Marilyn-MSNE-Maryvonne
Deposit type(s)	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Recoverable resources (tU)	67 206	6 336	20 817	15 900	279 185	50 859
Grade (% U)	0.14	0.069	0.35	0.20	0.07	OP 0.40 UG 0.15
Mining operation:						
Type (OP/UG/HL)	OP	HL	UG	OP/UG	OP	OP/UG
Size (tonnes ore/day)		1 800 kt/yr				4 200
Average mining recovery (%)						
Processing plant:						
Acid/alkaline	Acid	Acid	Acid	Alkaline	Acid	
Type (IX/SX)	SX	SX	SX			
Size (tonnes ore/day)						
Average process recovery (%)	95	75	92	87	89	85
Nominal production capacity (tU/year)	1 900	1 000	1 800	700	5 000	1 040
Plans for expansion						
Other remarks						

Environmental activities and socio-cultural issues

Both mining operations at Somaïr and Cominak have maintained their ISO 14001 certification for environmental management for many years (certification is renewed every three years). AREVA maintains that environmental issues, including water preservation is fundamentally important to their operations. The mandate of the AMAN Project, established in 2004, is to study the existing aquifers in the Arlit and Akokan areas to ensure an adequate supply of potable and industrial water is available and not being compromised. AREVA has initiated ways to conserve and reduce water consumption and reports that over the past 15 years the annual consumption of water at the mines has been reduced by 35% while uranium production at Somaïr has doubled in the past 10 years.

In April 2010, AREVA and local authorities signed a series of protocols and procedures to implement multipartite radiological control of materials and equipment in the streets of Arlit and Akokan, including more stringent monitoring of used materials being taken from the industrial sites.

Somaïr and Cominak manage two hospitals in Arlit and Akokan with technical support centres. First created to provide medical care for the miners and their families, the centres are now largely open to the public free of charge. Imouraren also recently opened a medical centre that treats local residents for free.

As the country's largest private employer, AREVA has been contributing to the improvement of living conditions in local communities. In 2010, AREVA initiated an ambitious societal policy and committed EUR 6 million per year for the next five years to implement it. Mining activity has resulted in the construction of housing and a modern network of water distribution and contributes to the funding of public services and the construction of educational facilities (schools, libraries, lunch rooms).

Uranium requirements

There are currently no uranium requirements in Niger. However, it has been reported that Niger is considering a civilian nuclear reactor to meet domestic energy requirements and assist in national economic development.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

In 2007, SOPAMIN was established by the government of Niger. SOPAMIN holds the state's shares in existing uranium companies operating in Niger and is responsible for commercial transactions, such as uranium sales.

One of the main objectives of Niger's national uranium policy is to achieve a higher degree of international competitiveness in the industry. In July 2011, President Issoufo stated that he would seek a better price for the country's uranium exports to maximise their value to support economic and social development. About one-third of Niger's export revenue comes from uranium.

The government of Niger has ordered an audit of AREVA's uranium mines in the country as negotiations for a new long-term contract were initiated. A new ten-year mining contract is due to be renewed at the end of 2013. The government of Niger has indicated its desire to increase taxes and is calling on AREVA to make additional infrastructure investments, including a new road to the remote mining region of Arlit.

Production each year is sold to joint venture partners in proportion to their equity at an "extraction price" (roughly based on operation costs) determined by the government. In February 2012, the extraction price was set at CFA 73 000/kgU (USD 145kgU; USD 56/lb U_3O_8), paid in Euros. The partners then sell or use the product. In the case of the government, uranium sales are made through a trading company.

Uranium prices

The price of uranium shipped is determined by joint agreement between the Nigerien state and the mining companies. An agreement on the price of uranium shipped in 2013 has not been reached.

Uranium exploration and development expenditures and drilling effort – domestic

(CFA francs thousands)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	10 864 951.8	2 307 464.5	61 857 202.9	10 448 240.7
Total expenditures	**10 864 951.8**	**2 307 464.5**	**61 857 202.9**	**10 448 240.7**
Total drilling (m)				
Total number of holes drilled				

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		14 829	324 987	324 987
Total		**14 829**	**324 987**	**324 987**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)			35 690	35 690	90
Open-pit mining (OP)		14 829	289 297	289 297	79
Total		**14 829**	**324 987**	**324 987**	**81**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG			35 690	35 690	90
Conventional from OP		10 077	77 315	77 315	95
Heap leaching* from OP		4 752	211 982	211 982	75
Total		**14 829**	**324 987**	**324 987**	**81**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		620	79 927	79 927
Total		**620**	**79 927**	**79 927**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)			18 685	18 685	90
Open-pit mining (OP)		620	61 242	61 242	94
Total		**620**	**79 927**	**79 927**	**93**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG			18 685	18 685	90
Conventional from OP		620	59 082	59 082	95
Heap leaching* from OP			2 160	2 160	75
Total		**620**	**79 927**	**79 927**	**93**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
	13 600	13 600

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	51 300	

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	110 149	4 197	4 264	4 822	123 432	3 859
Total	**110 149**	**4 197**	**4 264**	**4 822**	**123 432**	**3 859**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	49 733	2 650	2 831	3 318	58 532	2 320
Underground mining*	60 416	1 547	1 433	1 504	64 900	1 539
Total	**110 149**	**4 197**	**4 264**	**4 822**	**123 432**	**3 859**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	110 149	NA	NA	NA	NA	NA
Heap leaching*		NA	NA	NA	NA	NA
Total	**110 149**	**4 197**	**4 264**	**4 822**	**123 432**	**3 859**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
1 675	34.72	0	0	3 147	65.28	0	0	4 822	100

Uranium industry employment at existing production centres

(person-years)

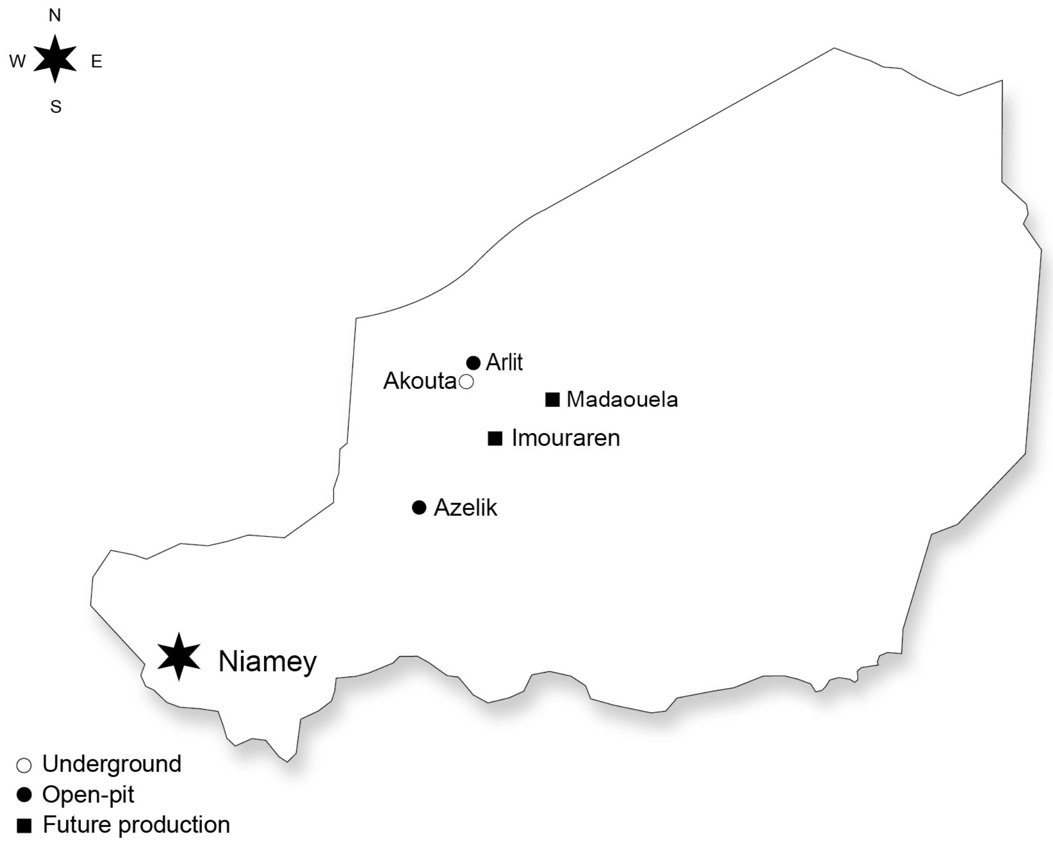
	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	2 915	2 915	2 915	2 915
Employment directly related to uranium production	NA	NA	NA	NA

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 000	1 000	5 400	5 400	1 000	1 000	5 400	5 400	1 000	2 000	10 500	10 500

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	1 000	10 500	10 500	NA	1 000	7 500	7 500	NA	1 000	7 500	7 500



Peru

Uranium exploration and mine development

Historical review

Macusani Uraniferous District (Department of Puno) is located in south-east Peru. The uraniferous mineralisation is found in acid volcanic Mio-Pliocene rocks (10 to 4 m.a.).

Radiometric prospecting revealed over 40 uraniferous areas, the most important of which are Chapi, Chilcuno-VI, "Pinocho", Cerro Concharrumio, Cerro Calvario.

Uranium mineralisation consists of pitchblende, gummite, autunite and meta-autunite filling sub-vertical to sub-horizontal fractures, with impregnation on both sides of the fracture. The host rocks are lapilli tuffs of the Quenamari Volcanic Formation.

Considering all the areas surveyed, Chapi is the most important site, and detailed radiometry, emanometry, trench and gallery work and diamond drilling has been carried out. The mineralisation is in sub-vertical fractures distributed in structural lineaments 15 to 150 m wide and 20 to 30 m thick. The grades vary between 0.03% U to 0.75% U, with an average of 0.1% U. Based on the exploration results as well as the geological and emanometry information, a minimum potential of 10 000 tU has been assigned to the Chapi site and 30 000 tU to the whole Macusani Uraniferous District.

Since 2003, private companies restarted the exploration in both Macusani and the Santa Lucia-Rio Blanco area, 250 km from Macusani, also in the Tertiary volcanic environment. The uranium potential of the remainder of the country is important. The Peruvian Institute of Nuclear Energy (IPEN), through its promotional activities, has proposed highlighting new areas of interest such as San Ramón (Oxapampa and Corongo) in the central region of Peru, where some work has been conducted to identify potential uraniferous regions.

Recent and ongoing uranium exploration and mine development activities

Several companies have focused on the area of Macusani in order to further develop uranium resources through drilling in different prospects within the uraniferous district of Macusani, Puno. Since 2003, exploration restarted in Macusani, Santa Lucia-Rio Blanco and Pampacolca (Arequipa), also in the Tertiary volcanic environment.

Uranium potential in other parts of Peru is important and IPEN, through its promotional activities, has proposed to highlight new areas of interest. In 2012, IPEN discovered new uranium occurrences in the San Ramón-Oxapampa region, where initial results demonstrate important uraniferous potential.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Macusani Uranium District (tU, in situ)

Through entry of several uranium private companies for exploration in the country, the resources have been increased with the development of new areas of uranium exploration in the Macusani District; however, no formal information about these reserves has been received by IPEN and so they are not included in the identified resource totals. In 2012, Macusani Yellowcake reported NI 43-101 compliant measured and indicated resources totalling 4 540 tU and inferred resources of 10 615 tU for holdings on the Macusani Plateau. Other exploration companies had drilling programmes planned for extensions of these deposits.

Uranium resources

Prospect	RAR	IR	Total
Chapi	1 670	1 720	3 390
Chilcuno VI	80	20	100
Pinocho	40	30	70
Concharumio	0	90	90
Total	**1 790**	**1 860**	**3 650**

Undiscovered conventional resources (prognosticated and speculative resources)

Macusani Uranium District	
Chapi	6 610 tU
Remainder of Macusani Uranium District*	19 740 tU
Total	**26 350 tU**
At country level	
Permo-triasic granites**	20 000 tU
Thirty-nine locations***	5 600 tU
Total	**25 600 tU**

* Extension of 1 000 km^2, distribution of Tertiary volcanic rocks with associated uranium.

** Granites with radioactive anomalies and uranium occurrences located in the departments of Junín and Pasco, average of 50 ppm U (0.005% U).

*** Others in the rest of the country, uranium deposits associated with hydrothermal deposits (Cu Pb-Ni-W).

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Mining activities, formerly conducted by the government, entered into a privatisation process with passage in 1992 of the Law of Mining Investment Promotion. This legislation aims to provide stability and a guaranteed framework for long-term investments in mining, including uranium. In recent years, the reactivation of interest in uranium exploration has resulted in permitting several foreign private companies to conduct exploration programmes in the zones where IPEN had previously performed prospecting and exploration work.

The state, in the promotion of investment in uranium mining, plans to evaluate the potential for uranium in the country in areas other than Macusani. One such area is in the Eastern Cordillera, where occurrences of uranium in granite-type rocks also have thorium potential.

The Technical Office of the National Authority (OTAN) is responsible for policy and regulatory issues. A new law involving the promotion and development of nuclear energy for electricity generation is being developed.

Currently, there are five active exploration companies, all from Canada: Vena Resources/Cameco, Southern Andes Energy Inc., Global Gold S.A.C. subsidiary of Macusani Yellowcake, Fission Energy Corp. and Wealth Minerals Ltd.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related		1 790	1 790	1 790
Total		**1 790**	**1 790**	**1 790**

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)		1 790	1 790	1 790
Total		**1 790**	**1 790**	**1 790**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Heap leaching** from OP		1 790	1 790	1 790
Total		**1 790**	**1 790**	**1 790**

* *In situ* resources.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related		1 860	1 860	1 860
Total		**1 860**	**1 860**	**1 860**

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)		1 860	1 860	1 860
Total		**1 860**	**1 860**	**1 860**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Heap leaching** from OP		1 860	1 860	1 860
Total		**1 860**	**1 860**	**1 860**

* *In situ* resources.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
6 610	20 000	20 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
19 740	19 740	

Poland

Uranium exploration and mine development

Historical review

Prospecting for uranium concentration in Poland began in 1948. An industrial plant in Kowary (Lower Silesian Voivodeship) was established that was involved in the exploitation and processing of local uranium deposits.

Research beginning in 1956 by the Polish Geological Institute involved the exploration of Carboniferous formations of the Upper Silesian Coal Basin, phosphorite formations and the analysis of drill cores from the Polish lowlands. As a result of this research, signs of uranium mineralisation were discovered in Lower Ordovician formations of the Podlasie Depression (the “Rajsk” deposit) and in Triassic formations of the Perybaltic Syneclize and the Sudetes (Okrzeszyn, Grzmiąca, Wambierzyce). In the Ladek and Snieznik Klodzki metamorphic rocks, small occurrences of uranium mineralisation and the Kopaliny-Kletno deposit were discovered.

Recent and ongoing uranium exploration and mine development activities

There are no current (up-to-date) uranium deposits documented in Poland. There are some perspective indications of uranium resources and currently some small prospects for the discovery of uranium that could potentially be economically exploited. In 2009, the Polish government decided to introduce nuclear energy and the Polish Nuclear Energy Programme is being prepared. One of the topics covered is research into the possibility of mining domestic uranium resources. Initiatives connected to this topic will be undertaken in the coming years.

In May 2012, one concession for prospecting a polymetallic uranium deposit was granted (the "Radoniów" area, valid from May 2012 to May 2015). This licence permits the performance of surface geophysical studies and the drilling of one control borehole. It also takes into account the possibility of further drilling in the case of positive results from the initial work.

At present research projects aimed at assessing the possibility of obtaining uranium from domestic low-grade ores and waste rock piles left at historic uranium mining operations dating from the 1950s and 1960s are being conducted. Special attention is being paid to the use of biological leaching.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The data presented in the table below summarises information from historic geological documentation that does not fulfil current requirements for resource reporting and the potential for mining under current economic conditions. Reinterpretation of geological data in 2009-2010 shows that Poland has no identified conventional uranium resources that could be mined under current market conditions. Without more precise and up-to-date exploration of these historically defined occurrences, there is no possibility for profitable exploitation. Detailed research of potential new resources is planned.

Region	Resources in place (t)	Uranium content (%)
"Rajsk" deposit (Podlasie Depression)	5 320.0	0.025
Okrzeszyn (Sudetes)	937.6	0.05-0.11
Grzmiaca (Sudetes)	792.0	0.05
Wambierzyce (Sudetes)	217.5	0.0236

Undiscovered conventional resources (prognosticated and speculative resources)

Historical research also led to the determination of 20 000 tU of speculative resources. However, as with the determinations of uranium occurrences noted above, the speculative resource determination needs to be done using modern methods to confirm the result.

Region	Speculative resources for depth to 1 000 m (t)
Perybaltic Syneclise	20 000

Uranium production

Historical review

In 1948, a government operated industrial plant was established in Kowary (Lower Silesian Voivodeship) to process ore mined from local uranium deposits. Exploitation of vein deposits in the Karkonosko-Izerski Block and metamorphic deposits in the Ladek and Snieznik Klodzki continued until 1967. Production data from these uranium deposits are presented below.

	Deposit name	Uranium resources (t)	Exploited (t)
1	Wolnosc	94.0	94.0
2	Miedzianka	14.7	14.7
3	Podgorze	280.0	199.0
4	Rubezal	0.5	0.5
5	Mniszkow	4.5	4.5
6	Wiktoria	0.28	0.28
7	Majewo	0.96	0.0
8	Wolowa Gora	2.5	2.5
9	Radoniow	345.0	214.0
10	Wojcieszyce	14.4	12.3

Exploitation of vein deposits in the Karkonosko-Izerski Block (Wolnosc, Miedzianka, Podgorze, Rubezal, Mniszkow, Wiktoria, Majewo, Wolowa Gora, Radoniow, Wojcieszyce) and of metamorphic deposits of Ladek and Snieznik Klodzki (where some small uranium occurrences and the Kopaliny-Kletno deposit were discovered) took place until 1967, at which time the deposits were almost completely depleted. In the Ladek and Snieznik Klodzki metamorphic rocks, a few occurrences of uranium mineralisation and the "Kopaliny-Kletno" deposit were discovered, from which approximately 20 tonnes of uranium were extracted.

During this period, all uranium produced was exported to the Soviet Union. It is estimated that between 1948 and 1967 approximately 650 tU were mined in the Sudetes of Poland. Chemical treatment of low-grade ores started in Kowary in 1969 and continued until 1972. The activity produced a significant volume of waste that was left in a tailings pond.

Status of production facilities, production capability, recent and ongoing activities and other issues

Currently in Poland, no licences for uranium production have been granted.

Environmental activities and socio-cultural issues

All exploitation activities associated with uranium mining and processing in Poland were performed between 1948 and 1976. Although the companies associated with this activity no longer exist, there remains a need to remediate the environment in the area around the sites where the mines operated. The Geological and Mining Law stipulates that the State Treasury is accountable for liabilities from all past uranium production activities in

Poland. Therefore, the government is responsible for funding the remediation, using either the national or the district Environmental Protection Fund.

The regional authorities of the Voivodship (local administration area) and its special inspectorates or officers are responsible for different aspects of the remediation. The local authorities approve remediation plans and supervise their execution and impacts. The inspectorates of the Environmental Protection of a particular Voivodship are responsible in general for environmental monitoring. Radiological monitoring is considered a part of this overall monitoring effort and it is being performed under the responsibility of the President of the National Atomic Energy Agency.

Since 1996, Poland has taken part in the PHARE Multi-country Environmental Sector Programme on "Remediation Concepts for the Uranium Mining Operations in Central and Eastern European Countries" (CEEC). In the framework of this programme, an inventory and a common database for the CEEC have been created. According to this inventory, the situation in Poland is characterised by a large number of small-scale liabilities from uranium exploration, localised over several places in the country and generally causing minor environmental impacts.

Only a limited number of issues related to mining and milling are considered to be causing serious impacts and the most important is the tailings pond in Kowary. The 1.3 ha hydrological construction is closed on three sides by a dam that has been modified a number of times in the past. The dam itself is 300 m long (the sum of three sides) and has a maximum height of 12 m. As a result of uranium processing activities, the tailings pond has been filled with about 250 000 tonnes of fine-grained gneisses and schists with average uranium content of 30 ppm (0.003% U). In the early 1970s, the Wroclaw University of Technology (WUT) received, by governmental decision, the ownership of both the area and the facilities of the former uranium mining company. Subsequently, a company owned by the WUT has continued to use the existing chemical plant for various experimental processes on rare earth metals, chemical production and galvanic processes. As a result, about 300 tonnes of remnants of rare earth metal processing and 5 000 m^3 of post-galvanic fluids, with up to 30 tonnes of solids with a high content of aluminium, nickel, zinc and sodium sulphates, have been deposited in the pond.

The remediation programme of the tailings pond was prepared in 1997 by the WUT and successfully carried out under the PHARE programme until 2003. The specific objectives of this programme are related to the construction of drainage systems, the design and construction of the tailings pond cover and the final site reclamation.

Three abandoned uranium mines in the Sudetes Mountains of south-west Poland have been successfully adapted for use as tourist attractions and for educational purposes.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The approximate amount of uranium required has been determined assuming the use of LWRs as outlined in the Polish Nuclear Energy Programme, beginning with the first 1 200 MWe or 1 650 MWe (net) unit expected to be in operation in 2024, including the first core load. The second nuclear power unit is planned to be in operation from 2027 (1 000 MWe to 1 650 MWe), as well as the third and fourth units of the same size in 2029.

Uranium exploration and development expenditures and drilling effort – domestic

(PLN [Polish zloty])

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	0	0	0	0
Government exploration expenditures	300 000	500 000	0	1 000 000
Industry* development expenditures	0	0	0	0
Government development expenditures	0	3 386 000	5 000 000	2 400 000
Total expenditures	300 000	3 886 000	5 000 000	3 400 000
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	0	0	0	0
Subtotal exploration holes drilled	0	0	0	0
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	0	0	**0**	**0**
Total number of holes drilled	0	0	**0**	**0**

* Non-government.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Granite-related	435	0	0	0	445	0
Metamorphite	215	0	0	0	215	0
Total	**650**	**0**	**0**	**0**	**650**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	NA	0	0	0	NA	0
Underground mining*	650	0	0	0	650	0
In situ leaching	NA	0	0	0	NA	0
Co-product/by-product	NA	0	0	0	NA	0
Total	**NA**	**0**	**0**	**0**	**NA**	**0**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	0	0	0	0	NA	NA	NA

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	0	0	0	0	0	0	0	1 000	1 650	4 500	7 000	7 000	10 000

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	0	0	0	0	0	0	0	740*	1 220*	790	900	900	1 000

Note: According to the assumption that 1 TWh requires 23 tNatU.

* First core load included.

Portugal

Uranium exploration and mine development

Historical review

The first uranium-radium deposits in Portugal were discovered in 1907 and the first mining concession (Rosmaneira) was granted in 1909, although Urgeiriça became the first producing mine in 1913. Radium was mined at Urgeiriça until 1944 (50 g of estimated radium production and 500 tonnes of lost uranium) and uranium mining began in 1951. Between 1945 and 1962 a foreign, privately owned enterprise, Companhia Portuguesa de Radium (CPR) extracted and processed ores from Urgeiriça and several other mines in the Beira Alta region of central Portugal. CPR also carried out radiometric surveys, detailed geological mapping, trenching and extensive core drilling with gamma ray logging. All targets were located in Beiras granitic formations of Hercynian age.

In 1954, the Portuguese government created the *Junta de Energia Nuclear* (JEN) under the supervision of the Prime Minister and started, in 1955, an extensive and systematic exploration programme of the territory based on geological mapping, car borne and ground radiometric surveys, geophysics (resistivity), trenching and core and percussion drilling. This programme successfully increased the resource inventory. Metasediments surrounding granitic formations proved to be a good target for hosting uranium mineralisation of economic interest. By the end of the exploration programme in 1959, JEN had discovered about 100 deposits of medium and small size in Hercynian granitic and perigranitic formations in Beiras and Alto Alentejo. The Beiras deposits together with the Urgeiriça ore mill treatment plant were managed as an integrated uranium production centre. The Alto Alentejo deposits, which include the larger national orebody (Nisa, with roughly 3 500 tU) were considered sufficient to support another production centre but remain untouched. The last attempt to start production in this area was abandoned in 1999 after a positive environmental assessment but a negative economic appraisal.

Since 1976 until the mid-1990s, exploration in crystalline regions continued, successfully identifying sufficient resources to replace those depleted by mining. Exploration in sedimentary formations from 1971 to 1982 (geological mapping, geochemistry, emanometry and drilling surveys in the western Meso-Cenozoic fringe of the Lusitanian Basin) did not result in the identification of resources of economic interest.

Recent and ongoing uranium exploration and mine development activities

No activity at home or abroad.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As reported in the 2007 edition of the Red Book, Portugal hosts an estimated 4 500 tU of RAR recoverable at costs of <USD 80/kgU and 6 000 tU RAR recoverable at costs of <USD 130/kgU. Additionally, 1 000 tU are reported at IR recoverable at costs <USD 130/kgU. Processing plus mining losses of ~25% have been applied in all resources estimate categories.

Undiscovered conventional resources (prognosticated and speculative resources)

As reported in the 2007 edition of the Red Book, undiscovered conventional resources are estimated to include 1 500 tU of prognosticated resources. Speculative resources recoverable at costs <USD 130/kgU are not reported, because only one out-dated appraisal is available.

Uranium production

Historical review

In 1950-1951, a uranium mill facility processing 50 000 t/yr was built at Urgeiriça, and underground extraction continued until 1973, followed by in-place leaching (IPL) between 1970 until 1991. The mine reached a depth of 500 m with a 1 600 m extension.

Between 1951 and 1962, CPR produced a total of 1 123 tU from 22 concessions, of which 1 058 tU were milled at the Urgeiriça plant and 65 tU at other mines by heap leaching. A low-grade concentrate was obtained by precipitation using magnesium oxide. During the period 1962 to 1977, the JEN took over the mining and milling activities from CPR, introducing organic solvent extraction in 1967 and expanding ore treatment capacity to 100 000 t/yr to produce a rich ammonium uranate concentrate. In July 1985, a new capacity expansion to 200 000 t/yr was implemented. A total of 825 tU were produced under JEN management from the Urgeiriça plant and the pilot plant at Senhora das Fontes. Between 1977 and 2001, ENU produced 1 772 tU. Of the total historical concentrate production, 25% came from Urgeiriça mine.

The Urgeiriça mill stopped conventional ore processing in 1999 and was decommissioned in March 2001. In this interim period only exchange ion resins charged in heap and in place leaching plants located in Bica e Quinta do Bispo mines were processed in the Urgeiriça plant and yellow cake produced thereafter. Globally, 57 orebodies have been mined, 29 by underground methods, 24 by open-pit and 4 by mixed underground open-pit methods. In 18 of these mines local ore treatment was used, but only at Urgeiriça uranium concentrates were produced at industrial scale. Two pilot treatment plants (Forte Velho and Srª das Fontes) produced limited amounts of concentrates (sodium uranate).

Ownership of Urgeiriça mill plant evolved over its operational history and after CPR concluded the agreement with the Portuguese government in 1962, JEN took over until 1977 when a publicly owned enterprise, Empresa Nacional de Urânio SA (ENU), acquired exclusive rights to uranium concentrate production and sales. In 1978, JEN exploration teams joined the Direcção-Geral de Geologia e Minas (DGGM). In 1992, ENU was integrated into the Portuguese state mining holding, Empresa de Desenvolvimento Mineiro (EDM). In March 2001, EDM decided to liquidate ENU by the end 2004.

Status of production facilities, production capability, recent and ongoing activities and other issues

Former production centres have been demolished and reclaimed. No future production centres are planned.

Environmental activities and social cultural issues

Site rehabilitation

During 2011 and 2012, the only uranium activities in Portugal were related to the rehabilitation and monitoring of deactivated mine sites.

In Portugal, EDM, the state-owned company responsible for dealing with mining legacy in general, has carried out remediation work on several sites. The work developed on former uranium and radium mine sites has required expenditures amounting to a total of more than EUR 12.2 million.

Mine site	Expenditure x 1 000 (EUR)		
	2011	2012	Total
Senhora das Fontes (conclusion)	336	0	336
Environmental monitoring and mine effluent treatment	163	290	453
Cunha Baixa	510	3 192	3 702
Bica	1 157	1 886	3 043
Urgeiriça – old industrial area and new tailing ponds	1 593	1 415	3 008
Barrôco I	68	491	559
Freixiosa	284	288	572
Rosmaneira	21	542	563
Total	**4 132**	**8 104**	**12 236**

In this respect, the most important works performed have been the beginning of rehabilitation of the industrial area of the Urgeiriça mine site and its more recent tailing ponds, as well as the remediation of Bica and Cunha Baixa. Rosmaneira, a smaller mine site related to radium exploitation in the first quarter of 20th century, has also been remediated. Field work for remediation was also developed at Barroco open-pit and Freixiosa underground and open-pit mine sites.

Monitoring of the radioactive impact has continued for the main sites and EURATOM has inspected the ongoing activity and checked the quality of work done on-site.

Uranium requirements

Portugal has no uranium requirements.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Energy policy in the government programme follows the same main lines as previously and a new energy strategy (Energia 2020) reaffirms the importance of renewable energy (mainly wind and hydropower) and energy efficiency as a means of reducing the external energy dependence, its impact on the trade balance and meeting commitments made with respect to the Kyoto Protocol agreement. Once again nuclear energy is not considered in the energy mix until 2020.

Uranium stocks

No change of stocks since the 2009 edition of the Red Book.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Vein	0	4 500	6 000	6 000	
Total	**0**	**4 500**	**6 000**	**6 000**	

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	500	500	80
Open-pit mining (OP)	0	4 500	5 500	5 500	75
Total	**0**	**4 500**	**6 000**	**6 000**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	500	500	80
Conventional from OP	0	4 500	5 500	5 500	75
Total	**0**	**4 500**	**6 000**	**6 000**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit Type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Vein	0	0	1 000	1 000	75
Total	**0**	**0**	**1 000**	**1 000**	

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	0	0	1 000	1 000	75
Total	**0**	**0**	**1 000**	**1 000**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP	0	1 000	1 000	1 000	75
Total	**0**	**1 000**	**1 000**	**1 000**	

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
1 000	1 500	1 500

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
NA	NA	NA

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit Type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Vein	3 720	0	0	0	0	0
Total	**3 720**	**0**	**0**	**0**	**0**	**0**

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	1 810	0	0	0	0	0
Underground mining*	1 326	0	0	0	0	0
In situ leaching	584	0	0	0	0	0
Total	**3 720**	**0**	**0**	**0**	**0**	**0**

* Pre-2008 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrate)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	3 136	0	0	0	0	0
In-place leaching*	250	0	0	0	0	0
Heap leaching**	321	0	0	0	0	0
Other methods***	13	0	0	0	0	0
Total	**3 720**	**0**	**0**	**0**	**0**	**0**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	168	0	0	0	168
Total	**168**	**0**	**0**	**0**	**168**

Russian Federation

Uranium exploration and mine development

Historical review

Since the beginning of uranium exploration in 1944, more than 100 uranium deposits have been discovered within 14 districts in the Russian Federation. The most significant deposits are located within four uranium-bearing districts:

- the Streltsovsk district, which includes 19 volcanic caldera-related deposits where the mining of some deposits is ongoing;
- the Trans-Ural and Vitim districts, where basal-channel sandstone-type deposits are being developed for uranium production by *in situ* leach mining;
- the Elkon district that contains large deposits of metasomatite-type that are planned to be mined.

Recent and ongoing uranium exploration activities

There are two types of uranium exploration activities in the Russian Federation, one involves prospecting aimed at new deposit discovery and the second involves exploration at earlier discovered deposits with a view to developing resource estimates and deposit delineation.

Uranium prospecting in the Russian Federation is financed from the state budget by the Federal Agency for Subsoil Use (Rosnedra). In 2011, the budget amounted up to RUB 0.7 billion (Russian rubles) and in 2012 it increased to RUB 0.9 billion. The Republic of Buryatia and the Trans-Baikal region were the main areas of exploration activity. The focus of these activities was the expansion of the resource base near the existing production centres (Khiagda and Priargunsky) and exploration for large deposits suitable for either conventional or ISL mining in new areas.

As a result of uranium prospecting activities in 2011, inferred resources were increased by 4 400 tU, prognosticated uranium resources by 8 200 tU and speculative resources by 54 100 tU. In 2012, prognosticated resources were further increased by 15 000 tU and speculative resources by an additional 31 500 tU. Although there were some additions to the total prognosticated resources, there has been an overall decrease since the 2011 Red Book due to re-evaluation of some previously reported amounts.

Preliminary exploration completed at the Balkovskoe deposit (Republic of Kalmykia) resulted in an estimated 5 000 tU prognosticated resources and 10 000 tU speculative resources. Hydrogeological and technological tests at these sites have established parameters favourable for ISL mining.

Preliminary exploration at the Dulesminskoe occurrence in the Vitimsky area (Republic of Buryatia) resulted in an estimated 8 500 tU prognosticated resources and 6 000 tU speculative resources. Prognosticated resources at the Krasnoye occurrence are estimated as 5 500 tU and speculative resources as 2 000 tU. The Dzhilindinskoye deposit has inferred resources of 1 700 tU, prognosticated resources of 3 100 tU and speculative resources of 10 000 tU. In addition, a number of prospects were identified in the Amalat area with total estimated prognosticated resources of 15 000 tU and speculative resources of 46 000 tU.

As a result of exploration at the Sirotinka occurrence (Transbaikal region), inferred resources have been estimated as 4 000 tU. In the Irkutsk region (Akitkan area), prognosticated resources have been estimated as 3 100 tU and speculative resources as 13 500 tU.

Subsidiaries of uranium holding company "Atomredmetzoloto" (ARMZ) performed exploration and resource estimation of uranium deposits which are being prepared for development.

The main exploration and resource estimation activities were completed in 2011-2012 in the Elkonsky area (the South Yakutia and Khiagda ore field) in the Vitim area of the Republic of Buryatia. In 2012, uranium resource estimation of deposits in the Elkonsky area (South Yakutia) was completed based on 2008-2011 exploration results. The resource feasibility study for the deposits in the Khiagda ore field was also completed in 2012.

Additionally, exploration was carried out at the Dalmatovskoye deposit (Kurgan region) and the Berezovoe deposit in the Transbaikal region.

In 2011, ARMZ's uranium exploration budget was RUB 1.3 billion and *in situ* resources were increased by 6 055 tU. In 2012, ARMZ's investments were RUB 0.8 billion and *in situ* resources owned by ARMZ mines were increased by 40 900 tU. The resources were approved by the Russian State Resource Committee. Most exploration and drilling was performed through ARMZ's drill company Rusburmash.

Exploration abroad

In 2011-2012, ARMZ, through its subsidiary Canadian company Uranium One, performed exploration in Kazakhstan at all joint ventures with Kazatomprom (Akbastau, Karatau, Betpakdala, Zarechnoye and Kyzylkym). The main goals were to transfer resources to higher-level categories, prepare deposits for development and ensure that planned production programmes are adequately supported by the resource base.

Australian public company Mantra Resources which owns the Mkuju River Uranium Project in Tanzania was acquired in 2011 by ARMZ. In 2011-2012, Mantra Resources continued exploration drilling focused on new mineralised zones and resources estimation. Mantra Resources completed the Mkuju River feasibility study and since 2012 has invested in detailed engineering for mine development.

There were also minor investments in exploration of prospective areas in Armenia made by the Armenian-Russian Mining Co.

Recent mine development activities

Mine development activities included pilot operations at mines under construction and project development for planned mines. In 2012, an ISL pilot test was completed at the Khokhlovskoe deposit (110 km from Dalur's main complex in the Kurgan region). Project development activities were performed on deposits in the Elkon and Trans-Baikal districts. The Elkon company proceeded with pre-feasibility studies and research activities in the Elkon district of the Republic of Sakha Yakutia and the Gornoe company completed exploration, engineering and hydrogeological studies but subsequently put the project on hold due to unfavourable market conditions. Another project, the Olovskaya mine was also put on hold due to the same reasons.

Uranium resources

Identified resources (reasonably assured and inferred resources)

In 2011-2012, a comprehensive technical and economic re-evaluation of known uranium resources was undertaken. As of 1 January 2011, total recoverable uranium resources in the Russian Federation attributable to category RAR and inferred amounted to 689 200 tU, an increase of 38 900 tU (6%) compared to 1 January 2011. This increase was mainly achieved by exploration of uranium metasomatic deposits in the Elkon area in the Republic of Sakha (Yakutia). Recoverable RAR increased by 20% and amounted to 261 900 tU, 83% of which are recoverable at a cost of <USD 130/kg and only 5% are recoverable at a cost of <USD 80/kg. Of the known RAR, 69% may be mined by the conventional underground mining method. Inferred uranium resources amounted to 427 300 tU, of which about 7% are recoverable at a cost of <USD 80/kg. About 63% of the inferred resources may be mined by the conventional underground mining method. All resources which are recoverable at a cost of <USD 80/kg are planned to be mined by the ISL method. Resources of two uranium and rare metals deposits, where uranium occurs as a by-product, have been reclassified as intrusive-type deposits.

Undiscovered conventional resources (prognosticated and speculative resources)

As of 1 January 2013, Russian prognosticated uranium resources amounted to 112 000 tU and speculative resources to 452 000 tU. In the Russian system of classification "prognosticated" corresponds to P1 and "speculative" to P2. The majority of the prognosticated resources are located in the Trans-Baikal Territory (the Streltsovsk and East Trans-Baikal uranium districts), the Republic of Buryatia (Vitim district), the Republic of Sakha-Yakutia (Elkon district) and the Republic of Kalmykia.

Uranium production

Historical review

The first Russian uranium mine was the Lermontov Complex, presently referred to as the Lermontov State Enterprise "Almaz". Almaz is located 1.5 km from the town of Lermontov in the Stavropol region (district). The Beshtau and Byk vein-type deposits were mined, both of which are currently depleted. Their original resources totalled 5 300 tU (at an average grade of 0.1% U) and were extracted by two underground mines starting in 1950. Mine 1 (Beshtau) was closed in 1975 and mine 2 (Byk) in 1990. The ore was processed at the local processing plant using sulphuric acid leaching. From 1965 to 1989, stope (block) and heap leaching were also used. From the 1980s until 1991, uranium ore transported from Ukraine and Kazakhstan was also processed at Almaz. Production from local deposits totalled 5 685 tU, with 3 930 tU extracted by underground mining and 1 755 tU by a combination of the different leaching technologies.

Between 1968 and 1980, 440 tU were produced by open-pit mining from the small Sanarskoye deposit in the Transural district. The Malyshevsk Mining Enterprise was the operator of this project.

The joint Stock Company "Priargunsky Mining-Chemical Production Association" (Priargunsky) has been the largest uranium production centre in the Russian Federation over the last decades. The Priargunsky production centre is located in the Chita region, 10-20 km from the town of Krasnokamensk (population of about 60 000). The production is based on 19 volcanic deposits of the Streltsovsk uranium district, which has an overall average grade of about 0.16% U. Mining has been conducted since 1968 by two open-pits (both now depleted) and five underground mines. Underground mines 1, 2 and Gluboky are active for more than 40 years and mine 6 started operating in 2012. Milling and processing has been carried out since 1974 at the local hydrometallurgical plant using sulphuric acid leaching with subsequent recovery by ion exchange extraction. Since the 1990s, low-grade ore has been processed by heap and stope/block leaching. To date, about 140 000 tU has been produced at the Priargunsky mining complex, making it the largest uranium production centre in the world. Cumulative production through 2012 in the Russian Federation totalled 153 000 tU.

Status of production capability

Uranium production in the Russian Federation is carried out by three mining centres owned by ARMZ Uranium Holding Co. (Atomredmetzoloto). In 2012, uranium production amounted to 2 862 tU, of which 2 001 tU were produced using the conventional underground mining method (including 1 763 tU produced at the hydrometallurgical processing plant from primary ore and 238 tU from the ore processed by heap leaching) and 861 tU using the ISL method.

The Priargunsky Mining and Chemical Works (Trans-Baikal Territory) remains the key uranium production centre in the Russian Federation. The resource base is represented by the volcanic-type uranium deposits of the Streltsovsk district with current *in situ* resources of about 111 000 tU (as of 1 January 2013).

In 2012, Priargunsky produced 2 001 tU. Uranium ore is mined from four underground mines (No. 1, No. 2, No. 8 and Gluboky) and processed at the local hydrometallurgical plant and a heap leaching site. In recent years production has been decreasing due to lower-ore grade being mined.

Measures were completed to stabilise production at Priargunsky, including the construction of two new mines (No. 6 and No. 8). Mine No. 8 was designed for development of the Malo-Tulukuevskoe deposit with uranium reserves of 12 536 tU. Mine No. 6 will process Argunskoe and Zherlovoye deposits with cumulative reserves of 40 456 tU. In 2012, the first stage of mine No. 8 (capacity – 100 000 tonnes of ore per year) was put into operation. Technical modernisation activities were also completed. In 2011-2012, exploration was conducted on the flanks and in deep horizons of the Streltsovsky ore field and exploration for new deposits in the adjacent areas of the South Priargun region was started.

Dalur (Kurgan region) has been developing the Dalmatovskoye deposit using sulphuric acid ISL mining method. In 2012, the first phase of exploration and pilot testing was completed for the Khokhlovskoye deposit. Recoverable resources of these two deposits is estimated at around 11 000 tU. In 2012, Dalur produced 529 tU. In 2011-2012, exploration at the Ust-Uksyanskoye deposit (western and central sectors of Dalmatovskoe deposit) was carried out and automation of main technical processes was completed.

Khiagda has been developing the Khiagdinskoye deposit for ISL mining. The recoverable resource base is estimated to amount to 32 000 tU. In 2012 production was 332 tU, an increase of 25% compared to 2011. According to the results of exploration, the State Reserves Committee approved the resources of the Khiagdinskoye deposit. In 2011-2012, the Khiagda company continued infrastructure development. The first stage of the mining camp was launched with the construction of the processing plant building and installation of the main process equipment was completed.

Employment in the uranium industry

In 2012, employment in the Russian uranium industry totalled 9 526, of which 8 753 worked for Priargunsky, 437 for Dalur and 336 for Khiagda. Of the Priargunsky employees, 5 037 were directly involved in uranium production and processing, while the remainder worked in auxiliary and service companies (coal production, power plant).

Future production centres

In 2011-2012, two uranium mining companies (Elkon and Gornoe) continued exploration, design studies and research work to prepare deposits in South Yakutia and the Trans-Baikal regions for development.

Elkon continued pre-feasibility and research studies towards construction of a large uranium production centre with an annual production capacity of up to 5 000 tU with by-product extraction of gold, silver, molybdenum and vanadium. Elkon *in situ* resources total 357 000 tU, a new resource estimate based on the results of exploration. Research and tests focused on capital cost optimisation and modern high-tech production. Development of processing methods is ongoing.

Gornoe was established to develop the Gornoe and Berezovoe deposits (with *in situ* resources of about 5 000 tU) in the Krasnochikoy district of the Trans-Baikal region. The deposits are planned to be mined using a conventional method combined with block and heap leaching for ore processing with an annual production capacity expected to be 300 tU. In 2011-2012, exploration, geotechnical and hydrogeological studies were completed. The project is currently on hold due to unfavourable market conditions.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Priargunsky Mining Combine (Priargunsky)	Dalur	Khiagda	Elkon Mining and Metallurgical Complex (Elkon)	Gornoe Uranium Mining Company (Gornoe)
Production centre classification	Existing	Existing	Existing	Prospective	Prospective
Date of first production	1968	2004	2010	2025	NA
Source of ore:					
Deposit name(s)	Antei, Streltsovskoe, Oktyabrskoe, etc.	Dalmatovskoe Khokhlovskoe, etc	Khiagda, Vershinnoe, etc	Yuzhnoe, Severnoe	Gornoe, Berezovoe
Deposit type(s)	Volcanic	Sandstone basal channel	Sandstone basal channel	Metasomatic	Vein
Recoverable resources (tU)	98 000	11 000	32 000	303 600	3 200
Grade (% U)	0.16	0.04	0.05	0.15	0.20
Mining operation:					
Type (OP/UG/ISL)	UG, HL	ISL	ISL	UG	UG, HL, IPL
Size (tonnes ore/day)	6 700	NA	NA	5 500	1 900
Average mining recovery (%)	95	75	75	85	70
Processing plant:					
Acid/alkaline	Acid	Acid	Acid	Acid	Acid
Type (IX/SX)	IX	IX	IX	IX	IX
Size (tonnes ore/day)	4 700	No data	No data	No data	No data
Average process recovery (%)	95	98	98	95	95
Nominal production capacity (tU/year)	3 000	800	1 000	5 000	300
Plans for expansion	Yes	Yes	Yes	No	No
Other remarks					

Secondary supply

Fabrication and/or use of mixed oxide fuel

Because of the exhaustion of resources with low production costs, the fuel supply for large-scale nuclear power, from a long-term perspective, requires consideration of fast breeder reactors.

To fulfil this task, in 2013-2014 the first BN-800 reactor at the Beloyarsk NPP will be launched. It will use a hybrid core consisting of fuel assemblies with uranium fuel and MOX fuel. Full transfer of the reactor core to MOX fuel will be accomplished by 2018.

Reprocessed uranium (RepU)

The Russian Federation has the capability to use reprocessed uranium (RepU) in the fuel cycles of thermal reactors. The reprocessed uranium is used as a secondary source for fabrication of nuclear fuel for Russian nuclear power plants. The Russian Federation also provides services for producing nuclear fuel from RepU for foreign customers.

Uranium requirements

As of 1 January 2013, 10 nuclear power plants in the Russian Federation with a total of 33 reactors and a total installed capacity of 25.2 GW were operational, generating 17% of the electricity produced in the country and 30% of the electricity produced in the European part of the Russian Federation in 2012. In 2011 and 2012, nuclear power plants generated 173 TWh and 177.3 TWh of electricity, respectively. Today the annual demand of Russian nuclear power plants in natural uranium equivalent is about 4 000 tonnes.

In connection with the revision of plans for nuclear power unit commissioning and the rates of their construction, two scenarios are being considered for developing the nuclear capacities and, consequently, the uranium raw material reactor needs in the Russian Federation. According to the low case scenario of nuclear power development, in the period from 2013 through 2020, nine NPP units are expected to be commissioned, each with the installed capacity of 1 000 to 1 200 MW. After 2020 and before 2035, the number of commissioned power units will be one unit per year on average. Under the high case scenario of nuclear power development, between 2013 and 2020, ten NPP units are expected be commissioned, each with the installed capacity of 1 000 to 1 200 MW. After 2020 and before 2035, the expected annual number of commissioned power units will be at a rate of two units per year. Uranium fuel requirements are being supplied with the uranium produced in the Russian Federation and Kazakhstan, uranium stockpiles and secondary sources.

Uranium exploration and development expenditures – non-domestic

(USD millions)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	5.9	6.4	8.8	4.3
Government exploration expenditures	0	0	0	0
Industry* development expenditures	20.4	24.7	21.3	12.2
Government development expenditures	0	0	0	0
Total expenditures	**26.3**	**31.1**	**30.1**	**16.5**

* Non-government.

Uranium exploration and development expenditures and drilling effort – domestic

(RUB billions [Russian rubles])

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	1.7	1.3	0.8	0.3
Government exploration expenditures	0.7	0.7	0.9	1.0
Industry* development expenditures	1.2	0.8	0.4	0.4
Government development expenditures	0	0	0	0
Total expenditures	3.6	2.8	2.1	1.7
Industry* exploration drilling (m)	114 200	122 810	56 750	46 450
Industry* exploration holes drilled	380	400	225	110
Government exploration drilling (m)	79 000	75 200	64 000	105 500
Government exploration holes drilled	440	430	380	520
Industry* development drilling (m)	NA	NA	NA	NA
Industry* development holes drilled	NA	NA	NA	NA
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	193 200	198 010	120 750	151 950
Subtotal exploration holes drilled	820	830	605	630
Subtotal development drilling (m)	NA	NA	NA	NA
Subtotal development holes drilled	NA	NA	NA	NA
Total drilling (m)	**193 200**	**198 010**	**120 750**	**151 950**
Total number of holes drilled	**820**	**830**	**605**	**630**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Sandstone	0	11 800	11 800	11 800
Granite-related	0	0	1 600	1 600
Intrusive	0	0	0	45 400
Volcanic-related	0	0	90 200	90 200
Metasomatite	0	0	104 100	104 100
Phospate	0	0	8 800	8 800
Total	**0**	**11 800**	**216 500**	**261 900**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	180 000	180 000	85-90
In situ leaching acid	0	11 800	11 800	11 800	75
Co-product and by-product	0	0	0	45 400	65
Unspecified	0	0	24 700	24 700	75
Total	**0**	**11 800**	**216 500**	**261 900**	**80**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	166 000	166 000	85
In situ leaching acid	0	11 800	11 800	11 800	75
In-place leaching*	0	0	500	500	70
Heap leaching** from UG	0	0	13 500	13 500	70
Unspecified	0	0	24 700	70 100	75
Total	**0**	**11 800**	**216 500**	**261 900**	**80**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	30 500	30 500	89 400
Granite-related	0	0	2 700	5 700
Intrusive	0	0	0	34 400
Volcanic-related	0	0	31 800	51 900
Metasomatite	0	0	221 600	240 400
Phosphate	0	0	2 800	5 500
Total	**0**	**30 500**	**289 400**	**427 300**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	234 100	268 400	85-90
Open-pit mining (OP)	0	0	300	300	70
In situ leaching acid	0	30 500	30 500	46 400	75
Co-product and by-product	0	0	0	34 400	65
Unspecified	0	0	24 500	77 800	75
Total	**0**	**30 500**	**289 400**	**427 300**	**80**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	227 600	259 300	85
In situ leaching acid	0	30 500	30 500	46 300	75
In-place leaching*	0	0	2 100	2 100	70
Heap leaching** from UG	0	0	4 400	7 100	70
Heap leaching** from OP	0	0	300	300	70
Unspecified	0	0	24 500	112 200	75
Total	**0**	**30 500**	**289 400**	**427 300**	**80**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	112 000	112 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
NA	NA	452 000

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	5 665	643	802	861	7 971	1 000
Volcanic caldera-related	137 635	2 920	2 191	2 001	144 747	2 133
Total	**143 300**	**3 563**	**2 993**	**2 862**	**152 718**	**3 133**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	38 655	0	0	0	38 655	0
Underground mining	98 980	2 920	2 191	2 001	106 092	2 133
In situ leaching	5 665	643	802	861	7 971	1 000
Total	**143 300**	**3 563**	**2 993**	**2 862**	**152 718**	**3 133**

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	135 060	2 660	2 002	1 763	141 485	1 940
In-place leaching*	241	0	0	0	241	0
Heap leaching**	2 334	260	189	238	3 021	193
In situ leaching	5 665	643	802	861	7 971	1 000
Total	**143 300**	**3 563**	**2 993**	**2 862**	**152 718**	**3 133**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
2 862	100	0	0	0	0	0	0	2 862	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	8 989	9 028	9 526	10 335
Employment directly related to uranium production	5 669	5 687	5 810	6 125

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 000	1 000	3 133	3 133	1 330	1 390	3 920	3 970	1 600	1 650	4 140	4 180

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 600	1 600	5 520	7 250	1 600	1 600	5 180	10 830	1 600	1 600	4 900	9 900

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	173.0	177.3

Installed nuclear generating capacity to 2035

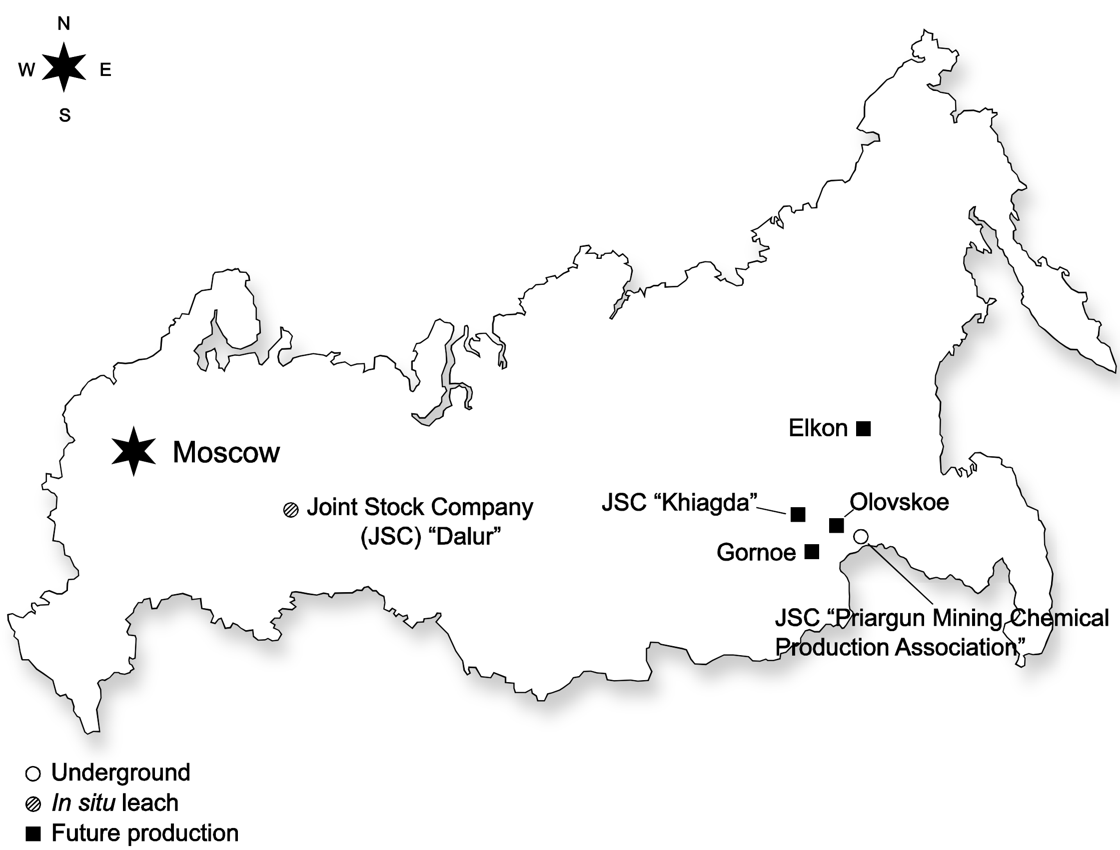
(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
24 200	24 600	24 200	24 200	23 300	23 300	23 500	26 500	27 100	34 800	28 200	38 600	30 000	40 300

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
3 800	3 800	3 800	3 800	3 700	3 700	3 700	4 200	4 300	5 500	4 450	6 150	4 800	6 400



Slovak Republic

Uranium exploration and mine development

Historical review

Beginning in 1947, uranium exploration (surface radiometric prospecting) has been performed in different areas of the Slovak Republic. Surface and airborne radiometric techniques, along with prospecting, borehole logging, geoelectric and geomagnetic prospecting and hydrogeochemistry were used to determine six regions of uranium mineralisation. Based on the results of this early work it was concluded that the Slovak Republic had only small uranium resources of economic interest. Between 1985 and 1990, state exploration activities in the eastern part of the Slovak Ore Mountains led to the estimation of resources of economic interest at the Košice deposit. Uranium mining was terminated in 1989-1990 as an attenuation programme for exploration and mining was instituted between 1990 and 2003, bringing state funded exploration activities to an end. No uranium exploration occurred between 1990 and 2005.

Recent and ongoing uranium exploration and mine development activities

At present, ten exploration licences for uranium are active in the Slovak Republic. Exploration companies involved include: Ludovika Energy Ltd (related to European Uranium Resources), performing exploration in six areas; Beckov Minerals Ltd (related to Ultra Uranium, Canada), performing exploration on two areas in western Slovakia; and Crown Energy Ltd (related to GB Energy, Australia), performing exploration in two prospecting areas in eastern Slovakia.

Tournigan Gold Corporation, a private Canadian company, changed its name to European Uranium Resources Ltd on 1 March 2012 and formed a strategic alliance with AREVA, the French nuclear energy and uranium mining conglomerate. Ludovika Energy Ltd (a subsidiary of European Uranium Resources) is continuing exploration in six prospecting areas in eastern areas of the Slovak Republic. The most prospective exploration licence covers uranium mineralisation in Kuriskova, near Košice. During 2011 and 2012, 16 additional exploration holes were drilled (totalling 5 179 m). On 30 January 2012, European Uranium Resources announced the results of a preliminary feasibility study (PFS) prepared by Tetra Tech, Inc. of Golden, Colorado. Highlights of the PFS include an initial rate of return of 30.8%, a 1.9-year payback, a net present value of USD 277 million at an 8% discount rate (pre-tax, base case assuming prices of USD 68/lb U_3O_8 and USD 15/lb Mo). Indicated resources total 28.5 million pounds of U_3O_8 (10 960 tU) and inferred resources amount to 12.7 million pounds of U_3O_8 (4 885 tU), using a cut-off of 0.05% U. Life of mine operating costs are USD 22.98/lb U_3O_8 (USD 59.75/kgU), assuming a net molybdenum credit of about USD 1.27 per pound of U_3O_8 (USD 3.30/kgU). The project can be developed as an underground mine and a processing facility that would utilise conventional alkaline (non-acid) processing (www.euresources.com).

Crown Energy Ltd (a subsidiary of GB Energy) drilled five exploration holes (totalling 204 m) in 2011. During 2012, GB Energy completed exploration programmes over the Kluknava and Vitaz-II exploration areas. In June 2012, following an extensive review of archival material, Crown Energy Ltd uncovered data from a 1960s drilling programme in the vicinity of the Kluknava and Vitaz-II licence areas. Given the potential for data that was generated from this activity to provide new information, GB Energy deferred new exploration works until the data could be fully analysed. Detailed study and results of interpretation of the 1960s programme is expected to be published in early 2014 (www.gbenergy.com.au).

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

In 2012, a pre-feasibility study was finalised and a new reserves calculation report for Košice I (Kuriskova area) was approved by the Commission for Reserves Classification (Ministry of Environment of the Slovak Republic). This revised total increased Košice I resources by over 9 000 tU from the total reported in 2011. At present, total indicated and inferred uranium resources in these two registered uranium deposits total 19 319 tU.

Deposit	Organisation	Ore resources (t)	U content (t)
Košice I	Ludovika Energy Ltd	5 427 000	15 830
Novoveská Huta	Ludovika Energy Ltd	3 876 000	3 488

Undiscovered conventional resources (prognosticated and speculative resources)

Prognosticated resources are estimated to occur in areas surrounding identified deposits and a new estimate of prognosticated resources for the Košice deposit has been developed.

Deposit	Estimated grade	Ore resources (t)	Contained tU
Košice I	0.2% U	1 845 432	3 691
Novoveská Huta	0.06% U	12 040 000	7 224

Uranium production

Historical review

During the first period of uranium exploration (1954-1957) a small amount (1.4 tU) was mined in the Novoveská Huta – Hnilcik region. From 1961 to 1990, a total of 210 tU was mined, mainly from Novoveská Huta as a by-product of copper mining, but also from the Muran, Kravany, Svabovce and Vikartovce deposits.

Environmental activities and socio-cultural issues

Environmental activities cover monitoring activities in the historical mining area of the Novoveská Huta deposit. Monitoring includes chemical analyses of mine water outflow as well as geochemical and geological engineering evaluations of the condition of tailings and waste rock piles.

Partial monitoring of such factors is part of a national environmental monitoring network that is focused on natural or anthropogenic geological hazards (as indicated by the acronym ČMS GF). Selected mining sites are monitored, including the above mentioned area.

Waste rock management must be performed according to Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC. In the Slovak Republic, related legislation is NR SR (National Council of the Slovak Republic) Act No. 514/2008 Col.

on the management of waste from extractive industries and the Decree of the MŽP SR (Ministry of the Environment of the Slovak Republic) No. 255/2010 Col., which executes the act on the management of waste from extractive industries.

Several studies and environmental evaluations of radioactive materials and the impacts of mining in this locality were conducted in the past:

- Bezák, J. and A. Donát (1996), Mine Waste Piles and Settling Pits – Evaluation of Natural Radioactivity of Selected Deposit Sites (*Haldy a odkaliská – zhodnotenie prirodzenej rádioaktivity vybraných ložísk nerastných surovín*). Ministry of the Environment of the Slovak Republic, Uranpres JSC.
- Daniel, J., E. Mašlár and I. Mašlárová (2001), Effectiveness of Remediation of Uranium Activities on Slovakian Territory (*Účinnosť revitalizácie po uránovej činnosti na území Slovenska*), Ministry of the Environment of the Slovak Republic, Uranpres JSC.
- Daniel, J., et al. (2005), Evaluation on Geological Works for U Ores in Selected Regions of the Western Carpathians in the Territory of Slovakia (*Zhodnotenie geologických prác na U rudy vo vybraných oblastiach Západných Karpát na území Slovenska*). Final report, Ministry of the Environment of the Slovak Republic, Uranpres JSC.
- Letkovičová, M. and Božíková, K. 2008: *Dlhodobá demograficko - epidemiologická štúdia obyvateľstva Spišskej Novej Vsi, Environment, a.s., Centrum bioštatistiky a environmentalistiky, Nitra* (Long-term demographic-epidemiologic population study; in Slovak language only).
- Thorne M. C., et al. (2000), Remediation of Uranium Liabilities in Slovakia. Final Report (AEA Technology, UK).

Uranium requirements*

The Slovak Republic has two nuclear power plants (Bohunice and Mochovce) with a total of four pressurised water reactors, type VVER-440. Two reactors are in operation at each site and all four reactors operate continually at increased power (107% of the nominal power). As of 31 December 2013, the total installed capacity amounted to 1 816 MWe.

An additional two reactors are currently under construction at the Mochovce site (units 3 and 4) and based on the updated schedule they are expected to be completed in 2014 and 2015, respectively.

In 2012, design and development work for the use of nuclear fuel with higher enrichment in units 3 and 4 of the Bohunice NPP was successfully completed and fresh nuclear fuel with an average enrichment of 4.87% ^{235}U was loaded into both reactors. Units 1 and 2 of the Mochovce NPP have used this type of fuel since 2011.

Supply and procurement strategy

Slovenské Elektrárne purchases complete fuel assemblies for all operating units from the Russian manufacturer. Therefore there is no special contract for uranium, conversion or enrichment services.

* Data provided by Slovenské Elektrárne, a.s.; ENEL Group.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Energy Policy of the Slovak Republic (Resolution of the Government of the Slovak Republic No. 29/2006)

One of the priorities set to facilitate meeting objectives of the energy policy is to utilise domestic primary energy sources for electricity and heat production in an economically effective basis.

Energy Security Strategy of the Slovak Republic (Resolution of the Government of the Slovak Republic No. 732/2008)

The objective of the energy security strategy is to achieve a competitive, secure, reliable and efficient supply of all forms of energy at reasonable costs that protect the consumer and the environment and promote sustainable development, security of supply and technical safety.

The high share of nuclear energy in the energy mix of the Slovak Republic relies on dependable sources of sufficient numbers of fuel elements, which are only at this time offered in Europe by the Russian Federation and France. It is considered that in the future, these fuel element producers could require from customers a counter-value in the form of uranium as a certain form of payment.

Legislative and economic support for the efficient and rational use of domestic uranium resources is needed to considerably reduce dependency on imported energy sources, whose market prices have risen sharply in past years. Increased uranium prices and thus nuclear fuel costs can privilege those states which will be able to supply their own uranium and require its further processing to produce nuclear fuel.

If the anticipated situation occurs, it will be necessary to create the appropriate legislative conditions for the extraction of uranium by amending relevant laws and strategic documents, including the Raw Materials Policy, since domestic deposits of uranium ore are located near Košice and Spisska Nova Ves – Novoveská Huta. The possibility of extracting uranium in the Slovak Republic is also to be assessed from the perspective of maximum environmental protection. Mining projects must be harmonised with the development of documentation by concerned municipalities and regional governments in conformity with the applicable legislation.

In order to meet targets of the Energy Security Strategy, it is necessary to assess the feasibility of the extraction of uranium in the Slovak Republic. It is important to rationally and effectively support the use of domestic energy sources with the aim of decreasing dependency on imports.

European Uranium signs Memorandum of Understanding with Slovak Ministry of Economy

In December 2012, European Uranium Resources Ltd (EUU) reported that it had signed a Memorandum of Understanding with the Ministry of Economy of the Slovak Republic. The memorandum defines the parameters by which EUU and the ministry will co-operate in advancing the Košice uranium deposit – on which EUU holds the exploration licence – through ongoing feasibility and environmental studies. A PFS completed by Tetra Tech, Inc. indicates that the Košice uranium deposit can be developed as an underground mine using best available technologies with minimal environmental impact and that it could be one of the lowest cost uranium producers in the world.

Uranium stocks

The Slovak Republic does not maintain an inventory of natural or reprocessed uranium but Slovenské Elektrárne maintains a small stock of enriched uranium in the form of complete fuel assemblies.

Uranium exploration and development expenditures and drilling effort – domestic

(EUR million)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	2.9	3.9	2.0	NA
Government exploration expenditures	0	0	0	0
Industry* development expenditures	0	0	0	NA
Government development expenditures	0	0	0	0
Total expenditures	**2.9**	**3.9**	**2.0**	**NA**
Industry* exploration drilling (m)	5 630	4 277	1 106	NA
Industry* exploration holes drilled	25	18	3	NA
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	0	0	0	NA
Industry* development holes drilled	0	0	0	NA
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	5 630	4 277	1 106	NA
Subtotal exploration holes drilled	25	18	3	NA
Subtotal development drilling (m)	0	0	0	NA
Subtotal development holes drilled	0	0	0	NA
Total drilling (m)	**5 630**	**4 277**	**1 106**	**NA**
Total number of holes drilled	**25**	**18**	**3**	**NA**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related		10 950**	10 950**	10 950**
Total		**10 950**	**10 950**	**10 950**

* *In situ* resources.

** Indicated resources (pre-feasibility study).

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)		10 950**	10 950**	10 950**	92***
Total		**10 950**	**10 950**	**10 950**	

* *In situ* resources.

** Indicated resources (pre-feasibility study).

*** Processing recovery.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG		10 950**	10 950**	10 950**	92***
Total		**10 950**	**10 950**	**10 950**	

* *In situ* resources.
** Indicated resources (pre-feasibility study).
*** Processing recovery.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related		4 881**	8 369**	8 369**
Total		**4 881**	**8 369**	**8 369**

* *In situ* resources.
** Inferred resources (pre-feasibility study).

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)		4 881**	8 369**	8 369**	
Total		**4 881**	**8 369**	**8 369**	

* *In situ* resources.
** Inferred resources (pre-feasibility study).

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG		4 881**	8 369**	8 369**	
Total		**4 881**	**8 369**	**8 369**	

* *In situ* resources.
** Inferred resources (pre-feasibility study).

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
	3 691	10 915

Note: Category shift concerning new reserves calculation and estimated ore quality.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Volcanic-related	211	0	0	0	211	0
Total	**211**	**0**	**0**	**0**	**211**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	50**	0	0	0	50**	0
Underground mining*	161**	0	0	0	161**	0
Total	**211**	**0**	**0**	**0**	**211**	**0**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

** Estimate.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	211	0	0	0	211	0
Total	**211**	**0**	**0**	**0**	**211**	**0**

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	14.3	14.4

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
1 816	1 816	1 816	1 816	2 692	2 692	2 692	2 894	2 692	2 894	2 692	2 894	2 692	2 894

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
391	377	362	362	659*	659*	506	553	514	553	514	553	514	553

Note: Data provided by Slovenské Elektrárne, a.s (ENEL Group).

* In annual requirements for 2015, first core loads of unit 4 of the Mochovce NPP are included (≈200 tU).

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	0	NA*	NA	0	NA
Producer	0	0	0	0	0
Utility	0	0	0	0	0
Total	**0**	**NA**	**NA**	**0**	**NA**

Note: Data provided by Slovenské Elektrárne, a.s (ENEL Group).

* In form of complete fuel assemblies.

Slovenia

Uranium exploration and mine development

Historical review

Exploration of the Žirovski Vrh area began in 1961. In 1968, the P-10 tunnel was developed to access the orebody. Mining began at Žirovski Vrh in 1982 and uranium concentrate production (as yellow cake) began in 1985.

Recent and ongoing uranium exploration and mine development activities

Expenditures for exploration ended in 1990. There are no recent or ongoing uranium exploration activities in Slovenia.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

A resource assessment of the Žirovski deposit was carried out in 1994. RAR are estimated to amount to 2 200 tU in ore with an average grade of 0.14% U in the <USD 80/kgU category. Inferred resources total 5 000 tU in the <USD 80/kgU category and 10 000 tU in the <USD 130/kgU category at an average grade of 0.13% U. This deposit occurs in the grey sandstone of the Permian Groeden formation, where the orebodies occur as linear arrays of elongated lenses within folded sandstone.

Undiscovered conventional resources (prognosticated and speculative resources)

Undiscovered resource estimates remain the same as reported earlier.

Uranium production

Historical review

The Žirovski Vrh uranium mine, located 20 km south-west of Škofja Loka, was the only uranium producer in Slovenia. Ore production began in 1982 and the associated ore processing plant (annual production capability of 102 tU) began operations in 1984, initially treating stockpiled ore. The ore (which occurs in numerous small bodies in the mineralised coarse-grained sandstone) was mined selectively using a conventional underground room and pillar, cut-and-fill operation with a haulage tunnel and ventilation shaft. In 1990, operations were terminated. Cumulative production from the Žirovski Vrh mine-mill complex totalled 382 tU (620 000 tonnes ore at an average grade of 0.072% U).

Status of production capability

In 1992, a decision for final closure and subsequent decommissioning of the Žirovski Vrh mine and mill was made and there has been no production at the facility since. All production was reserved for the former Yugoslavia and no export to the Soviet Union took place. In 1994, the plan for decommissioning the facility was accepted by Slovenian government authorities.

Environmental activities and socio-cultural issues

The government-owned Žirovski Vrh Mine Company manages all activities connected with the rehabilitation of the former uranium production site. It obtains all remediation permits required, monitors the environmental impact of the mine effluents (air and water) and maintains the area to prevent damage to the environment. Remediation of the Žirovski Vrh mine and mill site was completed in 2010.

The annual effective dose contribution from all mine objects has been decreased due to remediation activities from between 0.2 and 0.4 mSv/a, compared to 0.5 mSv/a during operation. Background annual effective levels are 5 mSv/a in the area surrounding the mine.

Associated with the facility are 620 000 tonnes of tailings (70 g U/t) and 80 000 tonnes of mine waste over an area of 4.5 ha on the slope of a hill between 530 and 560 m above sea level. The critical factor is the stability of the site. The mine waste pile containing 1 650 000 tonnes of mine waste and mill debris, over an area of 5 ha, is located in a former ravine. The mine effluents are monitored on a regular monthly basis for uranium, radium and other chemical contaminants.

Monitoring

The mine's air and water effluents have been monitored on a regular base since the start of the ore production in 1982. The programme, modified when production stopped in 1990, is ongoing. Emissions to surface waters and air are monitored and doses to the critical group of inhabitants have been calculated since 1980. Treatment of the mine's effluents is not planned due to low concentrations of the radioactive contaminants.

Tailings impoundment

There is one 4.5 ha specially designed long-term tailings site called Borst, with a capacity of 700 000 t. The tailings have been stored in dry condition due to filtration of the leached liquor. Borst was covered with a two-metre-thick, engineered multi-layer soil cover with a clay base to prevent leaching of contaminants. Although the remediation of the site was completed in 2010, it will probably require additional remediation measures due to activation of the landslide beneath the disposal site.

Waste rock management

All waste piles were relocated to the central mine waste pile Jazbec. All other sites have been decontaminated to a green field condition. The 5 ha Jazbec facility contains 1.8 million tonnes of mine waste and debris. It was covered with an engineered multi-layer, two-metre-thick soil cover. A concrete drainage tunnel was constructed at the bottom of the waste rock pile to drain seepage and groundwater into a local stream. The mine waste pile is ending a five-year transitional phase of long-term surveillance and maintenance. It has a national infrastructure site status. After the final administrative closure of the disposal site the permanent long-term surveillance and maintenance of the site will be, according to the Ionizing Radiation Protection and Nuclear Safety Act, entrusted to the Agency for Radioactive Waste Management.

Uranium requirements

The sole nuclear power plant in Slovenia is based at Krško. It started commercial operation in January 1983 and was modernised in 2000 with replacement steam generators that increased net capacity to 676 MWe. Net capacity was increased in 2006 to

696 MWe with low-pressure turbine replacement and again in 2009 to 698 MWe after modernisation of the turbine control system. The power plant is owned 50% by Slovenia and Croatia.

There has been no significant change in the Slovenian nuclear energy programme in the last two years (2011-2012). One nuclear power station (Nuklearna Elektrarna Krško) is in operation. Uranium requirements for Nuklearna Elektrarna Krško are relatively stable. The current fuel cycles are 18 months in duration and planned to continue at this cycle basis. In 2012, the Slovenian Nuclear Safety Administration approved the ageing management programme; a prerequisite for the operation of the Nuklearna Elektrarna Krško beyond 2030 up until the year 2043.

Supply and procurement strategy

The total uranium requirement of Nuklearna Elektrarna Krško per operating cycle remains as reported in 2011. There are no operating or strategic uranium reserves in Slovenia and supply is imported based on requirement contracts.

A new long-term supply contract was concluded in 2013. The current procurement strategy utilises enriched UF_6 supplied to the fuel manufacturer from the uranium supplier when it is required for fuel assembly construction. No physical deliveries of U_3O_8 or UF_6 are made to the Nuklearna Elektrarna Krško site. The manufactured fuel assemblies arrive just before they are used for power production. There are no plans in the foreseeable future to build a uranium stockpile by Nuklearna Elektrarna Krško. The strategy for commercial spent nuclear fuel management currently does not include the use of reprocessed uranium and Nuklearna Elektrarna Krško is not licenced for MOX use.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Slovenia is not a uranium producing country, uranium stocks are imported for the commercial operation of the nuclear power plant (Nuklearna Elektrarna Krško) as final products (manufactured nuclear fuel assemblies).

Uranium stocks

There is no uranium stock policy in Slovenia. Nuklearna Elektrarna Krško has no uranium stocks or intention to create a uranium stock policy. All required uranium stocks are purchased on a "just-in-time" basis.

Uranium prices

This information is considered confidential.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	2 200	2 200	2 200
Total	**0**	**2 200**	**2 200**	**2 200**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining	0	2 200	2 200	2 200
Total	**0**	**2 200**	**2 200**	**2 200**

* *In situ* resources.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	5 000	10 000	10 000
Total	**0**	**5 000**	**10 000**	**10 000**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining	0	5 000	10 000	10 000
Total	**0**	**5 000**	**10 000**	**10 000**

* *In situ* resources.

Prognosticated resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	1 060	1 060

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Underground mining[1]	382	0	0	0	382	0
Total	**382**	**0**	**0**	**0**	**382**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	5.90224	5.24368

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
698	698	688	698	688	698	688	698	688	698	688	698	688	698

Note: Low and high values were taken as dependable power and maximum designed net power, respectively.

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
149	149	119	179	119	179	119	179	119	179	119	179	119	179

Note: NEK operates 18-month cycles with a fresh fuel load of 224 tonnes of natural uranium equivalent. Some years no uranium supply is required (2012, 2015, 2018 and 2021). The values in the table are the average yearly values (i.e. 224 tU * 12/18 = 149 tU). Low and high variability is ±20% from the expected value; this is calculated from maximum change that could occur from a change in fuel assembly design or variation in cycle length (i.e. 12-24 months). The variability shown in previous reports (2005, 2007, 2009 and 2011) was lower than shown in the 2013 table, as it was based on observed 18-month cycle-to-cycle differences and may not be a fair representation in such a long timescale prediction.

South Africa

Uranium exploration and mine development

Historical review

South Africa has been an important player in the international market since it first started producing uranium in 1952. It has been steadily and consistently producing uranium since then, albeit at a lower level in recent years. Eight of the thirteen deposit types defined in the Red Book are found in South Africa, namely paleo-quartz-pebble conglomerate, sandstone, lignite-coal, black shale, intrusive, surficial, granite-related and phosphate deposits. The major part of the resource base is hosted by the quartz-pebble conglomerates and derived tailings, with significant amounts of resources in the sandstone and coal-hosted deposits. The other deposit types make a relatively small contribution to the national uranium resource inventory. Virtually all of South Africa's historical uranium production was derived from quartz-pebble conglomerate deposits with a small proportion being from the Palabora copper-bearing carbonatite. All current production is sourced from the quartz-pebble conglomerate deposits.

The majority of past production was as a by-product of gold, or to a minor extent, copper. Only two primary uranium producers have existed in South Africa. The first was the Beisa mine in the Free State in the early 1980s and the latter was the Dominion Reefs Uranium Mine near Klerksdorp which operated in the early 2000s.

There are six distinct uranium provinces in South Africa. The oldest are the Palaeozoic-aged Mozaan basin in the north-east and the slightly younger Witwatersrand Basin in central South Africa. The Precambrian-aged Palabora and Pilanesberg carbonatite complexes lie in the north, with the Precambrian to Cambrian granite complexes in the north-west. The sandstone deposits of the Karoo in the south central parts, as well as the coal- and shale-hosted deposits of the Springbok Flats are of Permo-Triassic age. The youngest are the Tertiary to recent surficial deposits in the Northwest Cape and the phosphorite deposits off the south-west coast.

The surge in the uranium price between 2005 and 2007 stimulated significant corporate interest in South Africa. Much of the ground over the Witwatersrand Basin was held by existing mining companies and extensive re-evaluations of uranium resource holdings were undertaken. Of great interest was the resources held in the vast tailings dams created by over 100 years of gold mining. Gold Fields, Rand Uranium, Harmony and AngloGold Ashanti launched detailed feasibility studies into the resources contained in tailings.

Available ground with known uranium occurrences such as in the Karoo Basin and Springbok Flats was snatched up by companies such as UraMin and Holgoun Energy. UraMin was subsequently taken over by AREVA, an acquisition that included the Trekkopjie deposit in Namibia and the Rystkuil Channel in the Karoo Basin. Smaller companies obtained prospecting licences over smaller known deposits in the Karoo Basin as well as deposits in the granitic and surficial terrains in the north-west of the country.

Recent and ongoing uranium exploration and mine development activities

Peninsula Energy Limited has a target to delineate about 12 000 tU_3O_8 (10 175 tU) tonnes of uranium oxide by the end of 2013 from the existing historical occurrences, their extensions and new exploration targets. Between January 2011 and June 2012, a total of 601 drill holes were drilled totalling about 21 640 m at sites 22, 29 and 45 (previously known as Matjieskloof, Quaggasfontein and Davidskolk respectively). In the same period, a total of 343 drill holes (~15 284 m) were re-probed. Drilling programmes at these sites have been successful in confirming the historic uranium mineralisation at each site. Peninsula Energy has identified new areas of uranium mineralisation in the stacked sandstone units which host extended uranium mineralisation beyond the historic drill limits, thereby increasing the resource potential. In December 2012, Peninsula Energy acquired all of AREVA's properties located in the Karoo uranium province, including the Ryst Kuil deposit. The current and ongoing work by Peninsula Energy is focused on developing sufficient resources to support the development of open-pit and underground mining operations that will supply a viable central processing facility near the town of Beaufort West.

HolGoun Uranium and Power Limited have completed a pre-feasibility study of its project in the Springbok Flats Basin and began a bankable feasibility study. Uranium is hosted by both coal and shale in the Springbok Flats. HolGoun's bankable feasibility study comprises resource and reserve estimations, bulk sampling and pilot plant test work, geotechnical and groundwater study, mine and underground infrastructure design, overall environmental issues, financial and economic evaluations and a mining rights application. The development of this project envisages an annual production capacity of about 700 tU_3O_8 (595 tU) at a feed grade of 0.96 kg/t of ore during the first seven years of production. Thereafter, the annual production will be about 500 tU_3O_8 (425 tU) at a feed grade of 0.63 kg/t of ore. Plans state that the project should become operational in 2017, if all assumptions are realised.

AngloGold Ashanti Limited has continued with near-mine gold exploration as well as extensions of the existing mining areas. The gold analysis is usually associated with uranium analysis as well. Drilling has been ongoing in the extensions of the Great Noligwa mining lease to determine the extent of remnant blocks of the Vaal Reef. More than 4 500 m of diamond drilling is planned for 2013 to increase the geological confidence at the Great Noligwa. Exploration targets have also been identified within the Kopanang mining lease and adjacent areas. Surface and underground drilling programmes are underway and results obtained are subject to continuous review to increase confidence in the structural model of the area. Furthermore, brownfield exploration is in progress at Moab Khotsong to provide required additional geological information for capital development as well as improve geological confidence. Six surface drilling machines and nineteen underground drilling machines were in operation during 2011 and 2012.

Gold One International Ltd acquired the Rand Uranium properties as well as the Ezulwini mine in 2012. One of the key objectives associated with these acquisitions was to re-establish the Cooke underground and Randfontein surface operations as gold mines and subsequently to develop uranium co-product potential. The Cooke underground operations comprise Cooke 1, 2, 3 and Ezulwini which are serviced by a developed network of mining and civil infrastructure with adequate electricity and water supplies. Ezulwini is being integrated into the Cooke underground complex as Cooke 4. The primary mining horizons in the Cooke operations include the Middle Elsburg reef which is a gold- and uranium-bearing reef which has been less extensively mined compared to the primarily gold-bearing reef known as the Upper Elsburg. Ongoing exploration and resource development work has highlighted numerous potential resource extensions. A feasibility study was completed in 2012 on a high uranium yielding area at Cooke 3, which consists of both unmined ground and a number of higher-grade pillars. The area is associated with existing underground development. The feasibility study considers uranium extraction through the Cooke 4 uranium plant (Ezulwini). The Randfontein surface operations host gold and uranium surface resources which present attractive opportunities for future extraction of uranium by Gold One. These tailings include the Cooke tailings dam, the Millsite complex, Lindum, Dump 20 slime and the Old 4 dam.

Harmony Gold Ltd has developed two uranium projects to feasibility stage: Harmony Uranium TPM (Tshepong, Phakisa and Masimong); and the Free State Tailings Uranium Project (FSTUP). The TPM Project will be extracting uranium from the Tshepong, Phakisa and Masimong underground mines while the FSTUP Project will be extracting uranium from the old tailings storage facilities owned by Harmony. The feasibility study of the TPM Uranium Project has been supported by a demonstration plant campaign and associated metallurgical test work.

Witwatersrand Consolidated Gold Resources Limited (Wits Gold) holds 14 prospecting rights in the southern Free State, Potchefstroom and Klerksdorp areas. These properties are located adjacent to operating mines, presenting opportunities for consolidation and future synergies with existing operations. Wits Gold's assets include its most advanced projects, the De Bron-Merriespruit (DBM) and Bloemhoek projects as well as three other projects; Robijn, Beisa North and Beisa South. An independent feasibility study for the DBM Project was completed in June 2012 and a bankable feasibility study is at an advanced stage. On the other hand, a pre-feasibility study has been completed for the Bloemhoek Project and synergies with adjacent operating mines are being investigated to fast track Bloemhoek's development timeline.

Namakwa Uranium has continued exploration in the Henkries Project, in which the area has been subdivided into Henkries Central, Henkries North and Henkries South. Most of the delineated resources, mainly in Henkries Central, occur within 20 m from the surface. Given the shallow and soft nature of the deposit as well as good infrastructure serving the project area, the project is regarded as potentially viable for future uranium extraction.

Uranium resources

All the resources reported are estimates obtained from exploration and mining companies' annual reports, as well as information obtained from AngloGold Ashanti, Peninsula Energy, Harmony Gold, HolGoun, Gold One, Wits Gold and Namakwa Uranium.

Identified conventional resources (reasonably assured and inferred resources)

The Witwatersrand Basin contains about 81% of total identified uranium resources in South Africa, in both the underground, hosted by quartz-pebble conglomerates, and their resulting tailings storage facilities. Approximately 49% of the total national identified resources are in the Witwatersrand underground operations, 32% in their associated tailings facilities, 14% in the Springbok Flats Basin and about 5% in the sandstone-hosted deposits of the Karoo Basin.

The reasonably assured conventional resources at a cost category of USD 80/kgU have increased by 17% compared to the same category of resources reported in the 2011 edition of the Red Book while there is an increase of about 21% at a cost category of USD 130/kgU. The inferred conventional resources at a cost category of USD 80/kgU have decreased by 23% compared to the same category reported in the 2011 edition of the Red Book, whilst there is an increase of 21% for USD 130/kgU category compared to the figure reported in 2011. The reasons for these changes include additional information obtained from extensive drilling programmes (which resulted in revised geological modelling and hence estimates), revised commodity prices and increased mining costs and hence increase of cut-off grades, amongst others.

Undiscovered conventional resources (prognosticated and speculative resources)

Undiscovered conventional resource figures have not been updated since the 1990s and remain as reported in the 2011 edition of the Red Book (prognosticated 34 900 tU recoverable at a cost of USD 80/kgU, 110 300 tU at a cost of USD 130/kgU and speculative resources amounting to 1 112 900 tU at an unassigned cost category).

Unconventional resources and other materials

As reported in the 2011 edition of the Red Book, a field of manganiferous phosphate nodules has been identified off the west and south-west coast of South Africa on the continental shelf. The nodules contain low grades of uranium and are currently considered uneconomic with respect to both phosphate and uranium extraction. However, renewed interest in phosphate-hosted uranium deposits may engender future investigation.

Uranium production

Historical review

South Africa has been a consistent producer of uranium since 1952, but its international importance has declined in recent years. In the late 1970s and early 1980s it was ranked the second or third largest producer in the world, but in recent years output has declined significantly and by 2010 South Africa ranked 12th in global uranium production. Peak production was achieved at over 6 000 tU/yr in the early 1980s when it accounted for 14% of total world output.

In 2011, the uranium production was 556 tU, which is about a 4% decrease compared to production in 2010. Furthermore in 2012, the uranium production decreased by 16% compared to the 2011 total, amounting to 467 tU. The decrease in the 2012 national total production was caused by the stoppage of production at Ezulwini which was sold to Gold One. Other reasons for the decrease in production at the existing production centre

(AngloGold Ashanti's Vaal River operations) include lower uranium grades than expected, lower gold production (uranium is produced as a by-product of gold), industry-wide strike actions and increased safety-related stoppages.

It is expected that in 2013 uranium production will increase due to the anticipated production at Mine Waste Solutions and Cooke 4 (formerly known as Ezulwini).

Status of production facilities, production capability, recent and ongoing activities and other issues

AngloGold Ashanti acquired the Mine Waste Solutions (MWS) tailings retreatment operation in the Vaal River region in July 2012. MWS comprises tailings storage facilities that originated from the processing of ore from the Buffelsfontein, Hartebeestfontein and the Stilfontein gold mines.

The Vaal River tailings storage facility reclamation project was initiated in 2011 to recover uranium oxide and gold from existing tailings storage facilities by utilising new technology developed by AngloGold. Synergies between the Vaal River and the MWS tailings storage facilities will allow MWS to exploit these tailings. Currently, the MWS material is processed for extraction of gold only. However, it is envisaged that the uranium circuit will be commissioned in the fourth quarter of 2013.

Uranium is produced at Vaal River by processing the reef material from Moab Khotsong, Great Noligwa and Kopanang in the Noligwa gold plant/South Uranium Plant circuit. The reef is milled at the Noligwa gold plant and treated in the South Uranium Plant for uranium oxide extraction by the reverse leach process. Ammonium diuranate (ADU or "yellow cake"), the final product of the South Uranium Plant, is transported to Nufcor (located near Johannesburg) where the material is calcined and packed for shipment to conversion facilities.

The expansion project at the South Uranium Plant was commissioned in 2012 and all the Kopanang reef is now subjected to the uranium extraction process. The replacement of the uranium solvent extraction section within the South Uranium Plant, to ensure sustainable operations over the life of the operation, is scheduled for completion towards the end of 2013.

A feasibility study, conducted by Gold One, for Cooke 3 was completed, which has considered extraction of uranium through the Cooke 4 uranium plant. The uranium plant upgrade will see the 50 000 tonnes of ore per month module operating by the end of 2013. In addition, the integration of the underground Cooke 4 operation into the larger Cooke 1-3 underground complex was completed in December 2012. With access to Cooke 4's uranium processing facility, Gold One can access joint underground resources and begin implementing its uranium co-product strategy. The Cooke 4 uranium plant has a capacity of processing up to 100 000 tonnes of ore per month.

Shiva Uranium is currently operating at the Dominion Reefs deposit, on three underground shafts; the Dominion 1 (D1), Dominion 2 (D2) and the Rietkuil declines. In February 2011, Shiva produced 1.6 tU_3O_8 (1.4 tU). However, no information is available on 2011 production. Shiva did not produce uranium in 2012 and no information on the reasons for not producing uranium as planned are available. It is also not known when uranium production will resume. Currently, only gold is produced at the Dominion Reefs mine.

The Harmony Uranium TPM Project was established to evaluate the potential for economic recovery of uranium from ore mined at Tshepong, Phakisa and Masimong mines in the Free State province. The project is expected to produce about 340 tU/yr at peak production of 280 000 tonnes of underground ore per month over a 20-year life. An engineering study was completed in 2012, resulting in a reduced capital cost for the project and mitigating potential gold loss in the uranium extraction process. The TPM and the FSTUP projects are being evaluated further but future uranium price projections will determine whether these projects will be able to move ahead.

Ownership structure of the uranium industry

AngloGold Ashanti's primary stock exchange listing is on the JSE Limited (Johannesburg Stock Exchange). It is also listed on the exchanges in New York, London, Australia and Ghana as well as on Euronext Paris and Euronext Brussels. In South Africa, AngloGold Ashanti operates six wholly owned underground mines which are located in two geographical regions in the Witwatersrand Basin. The most important are Vaal River Operations gold mines which produce uranium as a by-product. The Tau Lekoa mine was sold to Simmer and Jack in 2010.

Harmony Gold's primary listing is on the JSE Limited (share code: HAR) in South Africa. Harmony's ordinary shares are also listed on stock exchanges in London (HRM), Paris (HG) and Berlin (HAM1), and are quoted in the form of American depositary receipts on the New York and Nasdaq exchanges (HMY), and as international depositary receipts on the Brussels exchange (HMY).

Gold Fields is listed on JSE Limited (primary listing), the New York Stock Exchange (NYSE) and the Dubai International Financial Exchange (DIFX), the New Euronext in Brussels (NYX) and Swiss Exchange (SWX).

Witwatersrand Consolidated Gold Resources (Wits Gold Ltd) is listed on the main boards of the JSE Limited (South Africa) and the TSX (Canada) under the symbol WGR. Wits Gold also has a Level 1 ADR (American depository receipt) programme backed by the Bank of New York Mellon (OTC:WIWTY.PK). The company is an active gold exploration company with substantial mineral resources in the Witwatersrand Basin.

AngloGold Ashanti Ltd acquired the MWS tailings retreatment operation in the Vaal River region in July 2012 for about USD 335 million.

Gold One International Ltd (Gold One) is a mid-tier mining group that is listed on Australian Securities Exchange as well as on JSE. Gold One, created in 2009, concluded the acquisitions of Randfontein operations (owned by Rand Uranium Ltd) and Ezulwini Mining Company Ltd (owned by First Uranium Ltd) during the first half of 2012 for USD 250 million and USD 70 million respectively. These acquisitions have endowed Gold One with multiple production assets, including a uranium co-product strategy.

Peninsula Energy Ltd is a public company listed on the Australian Securities Exchange and incorporated in Western Australia. Tasman Pacific Minerals Limited is wholly owned by Peninsula Energy, which owns prospecting rights in the Karoo uranium province. Peninsula Energy acquired all the AREVA's assets in the Karoo uranium province in December 2012, including the Ryst Kuil Project.

Employment in the uranium industry

AngloGold Ashanti employed 199 workers in 2011 and 182 workers in 2012 at the uranium co-product operations in the Vaal River region. It is expected that in 2013, the number of employees directly related to uranium production will be 180. In 2012, the only employment directly related to uranium production in South Africa was in the Vaal River region by AngloGold Ashanti. However, once Mine Waste Solutions and Cooke 4 begin uranium operations the number of employees will rise significantly.

Future production centres

Future production centres include the Mine Waste Solution and Cooke 4. In addition, other future production centres may include Beaufort West (Karoo Basin), Springbok Flats (Settlers area), as well as TPM and FSTUP projects in the Free State goldfields.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6	Centre #7	Centre #8
Name of production centre	South Uranium Plant (AngloGold Ashanti)	Mine Waste Solutions (AngloGold Ashanti)	Cooke 4, previously known as Ezulwini (Gold One)	Dominion Reefs Uranium Mine (Shiva Uranium)	Beaufort West (Peninsula Energy)	TPM Uranium Project (Harmony Gold)	Free State Tailings Uranium Project (Harmony Gold)	Springbok Flats Basin (HolGoun)
Production centre classification	Existing	Committed	Existing	Existing	Planned	Planned	Planned	Planned
Start-up date	1979	2013	2009	2007	2016	2016	2016	2017
Source of ore:								
Deposit name(s)	Wits Basin (Kopanang, Great Noligwa and Moab Khotsong underground mines)	Tailings in the Vaal River region (Wits Basin)	Wits Basin (Cooke 1, 2, 3, 4 and Randfontein tailings)	Dominion Reefs	Karoo Uranium Province (Ryst Kuil and others)	Wits Basin (Tshepong, Phakisa and Masimong underground mines)	Wits Basin (Free State Tailings)	Springbok Flats Basin (Settlers area)
Deposit type(s)	Quartz-pebble conglomerate	Tailings	Quartz-pebble conglomerate	Quartz-pebble conglomerate	Sandstone	Quartz-pebble conglomerate	Tailings	Coal
Recoverable resources (tU)	39 904	56 148	32 305	NA	15 410	21 630	21 540	47 800
Grade (% U)	0.028	0.009	0.029	NA	0.104	0.017	0.008	0.096
Mining operation:								
Type (OP/UG/ISL)	UG	Tailings reprocessing	UG + Tailings	UG	OP + UG	UG	Tailings	UG
Size (tonnes ore/day)	8 767	61 978	1 670	NA	NA	9 370	11 525	NA
Average mining recovery (%)	60-80	100	NA	NA	NA	74	68	NA
Processing plant:								
Acid/alkaline	Acid	Acid	Acid	Acid	NA	Acid	Acid	Acid
Type (IX/SX/AL)	CCD/CCIX/SX	CCD/CCIX/SX	IX/SX	IX/SX	NA	SX	SX	SX
Size (tonnes ore/day)	8 767 tpd	61 978 tpd	1 670 tpd	NA	NA	9 370 tpd	11 525 tpd	NA
Average process recovery (%)	75	38	NA	NA	NA	86	68	68
Nominal production capacity (tU/year)	800	NA	500	NA	1 036	340	700	600
Plans for expansion	No	Yes	Yes	No	No	No	No	No
Other remarks	Replacing SX section in plant	Commissioning planned for the 4th quarter of 2013	(1)	(2)	NA	NA	NA	NA

1. Recommissioning planned for 2013, initially processing ore from Cooke 3 underground mine.
2. The uranium plant was reopened in the beginning of 2011, however due to unknown reasons the uranium processing was stopped several months later.

CCD = counter current decantation; CCIX = continuous counter current ion exchange.

Environmental activities and socio-cultural issues

Exploration and mining companies are committed to the responsible use and management of the natural resources under their prospecting and mining rights. Site visits and inspections are conducted regularly to verify that the commitments detailed in their environment management programmes are being adhered to. Exploration and drilling include a responsibility to rehabilitate each site once drilling has been completed. In terms of applications for mining rights, and a part of the Social and Labour Plan (SLP), the companies are required to inform the interested and affected parties in the proposed mining area of its intended activities. In the Wits Gold's DBM Project for example, a first publication participation meeting was held in March 2012 in the Virginia Free State province, and the community was provided with details on how to register as interested parties in order to participate in future forums related to Wits Gold's intended mining activities once the mining rights have been granted by the Department of Mineral Resources.

AngloGold Ashanti has designed a framework, following extensive stakeholder engagement, to integrate community development into core business activities, while providing support for national development policies and objectives, particularly those addressing youth unemployment.

To aid in the development of Gold One's mining communities, an agricultural co-operative was initiated during 2012 for the communities associated with the Cooke 1-4 underground operations and the Randfontein surface operations which supports about 35 beneficiaries, including the Slovo Park agricultural initiatives.

A wave of illegal strikes impacted mining company operations in 2011 through to the end of 2012. Although analysis of the root causes of the strikes is ongoing, certain key underlying themes have emerged that appear to have contributed to the unrest including, mainly, a significant economic inequality. In addition, the illegal and widespread nature of the strikes indicates a significant failure of the mining sector's established labour negotiation framework. There is a growing perception that the established union structures are no longer effectively protecting or promoting the interests of all rank and file members, including the more junior workers. However, the mining companies, the government and the labour unions are now working together to find a lasting solution to the problem.

Regulatory regime

The Department of Mineral Resources, the Department of Water Affairs, the Department of Environmental Affairs and the Department of Energy, including the National Nuclear Regulator, perform regulatory functions relating to exploration and mining of uranium in South Africa.

According to the Mineral Resources and Development Act No. 28 of 2002, an applicant of prospecting or mining right must make the prescribed financial provision for the rehabilitation or management of negative environmental impacts before the approval of such rights. If the holder of the prospecting or mining right fails to rehabilitate or is unable to undertake such rehabilitation then part or all of the financial provision will be used for rehabilitation. The holder of a prospecting or mining right must annually assess their environmental liabilities and accordingly increase their financial provision to the satisfaction of the Minister of Mineral Resources. If the minister is not satisfied with the assessment and the financial provision, then the minister may appoint an independent assessor to conduct the assessment and determine the financial provision. The requirement to maintain and retain the financial provision remains in force until a closure certificate has been issued after the closure of mining or prospecting operation. The minister may still retain a portion of the financial provision as may be required to rehabilitate the closed mining or prospecting operation in respect of latent or residual environmental impacts. No closure certificate will be issued until the rehabilitation has been done and the chief inspector, as well as all the governmental regulatory departments related to uranium exploration and mining, have confirmed that the provisions pertaining to health, safety, environment and management of potential pollution to water have been addressed.

Uranium requirements

Koeberg is South Africa's only nuclear power plant. It has two light water thermal reactors; Koeberg I commissioned in 1984 and Koeberg II in 1985, with a combined installed capacity of 1 840 MW. Together, they require ~292 tU/yr.

The government has drawn up the Integrated Resource Plan 2010, which includes increasing the nuclear capacity from 1.8 GWe to 9.6 GWe by 2030. To spearhead this programme, a National Nuclear Energy Executive Coordination Committee was established towards the end of 2011 as an authority for nuclear energy expansion programme. The committee incorporates the Nuclear Energy Corporation of South Africa (NECSA), South African electricity public utility (Eskom), the National Nuclear Regulator and governmental departments including the Department of Energy and the Department of Public Enterprises. The Deputy President of the Republic of South Africa is the chairman of the committee. Eskom is currently progressing with environmental investigation, including seismic hazards assessments of the proposed sites for nuclear power plants, including the Thyspunt (Eastern Cape Province) and the Duyneyfontein (Western Cape Province). The environmental investigation and assessments for the Thyspunt site has been completed.

The planned nuclear reactors and the existing Koeberg plant will require a total of about 2 000 tU/yr.

Supply and procurement strategy

With the commitment of government to build nuclear power stations to compliment the Koeberg plant, the government considers that preparatory work for beneficiation of uranium is important. According to the Beneficiation Strategy document published in 2011, interventions for the successful implementation of nuclear power generation include: quantification of uranium reserves; determining the economic feasibility of re-establishing uranium enrichment; developing a plan for comprehensive waste treatment and mine rehabilitation; and finalisation of the uranium policy with all the relevant stakeholders. Ten commodities, including uranium, were selected for promotion and enhance local beneficiation in South Africa. More information is found at www.info.gov. za/view/DownloadFileAction?id=147564.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The National Nuclear Regulator Act No. 47 of 1999, the Nuclear Energy Act No. 46 of 1999 and the Mineral and Petroleum Resources Development Act No. 28 of 2002 (MPRDA) are the basis of national policies relating to prospecting for and mining of uranium in South Africa, as well as the export of uranium and disposal of spent nuclear fuel. More information on these policies can be found on the following links:

- www.info.gov.za/view/DownloadFileAction?id=70614;
- www.info.gov.za/view/DownloadFileAction?id=70613;
- www.info.gov.za/view/DownloadFileAction?id=68062.

The Department of Mineral Resources has embarked on a process of reviewing the mining legislative framework, in which the Cabinet has approved the proposals on the amendment of the Mineral and Petroleum Resources Development Bill and gazetted it for further comments. The focus of the amendments is to remove ambiguities in the act that previously created room for multiple interpretations, to ensure the act remains current and relevant and to align the provisions of the act with relevant legislation in other parts of the government, among others. The amendments of the act will also integrate the mining licensing approach in government, together with the Department of Water Affairs as well as the Department of Environmental Affairs as compared to the current fragmented approach to licensing requirements for mining. More information on the amendments to the MPRDA can be found at www.info.gov.za/view/DownloadFileAction?id=181151.

Uranium stocks

The information and figures on uranium stocks are classified as confidential, and hence could not be accessed from Eskom.

Uranium prices

No uranium prices were available.

Uranium exploration and development expenditures and drilling effort – domestic

(ZAR [South African rand])

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	22 353 842	151 333 517	188 183 202	210 000 000
Government exploration expenditures	0	0	0	0
Industry* development expenditures	120 230 330	88 555 721	87 895 589	85 490 620
Government development expenditures	0	0	0	0
Total expenditures**	**142 584 172**	**239 889 238**	**276 078 791**	**295 490 620**
Industry* exploration drilling (m)	14 842	45 470	32 000	44 000
Industry* exploration holes drilled	80	435	414	614
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	31 325	43 048	52 354	52 344
Industry* development holes drilled	528	521	638	589
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	14 843	45 470	32 000	44 000
Subtotal exploration holes drilled	80	435	414	614
Subtotal development drilling (m)	31 325	43 048	52 354	52 344
Subtotal development holes drilled	528	521	638	589
Total drilling (m)	**46 168**	**88 518**	**84 354**	**96 344**
Total number of holes drilled	**608**	**956**	**1 052**	**1 203**

* Non-government.

** Includes expenditures for both uranium and gold in the Witwatersrand Basin.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone*	0	0	4 835	6 447
Paleo-quartz-pebble conglomerate**	0	113 024	169 536	226 048
Surficial	0	0	918	1 224
Total	**0**	**113 024**	**175 289**	**233 719**

* The recovery factor of 80% used for sandstone-hosted deposit resources is speculative.

** Paleo-quartz-pebble conglomerate resources include tailings resources as well.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)*	0	0	5 753	7 671	80
Co-product and by-product	0	113 024	169 536	226 048	78
Total	**0**	**113 024**	**175 289**	**233 719**	**78**

* The resources for sandstone-hosted deposits in the Karoo Basin are included in the open-pit method; however in reality the potential production will be conducted by both open-pit and underground mining, the ratio of resources to each method is unknown at present.

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG*	0	113 024	169 536	226 048	78
Conventional from OP	0	0	5 753	7 671	80
Total	**0**	**113 024**	**175 289**	**233 719**	**78**

* Conventional from UG also includes tailings resources from the Witwatersrand Basin.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	10 576	14 101
Paleo-quartz-pebble conglomerate*	0	69 286	103 929	138 572
Surficial	0	0	471	628
Lignite and Coal**	0	0	47 844	63 792
Total	**0**	**69 286**	**162 820**	**217 093**

* Includes tailings resources in the Witwatersrand Basin.

** Springbok Flats Basin contains both coal-hosted and shale-hosted uranium.

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)*	0	0	47 844	63 792	68
Open-pit mining (OP)**	0	0	11 047	14 729	80
Co-product and by-product	0	69 286	103 929	138 572	75
Total	**0**	**69 286**	**162 820**	**217 093**	**73**

* Underground mining resources only include resources from the Springbok Flats Basin. The resources from underground operations in the Witwatersrand Basin are included in the “co-product and by-product” category.

** Resources in the Karoo Basin are included in the open-pit mining method, even though both open-pit and underground mining method are expected to be used. The recovery factor used for the open-pit method (80%) is speculative only.

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	69 286	151 773	202 364	72
Conventional from OP	0	0	11 047	14 729	80
Total	**0**	**69 286**	**162 820**	**217 093**	**73**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
34 900	110 300	110 300

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	1 112 900

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Paleo-quartz-pebble conglomerate	156 808	582	556	467	158 413	540
Total	**156 808**	**582**	**556**	**467**	**158 413**	**540**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Co-product/by-product	156 808	582	556	467	158 413	540
Total	**156 808**	**582**	**556**	**467**	**158 413**	**540**

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	156 808	582	556	467	158 413	540
Total	**156 808**	**582**	**556**	**467**	**158 413**	**540**

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
0	0	467	100	0	0	0	0	467	NA

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	4 825	4 320	237	3 900
Employment directly related to uranium production	1 286	1 270	182	1 150

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	540	0	0	0	1 100	1 380	0	0	1 540	3 180

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	1 360	3 000	0	0	1 185	2 830	0	0	892	2 530

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	12.099	13.502

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
1 840	1 840	1 840	1 840	1 840	1 840	1 840	1 840	1 840	7 200	1 840	14 400	1 840	20 000

Annual reactor-related uranium requirements to 2035 (excluding MOX)

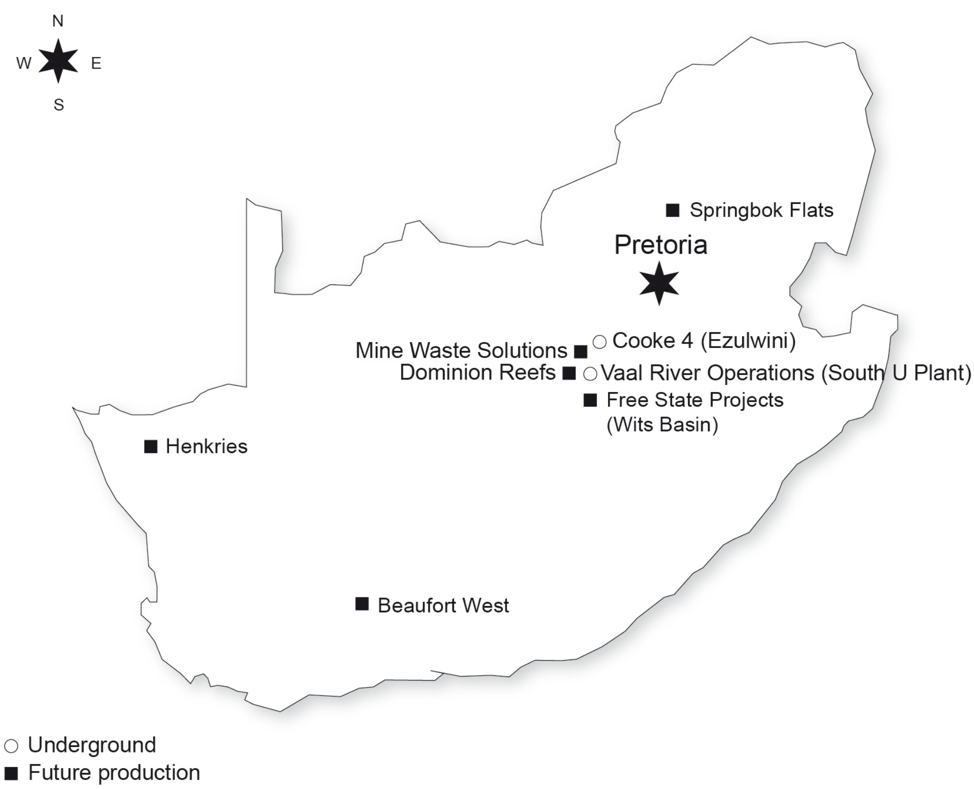
(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
292	292	292	292	292	292	292	292	292	1 188	292	2376	292	3 300

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	NA	NA	NA	NA	NA
Producer	NA	NA	NA	NA	NA
Utility	NA	NA	NA	NA	NA
Total	**NA**	**NA**	**NA**	**NA**	**NA**



Spain

Uranium exploration and mine development

Historical review

Uranium exploration started in 1951 and was carried out by the Junta de Energía Nuclear (JEN). Initial targets were the Hercynian granites of western Spain. In 1957 and 1958, the first occurrences in Precambrian-Cambrian schists were discovered, including the Fe deposit, located in the province of Salamanca. In 1965, exploration of sedimentary rocks began and the Mazarete deposit in Guadalajara province was discovered. In 1972, the Empresa Nacional del Uranio, S.A. (ENUSA) (today ENUSA Industrias Avanzadas, S.A.), a state-owned company, was established to take charge of all the nuclear fuel cycle front-end activities. Its shareholders are the SEPI (Sociedad Estatal de Participaciones Industriales) holding 60% of the capital, and the CIEMAT (Centro de Investigaciones Energéticas Medioambientales y Tecnológicas, before JEN), holding the remaining 40%. Exploration activities by the ENUSA ended in 1992. Joint venture exploration between ENUSA and other companies continued until the end of 1994. During this period, most of the Spanish territory was surveyed using a variety of methods, adapted to different stages of exploration, and ample airborne and ground radiometric coverage of the most interesting areas was achieved.

Recent and ongoing uranium exploration and mine development activities

Berkeley Resources has been granted a total of 20 exploration licences spanning the provinces of Salamanca and Cáceres covering a total of 66 400 ha. This company has been actively exploring for uranium for several years, with a focus on a number of historically known uranium projects located within their tenements.

In April 2009, the Council of Ministers approved a collaboration agreement signed between Berkeley and ENUSA to complete a feasibility study over the following 18 months on the state reserves within the Salamanca province. Through this agreement Berkeley could purchase up to 90% of the assets, including exploration and exploitation of the identified resources and processing at the existing Quercus plant.

Shortly after Ministerial Cabinet approval of the agreement between Berkeley and ENUSA in April 2009, the Mining Domain Feasibility Study (MDFS) on the state reserves in the Salamanca province commenced. The MDFS was completed, including the verification of historical ENUSA data and subsequent mineral resource estimates of the Aguila, Alameda and Villar deposits in compliance with the JORC Code.

Berkeley's "Salamanca" Project comprises the Retortillo, Alameda and Gambuta (in the Cáceres province) deposits plus a number of other satellite deposits located in western Spain.

In November 2012, Berkeley completed an initial assessment of the integrated development of Retortillo and Alameda and reported the results of the Scoping Study, which according to that company demonstrated the potential of the Salamanca Project to support a significant scale uranium mining operation.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The total RAR are 14 000 tU and are reported as recoverable by open-pit mining. Inferred resources are not reported as the figures are not currently available, but they are also recoverable by open-pit mining. The RAR data incorporate mining (recovery factor: 0.85) and milling losses (recovery factor: 0.75).

Uranium production

Historical review

Production started in 1959 at the Andújar plant, Jaen province, and continued until 1981. The Don Benito plant, Badajoz province remained in operation from 1983 to 1990. Production at the Fe mine (Salamanca province) started in 1975 with heap leaching (Elefante plant). A new dynamic leaching plant (Quercus) started in 1993 and was shut down in December 2000. The licence for a definitive shutdown of the production, submitted to regulatory authorities in December 2002, was approved in July 2003.

Status of production capability

Mining activities were terminated in December 2000 with the closure of Saelices el Chico uranium mines and production of uranium concentrates ended in November 2002 when the associated Quercus processing plant was shut down. A decommissioning plan was presented to regulatory authorities in 2005. However, due firstly to the need to decommission the former Elefante processing plant and the restoration of mines at the same site before decommissioning Quercus and secondly, the 2009 agreement between ENUSA and Berkeley, the decommissioning plan was put on standby. Nevertheless, by the end of October 2013 another plan for a partial decommissioning is to be presented to regulatory authorities.

Ownership structure of the uranium industry

Quercus, the only production facility in Spain still pending decommissioning belongs to the company ENUSA Industrias Avanzadas, S.A.

Employment in the uranium industry

Employment at the Fe mine totalled 23 at the end of 2012. All of these workers are dedicated to the mining restoration, surveillance and decommissioning programmes.

Future production centres

Berkeley Minera España has announced its intention to bring three potential open-pit uranium mines into production: Retortillo-Santidad, Alameda and Gambuta (the former two in the Salamanca region and the latter in the Cáceres region). Berkeley applied to the competent authority (autonomous government) for an exploitation permit for the Retortillo-Santidad Project in October 2011 and requested reinstatement of authorisation for the radioactive facility to the Ministry of Industry, Energy and Tourism (MINETUR), in March 2012. The project, according Berkeley, should have an average production of 1.2 million lbs U_3O_8/yr (460 tU/yr) during a ten-year period of operation, with maximum production of 1.5 million lbs U_3O_8/yr (575 tU/yr). In March 2013, Berkeley also applied an exploitation permit for the Gambuta uranium field, with planned production of 1.3 million lbs U_3O_8/yr (500 tU/yr) over eight years of operation. Regarding Alameda, Berkeley foresees an average production of 2 million lbs U_3O_8/yr (770 tU/yr) over nine years of operation.

Secondary sources of uranium

Spain reports mixed oxide fuel and re-enriched tails production and use as zero.

Environmental activities and socio-cultural issues

The present condition of former uranium production facilities in Spain are as follows:

- Fábrica de Uranio de Andújar (Jaén province): Mill and tailings piles have been closed and remediated, with an ongoing ten-year surveillance and control programme (groundwater quality, erosion control, infiltration and radon control). This programme has been extended.
- Mine and plant “LOBO-G” (Badajoz province): The open-pit and mill tailings dump have been closed and remediated, with a surveillance and control programme (groundwater quality, erosion control, infiltration and radon control) in place until 2004. A long-term stewardship and monitoring programme was begun after the declaration of closure.
- Old mines (Andalucía and Extremadura regions): Underground and open-pit mines were restored, with work completed in 2000.
- Two old mines in Salamanca (Valdemascaño and Casillas de Flores) were restored in 2007, following which a surveillance programme was initiated, ending in 2011. Results were evaluated by regulatory authorities and it was determined that an extension of the surveillance period until 2016 was required.
- Elefante plant (Salamanca province): The decommissioning plan, including industrial facilities and heap leaching piles, was approved by regulatory authorities in January 2001. The plant was dismantled and ore stockpiles were levelled and covered in 2004. A monitoring and control programme has been in place since 2005.
- In 2004, the mining restoration plan of the open-pit exploitation in Saelices el Chico (Salamanca province) was approved by regulatory authorities. Implementation of this plan was finished in 2008 and the proposed surveillance and control programme was sent to regulatory authorities for approval. Approval of a surveillance programme for at least five years is expected in the near future.
- Quercus plant (Salamanca province): Mining activities ended in December 2000 and uranium processing in November 2002. A decommissioning plan was submitted to regulatory authorities in 2005. However, due to the need for decommissioning of the former Elefante processing plant and restoring some of the mines at the same site before turning to the decommissioning of Quercus and due to the 2009 agreement between ENUSA and Berkeley, this decommissioning plan has been put on standby. By the end of October 2013, another plan for a partial decommissioning has to be presented to regulatory authorities. During this time a surveillance and maintenance programme has been in place for the plant and associated facilities.

Uranium mining regulatory regime

In Spain, the mining regime is regulated by the Mines Act (Act 22/1973), modified by Act 54/1980 and by Royal Decree 2857/1978. The investigation and use of radioactive ores is governed by this act in those areas that are not specifically considered in the Nuclear Energy Act (Act 25/1964), Chapter IV of which deals with the prospecting, investigation and use of radioactive ores as well as the commercialisation of such ores and their concentrates.

According to Article 2 of the Mines Act, all natural deposits and other geological resources in Spain are assets belonging to the public domain, investigation and use of which may be undertaken directly by the state or assigned in accordance with the rules. Pursuant to Article 1 of Act 54/1980, which amends the Mines Act, radioactive ores are part of Section D, i.e. resources of national energy interest.

Pursuant to Article 19 of the Nuclear Energy Act, the prospecting, investigation and use of radioactive ores and the obtaining of concentrates are declared to be free throughout the entire national territory, except in those areas set aside by the state. Individuals or companies who wish to prospect for radioactive ores are required to request an investigation permit from the state and subsequently, if the existence of one or more resources open to rational exploitation is revealed, to request an exploitation licence. This licence confers the right to exploit the resources and is granted for a 30-year period, extendable by similar periods to a maximum of 90 years. The permits and licences are granted by the autonomous communities, in keeping with the transfer to them of state competences in mining and energy issues, except when the mining activity in question affects several autonomous communities or state reserves in which case the competent authority is the MINETUR, by virtue of the Mines Act.

The CSN (Nuclear Safety Council) is the organisation responsible for nuclear safety and radiological protection. In accordance with Article 2 of the act creating the CSN (Act 15/1980), one of the main competences of the council is to issue reports to the MINETUR on nuclear safety and radiological protection, prior to the resolutions adopted by the latter regarding the granting of authorisations for the operation, restoration or closure of uranium mines and production facilities. These reports are mandatory in all cases and binding when negative in their findings or denying authorisation, or as regards the conditions established when they are positive.

Regarding restoration plans and financial guarantees for the mining activities, according to the Royal Decree 975/2009 of 12 June on the management of waste resulting from extractive industries and the protection and restoration of the environment affected by mining activities, a restoration plan must be submitted for approval to the mining authority (the autonomous community or MINETUR, in the case of those mining activities affecting several autonomous communities or state reserves), the approval of which will be given together with the granting of the exploitation licence. The mining authority will neither grant the licence nor approve the plan unless environmental restoration of the site is guaranteed. To that end, two financial guaranties have to be set up by the company before starting any mining activity, one for the rehabilitation of the environment affected by the exploitation of the ores and the second one for the management of the generated waste, both to comply with the objectives and conditions established in the authorised restoration plan even in the case that the company does not exist at the time of the restoration.

Regarding decommissioning of the associated milling facilities, those are considered, by the Regulation on Nuclear and Radioactive Installations (RINR, approved by Royal Decree 1836/1999 and modified by Royal Decree 35/2008) as radioactive facilities of the nuclear fuel cycle and are subject to previous construction and exploitation licences. An exploitation licence requires the applicant to submit decommissioning and closure forecasts, including, among other things, the final management of the radioactive wastes as well as the economic and financial calculations to guarantee closure of the site. A draft amendment of the RINR for the constitution of a financial guarantee before granting this licence is under development.

Uranium requirements

As of 1 July 2013, the net capacity of the eight operating Spanish nuclear reactors (Santa María de Garoña, Almaraz units 1 and 2, Ascó units 1 and 2, Cofrentes, Vandellós 2 and Trillo nuclear power plants) was about 7.52 GWe. However, the Santa María de Garoña

NPP was shut down on 6 July 2013, leading to a current net capacity of 7.1 GWe. No new reactors are expected to be built in the near future. Through 2010 and 2011, the Spanish government approved ten-year licence extensions for Ascó units 1 and 2, Almaraz units 1 and 2, Vandellós unit 2 and the lone Cofrentes unit. The Trillo NPP has permit for operation until 2014. Accordingly, uranium requirements for the Spanish nuclear fleet in the coming years will foreseeably range from 1 250 to 1 350 tU/yr.

Supply and procurement strategy

All uranium procurement activities are carried out by ENUSA Industrias Avanzadas S.A. on behalf of the Spanish utilities that own the eight operating nuclear reactors in Spain.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Spain's uranium import policy provides for diversification of supply. The Spanish legislation leaves uranium exploration and production open to national and foreign companies.

Uranium stocks

Present Spanish regulation provides that a strategic uranium inventory contained in enriched uranium should be held jointly by the utilities that own NPPs. The current stock contains the equivalent of at least 608 tU (721 tU_3O_8). Additional inventories could be maintained depending on uranium market conditions.

Uranium exploration and development expenditures and drilling effort – domestic

(USD)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	10 222 659	10 335 065	12 105 683	13 000 000
Government exploration expenditures	0	0	0	0
Industry* development expenditures	0	0	0	0
Government development expenditures	0	0	0	0
Total expenditures	**10 222 659**	**10 335 065**	**12 105 683**	**13 000 000**
Industry* exploration drilling (m)	16 190	21 197	12 857	13 033
Industry* exploration holes drilled	66	346	214	174
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	16 190	21 197	12 857	13 033
Subtotal exploration holes drilled	66	346	214	174
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**16 190**	**21 197**	**12 857**	**13 033**
Total number of holes drilled	**66**	**346**	**214**	**174**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related	0	0	0	14 000
Total	**0**	**0**	**0**	**14 000**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	0	0	0	14 000	85
Total	**0**	**0**	**0**	**14 000**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP	0	0	0	14 000	75
Total	**0**	**0**	**0**	**14 000**	

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Granite-related	5 028	0	0	0	5 028	0
Total	**5 028**	**0**	**0**	**0**	**5 028**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	5 028	0	0	0	5 028	0
Total	**5 028**	**0**	**0**	**0**	**5 028**	**0**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	4 961	0	0	0	4 961	0
Other methods*	67	0	0	0	67	0
Total	**5 028**	**0**	**0**	**0**	**5 028**	**0**

* Includes mine water treatment and environmental restoration.

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres	25	24	23	22
Employment directly related to uranium production	0	0	0	0

Net nuclear electricity generation

	2011	2012
Nuclear electricity generated (TWh net)	55.1	58.6

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
7 443	7 515	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		7 069	7 069	7 069	7 069	7 069	7 069	NA	NA	NA	NA	NA	NA

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
1 324	939	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		1 650	1 660	1 250	1 350	1 250	1 350	1 250	1 350	NA	NA	NA	NA

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	0	0	0	0	0
Producer	0	0	0	0	0
Utility	NA	608	0	NA	NA
Total	**NA**	**608**	**0**	**NA**	**NA**

Sweden*

Uranium exploration and mine development

Historical review

Uranium exploration in Sweden was first carried out between 1950 and 1985, initially through AB Atomenergi and from 1967 by the Geological Survey of Sweden (SGU) and associated companies. At the end of 1985, exploration activities were stopped due to the availability of uranium at low prices on the world market. This early work did, however, result in the delineation of four main uranium provinces in Sweden.

The first is in the Upper Cambrian and Lower Ordovician sediments in southern Sweden and along the border of the Caledonian mountain range in central Sweden. The uranium occurrences are stratiform, in black (alum) shales. Billingen (Vastergotland), where the Ranstad deposits are located, covers an area of more than 500 km^2.

The second uranium province, Arjeplog-Arvidsjaur-Sorsele, is immediately south of the Arctic Circle. It comprises one deposit (Pleutajokk) and a group of more than 20 occurrences. The individual occurrences are discordant, of a vein or impregnation-type, associated with sodium-metasomatism.

A third province is located north of Ostersund in central Sweden. Several discordant mineralised zones have been discovered in, or adjacent to, a window of Precambrian basement within the metamorphic Caledonides. A fourth province is located near Asele in northern Sweden.

Since 2007, a number of exploration companies have been active in Sweden, in many cases focusing work on areas where discoveries were made during the initial phase of exploration. Two Canadian companies, Mawson Resources and Continental Precious Minerals, have been most active and between the two companies 12 800 tU (33 280 Mlbs U_3O_8 *in situ*) has been reported from nine historical occurrences using SGU data with some recently twinned drill holes. The Duobblon Project is the largest with an inferred resource of 3 370 tU grading 0.024% U. In addition to these small epigenetic vein, fracture and intrusive-related uranium deposits, some companies are reassessing the massive low-grade potential of the black shales of central Sweden.

Recent and ongoing uranium exploration and mine development activities

Most activity during 2011 and 2012 has been related to the potential of the alum (black) shale where uranium can be recovered as a by-product along with other co-products such as molybdenum, vanadium, nickel, zinc and petroleum products. Exploration expense figures for the course of these two years is however not available.

* Report prepared by the Secretariat, based on previous Red Books and company reports.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As a result of a review of exploration activities of Mawson Resources and Continental Precious Minerals and a re-evaluation of resource figures, total recoverable identified conventional resources have been reduced by about 30% compared to figures presented in the 2011 Red Book, with the majority of the reduction in the inferred category.

Undiscovered conventional resources (prognosticated and speculative resources)

Neither prognosticated nor speculative resources are reported in Sweden.

Unconventional resources and other materials

In past editions of the Red Book, the potential for very large, low-grade resources of uranium in the alum shale was noted (300 000 tU mineable in the Billingen area of southern Sweden alone) and limited production was undertaken in the 1960s. By the late 1980s however, the cost of production was considered too high for economic production with uranium prices of the time and these deposits were no longer reported in the Red Book.

With renewed interest in uranium owing to strengthening prices since 2003, exploration of the alum shale in central Sweden was resumed with alternative production methods under consideration to reduce production costs. Continental Precious Minerals has 72 mineral exploration licences throughout Sweden but the company has been focusing on its Viken licence in central Sweden, a black shale deposit with elevated concentrations of uranium, nickel, molybdenum and vanadium with a reported largely inferred resource of 402 925 tU with a grading of 0.014% U. The deposit also contains high values of nickel, molybdenum and vanadium. Continental is investigating mining by a relatively shallow open pit with bioleaching as a process technology.

In late 2009, ASX (Australian Securities Exchange) listed Aura Energy applied for significant landholdings to investigate the alum shale. The company initially reported a JORC compliant *in situ* inferred resource at its Häggån Project of 111 933 tU at 0.013% U. This was subsequently upgraded to 307 692 tU. Further increases can be expected, since the existing resource estimate is based on 15% of the Häggån Project area. A scoping study was completed which examined a range of heap leach options including bioheap leaching, with positive results reported. Aura and AREVA entered into a binding co-operation agreement in February 2013 however, after completing due diligence on the project, AREVA announced in July 2013 that it would not proceed with a proposed partnership to develop the Häggån Uranium and Polymetallic Project.

In December 2011, Tournigan Energy acquired all of Mawson Resource's "non-core" uranium interests in Sweden and Finland and subsequently changed its name to European Uranium Resources Ltd. AREVA, a major shareholder in Mawson, participated in an exclusive private placement with the new company. Mawson's main focus is their Rompas Gold-Uranium Project in Finland and European Uranium Resources's main focus is their Kuriskova uranium deposit in the Slovak Republic. The deal has resulted in Mawson shareholders owning approximately 20.5% of the restructured Tournigan (European Uranium Resources).

Mawson Resources completed work on the Tåsjö Project in 2006 and 2007, investigating uranium contained in mineralised phosphatic shale with rare earth elements in northern Sweden. The area was discovered in 1957 by the Swedish Atomic Energy Company and subsequently explored in the early 1970s by the SGU and the Stora Kopparberg and Boliden companies. The size of the exploration target outlined by the Swedish Atomic Energy Company in the 1960s was confirmed by Mawson at about

42 300 tU at 0.042% U, although the tonnages and grades are considered conceptual at this time.

Clearly there are significant unconventional uranium resources that potentially could be available to the market in future years if costs of production of the bioheap leaching technology under evaluation justify economic production. The deposits also contain high values of molybdenum, vanadium, nickel and zinc.

Uranium production

Historical review

In the 1960s, a total of 200 tU were produced from the alum shale deposit in Ranstad that represents all of Sweden's historical production. This mine is now being restored to protect the environment.

Status of production capability

There is currently no uranium production in Sweden.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1
Name of production centre	Häggån
Production centre classification	Prospective
Date of first production	NA
Source of ore:	
Deposit name(s)	Häggån
Deposit type(s)	Black shales*
Recoverable resources (tU)	96 330
Grade (% U)	0.013
Mining operation:	
Type (OP/UG/ISL)	OP
Size (tonnes ore/day)	80 000
Average mining recovery (%)	NA
Processing plant:	
Acid/alkaline	Acid
Type (IX/SX)	Bioheap leaching
Size (tonnes ore/day)	
Average process recovery (%)	85
Nominal production capacity (tU/year)	3 000
Plans for expansion	
Other remarks	Co-product along with Ni and Mo

* Classified as unconventional resources.

Future production centres

Aura's Häggån Project consists of 110 km^2 in the Storsjön District in Sweden. Uranium occurs along with molybdenum, nickel, vanadium and zinc in black shales which form a 20 to 250-metre-thick near-continuous sheet throughout the area drilled by Aura during the 2008-2011 programmes. A scoping study was completed in February 2012 by independent consultants RMDSTEM Limited using initial pit shells containing >741 Mt ore with much of the prospective area remaining in the tenements untested by drilling. The two stages of bioheap leaching test work show up to 85% uranium extraction, as well as 58% nickel and 18% molybdenum. An annual production rate of 3 000 tU is being considered which would place Häggån in the top five current and planned uranium producers. Aura is now focusing on moving the project into pre-feasibility.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Sweden does not currently use mixed oxide fuel or reprocessed uranium.

Environmental activities and socio-cultural issues

The Ranstad mine was rehabilitated in the 1990s at a total cost of SEK 150 million (Swedish krona; about USD 20 million). An environmental monitoring programme is now being carried out. Local resistance has blocked efforts to renew uranium exploration in the area.

Uranium requirements

By the end of 2005, 2 of Sweden's 12 nuclear power reactors, Barsebäck 1 (1999) and Barsebäck 2 (2005), had been retired from service as a result of a 1980 referendum decision to restrict the construction of new power reactors, bolstered to phase-out nuclear power following the Chernobyl accident. The remaining 10 reactors require about 1 500 to 2 000 tU annually.

Swedish utilities have been expanding nuclear capacity through power uprates at the existing reactors in an effort to replace the 1 200 MWe (gross) lost when Barsebäck 1 and 2 were closed. By the end of 2010, over 1 000 MWe had been added to the ten reactors that remain in operation.

In Sweden, a tax is applied on the production of electricity at nuclear plants, regulated by the Act on Excise Duties on Thermal Capacity on Nuclear Power Reactors. Originally imposed in the late 1990s, the tax rate was increased in 2006 and again in 2008, amounting to a total of about SEK 4 billion (EUR 435 million).

In 2010, the government narrowly voted in favour of two bills that gave new life to the country's nuclear power programme. The first allows for the construction of replacement reactors once the existing reactors have reached the end of their operational lifetime, effectively overturning an earlier decision to phase-out nuclear power. The replacement reactors must be built on the same site as those operating today and construction can only begin once the older plant is permanently shut down (without refurbishment and life extension, the earliest retirements could take place in the early 2020s). The second bill increases the amount of compensation paid by companies who own nuclear reactors and increases by four times the financial liability of these same owners.

Following the Fukushima Daiichi accident, the government ordered a comprehensive review of the current reactor fleet ahead of the EU stress tests, at the same time indicating that the recent legislative changes would not be reconsidered. The national review and the EU stress tests identified a number of measures to strengthen safety, in particular relating to responses to severe accidents, some of which have already been implemented and others are scheduled for implementation. All modernisation and safety upgrades identified for all nuclear plants are to be completed by 2015.

Nationally owned Vattenfall, the largest Nordic utility, filed an application in 2012 to build up to two reactors to replace its older units, noting that an investment decision would not be made for a number of years. In response to the application, the Swedish Radiation Safety Authority indicated that the application process may take up to 15 years in total and that regulations for new reactors would not be finalised until the end of 2014, at the earliest. In 2013, Vattenfall announced a plan to invest USD 2.4 billion between 2013 and 2017 to further modernise and upgrade its five most recently built units (Ringhals 3, 4 and Forsmark 1-3) in order to continue operations for up to 60 years.

Supply and procurement strategy

The utilities are free to negotiate their own purchases.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Two separate permits under the Minerals Act and the Environmental Code are required to mine uranium deposits in Sweden. In addition, the Nuclear Activities Act contains provisions regulating the right to acquire, possess or deal in any other way with nuclear materials or minerals containing such materials.

Permit applications under the Environmental Code are considered by the government and permits may only be granted if approval has been recommended by the local authority in whose areas the deposit occurs.

Uranium stocks

The Swedish parliament decided in 1998 to replace the previous obligation that utilities had to keep a stockpile of enriched uranium corresponding to the production of 35 TWh with a reporting mechanism. Sweden reports no information on uranium stocks.

Uranium prices

As Sweden is now part of the deregulated Nordic electricity market, costs of nuclear fuel are no longer reported.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related			4 248	4 248
Volcanic-related			551	551
Metasomatite			1 696	1 696
Total			**6 495**	**6 495**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified			4 870	4 870	75
Total			**4 870**	**4 870**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified			4 870	4 870	75
Total			**4 870**	**4 870**	

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related			603	603
Volcanic-related			4 849	4 849
Metasomatite			852	852
Total			**6 304**	**6 304**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified			4 725	4 725	75
Total			**4 725**	**4 725**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified			4 725	4 725	75
Total			**4 725**	**4 725**	

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Black shale	200	0	0	0	200	0
Total	**200**	**0**	**0**	**0**	**200**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	200	0	0	0	200	0
Total	**200**	**0**	**0**	**0**	**200**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	200	0	0	0	200	0
Total	**200**	**0**	**0**	**0**	**200**	**0**

Net nuclear electricity generation*

	2011	2012
Nuclear electricity generated (TWh net)	58.0	61.2

* Data from 2013 edition of *OECD Nuclear Energy Data*.

Installed nuclear generating capacity to 2035*

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
9 400	9 400	9 500**	NA	NA	NA	10 100	NA	NA	NA	10 100	NA	NA	NA

* *Data from 2013 edition of OECD Nuclear Energy Data.*

** Secretariat estimate.

Annual reactor-related uranium requirements to 2035 (excluding MOX)*

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
1 468	1 468	NA	NA	NA	1 900	NA	1 900	NA	1 900	NA	1 900	NA	1 900

* *Data from 2013 edition of OECD Nuclear Energy Data.*

Tanzania*

Uranium exploration and mine development

Historical review

Uranium was first discovered in Chiwiligo pegmatite in the Uluguru Mountains in 1953. The first general evaluation of uranium potential of Tanzania was a country-wide airborne geophysical survey for the government between 1976 and 1979. Results revealed a large number of radiometric anomalies in a variety of geological settings.

A uranium exploration programme was subsequently carried out by Uranerzbergbau GmbH between 1978 and 1983, but was stopped because of declining uranium prices. Targets of this survey were anomalies in the Karoo, in younger surficial sediments, in phosphatic sediments of Pleistocene age and carbonatite of the Gallapo. Numerous occurrences of surface uranium mineralisation were identified and the potential for several uranium deposit types in the country were recognised.

A large part of the southern Tanzanian geology is comprised of Karoo rocks, terrigenous sediments of a few thousand metres of thickness that accumulated in basins during the Late Paleozoic-Early Mesozoic. The basal series is comprised of glacial deposits, which in turn are overlain by fluvial-deltaic coal-bearing sediments succeeded by arkoses and continental red beds. Transitional carbonaceous shales with coals gradually develop into thick lacustrine series which are topped by Late Permian bone-bearing beds. The Triassic is characterised by a very thick fluvio-deltaic succession of siliciclastics resting with regional unconformity on the Permian. This Early Triassic sequence exhibits well-developed repetitive depositional cycles. Heightened uranium values are observed in the Triassic arenaceous series with diagenetic alteration and subsequent cementation.

Recent and ongoing uranium exploration and mine development activities

Mantra Resources completed an environmental and social impact assessment in 2011 and submitted the reports to the Tanzanian National Environmental Management Council in support of an application for a mining licence. Mantra Resources was acquired in 2011 by the Russian Atomredmetzoloto (ARMZ). An updated resource of the Nyota deposit estimate in September 2011 boosted total *in situ* resources by over 40% to 119.4 Mlbs U_3O_8 (45 924 tU) and formed the basis of a feasibility study.

Drilling activities and historical data analysis resulted in a 28% total resources increase in March 2013 to 152.1 Mlbs U_3O_8 (58 505 tU), including 124.6 Mlbs U_3O_8 (47 927 tU) measured and indicated at an average grade of 303 ppm U_3O_8 (0.0257% U) at a 100 ppm U_3O_8 (0.0085% U) cut-off grade. Exploration potential has been identified in areas adjacent to Nyota. In 2012, Mantra Resources continued regional exploration drilling at the Mkuju River regional area and near Nyota, which focused on new mineralised zones and resources estimation.

* Secretariat estimate based on company reports and other publicly available data.

Recent activity at the Mkuju River Project focused on feasibility study optimisation and update, licensing and permitting. An application for a special mining licence has been submitted to the Tanzanian authorities. In June 2012, the UNESCO World Heritage Committee approved an application by the Tanzanian government for a minor adjustment to the boundary of the Selous World Heritage Game Reserve removing the Mkuju River Project and an adjacent buffer zone from the Selous World Heritage Game Reserve site. The Mkuju River uranium mine project obtained an environmental impact assessment certificate in October 2012 from the Tanzanian government and in April 2013, a mining licence was granted to Mantra.

Drilling to date by Uranex at Likuyu North has identified a mineralised zone extended to 2.6 km of the 5 km zone defined by the surface radiometric anomaly. In April 2012, a maiden resource was estimated at 6.1 Mlb U_3O_8 (2 346 tU) with an average grade of 237 ppm U_3O_8 (0.02% U) reported at a 100 ppm U_3O_8 (0.0085% U) cut-off grade. Efforts have been undertaken to define economic uranium mineralisation within the project area that is not associated with surface radiometric anomalism and three zones were targeted for drilling at Likuyu North during the 2012 drilling programme.

Uranium Resources Plc. completed 159 diamond drill holes (39 000 m) and announced the maiden resource of 3.6 Mt ore containing 2 Mlb U_3O_8 (769 tU) with grading of 255 ppm U_3O_8 (0.00216% U) at the Mtonya Project. The resource is potentially amenable to *in situ* leach recovery. The uranium mineralisation is known to occur to depths of 350 m in continuous 30- to 50-metre-wide roll fronts. In total, three tiers of redox up to 200 m thick were identified.

In 2010, a Memorandum of Understanding signed between Japan Oil, Gas and Metal National Corporation and the Geological Survey of Tanzania has resulted in the two institutions joining efforts to explore and assess mineral resources in the country.

In 2013, Australian-based East African Resources Ltd (EAR) obtained prospecting licences for the Madaba property, where work carried out from 1979-1982 by Uranerzbergbau GmbH identified six anomalous uranium zones. The site is also located within the Selous World Heritage Game Reserve. EAR has commissioned an environmental impact assessment as requested by the Ministry of Natural Resources and Tourism (MNRT) in support of an application for site access.

Mantra Resources contributed 75% to the total metres drilled for uranium exploration in Tanzania during 2010-2013 and 88% to the total number of drill holes. The bulk of Mantra's exploration expenditures have been devoted to new resources identification at the Nyota deposit and resources conversion from inferred to RAR. The remaining exploration drilling was carried out by Uranex at Likuju North and by Uranium Resources Plc. at the Mtonya deposit. The table does not include feasibility study expenditures for the Mkuju River Project development.

All development expenditures in Tanzania were invested by Mantra Resources for the Mkuju River feasibility study. Since 2012, Mantra also started to invest in detailed engineering and grade control projects for the Mkuju River development.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Currently total identified *in situ* uranium resources from four areas in Tanzania amount to 72 738 tU, an increase of 60% compared to the total reported in 2011. Over 80% of the total relates to the Nyota sandstone deposit at Mkuju River. It contains 47 927 tU of measured and indicated and 10 578 tU of inferred resources all in the <USD 80/kgU cost category (<USD 31/lb U_3O_8).

The Manyoni playa lake calcrete deposits make up 11 146 tU of identified resources of which 9 477 tU is inferred. The remaining resource includes two sandstone-type deposits: the Likuju North of 2 312 tU and the Mtonya deposit which comprises 775 tU and is potentially *in situ* recovery amenable.

Undiscovered conventional resources (prognosticated and speculative resources)

Undiscovered resources are not reported, however there is potential for sandstone-type uranium deposits in Karoo sediments in several areas.

Uranium Production

There has been no uranium produced in Tanzania.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1
Name of production centre	Mkuju River
Production centre classification	Planned
Date of first production	2017
Source of ore:	
Deposit name(s)	Nyota
Deposit type(s)	Sandstone
Recoverable resources (tU)	31 700
Grade (% U)	0.0425
Mining operation:	
Type (OP/UG/ISL)	OP
Size (tonnes ore/day)	18 000
Average mining recovery (%)	90
Processing plant:	
Acid/alkaline	Acid
Type (IX/SX)	Resin-in-pulp
Size (tonnes ore/day); For ISL (mega or kilolitre/day or litre/hour, specify)	18 000
Average process recovery (%)	85
Nominal production capacity (tU/year)	3 000
Plans for expansion	
Other remarks	Feasibility study updated in 2013. Feed phase studies are under development

Future production centres

The initial Mkuju River feasibility study was completed in 2011 and updated in 2013. The 2013 definitive feasibility study was based on 2012 resource estimates, new technical optimisation and cost reduction calculations. Steady state production is expected to be reached in two years, based on average annual steady state throughput of 7 million tonnes of ore feed. Life of the facility is estimated at 11 years (including 1 year of ramp-up), with potential to be extended longer subject to drilling of the inferred resources and nearby targets. The average strip ratio over the life of mine is 1:4.1. The process plant is based on conventional acid leach and resin-in-pulp technology. The overall metallurgical uranium recovery was about 85%. Further evaluation is ongoing. Development of the Mkuju River uranium mine project is still uncertain with an estimated date of start-up around 2017.

The potential of ISL amenability for a part of the Nyota deposit uranium resources located outside the open-pit area and below the water table is under consideration. ISL tests were completed in 2013 and planned to be followed up in 2014, pending permission from Tanzanian authorities.

Environmental activities and socio-cultural issues

The Tanzanian government has worked to allay public concerns over the prospect of uranium mining. The environmental, health, economic and social impacts are to be carefully considered and the government indicated that it is aware of the high safety standards required for uranium mining in order to protect people and the environment.

Elephant poachers have taken advantage of the road constructed for access to Mkuju River Uranium Project, located in the area excised from the Selous World Heritage Game Reserve. The operator has a project team with instructions to resist poaching efforts, setting up a special task force using helicopters and unmanned aircraft to locate the poachers. The UNESCO World Heritage Committee is monitoring the situation since all of its demands must be met in order to fulfil the Mkuju River project requirements.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

In 2010, the Tanzanian government substantially amended the Mining Act of 1998. The revised act increased royalty payments for mineral extraction on the gross value of minerals produced (from 3% to 5% for uranium) and mandated the government the ability to acquire shareholdings in future mining projects through a development agreement negotiated between the government and the mineral rights holder. The Parliamentary Committee for Energy and Minerals in Tanzania has directed that no mining of uranium can take place until a policy and legislation on extraction are in place.

The IAEA conducted a Uranium Production Site Appraisal Team (UPSAT) review in 2013, providing recommendations to the country, a new comer to uranium mining, in the application of international good practices and preparations for planned uranium mining activities. The scope of the appraisal process included exploration, resource assessment, planning, environmental and social impact assessment, mining, processing, waste management, site management, remediation and final closure.

Uranium stocks

None.

Uranium exploration and development expenditures and drilling effort – domestic

(USD thousands)

	2010	2011	2012	2013 (expected)
Industry exploration expenditures	8 052	9 557	14 674	2 000**
Government exploration expenditures	0	0	0	0
Industry* development expenditures	15 731	16 000	14 197	5 960
Government development expenditures	0	0	0	0
Total expenditures	**23 783**	**25 557**	**28 871**	**7 960****
Industry* exploration drilling (m)	158 979	62 771	72 435	4 970
Industry* exploration holes drilled	2 431	720	660	61
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Industry* development drilling (m)	0	0	1 457	12 487
Industry* development holes drilled	0	0	34	368
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	158 979	62 771	72 435	4 970
Subtotal exploration holes drilled	2 431	720	660	61
Subtotal development drilling (m)	0	0	1 457	12 487
Subtotal development holes drilled	0	0	34	368
Total drilling (m)	**158 979**	**62 771**	**73 892**	**17 457**
Total number of holes drilled	**2 431**	**720**	**694**	**429**

* Non-government.

** Secretariat estimate.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		47 927	48 889	48 889
Surficial			1 669	1 669
Carbonate				
Total		**47 927**	**50 558**	**50 558**

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)		47 927	50 558	50 558
Total		**47 927**	**50 558**	**50 558**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from OP		47 927	50 558	50 558
Total		**47 927**	**50 558**	**50 558**

* *In situ* resources.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		10 578	12 703	12 703
Surficial			9 477	9 477
Total		**10 578**	**22 180**	**22 180**

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)		10 578	21 405	21 405
Total		**10 578**	**22 180**	**22 180**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from OP		10 578	21 405	21 405
In situ leaching acid			775	775
Total		**10 578**	**22 180**	**22 180**

* *In situ* resources.

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	0	0	0	0	3 000	0	

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	2 000	0		0	0	0	1 000	0	0	0	0

Thailand

Uranium exploration and mine development

Historical review

Uranium exploration was carried out in the early 1970s by the Royal Thai Department of Mineral Resources (DMR). Uranium occurrences were found in various geological environments including sandstone and granite host rocks. Sandstone-type mineralisation occurs in the Phu Wiang district of the Khon Kaen provinces, north-eastern Thailand. This area had been independently investigated by DMR. The area was investigated in co-operation with foreign organisations. The granite-hosted uranium occurrences associated with fluorite were discovered in the Doi Tao district, Chiang Mai province and the Muang district of Tak provinces, northern Thailand. These occurrences have received the most attention.

The most important uranium exploration activity carried out in Thailand is the nationwide airborne geophysical survey completed between 1985 and 1987. The survey was conducted by Kenting Earth Sciences International Limited of Canada, as contractor to DMR.

Recent and ongoing uranium exploration and mine development activities

There is no known recent or ongoing uranium exploration or mine development activities in any part of Thailand.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

There has been no production history of conventional resources, so there is no identified conventional resource.

Undiscovered conventional resources (prognosticated and speculative resources)

There are no known undiscovered conventional resources.

Unconventional resources and other materials

There has been active study in uranium extraction from Thailand's seawater since the end of 2011. To date, no U_3O_8 has been separated and purified yet. The objective of the study is to study the extraction technique, rather than the actual amount and rate of recovery of the uranium.

Uranium production

Historical review

There has been no historical uranium production in Thailand.

Status of production facilities, production capability, recent and ongoing activities and other issues

There is no past or current production facility in Thailand.

Ownership structure of the uranium industry

NA.

Employment in the uranium industry

None.

Future production centres

In the future, if uranium extraction from seawater becomes economically competitive, the Electricity Generating Authority of Thailand (EGAT) may consider investment in a production centre. But, for now, there is no foreseeable plan.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

There is no production or use of MOX fuels in Thailand.

Production and/or use of re-enriched tails

There is no production or use of re-enriched fuels in Thailand.

Production and/or use of reprocessed uranium

There is no production or use of reprocessed uranium in Thailand.

Regulatory regime

There is no regulatory regime for uranium mining in Thailand because there is no uranium industry here. But currently, the Office of Atoms for Peace (OAP) is the regulator on the use of atomic energy in Thailand. So if there is a uranium mining industry in Thailand in the future, OAP will most likely be the main agency responsible for regulation.

Uranium requirements

After the Fukushima Daiichi accident and unsatisfactory public acceptance in nuclear energy, the government postponed the first two units to be connected to the grid in 2026 and 2027. However, the government has not made any formal decision to go nuclear yet. The uranium requirement is based on the assumption that the first plant will start operation in 2026 and the second plant in 2027. Each unit will produce about 1 000 MWe.

Supply and procurement strategy

All fuel assemblies for future nuclear power plants will be purchased from overseas. There is no current plan on future procurement strategy. There is no plan in the foreseeable future to setup a fuel production plant in Thailand.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

There is no current government policy on uranium. But, there are laws and regulations on the use of atomic energy and radioactive materials. Uranium import and export is included in these laws. The laws are the Atomic Energy for Peace Act B.E. 2504 (1961) and the Ministerial Act on Licensing and Management Procedures for Special Nuclear Materials B.E. 2550 (2007).

Uranium stocks

There is no uranium stock for use in nuclear power reactors in Thailand.

Uranium prices

There is no known uranium transaction in Thailand, so there is no public data on uranium price in Thailand.

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
0	0	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		0	0	0	0	0	0	0	0	0	3 000	0	3 000

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
0	0	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		0	0	0	0	0	0	0	0	0	480	0	480

Note: No first core loads for three new plants are included in the uranium requirements data. The uranium requirement figures provided do not include plans to build an inventory of uranium.

Turkey

Uranium exploration and mine development

Historical review

General Directorate of Mineral Research and Exploration (MTA)

Uranium exploration in Turkey began in 1956-1957 and was directed towards the discovery of vein-type deposits in crystalline terrain, such as acidic igneous and metamorphic rocks. As a result of these activities, some pitchblende mineralisation was found but these occurrences did not form economic deposits. Since 1960, studies have been conducted in sedimentary rocks which surround the crystalline rock and some small orebodies containing autunite and torbernite mineralisation have been found in different parts of the country. In the mid-1970s, the first hidden uranium deposit with black ore, below the water table, was found in the Koprubaşı area. As a result of these exploration activities, a total of 9 129 tU_3O_8 (7 740 tU) *in situ* resources were identified in the Manisa-Köprübaşı (2 852 tU_3O_8; 2 419 tU), Uşak-Eşme (490 tU_3O_8; 415 tU), Aydın-Koçarlı (208 tU_3O_8; 176 tU), Aydın-Söke (1 729 tU_3O_8; 1 466 tU) and Yozgat-Sorgun (3 850 tU_3O_8; 3 265 tU) regions.

Eti Mine Works General Management (Eti Maden)

State-owned Eti Maden is responsible for a total of six uranium sites with uranium resources. Geological exploration has been performed by MTA at these sites in the past. Between 1960-1980 uranium exploration was performed by aerial prospecting, general and detailed prospecting on-site, geologic mapping studies and drilling activities. These uranium sites were transferred to Eti Maden as possible mines which can be operated by the state under law number 2840 on the "Operation of Boron Salts, Trona and Asphaltite Mines and Nuclear Energy Raw Materials" (10 June 1983).

Recent and ongoing uranium exploration and mine development activities

General Directorate of Mineral Research and Exploration (MTA)

In 2011, granite, acidic igneous and sedimentary rocks around Kütahya, Uşak and Manisa (an area of approximately 5 000 km^2) were explored for radioactive raw materials. Studies have also been performed in sites licenced by Eti Maden inside Manisa, Uşak and Aydın.

In 2012, granite, acidic igneous and sedimentary rocks around Manisa, Denizli and Aydın (an area of approximately 5 000 km^2) were explored for radioactive raw materials. Exploration for radioactive raw materials was also performed in sites licenced by MTA inside Manisa, Uşak and Nevşehir.

In 2013, granite, acidic igneous and sedimentary rocks around Aydın and Denizli (an area of approximately 5 000 km^2) will be explored for radioactive raw materials. Exploration for radioactive raw materials will also be performed in sites licenced by MTA inside Manisa, Uşak and Nevşehir.

Private sector exploration

Adur, a wholly owned subsidiary of Anatolia Energy, a Turkish uranium exploration company with current and active drill programmes at the Temrezli and Sefaatli uranium sites, has carried out exploration and resource evaluation drilling with a total of 69 drill holes completed for a total drill advance of over 8 500 m in the last two years (2011 and 2012). This drilling was in the Yozgat province, primarily in the Temrezli region. To date, 83 holes for over 10 000 m have been completed. The drilling in Temrezli, mostly twinning the earlier MTA drill holes but also in-fill and step-out holes, confirmed work conducted in the 1980s and extended the uranium mineralisation to the north-east over a strike length of more than 3 000 m.

All drill holes were geologically and geophysically logged, the latter using the company's matrix system from Mount Sopris with a probe-type 2PGA-1000 to record gamma ray intensity in counts per second (cps), electrical self-potential and single-point electrical resistance.

In 2011, CSA Global Pty Ltd prepared a JORC compliant mineral resource estimate for the Temrezli deposit of 17.4 Mlb U_3O_8 (6 693 tU) indicated and inferred *in situ* uranium at an average grade of 1 170 ppm (0.117% U_3O_8, or 0.01% U).

The resource estimate was based on a 3-D interpretation of uranium mineralised lenses, followed by geostatistical analysis and grade interpolation within the mineralised lenses. Approximately 61% of the resource is contained in two discrete lenses of mineralisation with a high level of grade continuity and consistent thickness at an average depth of 120 m. Preliminary metallurgical bottle-roll leach test work confirmed MTA's earlier work and returned 93% and 90% uranium recovery using an acid or alkali leach, respectively.

Hydrological test drilling was initiated at Temrezli in late 2012 in order to assess the regional groundwater conditions and to conduct hydraulic testing of the mineralised horizons at a scale typically seen at ISL operations. This programme was planned by Errol Lawrence of HydroSolutions, a US-based hydrogeologist with considerable experience in ground water conditions relating to uranium ISL operations throughout western United States. The test confirmed the aquifer has sufficient flow rate for ISL mining.

Regional exploration identified new areas of mineralisation, at West Sorgun and Akoluk. The rotary and diamond drill programme tested a number of regional sites that are considered prospective for Eocene-aged sediment-hosted uranium mineralisation, similar to what is seen at the Temrezli uranium deposit.

At West Sefaatli, Sefaatli, East Sefaatli, Akoluk and Sorgun, first pass drilling was completed at a number of sites that lie peripheral to the regional granite batholith that contain mapped outcrops of the target Eocene sediments. The results received from gamma logging of the regional holes ranged from naturally occurring background values to elevated and anomalous responses up to five times background for holes in the West Sorgun and Akoluk areas. Second phase, follow-up drilling is planned to be undertaken at West Sorgun to better evaluate the extent and tenor of the recently discovered anomalous cps values.

A limited drilling programme in the Sefaatli area confirmed sporadic uranium mineralisation first discovered by the MTA in the 1980s. This is the region's second most significant occurrence of uranium mineralisation with equivalent uranium values up to 1 310 ppm eU_3O_8 for mineralised lenses 1.4 m thick at depths between 20 and 43 m. These results combined with a high water table and a sandstone-rich stratigraphy, suggest that the mineralisation style appears similar to that observed at Temrezli and thus may be amenable to ISL mining.

Adur has planned a drilling programme of approximately 50 bore holes for the autumn 2013 period. This programme will consist of drilling at the Temrezli uranium deposit and regional exploration areas beginning with the Sefaatli prospect. In addition to the drilling programme, a second phase of hydrological testing is to be carried out in the Temrezli region. Exploration and development drilling is to continue in 2013 at the şefaatli prospect and is expected to increase the known uranium resources to approximately 5-6 Mlb U_3O_8 (1 925-2 310 tU).

Since early stage studies indicate that the Temrezli uranium deposit will be amenable to ISL mining, a preliminary economic assessment (PEA) contract was awarded to US-based WWC Engineering of Sheridan, Wyoming. The PEA is expected to be completed in 2013. The initial focus of the PEA will be the production of up to 1 Mlb U_3O_8 (385 tU) by ISL for an initial mine life of up to ten years. Additional exploration and development drilling at the Temrezli Project is to be conducted and this work is expected to increase the resource to as much as 3 Mlb U_3O_8 (1 155 tU).

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Identified conventional uranium resources in Turkey determined from exploration activities performed by MTA in the past are listed on the next page, with the addition of JORC compliant resources identified through recent work by Adur exploration, described in more detail on the next page:

- Manisa-Köprübaşı: 2 852 tU in ten orebodies and at grades of 0.04-0.05% U_3O_8 (0.034-0.042% U) in fluvial Neogene sediments.
- Uşak-Eşme: 490 tU at 0.05% U_3O_8 (0.042% U) in Neogene lacustrine sediments.
- Aydın-Koçarlı: 208 tU at 0.05% U_3O_8 (0.042% U) in Neogene sediments.
- Aydın-Söke: 1 729 tU at 0.08% U_3O_8 (0.068% U) in gneiss fracture zones.
- Yozgat-Sorgun: 6 700 tU at 0.1% U_3O_8 in Eocene deltaic lagoon sediments.

Undiscovered conventional resources (prognosticated and speculative resources)

None reported.

Unconventional resources and other materials

None reported, but grassroots exploration is in place.

Uranium production

Historical review

Research on laboratory-scale production of uranium yellow cake and the production of nuclear fuel was performed in the past (7th National Development Plan of the Republic of Turkey between 1996 and 2000).

Status of production facilities, production capability, recent and ongoing activities and other issues

None reported.

Environmental activities and socio-cultural issues

An EIA is not required by the Ministry of Environment and Urbanisation for uranium exploration. However, an EIA is required with an application for a licence to operate a uranium mine. Licensing for exploration and mine development activities in wildlife protection and development sites require the submission of an EIA report.

Regulatory regime

In Turkey, nuclear installations are licensed by the Turkish Atomic Energy Authority (TAEK) regarding nuclear safety, security and radiation protection issues. The licensing procedure for nuclear fuel cycle facilities is laid out in the "Decree on Licensing of Nuclear Installations". According to this decree nuclear fuel cycle facilities are:

- mining, milling and refining facilities;
- conversion facilities;
- enrichment facilities;
- nuclear fuel element fabrication facilities;
- reprocessing facilities for used fuel elements;
- radioactive waste management facilities for processing the radioactive wastes (including final storage).

TAEK was established by the "Law on Turkish Atomic Energy Authority" in 1982. TAEK is a government body reporting to the Prime Minister. TAEK has been affiliated with the Ministry of Energy and Natural Resources (MENR) since 2002 and has missions to both promote and regulate nuclear facilities in Turkey. As a result, TAEK is not an independent regulatory body. However, an independent regulatory body in compliance with international standards has been envisaged in the draft Nuclear Energy Law.

The licensing procedure for nuclear fuel cycle facilities is initiated by an application from the owner to be recognised as such. The licensing process comprises three main stages in succession: site licence, construction licence and operating licence. There are several permits functioning as hold points during the licensing process, such as a limited work permit, start test operating, pre-operational test permit, full capacity work permit, permission to restart operations and permission to modify the installation. For each authorisation, documents required for review and assessment of TAEK are defined in the decree. The authorisation process for the decommissioning stage is not defined in the decree however; authorisation for decommissioning will be defined in a draft law and other relevant legislation.

The Law on Mining (number 3213) of 4 June 1985 includes articles for environmental remediation during and after mining activities. Mining organisations must submit a financial bond for environmental remediation prior to the issuance of a mining licence. After mining activities have been completed and the site has been environmentally remediated, the submitted financial bond is returned to the mining organisation. In case the financial bond is not sufficient to implement environmental remediation activities, additional costs are requested from the operator according to law number 6183.

Uranium requirements

There are no nuclear power plants in operation, under construction or decommissioned in Turkey. However, Turkey has been considering building a nuclear power plant since the 1970s. Rising energy demand, import dependence and industrial activity are the driving forces behind Turkey's move toward developing a civil nuclear power generation programme. Turkey's recent efforts in this area can be characterised as a first-of-a-kind approach in the nuclear sector and has been referred to as an intergovernmental agreement (IGA) model, with long-term contracts in the frame of power purchase agreements (PPA). In this approach, a project company undertakes to design, build, operate and maintain a power plant, whereas the Turkish government is responsible for providing the site, various financial and non-financial guarantees, construction support and licensing. The project company is also responsible for managing wastes and decommissioning the facility.

An IGA, signed with the Russian Federation for the construction of four VVER-1200 units at the Mediterranean Akkuyu site, entered into force on 21 July 2010. The Russian side established a project company in Turkey and it started site surveys and EIA studies. The Russian side will have the majority share of the power plant and own the plant during its entire operational lifetime. Turkey also signed an IGA with Japan on 3 May 2013 to build four ATMEA1 units at the Black Sea Sinop site. This agreement will be presented to the Turkish parliament for ratification together with the respective annexes, attachments and appendices under negotiation. In this respect, the fuel cycle strategy and all related issues of the nuclear power plant, to be established in Sinop, will be identified and settled after negotiations are finalised.

Supply and procurement strategy

In order to promote private sector investments for the construction and operation of nuclear power plants, the Law on the Construction and Operation of Nuclear Power Plants and Energy Sale, numbered 5710 and dated 9 November 2007 ("Nuclear Law") was enacted in Turkey. Article 3 of the Nuclear Law states that the procedures and principles regarding fuel supply shall be prepared by the Ministry of Energy and Natural Resources and set up in a regulation which shall come into force with the approval of the Council of Ministers.

Provisions related to fuel supply for the Akkuyu NPP have been included under the IGA signed with the Russian Federation for the construction of the four VVER-1200 units. Under Article 12 of this agreement it is stated that nuclear fuel shall be sourced from suppliers on the basis of long-term agreements between the project company established by the Russian side in Turkey and the suppliers.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The law on the "Operation of Boron Salts, Trona and Asphaltite Mines and Nuclear Energy Raw Materials" numbered 2840 and dated 10 June 1983 states that the exploration and operation of such mines are carried out by the state.

Mining Law numbered 3213 (dated 4 June 1985) classifies uranium reserves under the 6th group of mines together with all other radioactive minerals and supersedes law number 2840. Article 49 of law number 3213 states that provisions under law number 2840 are preserved, although private companies are now allowed to explore for and operate thorium and uranium mines. Article 50 states that exploration and operation of thorium and uranium mines are subject to this law and the minerals extracted can only be sold to entities determined by the Council of Ministers.

Uranium stocks

Uranium stocks in Turkey consist of natural uranium used by the Çekmece Nuclear Research and Training Center affiliated to Turkish Atomic Energy Authority for research purposes.

Uranium exploration and development expenditures and drilling effort – domestic

(TRY [Turkish lira] – excluding VAT)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures			3 255 000	500 000
Government exploration expenditures	228 950	1 076 492.40	1 366 696	3 350 000
Industry* development expenditures	490 000	2 015 000	530 000	2 000 000
Government development expenditures	46 477	498 459		
Total expenditures	**765 427**	**3 589 951**	**5 151 696**	**5 850 000**
Industry* exploration drilling (m)			3 098	1 087
Industry* exploration holes drilled			27	12
Government exploration drilling (m)			6 172	11 250
Government exploration holes drilled			30	50
Industry* development drilling (m)	1 392	5 137	504	3 985
Industry* development holes drilled	7	38	4	38
Government development drilling (m)		1 241.20		
Government development holes drilled		7		
Subtotal exploration drilling (m)			9 270	12 337
Subtotal exploration holes drilled			57	62
Subtotal development drilling (m)	1 392	6 378.20	504	3 985
Subtotal development holes drilled	7	45	4	38
Total drilling (m)	**1 392**	**6 378.20**	**9 774**	**16 322**
Total number of holes drilled	**7**	**45**	**61**	**100**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		7 705	7 705	7 705
Metamorphite		1 730	1 730	1 730
Total		**9 435**	**9 435**	**9 435**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)		5 280	5 280	5 280
Unspecified		4 155	4 155	4 155
Total		**9 435**	**9 435**	**9 435**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Heap leaching** from OP		5 280	5 280	5 280
Unspecified		4 155	4 155	4 155
Total		**9 435**	**9 435**	**9 435**

* *In situ* resources.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		2 545	2 545	2 545
Total		**2 545**	**2 545**	**2 545**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified		2 545	2 545	2 545
Total		**2 545**	**2 545**	**2 545**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified		2 545	2 545	2 545
Total		**2 545**	**2 545**	**2 545**

* *In situ* resources.

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	0	0	0	0	0	NA	1 200	NA	7 040	NA	9 280	NA	9 280

Annual reactor-related uranium requirements to 2035 (excluding MOX)*

(tonnes UO_2)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
0	0	0	0	0	0	0	87**	0	90	NA	90	NA	90

* Values are estimates for the Akkuyu NPP and will be determined after completion of plant design.

** First core load of the Akkuyu NPP's first unit is included in the data.

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	1.97				
Total	**1.97**				

Ukraine

Uranium exploration and mine development

Historical review

Prospecting for uranium in Ukraine began in 1944 as an update of earlier work and mining activities in the North Krivoy Rog ore area. The Pervomayskoye and Zheltorechenskoye uranium deposits were discovered and following mine development were mined out in 1967 and 1989 respectively. The first sandstone-type deposits (Devladovskoye) were discovered in 1955.

In the mid-1960s, the main geological exploration was concentrated in the Kirovograd ore region for discovery of metasomatite-type uranium deposits. The Michurinskoye, Vatutinskoye, Severinskoye, Central and Novokonstantinovskoye deposits were discovered as a result of this work.

Metasomatite-type deposits comprise the bulk of uranium resources in Ukraine, with uranium content in ores about 0.1-0.2%. These deposits are considered suitable for mining.

The second kind of economic deposit is the sandstone-type, but they comprise only a small part of the total resource base. Uranium contents in sandstone deposits range between 0.02 and 0.06%. They are suitable for extraction by ISL.

Ongoing uranium exploration and mine development activities

Using exploration criteria and indications on the basis of international and national practice, specialists of SE "Kirovgeology" compiled a new prediction map of Ukraine for uranium at a scale 1:500 000, where ore areas and potential ore regions and geological nodes have been distinguished based on potential for finding deposits of different geological types. Ore grades of these prospective deposits are expected to surpass the currently known metasomatite-type deposits.

In 2011-2012, prospecting work for discovery of deposits of different geological/ commercial types was conducted. This included prospecting of sandstone-type uranium deposits on the Troytskaya (45 km^2) and Vladimirskaya (26 km^2) geological squares and for vein-type uranium deposits on the Rozanovskaya geological square (45 km^2) at a scale of 1:25 000.

In addition, geological prognostic work at a scale of 1:25 000 within the southern part of the Kirovogradskiy uranium ore fault was undertaken to locate uranium ore occurrences. Prospecting for uranium deposits (granite-related type) in the Pokrovskiy territory (14 km^2) of the west Ingulskiy zone, at a scale 1:10 000, along with prospecting for rich uranium ore occurrences in the crystalline foundation of Ukrainian Shield, within the borders of the Nikolaevskiy ore field.

Estimation of the Dibrovskoye REE-thorium mineralisation within the Pryazov block of the Ukrainian Shield was initiated with an assessment of prognosticated uranium and thorium resources. Exploration is planned for metasomatite-type deposits, particularly within the areas of current operating mines.

A project to evaluate the metal genetic potential and thorium potential in the Precambrian rocks of the Ukrainian Shield was undertaken. During the work, 1 372 ore occurrences were analysed including 184 thorium occurrences. As a result, a genetic classification of thorium occurrences was completed which included 5 genetic type and 12 subtypes of thorium occurrences in the Precambrian rocks. A map was completed of thorium occurrences in the Precambrian foundation of Ukrainian Shield at a scale of 1:500 000 and 1:1 000 000. As a result, prospective regions for thorium in the territory of the Ukrainian Shield were identified, including 2 metal genetic districts, 3 metal genetic zones and 30 perspective ore areas with total thorium potential of about 251.7 thousand tonnes Th. For estimation of prognostic resources within the aforementioned territories, it is proposed to proceed with geological prognostic work at a scale of 1:200 000 and 1:50 000.

Government and private companies in Ukraine do not conduct any exploration for uranium in other countries. Neither foreign government nor private companies conduct uranium exploration activities in Ukraine.

Ukraine thorium deposit types and speculative resources

(Tonnes Th)

Deposit type	Resources kilo T (*in situ*)
Carbonatite	0
Placer	0
Granite-related	53 940
Alkaline rocks	37 037
Metasomatite	150 439
Metamorphic	10 253
Other	0
Total	**251 663**

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As on 1 January 2013, identified uranium resources (RAR and IR) recoverable at costs <USD 260/kgU amounted to a total of 223 620 tU. Uranium resources recoverable at costs <USD 80/kgU totalled 59 642 tU. Mining and processing losses are taken into account in these figures. These represent a slight decline in resource figures reported in 2011, due principally to depletion by mining.

The main uranium resources of economic interest are concentrated in Ukraine within two types of deposits:

- Metasomatite-type mono-metallic deposits located within the Kirovograd ore block of the Ukrainian Shield. The uranium content in the ore is about 0.1-0.2% U and the deposits are considered suitable for underground mining.
- Sandstone-type uranium deposits located within the Dnieper-Bug metallogenic area (17.3 thousand km^2). In addition to uranium, molybdenum, selenium and rare earth elements of the lanthanide group occur in these areas. Uranium content in the ore ranges between 0.01 to 0.06% U. These deposits are considered suitable for recovery by ISL.

Undiscovered resources (prognosticated and speculative resources)

Undiscovered resources are estimated at 277 500 tU. From this total, prognosticated resources, mainly confined to the flanks of existing deposits, total 22 540 tU. Speculative resources are estimated to amount to 255 000 tU. The resources were calculated in consideration of prediction-prospecting works in the Central-Ukrainian metallogenic area and 1:500 000 uranium prognostication maps compiled by "Kirovgeology". They are subdivided according to geological types as follows:

- 133 500 tU of metasomatite-type;
- 20 000 tU of sandstone deposits on the Ukrainian Shield;
- 16 500 tU of sandstone (in bitumen) outside the Ukrainian Shield;
- 40 000 tU of unconformity-type deposits;
- 30 000 tU of granite-related type deposits;
- 15 000 tU of "intrusive" potassium metasomatite deposits.

Uranium production

The mining of uranium ore began in 1946 at deposits Pervomayskiy and Zheltorechenskiy by the conventional underground method. In 1949, the first Ukraine uranium processing plant, the Pridneprovskiy Chemical Plant (PCP) in the town of Dneprodzerzhinsk, started production. In 1951, the government created the Vostochnyi mining-processing combinat (VostGOK) in the city of Zheltye Vody in the Dnepropetrovsk region to mine and process ores from Pervomayskiy and Zheltorechenskiy deposits in the North Krivoy Rog area. The Pervo-mayskiy deposit was completely mined out in 1967 and the Zheltorechenskiye deposit in 1989. In 1959, the second uranium processing plant was built in the town of Zheltye Vody.

Today VostGok operates uranium production facilities in the central Ukrainian ore province by mining the Michurinskiy (3 km south of Kirovograd) and Vatutinskiy deposits (near the town of Smolino). VostGOK began mining the Novokonstantinovskiy deposits in 2011, which are located 40 km west of Kirovograd and plans to begin mining the Severinskiy deposits in 2020 (4 km north of Kirovograd).

The Michurinskiy deposits were discovered in 1964 and in 1967 construction of the Ingulsky mine began. The average uranium content of these orebodies is about 0.1% U. Radiometric sorting, conducted at the mine, increases the uranium content of ore delivered to the processing plant to about 0.1-0.2%. Two shafts, 7 m in diameter, have been sunk. The ore is lifted along the northern shaft in two buckets with a loading capacity of 11 tonnes. The southern shaft is used for transporting workers and provisions and for other technical purposes. A ventilation shaft supplies 480 m^3 of fresh air per second to the underground mine. Mining is conducted in blocks 60-70 m in height at depths of 90 m, 150 m and 240 m below the surface.

The Central deposit is mined by two shafts to horizons at 380 m and 1 000 m. It is connected to the Michurinskiy deposit by an underground transport drift 5.2 km long at the 300 m level. The ore is transported by drift on elevating shafts of the Ingulskiy mine.

The Vatutinskiy deposits were discovered in 1965 and in 1973 construction of the Smolinsky mine began. The industrial area of the Smolinsky mine is situated 80 km west of Kirovograd. Transportation of the mined rocks to the surface is conducted by two paired shafts (the "main" and "helping" shafts) sunk to a depth of 460 m. The lower part of the deposits, extending to a depth of 640 m, was stripped by two blind stems ("Blind-1" and "Blind-2").

Stationary compressor terminals have been installed on the surface of each shaft to produce compressed air used for drill and blasting operations. Within each cleaned block, after conducting drill blasting operations, ore is moved to a loading pocket, unloaded from mine cars and transported by electric-powered trams to the main shaft, where it is crushed before being lifted to the surface. Radiometric ore-dressing, storage, loading of railway wagons and shipping to the processing plant is conducted on the surface. Mined-out space is backfilled by hardening hydro-packing. A total of about 850 persons are involved in operations.

The Novokonstantinovskiy deposit is mined by three shafts to horizons 480 m and 1 100 m below the surface. Mining started in 2011. The Severinkovskoye and Podgayscevskiy deposits are planned to be mined by two shafts to a depth of 650 m.

In 1961, Ukraine began using ISL uranium recovery and from 1966 to 1983 uranium in the Devladovskiy and Bratskiy deposits was recovered using sulphuric acid ISL at depths of about 100 m. At present the condition of the mined-out deposits is being monitored. Development of the Safonovskiy and Sadoviy deposits by ISL using low acid concentration leaching chemicals is being planned.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Ingulskiy mine	Smolinskiy mine	Novokonstanti-novskiy mine	Safonovskiy mine	Severinskiy mine
Production centre classification	Existing	Existing	Existing	Committed	Planned
Date of first production	1968	1973	2011	2015	2020
Source of ore:					
Deposit name(s)	Michyrinskiy, Centralniy	Vatutinskiy	Novokonstanti-novskiy	Safonovskiy	Severinskiy Podgaytsevskiy
Deposit type(s)	Metasomatic	Metasomatic	Metasomatic	Sandstone	Metasomatic
Recoverable resources (tU)	66 262	5 028	89 526	2 248	48 120
Grade (% U)	0.1	0.17	0.14	0.02	0.1
Mining operation:					
Type (OP/UG/ISL)	UG	UG	UG	ISL	UG
Size (tonnes ore/day)	2 000	2 000	6 000	NA	4 200
Average mining recovery (%)	95	96	96	75	96
Processing plant:					
Acid/alkaline	Acid	Acid	Acid	Acid	Acid
Type (IX/SX)	IX	IX	IX	IX	IX
Size (litre/day)	NA	NA	NA	15 000 litre/day	NA
Average process recovery (%)	93	94	94	95	92
Nominal production capacity (tU/year)	450	500	1 500	150	1 200
Plans for expansion	Yes	No	Yes	No	No

Status of production facilities, production capability, recent and ongoing activities and other issues

Hydrometallurgical processing plant

VostGOK's hydrometallurgical processing plant is situated in Zheltye Vody. The annual capacity of the plant is 1.5 Mt ore with 30 to 35 persons employed per shift. Ore is transported to the plant by specially equipped trains from two mines – Ingulskiy (100 km west) and Nalokonstantinovskiy (130 km west). After crushing and radiometric sorting, the ore is leached in autoclaves using sulphuric acid at temperatures of 150 to 200°C at 20 atmospheres for 4 hours. Acid consumption is 80 kg/t ore. For uranium extraction, ion-exchange resin is applied. After washing with a mixture of sulphuric and nitric acids, the uranium-bearing solution is subjected to further concentration and purification by solvent extraction. Ammonium gas is used for precipitation. Dewatered precipitate is subjected to calcination at 800°C until a dark colour product is obtained.

Innovation techniques in uranium production

Metasomatite-type deposits in Ukraine have a uranium content in ore of about 0.1%, with mineralisation (uraninite, brannerite, coffinite, nasturane) disseminated throughout the volume of ore in steeply dipping orebodies. Since the mines are located some 100 and 150 km from the hydrometallurgical plant, transportation costs add to mining and processing costs.

Quarrying is conducted by the underground mining and processing is initiated by crushing underground followed by recovery through sulphuric acid in autoclaves. Low-grade uranium ores combined with expensive mining and ore processing techniques makes uranium production unprofitable under current market conditions. In order to decrease production costs, innovative technologies are being introduced, such as underground radiometric sorting, in-place leaching and heap leaching and reprocessing of dumps from operating mines.

Multistage radiometric separators, designed by VostGOK for different size lumps, allow sorting of mined ore and material in mine dumps. Through sorting, uranium content in ore may reach 0.03-0.3% U when sent for processing. The uranium content in "tailings" is 0.006% or less.

If rocks in dumps have an average specific activity at the level of 1 500-1 600 Bk/kg, then the waste materials remaining after radiometric separation will have only 350-650 Bk/kg and can be used as a second class construction material with specific activity within the limits 370-740 Bk/kg.

Separators may be installed on the surface and in underground mines. Output of a system of two separators (for different machine classes) is 1 500 thousand tonnes of ore per year.

Three products are obtained during radiometric separation of dump rocks:

- 30% – uranium concentrate with 0.05-0.06% uranium;
- 55% – pure "tailings" with specific activity less than 740 Bk/kg for use as second class construction material;
- 15% – inert material for use as hydro-backfill of mined-out space.

After crushing, uranium concentrate is treated by HL. Recovery of uranium during HL is about 70-75%. The cost of 1 kg of ready product from HL is 62% of the cost of processing this concentrate in the hydrometallurgical plant.

Poor orebodies with a uranium content of 0.04-0.06% are mined by applying the IPL method. An optimal technique of explosion has been put into use for disaggregating the ore blocks. The uranium concentration in the productive solution declines from

1 000 mg/Ll at the beginning of leaching to 50 mg/l at the end of leaching the disaggregated ore blocks. The cost of IPL is 58% less than conventional mining and processing technology. Three blocks have now been prepared for mining by IPL.

Uranium ore in most of the metasomatite deposits is suitable for HL. However, finely disseminated uranium mineralisation in highly durable albitites of low permeability is not suitable for HL without prior crushing. Therefore, the degree of crushing is the most important parameter that determines the permeability and in turn, uranium recovery. The maximum size of uranium mineral particles is usually from 1 to 5 mm. With an optimum size of ore of 10 mm, 80-90% uranium recovery can be achieved after 2-3 months of leaching.

The heaps contain ore with a uranium content 0.05-0.08% U, obtained as a result of dump sorting with uranium content 0.5-0.6% U. The volume is typically 40 thousand tonnes of ore up to a height of 6-8 m. At the Vatutinskoye deposits, the HL site is being built and at the Michurinskoye deposits is committed for construction. HL sites consist of 4 heaps with a total volume of processing of 160 thousand tonnes of ore per year.

The technology of radiometric ore-dressing at radiometric processing plants (RPPs) available at each uranium pit is being improved. While only two years ago at the Smolinskaya RPP specific activity in tailings was 1 900 Bk/kg, now it has been reduced to 1 100 Bk/kg. Applying a new generation of separators will further reduce the specific activity of tailings to 500-600 Bk/kg, which corresponds to specific activity requirements for second class construction material. In this way sorted tailings may be used as construction materials for highways and industry, reducing the volume of waste from ore mining.

Ownership of uranium industry

All enterprises in the uranium industry (geology, mining, fuel processing) are owned by the state. The mining and processing enterprise VostGOK is part of the Department of Strategic Policy of Investments and Nuclear Energy Complex in the Ministry of Energy and Coal Industry of Ukraine. SE "Kirovgeology" is responsible for the uranium mineral resources of Ukraine (geological survey, evaluation and exploration of deposits, calculation of U resources and reserves) and is part of the State Service of Geology and Resources of Ukraine in the Ministry of Ecology and Natural Resources.

In April 2008, the Ukrainian government found a new "nuclear fuel" company through the merger of existing organisations in the sphere of the Ministry of Fuel and Energy.

Secondary sources of uranium

- Mixed oxide fuel has never been produced in Ukraine and is not used in its NPPs.
- Re-enrichment tails have never been produced or used in Ukraine.
- Reprocessing spent nuclear fuel is not conducted in Ukraine nor has it been used.

Environmental activities and social-cultural issues

The main environmental impacts of uranium production at mines result from ore sheds, tailings dumps, radiometric ore-dressing, waste rock dumps, ventilation systems and transport pathways (railways, roads). The main environmental impact from hydro-metallurgical plants and heap leaching sites are harmful chemical and ore dust emissions, airborne transportation of aerosols and groundwater contamination from tailings impoundments. To assure environmental impacts are minimised, permanent monitoring is being conducted.

At the hydrometallurgical plant (Zheltye Vody), processing wastes (tailings) are stored and recycled water is used in the technological process. Two tailings impoundments have been used, one situated 9 km from the hydrometallurgical plant consisting of two sections (135 and 163 ha) and the second 0.5 km from the plant (55 ha) – although the latter has reached capacity and reclamation is ongoing.

There are issues connected with the decommissioning of uranium mining and uranium processing enterprises. At the now closed Prydnieprovsky chemical plant, nine tailings impoundments were used (covering a total area of 268 ha containing 42 Mt of wastes) with total activity of 75 000 Ci (Curie) and some buildings and other facilities are contaminated with radioactivity. The Cabinet of Ministers initiated a state programme to deal with the issues and since 2005 have remediate the area to an environmentally safe condition with state funds amounting to UAH 22.3 million (Ukrainian hryvnia – about USD 4.5 million).

The total cost of improving radiation protection at all enterprises of the atomic industry and all contaminated areas resulting from mining and processing of uranium is expected to amount to USD 360 million, including decontamination of polluted soils, environmental monitoring, installation of monitoring systems where necessary and improved technology for the management of water flows, radioactive rocks in dumps, polluted equipment and land areas.

Uranium requirement

Uranium production in Ukraine meets 30% of domestic nuclear energy requirements. Nuclear fuel requirements have always been provided by importing fuel elements from the Russian Federation (provided by TVEL). Annual fuel loadings of the 4 operating NPPs (comprised of 13 VVER-1000 units and 2 VVER-440 units) amount to 15 sets of fuel elements at a total cost of about USD 300 million. It is expected by 2014-2015 that 100% of uranium requirements for the Ukrainian nuclear fleet will be met by domestic production.

Installed nuclear generating capacity by 2035

At present, 15 reactors are operating at 4 NPPs: 6 VVER-1000 units at Zaporozhskaya; 3 VVER-1000 units at South-Ukrainian; 2 VVER-1000 and 2 VVER-400 units at Rovenskaya; and 2 VVER-1000 units at Khmelnitskaya.

The national programme for nuclear energy production foresees that by 2030, 45% of electricity will be from NPPs. To achieve this, annual nuclear energy production will have to increase up to 75.2 billion kW/h. This will require life extensions of operating NPPs, the construction of 12 additional units (with 10 of these having a total capacity of 1 500 MW) and the decommissioning of 12 reactors at the end of their operational lifetime.

Uranium policies, uranium stocks and uranium prices

The Ukrainian government policy is aimed at increasing the production of natural uranium and improving the attractiveness of uranium projects in Ukraine for foreign investment. Doing so will be necessary to meet the national policy of increasing domestic uranium mining to meet 100% of Ukrainian NPP requirements.

Resolution N1004, regarding the "Complex Program of Creation Nuclear Fuel in Ukraine" dated 23 September 2009, was approved by the Cabinet of Ministers. It specifies that uranium enrichment will be conducted abroad.

On 17 April 2009, the Cabinet of Ministers of Ukraine issued Resolution N 650-p "Some Questions of Liquidation and Organisation of State Mergers in the Nuclear Industry". This resolution founded the "Nuclear Fuel" company by state merger of all enterprises and scientific-research institutes connected to the nuclear fuel cycle. The resolution is aimed to improve investment conditions.

The joint venture "plant for the manufacture of nuclear fuel for nuclear reactors VVER-1000 type" was established in Ukraine in October 2011. The plant will be situated in the Kirovograd region, close to the Vatutinskiy uranium deposits. A 50% +1 share in the joint venture belongs to the Russian company "TVEL".

A technical-economical assessment for the construction of a plant was approved by the Cabinet of Ministers of Ukraine (statement N437 dated 27 June 2012). The total cost of construction is estimated to amount to UAH 3.7 billion (about USD 745 million) and the construction schedule aims to have stages I and II completed in 2015 and 2020, respectively. The capacity of the plant will be 800 nuclear fuel sets per year and the uranium isotopic enrichment will be undertaken in the Russian Federation.

The decision to build a centralised storage facility for spent fuel from domestic VVER reactors at the Chernobyl NPP site was made on 2 September 2012 (the Law of Ukraine N4384). Commissioning is planned in 2016.

In September 2012 the decision was made, with Russian co-operation, to complete the construction of two power blocks (N3 and N4) at the Khmelnitsky atomic power station (the Law of Ukraine from 02/09/12 N4384). The date of commissioning of blocks N3 and N4 is 2018 and 2020, respectively.

Uranium exploration and mine development expenditures and drilling efforts – domestic

(UAH million [Ukrainian hryvnia] as of 1 January 2013)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	0	0	0	0
Government exploration expenditures	25.3	15.9	15.1	15.0
Industry* development expenditures	0	0	0	0
Government development expenditures	NA	NA	5.8	6.0
Total expenditures	**25.3**	**15.9**	**20.8**	**21.0**
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Government exploration drilling (m)	10 165	4 906	4 683	5 000
Government exploration holes drilled	67	36	34	38
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	NA	NA	13 063	14 850
Government development holes drilled	NA	NA	52	60
Subtotal exploration drilling (m)	10 165	4 906	4 683	5 000
Subtotal exploration holes drilled	67	36	34	38
Subtotal development drilling (m)	NA	NA	13 063	14 250
Subtotal development holes drilled	NA	NA	52	60
Total drilling (m)	**10 165**	**4 906**	**17 746**	**19 250**
Total number of holes drilled	**67**	**36**	**86**	**98**

* Non-government

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	6 730	6 730	6 730
Metasomatite	0	35 948	78 069	134 647
Total	**0**	**42 678**	**84 799**	**141 377**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining		35 948	78 069	134 647	88.4
In situ leaching acid		6 730	6 730	6 730	75
Total		**42 678**	**84 799**	**141 377**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	35 948	78 069	134 647	88.4
In situ leaching acid		6 730	6 730	6 730	75
Total		**42 678**	**84 799**	**141 377**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Sandstone		897	897	897	75
Metasomatite		16 035	31 982	80 437	88.7
Total		**16 932**	**32 879**	**81 334**	

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining		16 035	31 982	80 437	88.7
In situ leaching acid		897	897	897	75
Total		**16 932**	**32 879**	**81 334**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP					
Conventional from UG		16 035	31 982	80 437	88.7
In situ leaching acid		897	897	897	75
Total		**16 932**	**32 879**	**81 334**	

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	8 400	22 500

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	120 000	135 000

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Sandstone	3 925	0	0	0	3 925	25
Granite-related	35 000				35 000	
Metasomatite	86 277	837	873	1 012	88 999	1 050
Total	**125 202**	**837**	**873**	**1 012**	**127 924**	**1 075**

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining[1]	10 000	-	-	-	10 000	-
Underground mining[1]	101 277	837	873	1 012	103 999	1 050
In situ leaching	3 925	-	-	-	3 925	25
Co-product/by-product	10 000	-	-	-	10 000	-
Total	**125 202**	**837**	**873**	**1 012**	**127 924**	**1 075**

1. Pre-2009 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrate)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	125 179	827	859	991	127 856	1 039
In-place leaching*	3	4	4	7	18	10
Heap leaching**	20	6	10	14	50	36
Total	**125 202**	**837**	**873**	**1 012**	**127 924**	**1 085**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2012

Domestic				Abroad				Total	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
1 012	100							1 012	100

Uranium industry employment at existing production centres

(persons/years)

	2010	2011	2012	2013 (expected)
Total employment at existing production centres	4 310	4 470	4 490	NA
Direct employment in uranium production	1 420	1 580	1 600	1 580

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 075	NA	NA	NA	810	3 230	NA		NA	NA	810	5 500

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	250	5 800	NA	NA	170	6 400	NA	NA	NA	NA

Net nuclear electricity generation

	2011	2012
Net nuclear electricity generation (TWh net)	90.25	90.14

Installed nuclear generating capacity to 2035

(MWe net)

2012	2013	2015		2020		2025		2030		2035	
13 800	13 800	Low	High	Low	High	Low	High	Low	High	Low	High
		15 800	17 900	16 600	20 200	18 800	26 200	20 000	26 200	26 000	30 500

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2012	2013	2015		2020		2025		2030		2035	
2 480	2 480	Low	High	Low	High	Low	High	Low	High	Low	High
		2 840	3 230	3 020	3 600	3 020	3 660	3 600	4 800	4 800	5 300

United Kingdom

Uranium exploration and mine development

Historical review

Some uranium mining occurred in Cornwall, as a sideline to other mineral mining, especially tin, in the late 1800s. Systematic exploration occurred in the periods 1945-1951, 1957-1960 and 1968-1982, but no significant uranium reserves were located.

Recent and ongoing uranium exploration and mine development activities

Exploration in overseas countries is carried out by private companies operating through autonomous subsidiary or affiliate organisations established in the country concerned (e.g. Rio Tinto).

There were no industry expenditures reported for domestic exploration from 1988 to the end of 2012, nor were there any government expenditures reported for exploration either domestic or abroad. Since 1983, all domestic exploration activities have been halted.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The reasonably assured resource and inferred resources are essentially zero. There has been no geological appraisal of the UK (United Kingdom) uranium resources since 1980.

Undiscovered conventional resources (prognosticated and speculative resources)

There are small quantities of *in situ* undiscovered resources as well as speculative resources. Two districts are believed to contain uranium resources: the metalliferous mining region of south-west England (Cornwall and Devon) and north Scotland including Orkneys.

Unconventional resources and other materials

None to report.

Uranium production

The United Kingdom is not a uranium producer.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

None of the reactors in the United Kingdom currently use MOX fuel. In 2001, the UK government announced approval for MOX manufacture in the UK. In December 2001, British Nuclear Fuels Limited (BNFL) started the first stage of plutonium commissioning of the Sellafield MOX plant (SMP). The plant manufactured MOX fuel from plutonium oxide separated from the reprocessing of spent fuel and tails of depleted uranium oxide. Detailed programmes for SMP are considered to be commercially confidential.

On 3 August 2011, the Nuclear Decommissioning Authority (NDA) announced that the SMP was to be closed due to a downturn in the prospects for Japanese MOX customers following the accident at the Fukushima Daiichi nuclear power plant in March 2011. On 7 June 2012, it was announced that the Thermal Oxide Reprocessing Plant (THORP) would be closed in 2018 after current contracts are completed.

Production and/or use of re-enriched tails

Urenco has a long-term contractual agreement to upgrade tails material, but considers this to be commercially confidential. In November 2012, the Capenhurst site (the location of a gaseous diffusion enrichment facility that was closed in 1982), including legacy uranium enrichment tails, was transferred to Urenco, operator of the adjacent centrifuge enrichment plant. An agreement between the NDA and Urenco was signed for the processing of these NDA-owned legacy materials.

Uranium requirements

As at the end of December 2012, there were 16 licensed reactors with a combined capacity of 9.2 GW operating in the United Kingdom. The UK reactor fleet is comparatively old and operators have stated that they expected up to 7.4 GW of existing nuclear capacity could close by 2019, although lifetime extension plans could extend operations of some reactors until 2023. The government has taken a series of facilitative actions to encourage nuclear new build and industry has announced ambitions for construction of up to 16 GW by 2025. New nuclear investments will be part of the total GBP 75 billion estimated for new power generation capacity needed by 2020. Three consortia are currently preparing for the construction of new nuclear power plants:

- NNB Generation Company (NNBGenco) is a joint venture led by EDF. NNBG has plans to build up to 6.4 GW at Hinkley Point in Somerset and Sizewell in Suffolk.
- Horizon Nuclear Power, owned by Hitachi-GE Nuclear Energy Ltd, has plans to build up to 6.6 GW at Wylfa in Anglesey and Oldbury in Gloucestershire.
- NuGen is a consortium of GDF Suez and Iberdrola. NuGen has plans to build up to 3.6 GW at Moorside near Sellafield in Cumbria;

Among the consortia, NNBGenco has made most progress having received regulatory approval (site licence, environmental permits and generic design assessment [GDA] of its EPR reactor design) in late 2012.

The GDA is one of the facilitative actions set out in the Nuclear White Paper 2008 and is undertaken by the Office for Nuclear Regulation (ONR) and the Environment Agency. GDA is a voluntary process that allows regulators to begin consideration of the generic safety, security and environmental aspects of designs for NPPs prior to applications for site-specific licence and planning consents.

For new nuclear build, Section 45 of the Energy Act 2008 requires prospective nuclear operators to submit a funded decommissioning programme (FDP) for approval by the Secretary of State for Energy and Climate Change (DECC). DECC published final FDP statutory guidance in December 2011 to assist operators to develop their programmes.

The government received an FDP submission from NNBG in March 2012. Discussions with NNBGenco are continuing and are expected to be concluded later in 2013.

In the near to medium future the uranium requirements in the United Kingdom are difficult to predict due to the proposed new build programme and the potential for commercial operators of existing power stations to obtain regulatory approval for life extensions beyond their current scheduled closure dates.

Uranium policies, uranium stocks and uranium prices

Uranium stocks

The UK uranium stockpile practices are the responsibility of the individual bodies concerned. Actual stock levels are commercially confidential.

Uranium prices

Uranium prices are commercially confidential in the United Kingdom.

United States

Uranium exploration and mine development

Historical review

From 1947 through 1970, the United States government fostered a domestic private-sector uranium exploration and production industry to procure uranium for military uses and to promote research and development in peaceful atomic energy applications. By late 1957, the number of new deposits being brought into production by private industry and production capability had increased sufficiently to meet projected requirements. Federal exploration programmes were brought to an end.

Exploration by the US uranium industry increased throughout the 1970s in response to rising prices and the projected large demand for uranium to fuel an increasing number of nuclear reactors being built or planned for civilian electric power stations. A peak total in annual surface drilling was reached in 1978.

Exploration has primarily been for sandstone-type uranium deposits in districts such as the Grants Mineral Belt and Uravan Mineral Belt of the Colorado Plateau and in the Wyoming basins and Texas Gulf Coastal Plain region.

Recent and ongoing uranium exploration and mine development activities

In 2012, expenditures for uranium surface drilling amounted to USD 66.6 million, up USD 23 million from expenditures in 2011 of USD 53.6 million (see table). This 24% increase is a continuation of the upward trend in investment from 2009 to 2012, following the sharp decline in late 2008. From 2004 to late 2008 there was a 673% increase in uranium surface drilling expenditures.

In 2011, private industry total expenditures for uranium exploration and mine development activities were USD 150.4 million, a 4% increase from 2010 expenditures of USD 144.0 million. In 2012, expenditures increased to USD 166.0 million, a 10% increase from 2011.

In 2012, expenditures on US uranium production, including facility expenses, were USD 186.9 million, 11% more than the USD 168.8 million spent in 2011. In 2010 uranium production expenditures were USD 133.3 million. Expenditures for land in 2012 were USD 16.8 million, a 14% decrease compared with 2011. In 2011 land expenditures were USD 19.6 million. Land expenditures have generally remained flat since 2009.

The total expenditures for land, exploration, drilling, production and reclamation increased by 11% from USD 319.2 million in 2011 to USD 352.9 million in 2012. Reclamation expenditures were USD 49.3 million, a 46% increase compared with 2011.

United States uranium expenditures, 2004-2012

(USD million)

Year	Drilling	Production	Land and other				Total expenditures
			Total land and other	Land	Exploration	Reclamation	
2004	10.6	27.8	48.4	NA	NA	NA	86.9
2005	18.1	58.2	59.7	NA	NA	NA	136.0
2006	40.1	65.9	155.2	41.0	23.3	50.9	221.2
2007	67.5	90.4	178.2	77.7	50.3	50.2	336.2
2008	81.9	221.2	164.4	65.2	50.2	49.1	467.6
2009	35.4	141.0	104.0	17.3	24.2	62.4	280.5
2010	44.6	133.3	99.5	20.2	34.5	44.7	277.3
2011	53.6	168.8	96.8	19.6	43.5	33.7	319.2
2012	66.6	186.9	99.4	16.8	33.3	49.3	352.9

Notes: Expenditures in nominal USD. Totals may not equal sum of components because of independent rounding.

Drilling: All expenditures directly associated with exploration and development drilling.

Production: All expenditures for mining, milling, processing of uranium, and facility expense.

Land and other: All expenditures for: land; geological research; geochemical and geophysical surveys; costs incurred by field personnel in the course of exploration, reclamation and restoration work; and overhead and administrative charges directly associated with supervising and supporting field activities.

NA = Not available. W = Data withheld to avoid disclosure of individual company data.

Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 8.

The number of holes and total metres drilled for uranium decreased from 2008 to 2009, from 9 355 holes and 1 552 656 m to 5 679 holes and 1 140 565 m, respectively (see table below). In 2010, the number of holes and total metres drilled increased to 7 209 holes and 1 494 744 m. In 2011 and 2012, the increasing trend continued with 10 597 holes drilled in 2011 and 11 082 holes drilled in 2012. The total metres drilled increased 13% from 1 927 866 m in 2011 to 2 181 156 m in 2012.

In 2011 and 2012, there were no exploration expenditures for uranium domestically or abroad by the US government. Data on industry exploration expenses abroad are not available.

Following the decreasing trend in development and production expenditures from 2008-2009, the period from 2010 to 2012 saw a turnaround with increased expenditures of 20% to 25% per year. Much of the increase in development and production expenditures from 2010 to 2012 was due to generally strong uranium (and vanadium) prices as well as the need to meet longer-term demand resulting from the expansion of nuclear power in the United States and around the world. An additional contributing factor is the end of the 20-year Megatons-to-Megawatts programme in 2013, which through an agreement between the United States and the Russian Federation has produced the equivalent of 9 200 tU/yr.

Exploration and development continued to be focused primarily on sandstone-hosted uranium deposits within known US uranium provinces. Most exploration occurred on deposits that were identified in the 1970s and earlier, or on extensions and satellites of operating mines. However, in 2012 exploration expanded to include previously unexplored targets. The properties described below are those that are most significant, because they are closest to production or contain a significant resource. It is not intended to be a comprehensive list of all US uranium occurrences undergoing some form of exploration or development.

United States uranium drilling activities, 2003-2012

Year	Exploration drilling		Development drilling		Exploration and development drilling	
	Number of holes	Metres (thousand)	Number of holes	Metres (thousand)	Number of holes	Metres (thousand)
2003	NA	NA	NA	NA	W	W
2004	W	W	W	W	2 185	381
2005	W	W	W	W	3 143	508
2006	1 473	250	3 430	577	4 903	827
2007	4 351	671	4 996	898	9 347	1 569
2008	5 198	775	4 157	778	9 355	1 553
2009	1 790	320	3 889	820	5 679	1 141
2010	2 439	445	4 770	1 050	7 209	1 495
2011	5 441	1 013	5 156	915	10 597	1 928
2012	5 112	1 051	5 970	1 131	11 082	2 181

Note: Totals may not equal sum of components because of independent rounding.

NA = Not available. W = Data withheld to avoid disclosure of individual company data.

Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 1.

Conventional mine development

Energy Fuels Inc. operated the Arizona One mine in Arizona, intermittently operated mines in the La Sal Complex (La Sal, Beaver and Pandora) and the Daneros mine in Utah. Energy Fuels is also developing the fully permitted Canyon and Pinenut breccia pipe deposits in Arizona. The following mines owned by Energy Fuels are either fully, or close-to-fully, permitted and on standby status:

- Sunday Complex (Topaz, St Jude, Carnation, Sunday and West Sunday) in Colorado with mines that are partly permitted on care and maintenance.
- Whirlwind mine in Colorado which is fully permitted and completely rehabilitated.
- Energy Queen mine in Utah which is almost fully permitted and is being rehabilitated.
- Henry Mountains Complex in Utah (Tony M mine) which is permitted and on care and maintenance status.

Significant proposed conventional mines owned by other companies include:

- Strathmore Mineral's Gas Hills District in Wyoming is planned to be developed using multiple shallow open pits with the ore processed by heap leaching. This mine is in the early stages of permitting with a mine permit application submitted to the state of Wyoming.
- Strathmore Mineral's Roca Honda mine has a mine permit application filed with the state of New Mexico and data acquisition is in process for a mill licence application to the Nuclear Regulatory Commission (NRC).
- Energy Fuel's Sheep Mountain property in Wyoming is updating its mine plan and bonding requirements and gathering data for a mill licence application. Sheep Mountain has an active permit with the state of Wyoming, but the mine has been idle since 1988.
- Rio Grande Resource's Mt. Taylor mine is on continued standby while the owners evaluate whether to apply for a conventional mill licence to process their ore, or mine using *in situ* recovery instead.
- Uranium Resources Inc.'s Juan Tafoya and Cebolleta projects in New Mexico were acquired from Neutron Energy in 2012. A letter of intent to construct a conventional mill to process ore from these deposits has been filed with the NRC.
- Virginia Uranium Inc.'s Coles Hill deposit in Virginia is the largest undeveloped uranium deposit in the United States. Development of Coles Hill cannot proceed until a state moratorium on uranium mining is lifted.
- Kimmerle Mining plans to reopen their small Green River #9 mine in Utah, trucking ore approximately 240 km from this mine for processing at the White Mesa Mill.

Advanced exploration stage projects entering the feasibility stage include:

- Oregon Energy's volcanogenic Aurora deposit in southern Oregon.
- Laramide Resources' La Sal mine on the Colorado Plateau and La Jara Mesa mine in New Mexico.
- Black Range Mineral's Hansen/Taylor Ranch Project located in the Rocky Mountains of Colorado, proposed to be mined using underground borehole mining with ablation.
- Energy Fuel's Sage Plain Project in Utah.

ISR mine development

Cameco Corporation's Smith Ranch/Highland mine in Wyoming continued to produce uranium, with exploration and development focused on potential satellite deposits, including Gas Hills/Peach, North Butte/Brown Ranch, Ruby Ranch and Ruth. The North Butte property is fully permitted and under development and permitting for Ruby Ranch is underway. Cameco targeted expansion into satellite properties near their Crow Butte mine in Nebraska, completing licence applications for the North Trend and Marsland projects.

Exploration and development continued on trend and in other areas of the private ranch where the Alta Mesa mine is operated by Mestena Uranium in Texas. Uranium Energy Corporation (UEC) operated the La Palangana mine in Texas, processing loaded resins at the Hobson plant about 90 miles north of the mine. UEC is exploring and developing several other properties in Texas as satellites to the Hobson plant, including the fully permitted and developing Goliad mine as well as the Burke Hollow, Channen and Salvo exploration projects. The Willow Creek mine in Wyoming continued operating; however, development of the fully permitted Moore Ranch satellite property was discontinued in 2011.

Other significant developing ISR properties include:

- Lost Creek, Wyoming (Ur-Energy), where permitting was completed in 2011 and construction began in 2012.
- Hank/Nichols, Wyoming (Uranerz), which is fully permitted and under construction with permitting underway for the Jane Dough satellite well field.
- Dewey-Burdock, South Dakota (Powertech Resources), which is in the advanced stage of permitting.
- Lance/Ross in Wyoming (Strata Energy), which is in the advanced stage of permitting.
- Uranium Resources Inc.'s Church Rock/Mancos deposit in New Mexico with a completed feasibility study, but for which the company has deferred development because of low uranium prices.

Advanced ISR exploration projects entering the feasibility or permitting stage include:

- Uranium One/ARMZ's Jab/Antelope Project in the Great Divide Basin and their Ludeman Project, which is expected to be developed as a satellite property to the Willow Creek mine in the Powder River Basin of Wyoming.
- Uranerz's Reno Creek Project, which is expected to be developed as a satellite to their Nichols Ranch mine in the Powder River Basin of Wyoming.
- Exploration continues for ISR mines in the Wyoming Basins, along the Texas Gulf Coast and in the Grants district of New Mexico.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Estimates of RAR in the United States are unchanged from the prior-reported estimates that were updated as of 2011. The United States does not report resources for the inferred category separately.

Undiscovered conventional resources (prognosticated and speculative resources)

Prognosticated and speculative uranium resources for the United States were last assessed in 1980. Records of these estimates are no longer available; therefore the values cannot be corroborated. For this reason, undiscovered resources are no longer reported by the United States pending development of new undiscovered resource estimates and/or confirmation of the older estimates.

Unconventional resources and other materials

NA.

Uranium production

Historical review

Following the passage of the Atomic Energy Act of 1946 (AEA), designed to meet US government uranium procurement needs, the Atomic Energy Commission (AEC) from 1947 through 1970 fostered development of a domestic uranium industry (chiefly in the western United States) through incentive programmes for exploration, development and production. To assure that the supply of uranium ore would be sufficient to meet future needs, the AEC in April 1948 announced a domestic ore procurement programme designed to stimulate prospecting and to build a domestic uranium mining industry. The AEC also negotiated concentrate procurement contracts, pursuant to the AEA, as amended in 1954, with guaranteed prices for source materials delivered within specified times. Contracts were structured to allow milling companies that built and operated mills the opportunity to amortise plant costs during their procurement-contract period. By 1961, a total of 27 mills were being operated. Overall, 32 conventional mills and several pilot plants, concentrators, up graders, heap leach and solution-mining facilities were operated at various times. The AEC, as the sole government purchasing agent, provided the only US market for uranium. Many of the mills were closed soon after completing deliveries scheduled under AEC purchase contracts, though several mills continued to produce concentrate for the commercial market after fulfilling their AEC commitments.

The AEA, as amended, made lawful the private ownership of nuclear reactors for commercial electricity generation. By late 1957, domestic ore reserves and milling capacity were sufficient to meet the government needs. In 1958, the AEC's procurement programmes were reduced in scope and, in order to foster utilisation of atomic energy for peaceful purposes, domestic producers of ore and concentrate were allowed to sell uranium to private domestic and foreign buyers. The first US commercial-market contract was finalised in 1966. The AEC announced in 1962 a "stretch out" of its procurement programme that committed the government to take only set annual quantities of uranium for 1967 through 1970: this also assisted in sustaining a viable domestic uranium industry. The US government's natural uranium procurement programme ended in 1970 and the industry became a private sector, commercial enterprise with no government purchases; however, the government continues to monitor private-industry exploration and development activities to meet federal information and data needs.

Exploration by the US uranium industry increased throughout the 1970s in response to rising prices and the projected large demand for uranium to fuel an increasing number of commercial nuclear power plants that were under construction or planned to be built. A peak in US production occurred in 1980 (16 809 tU) and subsequently, the industry experienced generally declining production from 1981 to 2003. Beginning in 2004, production began increasing once again in response to higher uranium prices. Since 1991, production from ISR mining has dominated US annual production.

Status of production facilities, production capability, recent and ongoing activities and other issues

US uranium mines produced 1 582 tU in 2011, 3% less than in 2010. In 2012, US uranium mines produced 1 667 tU, 5% more than in 2011. Production in 2012 was from 11 mines (underground and ISR) and one other source. Six underground mines produced ore containing uranium during 2012, one more than during 2011. Uranium ore from underground mines is stockpiled and shipped to the White Mesa Mill, to be milled into uranium concentrate (a yellow or brown powder).

Total production of US uranium concentrate (yellowcake) in 2011 was 1 535 tU, a 6% decrease from 2010. In 2012, uranium concentrate production was 1 595 tU, 4% more than in 2011, from six facilities (one mill and five ISR plants).

At the end of 2012, one uranium mill (White Mesa in Utah) was operating with a capacity of 1 814 tonnes of ore a day. Two mills (Shootaring Canyon in Utah and Sweetwater in Wyoming) were on standby status with a combined capacity of 3 400 tonnes ore per day. One mill (Piñon Ridge) was planned for Colorado. The NRC received letters of intent for mill licence applications from Uranium Resources Inc. (Juan Tafoya mine area, New Mexico), General Atomics (Mt. Taylor Mine area, New Mexico) and Oregon Energy LLC (Aurora deposit area, Oregon).

Five ISR plants were operating in 2012 with a combined capacity of 3 770 tU per year (Crow Butte, Nebraska; Alta Mesa, Texas; La Palangana, Texas; Smith Ranch-Highland and Willow Creek in Wyoming). Smith Ranch, Crow Butte, Alta Mesa and Willow Creek processed lixiviant at the mine site and loaded resins were trucked from La Palangana to the Hobson plant in Texas for processing. The Kingsville Dome and Rosita ISR mines in Texas were on standby with a total capacity of 770 tU per year. The Lost Creek and Nichols Ranch ISR projects were under construction in Wyoming and seven other ISR plants are planned in New Mexico, South Dakota, Texas and Wyoming. Existing and new ISR properties are most likely to be the largest contributors to expanded US production in the near term.

Ownership structure of the uranium industry

Six facilities produced uranium in 2012, one more than in 2011. Ownership of these facilities included public and privately held firms with both foreign and domestic participation. Declining uranium prices have led to some consolidation in the ownership of US uranium production and processing facilities. Energy Fuels Inc. acquired a number of conventional mines and the only operating mill in the United States from Denison Mines Corporation, Titan Uranium and Aldershot Resources. These acquisitions have consolidated ownership of conventional uranium resources on the Colorado Plateau, as well as the Sheep Mountain mine in Wyoming. Uranium Resources Inc. solidified its presence in New Mexico through the acquisition of Neutron Energy. Neutron Energy's properties included advanced stage properties in the Grants Mineral Belt and the Ambrosia Lake regions of New Mexico plus additional properties in South Dakota and Wyoming.

Employment in the uranium industry

Employment in the raw materials sector (exploration, mining, milling and processing) of the US uranium industry generally declined during the period 1998 to 2003, then steadily increased from 2004 to 2008. Employment levels in 2009 showed the first significant decrease over the preceding five years, but since 2009 there have been marginal gains in total employment. In 2012, total employment in the US uranium production industry was 1 017 person-years, a decrease of nearly 7% from the 2011 total of 1 089 person-years. Exploration employment was 161 person-years, a 23% decrease compared with 2011. Milling and processing employment was 394 person-years in 2012, a 6% decrease from 2011. Uranium mining employment in 2012 was 462 person-years, the same as in 2011, while reclamation employment increased 75% from 2011 to 2012 to 179 person-years. Uranium production industry employment in 2012 was in 11 states: Arizona, Colorado, Nebraska, New Mexico, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington and Wyoming.

Uranium production centre technical details

(as of 31 December 2012)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Crow Butte	Smith Ranch Highland	White Mesa Mill	Hobson ISR Plant	Alta Mesa
Production centre classification[1]	Existing	Existing	Existing	Existing	Existing
Date of first production	1991	1988	1980	1979	2005
Source of ore:					
Deposit name(s)	Crow Butte and North Trend	Smith Ranch Highland	Various	Palangana	Alta Mesa
Deposit type(s)	Sandstone	Sandstone	Sandstone, breccia pipe	Sandstone	Sandstone
Recoverable resources (tU)	W	W	W	W	W
Grade (% U)	W	W	W	W	W
Mining operation:					
Type (OP/UG/ISR)	ISR	ISR	UG	ISR	ISR
Size (tonnes ore/day)	NA	NA	NA	NA	NA
Average mining recovery (%)	NA	NA	NA	NA	NA
Processing plant:					
Acid/alkaline			Acid		
Type (IX/SX)	ISX	IX	SX	IX	IX
Size (tonnes ore/day) For ISR	NA	NA	1 538	NA	NA
Average process recovery (%)	NA	NA	NA	NA	NA
Nominal production capacity (tU/year)[1]	385	2 116	NA	385	385
Plans for expansion	Unknown	Unknown	Unknown	Unknown	Unknown
Other remarks[1]	Operating	Operating	Operating	Operating	Producing
State	Nebraska	Wyoming	Utah	Texas	Texas

1. US Energy Information Administration, Domestic Uranium Production Report, 2012, Tables 4 and 5.

NA = Not available. W = Data withheld to avoid disclosure of individual company data.

Uranium production centre technical details *(continued)*

(as of 31 December 2012)

	Centre #6	Centre #7	Centre #8	Centre #9	Centre #10
Name of production centre	Willow Creek Project	Lost Creek	Hank/Nichols	Goliad Uranium Project	Moore Ranch
Production centre classification[1]	Existing	Committed	Committed	Planned	Planned
Date of first production	NA	NA	NA	NA	NA
Source of ore:					
Deposit name(s)	Willow Creek	Lost Creek	Nichols Ranch and Hank	Various	Various
Deposit type(s)	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Recoverable resources (tU)	NA	NA	NA	NA	NA
Grade (% U)	NA	NA	NA	NA	NA
Mining operation:					
Type (OP/UG/ISR)	ISR	ISR	ISR	ISR	ISR
Size (tonnes ore/day)	NA	NA	NA	NA	NA
Average mining recovery (%)	NA	NA	NA	NA	NA
Processing plant:					
Acid/alkaline					
Type (IX/SX)	IX	IX	IX	IX	IX
Size (tonnes ore/day) For ISR	NA	NA	NA	NA	NA
Average process recovery (%)	NA	NA	NA	NA	NA
Nominal production capacity (tU/year)[1]	500	769	769	385	192
Plans for expansion	Unknown	Unknown	Unknown	Unknown	Unknown
Other remarks[1]	Producing	Under Construction	Under Construction	Permitted and licensed	Permitted and licensed
State	Wyoming	Wyoming	Wyoming	Texas	Wyoming

1. US Energy Information Administration, Domestic Uranium Production Report, 2012, Tables 4 and 5.

NA = Not available.

Future production centres

There are a number of non-ISR production centres that are either in the permitting and licensing process or are under development. Uranium Equities continues to develop a modified ion exchange process of uranium extraction from phosphate with Cameco Corporation. In 2012, their "PhosEnergy" extraction process was tested at a demonstration plant in the United States and four, ten-day tests were completed in May 2012 using phosphate streams from two different fertiliser facilities. Uranium recovery of over 90% was reported from these streams at operating costs of USD 18/lb U_3O_8 (USD 46.80/kgU) and capital plant costs of about USD 156 million for a 1 Mtpa P_2O_5 phosphate facility in the south-eastern United States. The company is working to identify a site in the United States for a demonstration plant at a phosphate production facility prior to full-scale commercialisation.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Beginning in 2019, mixed oxide (MOX) fuel will be fabricated at the Department of Energy's (DOE) Savannah River site in South Carolina using surplus military plutonium to fabricate fuel for commercial reactors. In February 2011, the Tennessee Valley Authority (TVA) and AREVA signed a Letter of Intent to begin evaluating the use of MOX at TVA's Sequoyah plant in Tennessee and the Browns Ferry plant in Alabama. In order to use MOX at the TVA nuclear power plants, TVA will need to submit requests for licence amendments for the plants to the NRC. To date, no such applications have been filed with the NRC. Once filed, it is likely to take the NRC one to two years to complete their review of the applications.

Production and/or use of re-enriched tails

The DOE and the Bonneville Power Administration initiated a pilot project to re-enrich 8 500 tonnes of the DOE's enrichment tails inventory. Between 2005 and 2006, this project produced approximately 1 940 tU equivalent for use between 2007 and 2015 at Northwest Energy's 1 190 MWe Columbia generating station in Washington State. In mid-2012, Northwest Energy and United States Enrichment Corporation (USEC), in conjunction with the DOE, developed a new plan to re-enrich a second portion of DOE's high-assay tails. The resulting low-enriched uranium (LEU) will be used to fuel Northwest Energy's Columbia generating station through 2028 and Northwest Energy will also provide some LEU to TVA starting in 2015.

Production and/or use of reprocessed uranium

Reprocessed uranium use and production is zero.

In June 2008, the DOE submitted a licence application to the NRC to receive authorisation to begin construction of a repository at Yucca Mountain, and in September 2008, the NRC formally docketed the application. President Obama announced in March 2009 that the proposed permanent repository at Yucca Mountain "was no longer an option" and that the Blue Ribbon Commission on America's Nuclear Future (BRC) would evaluate alternatives to deal with spent nuclear fuel. On 26 January 2012, the BRC issued its final report that recommended moving forward with a publicly supported siting process for a permanent repository and federally chartering of an organisation to manage this process. The BRC also recommended development of an interim storage site for spent nuclear fuel until a permanent repository is available. With regard to reprocessing or recycling, the BRC noted that "… no currently available or reasonably foreseeable reactor and fuel cycle technology developments – including advances in reprocessing and recycling technologies – have the potential to fundamentally alter the waste management challenge this nation confronts over at least the next several decades, if not longer …"

Environmental activities and socio-cultural issues

Remediation activities

The US Environmental Protection Agency (EPA) is engaged in remediating uranium mining and milling impacted sites on the Navajo Nation. Between 2008 and 2012, high-priority remediation for 34 contaminated homes, 9 mine sites and drinking water supplies for 1 825 families was completed. In addition, 240 water supplies and 520 mines were assessed. In 2011, the US Department of the Interior announced that it will work with Newmont Mining to restore the Midnite Mine on the Spokane Indian Reservation in Washington State, including the backfilling of two open pits.

DOE lease tracts

The DOE administers leases on approximately 25 000 acres in 31 lease tracts considered favourable for uranium on the Colorado Plateau. These tracts were withdrawn from the public domain in the 1940s and leased in ten-year increments. Twenty-nine of the thirty-one tracts are actively being held under lease by a number of different mining companies. The DOE performed a blanket environmental assessment (EA) of the impacts of activities on these tracts by leaseholders in 2006. In 2008, environmental groups challenged the thoroughness of this EA and in 2011 a federal court invalidated the EA. Leaseholders are prohibited from performing exploration activities on these tracts including drilling, mining or reclamation until a full environmental impact statement is completed for the Dolores River Drainage – the area potentially impacted by leaseholder activities. The DOE is preparing a programmatic environmental impact statement (EIS) in response to this ruling. This EIS will include impacts of building the proposed Piñon Ridge mill in this drainage area.

US Congress Remediation Report

In late 2012, US Congress mandated that the DOE prepare a report on the location and priority ranking for remediation of all mines that provided uranium for atomic energy defence activities. Initial estimates are that over 4 000 mines may fall into this category. The final report, including a list of priority mines requiring remediation as well as cost estimates and the feasibility of remediation, is mandated to be completed in 18 months.

Legislation

Federal

The mining of "hardrock" minerals, such as gold, silver and uranium on federal lands is, in part, governed by the General Mining Act (GMA) of 1872. Under this law, an individual or company has the right to stake a claim on open public land if they discover a valuable deposit of "hardrock" minerals. The 1872 legislation also allows the government to charge a onetime fee of USD 2.50 to USD 5.00 per acre (which has never been adjusted for inflation) for filing the claim. However, the GMA does not require the owner of a claim to pay a lease payment or a royalty to the federal government. There have been proposals to modify the GMA and one such proposal, the Uranium Resource Stewardship Act (URSA), pertains to uranium. This proposed legislation was introduced in the 112th Congress, First Session, as H.R. 1452. Under this proposed law, the Mineral Leasing Act would be amended to allow the government to lease the land and charge an annual rent of at least USD 2.50 per acre the first year and USD 3.00 per acre for each year thereafter. The developers would also pay a royalty of 12.5% of the value of the uranium mined each year. The proposed law explicitly states that the revenues could be used for cleaning up uranium mill tailings and reclaiming abandoned uranium mines on federal land. The

URSA was not voted upon in the 112th Congress, and as of May 2013, similar legislation had not been introduced in the 113th Congress. Updating the GMA is likely to affect the economics of uranium mining as well as proposed uranium mines near the Grand Canyon National Park, as discussed below.

State

Virginia: The largest known undeveloped reserve of uranium in the United States and the seventh largest in the world is located on private land at Coles Hills in south central Virginia. In 1982, the Virginia state legislature passed a law that prohibited the issuance of any mining permits until the necessary state regulations were in place. With interest in nuclear power in the mid-2000s and increasing uranium prices, interest in developing the Coles Hill deposit intensified. In 2007, Virginia Uranium Inc. (VUI) was formed and granted permits for exploratory drilling. In 2009, because of the lack of familiarity with uranium mining/milling, the state legislature requested the National Academy of Sciences (NAS) to analyse the health, safely and regulatory impacts of uranium mining and milling in Virginia. In December 2011, the NAS released their report, which concluded "… that there are 'steep hurdles to be surmounted' before mining and processing could take place within a regulatory setting that protects workers, the public and the environment, especially given that the state has no experience regulating the mining and processing of this radioactive element."

Shortly after the NAS report was released, the state of Virginia established a working group to develop the necessary regulatory framework for uranium mining and milling in Virginia. In late 2012, the working group released its report, outlining the role of various state agencies, the needed environmental and other analyses and the method by which the state would interact with the federal government. However, in early 2013, legislation to implement the working group's recommendations was withdrawn. As of May 2013, the legislation has not been reintroduced.

New Mexico: The Mt. Taylor mine is located in an area designated in 2009 as a Native American traditional cultural property by New Mexico Cultural Properties Review Committee. In 2011, the Fifth Judicial District Court of New Mexico reversed this designation, reasoning that the area was too large to be reasonably monitored by the state to the level required by this designation. This ruling eased the way for reopening of the mine and exploration of other areas on Mt. Taylor.

Litigation

There are substantial uranium reserves on federal lands in the general proximity to the Grand Canyon National Park in northern Arizona. With the increase in uranium prices through the mid-2000s, interest increased in developing some of these deposits and reopening mines that were closed when uranium prices were much lower. In July 2009, the US federal government announced its intent to withdraw public land and National Forest System lands from location and entry under the 1872 Mining Law for up to 20 years. In January 2012, after completing an EIS and a long review period, the US federal government finalised the decision. It is important to note that this mining "ban" does not apply to existing mines or to existing claims made under the Mining Act of 1872.

Since the "ban" only applies to new claims and new mines, Energy Fuels Inc. subsequently announced that they were planning to reopen a closed mine in the area covered by the ban. Approvals to begin mining at that site were issued in 1986, but because of low uranium prices at the time, the mine was closed before any ore was extracted. In June 2012, the government ruled that because the approvals were granted, reopening this mine did not violate the "ban". In March 2013, a Native American tribe and a number of environmental groups challenged the decision in court, arguing that the 1986 approvals were essentially obsolete.

Later that month the National Mining Association and others filed a series of lawsuits challenging the land withdrawal and the underlying federal authority to do so. In these lawsuits, they argued that:

- the withdrawal imposes immediate and substantial delays and costs;
- the government does not have authority to withdraw public lands in excess of 5 000 acres;
- the withdrawal was “an arbitrary agency action”;
- the EIS did not comply with the National Environmental Policy Act (NEPA);
- the withdrawal was not necessary to protect the park.

In May 2013, the US federal government decision to withdraw and protect the subject lands was upheld in court.

Regulatory regime

Regulation

Uranium recovery is regulated by the NRC, the EPA, individual states and mining regulations for federal lands administered through the federal agency that controls this land (such as the Bureau of Land Management). Before mining commences, EISs must be completed, adequate bonding must be posted and additional regulatory requirements specified by federal and state agencies must be satisfied.

The NRC has initiated an effort to update its guidance for uranium recovery facilities. These updates are related to: technical and environmental regulations for conventional, heap leach and ISR facilities; licence application formats; restoration action plans and pre-licence exploration vs. post-licence operations. Licensing of an ISR facility by the NRC takes on average 3.5 years and costs USD 2.6 million. Length and cost estimates for licensing by other agencies are not available. Currently there are 28 licensing actions on file with the NRC, including 1 draft licence (Crow Butte Expansion), 10 new applications and 12 restarts of expansions. This does not include licensing actions in agreement states such as Texas, where licensing is completed by the state with NRC oversight.

The EPA is reviewing and revising its standards for uranium and thorium milling facilities. The standards apply to by-product material from conventional mills, ISR and heap leach facilities, but not to conventional open-pit or underground mines. Any revisions are expected to address such issues as groundwater protection and significant changes in uranium industry technology, judicial decisions relevant to the regulation and the need for new assessments to account for unanticipated risks to the public and the environment. As of 31 December 2012, the EPA had not issued a notice of proposed rulemaking, and no date to do so has been projected by the EPA. Any new or revised standards must be adopted by the NRC, their Agreement States and the DOE.

Uranium requirements

Annual uranium requirements for the United States for the period 2012 to 2040 are projected to increase from 23 083 tU in 2012 to 24 733 tU in 2035 (high case). This increase is based on the possibility that some nuclear power plants may apply for and receive licence renewals to operate for an 80-year extended life cycle, as well as the deployment of new nuclear technology. The projected increase in requirements is however tempered by the expected retirement of some reactors after 60 years of operation as well as announced early retirements such as those at Crystal River (Florida), Kewaunee (Wisconsin), Oyster Creek (New Jersey), San Onofre (California) and Vermont Yankee (Vermont).

Supply and procurement strategy

The United States allows supply and procurement of uranium to be driven by market forces with resultant sales and purchases conducted solely in the private sector by firms involved in the uranium mining and nuclear power industries.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The Russian Federation and the United States signed a 20-year, government-to-government agreement in February 1993 for the conversion of 500 tonnes of Russian highly enriched uranium (HEU) from nuclear warheads to LEU suitable for use as nuclear fuel (referred to as the Megatons-to-Megawatts agreement). As of 31 December 2012 the USEC, the US executive agent for the HEU agreement, announced 472.5 tonnes of HEU had been recycled into 13 603 tonnes of LEU and eliminating 18 899 warheads. As of 31 December 2012, the programme, which will expire in late 2013, had not been extended. In March 2011, USEC signed a ten-year contract with TENEX (the Russian executive agent of the Megatons-to-Megawatts agreement) to supply commercial-origin Russian LEU beginning in 2011 and continuing through 2022.

In December 2008, the DOE released a plan to manage its excess uranium inventory. The plan includes the sale or transfer of 22 700 tNatU, over ten years (2008-2017). The plan, designed partly to minimise adverse impacts on the domestic uranium industry, specifies that transfers cannot exceed 10% of US commercial uranium requirements in any given year. On 1 March 2011, the Secretary of Energy authorised the additional transfer of 1 605 tNatU/yr in 2011, 2012 and 2013. The sale of this additional uranium from the DOE's excess inventory will fund accelerated clean-up work at the Portsmouth gaseous diffusion enrichment plant from 2011 through 2013. Based on a market impact analysis performed by Energy Resources International, Inc., the Secretary of Energy determined that there would be no adverse material impact on the domestic uranium industry from the transfer of uranium to fund the Portsmouth clean-up. In May 2013, operations at the Paducah gaseous diffusion enrichment plant were terminated.

Uranium stocks

As of 2012, the total inventories (including government, producer and utility stocks) in the United States amounted to 102 469 tU. Of this total, government stocks were 56 031 tU, which includes 17 596 tU of uranium concentrates, 12 485 tU of enriched uranium and 25 950 tU of depleted uranium. Total commercial inventories (producer and utility stocks) in 2012 were 46 438 tU, an 8% increase from the 43 120 tU of inventories held in 2011. Over 80% of the commercial inventories, or 37 490 tU, were held by owners and operators of commercial reactors. This was an 8% increase from the 34 555 tU owned by this group at the end of 2011.

Enriched uranium inventories held by utilities (including fuel elements in storage) increased 37% from 2011 to 2012 (39 324 tU in 2011 to 53 844 tU in 2012), whereas natural uranium inventories held by utilities (including UF_6 in storage) decreased 14% from 2011 to 2012 (50 601 tU in 2011 to 43 622 in 2012).

Uranium prices

Owners and operators of US civilian nuclear power reactors purchase uranium under spot contracts and long-term contracts. A spot contract is defined as a one-time delivery of the entire contract to occur within one year of contract execution. A long-term contract is defined as one or more deliveries to occur after a year following contract execution.

In 2012, under spot contract purchases amounted to 3 109 tU, a 33% decrease from the 4 626 tU purchased under spot contracts in 2011. The weighted average spot price decreased 7% from USD 142/kgU in 2011 to USD 133/kgU in 2012. The uranium purchased under long-term contracts in 2012 amounted to 18 797 tU, a 16% increase from the 16 264 tonnes purchased in 2011. The weighted average price under long-term contracts in 2012 was about USD 145/kgU, as it was in 2011.

Seventeen per cent of the uranium delivered in 2012 was US-origin uranium. Foreign-origin uranium accounted for the remaining 83% of deliveries. Australian-origin and Canadian-origin uranium together accounted for 35% of deliveries. Uranium originating in Kazakhstan, Russian Federation and Uzbekistan accounted for 29% and the remaining 19% originated from Brazil, China, Malawi, Namibia, Niger, South Africa, and Ukraine.

Uranium exploration and development expenditures and drilling effort – domestic

(USD million)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures[1]	34.5	43.5	33.3	NA
Government exploration expenditures	0	0	0	NA
Industry* development expenditures[2]	109.5	106.9	132.7	NA
Government development expenditures	0	0	0	NA
Total expenditures	**144**	**150.4**	**166**	**NA**
Industry* exploration drilling (m)[3]	445 009	1 012 549	1 050 649	NA
Industry* exploration holes drilled[4]	2 439	5 441	5 112	NA
Government exploration drilling (m)	0	0	0	NA
Government exploration holes drilled	0	0	0	NA
Industry* development drilling (m)[5]	1 049 735	915 317	1 130 507	NA
Industry* development holes drilled[6]	4 770	5 156	5 970	NA
Government development drilling (m)	0	0	0	NA
Government development holes drilled	0	0	0	NA
Subtotal exploration drilling (m)	445 009	1 012 549	1 050 649	NA
Subtotal exploration holes	2 439	5 441	5 112	NA
Subtotal development drilling (m)	1 049 735	915 317	1 130 507	NA
Subtotal development holes	4 770	5 156	5 970	NA
Total drilling (m)	**1 494 744**	**1 927 866**	**2 181 156**	**NA**
Total number of holes drilled	**7 209**	**10 597**	**11 082**	**NA**

* Non-government.

1. Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 8, Exploration.
2. Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 8, Drilling + Land + Reclamation.
3. Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 1, Exploration, Feet (converted into metres using EIA Uranium Industry Annual Appendix D Uranium Conversion Guide).
4. Source: US Energy Information Administration Domestic, Uranium Production Report, 2012, Table 1, Exploration, Number of Holes.
5. Source: US Energy Information Administration Domestic, Uranium Production Report, 2012, Table 1, Development Drilling.
6. Source: US Energy Information Administration Domestic, Uranium Production Report, 2012, Table 1, Development Drilling.

Average US uranium prices, 2000-2012

(USD per kilogram U equivalent)

Year	Spot contracts	Long-term contracts
2012	132.69	144.68
2011	142.18	145.33
2010	114.36	131.11
2009	120.76	118.91
2008	174.06	108.12
2007	229.44	63.57
2006	102.64	42.59
2005	52.10	35.62
2004	38.40	31.82
2003	26.26	28.44
2002	24.15	27.51
2001	20.59	28.49
2000	22.20	30.42

1. US Energy Information Administration, Uranium Marketing Annual Report, 2012, Table 7.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unconformity-related	0	0	0	0	NA
Sandstone	0	39 064	191 953	401 149	NA
Intrusive	0	0	W	W	NA
Volcanic and caldera-related	0	0	W	W	NA
Other*	0	0	W	W	NA
Total	**0**	**39 064**	**207 435**	**472 056**	**NA**

* Includes surficial, collapse breccia pipe, phosphorite and other types of deposits, as well as rocks with elevated uranium content. Pegmatite, granites and black shale are not included.

W = Data withheld to avoid disclosure of individual company data.

Source: US Energy Information Administration, Uranium Reserves Data.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	82 863	233 960	NA
Open-pit mining (OP)	0	2 472	35 847	125 025	NA
In situ leaching alkaline	0	36 592	88 530	110 991	NA
Unspecified	0	0	195	2 080	NA
Total	**0**	**39 064**	**207 435**	**472 056**	**NA**

Source: US Energy Information Administration, Uranium Reserves Data.

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	NA	NA	NA	NA
Conventional from OP	0	NA	NA	NA	NA
In situ leaching acid	0	NA	NA	NA	NA
In situ leaching alkaline	0	NA	NA	NA	NA
In-place leaching*	0	NA	NA	NA	NA
Heap leaching** from UG	0	NA	NA	NA	NA
Heap leaching** from OP	0	NA	NA	NA	NA
Unspecified	0	NA	NA	NA	NA
Total	**0**	**39 064**	**207 435**	**472 056**	**NA**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Source: US Energy Information Administration, Uranium Reserves Data.

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Unconformity-related	NA	NA	NA	NA	NA	NA
Sandstone	NA	NA	NA	NA	NA	NA
Hematite breccia complex	NA	NA	NA	NA	NA	NA
Quartz-pebble conglomerate	NA	NA	NA	NA	NA	NA
Vein	NA	NA	NA	NA	NA	NA
Intrusive	NA	NA	NA	NA	NA	NA
Volcanic and caldera-related	NA	NA	NA	NA	NA	NA
Metasomatite	NA	NA	NA	NA	NA	NA
Other*	NA	NA	NA	NA	NA	NA
Total	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

* Includes surficial, collapse breccia pipe, phosphorite and other types of deposits, as well as rocks with elevated uranium content. Pegmatite, granites and black shale are not included.

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Open-pit mining*	0	0	0	0	0	0
Underground mining*	NA	W	W	W	W	NA
In situ leaching	NA	W	W	W	W	NA
Co-product/by-product	NA	W	W	W	W	NA
Total	**365 270**	**1 630**	**1 582**	**1 667**	**370 149**	**NA**

Note: Data not available prior to 1968. 2011 Red Book used as the baseline.

W = Data withheld to avoid disclosure of individual company data.

* Pre-2008 totals may include uranium recovered by heap and in-place leaching.

Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 2.

Historical uranium production by processing method

(tonnes U in concentrate)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	NA	W	W	W	NA	NA
In-place leaching*	NA	W	W	W	NA	NA
Heap leaching**	0	0	0	0	0	NA
U recovered from phosphate rocks	0	0	0	0	0	NA
Other methods***	0	0	0	0	0	NA
Total	**364 642**	**1 626**	**1 535**	**1 595**	**369 398**	**NA**

W = Data withheld to avoid disclosure of individual company data.

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 3.

Ownership of uranium production in 2012

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
0	0	W	W	0	0	W	W	1 667	100

W = Data withheld to avoid disclosure of individual company data.

Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 2.

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013 (expected)
Total employment related to existing production centres[1]	948	1 089	1 017	NA
Employment directly related to uranium production[2]	737	881	856	NA

1. Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 6, all sectors except Reclamation.
2. Source: US Energy Information Administration, Domestic Uranium Production Report, 2012, Table 6, all sectors except Exploration and Reclamation.

Short-term production capability

(tonnes U/year)

2011				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Mixed oxide fuel production and use[1]

(tonnes of natural U equivalent)

Mixed oxide (MOX) fuel	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	0	0	0	0	0	0
Use	0	0	0	0	0	0
Number of commercial reactors using MOX	0	0	0	0	0	0

1. *OECD Nuclear Energy Data 2013*.

Re-enriched tails production and use[1]

(tonnes of natural U equivalent)

Re-enriched tails	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	1 939.8	0	0	0	1 939.8	0
Use	1 376.1	0	191	0	1 567.1	372.7

1. Data provided by Energy Northwest, owner-operator of the Columbia Generating Station.

Reprocessed uranium use[1]

(tonnes natural U equivalent)

Reprocessed uranium	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Production	0	0	0	0	0	0
Use	0	0	0	0	0	0

1. *OECD Nuclear Energy Data 2013*.

Net nuclear electricity generation[1]

	2011	2012
Nuclear electricity generated (TWh net)	790	769

1. *OECD Nuclear Energy Data 2013*.

Installed nuclear generating capacity to 2035[1]

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
101 400	101 400p	100 300	102 200	104 200	104 900	104 900	110 600	104 900	121 900	102 800	121 900	74 900	122 500

1. *OECD Nuclear Energy Data 2013*. P = provisional data.

Annual reactor-related uranium requirements to 2035 (excluding MOX)[1]

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
21 899	23 083p	18 348	18 348	19 970	19 970	19 878	19 878	21 262	24 649	20 833	26 649	15 269	24 733

1. US Energy Information Administration Form 858, Uranium Marketing Annual Survey. P = provisional data.

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	LWR reprocessed uranium stocks	Total
Government[1]	17 596	12 485	25 950	NA	56 031
Producer[2]	NA	NA	NA	NA	8 948
Utility[2]	16 779[3]	20 711[4]	NA	NA	37 490
Total	**NA**	**NA**	**NA**	**NA**	**102 469**

1. US Department of Energy, Excess Uranium Inventory Management Plan, December 2008.
2. US Energy Information Administration, Uranium Marketing Annual Report, 2012, Tables 22 and 23.
3. The value for natural uranium stocks in this table does not include natural uranium hexafluoride (UF_6). Values for total utility natural uranium stocks in the text include natural UF_6.
4. The value for enriched uranium stocks in this table does not include fabricated fuel elements held in storage prior to loading in the reactor. Values for total utility enriched uranium in the text include fabricated fuel elements in storage.

Viet Nam

Uranium exploration and mine development

Historical review

The first exploration programmes were started prior to 1955 by French geologists of the Geological Department of Indochina. Beginning in 1978, a systematic regional exploration programme was conducted over the entire country using radiometric methods combined with geological observations. About 25% of the country was also covered by an airborne radiometric/magnetic survey at a scale of 1:25 000 and 1:50 000. This led to the discovery of a large number of promising areas in the provinces of Cao Bang, Lao Cai, Yen Bai and Quang Nam. Uranium mineralisation in Viet Nam is associated with rare earth deposits (Cao Bang province), phosphate deposits, sandstone and coal deposits (Quang Nam province).

Between 1997 and 2002, the Geological Division for Radioactive and Rare Elements (GDRRE) carried out detailed uranium exploration and evaluation (including drilling, trenching and bulk sampling) in the Palua and Parong areas of the Quang Nam province.

Recent and ongoing uranium exploration and mine development activities

Since 2010, the GDRRE in the Ministry of Natural Resources and Environment has been carrying out uranium exploration in the Parong area in the Quang Nam province in central Viet Nam. The project consists of an investigation and evaluation of Triassic sandstone-type deposits.

Exploration activities on the Parong deposit, covering an area of 1.9 km^2, consist of geophysical and geological surveys, trenching, drilling and mining tests. Over the main part of the deposit, 712 holes (60 954 m) have been drilled on a 25 x 25 m^2 grid to depths of between 30 and 150 m. Extensions of the deposit have also been drilled on a more widely spaced grid (between 50 x 50 m^2 and 50 x 25 m^2).

A mining test was conducted via a 130 m adit from which 3 holes have been drilled to 300 m for hydrogeological tests. Results show a limited amount of water in the formations.

Mineralisation at Parong is associated with medium coarse-grained sandstone with organic matter. Three main levels of mineralisation in reduced formations have been defined, separated by oxidised sandstone. Mineralisation over a lateral extension of 200-300 m has been intersected that varies in thickness from a few centimetres to a few metres.

In support of this exploration project, research on leaching ore treatment methods, laboratory and pilot-scale tests, as well as investigations on the management of mining wastes and tailings have been carried out by the Institute for Technology of Radioactive and Rare Elements (ITRR). The results show that the heap leach method is suitable for the low-grade Parong ore, with uranium recovery greater than 75% achieved.

Uranium resources

Identified conventional resources

In 2011-2012, the uranium potential of part "A" of the Parong area (drilled at a 25 x 25 m^2 grid) was assessed. Uranium resources, estimated using a 0.0085% U cut-off grade, amount to 1 200 tU at an average grade of 0.034% U. These resources can be classified as RAR resources in the highest cost category (<USD 260/kgU or <USD 100/lb U_3O_8).

Results of a previous evaluation (uranium resources as of 31 December 2008) in the main area of the Quang Nam province concluded that:

- the Palua deposit consists of five orebodies with total resources amounting to 4 596 tU, including 984 tU inferred resources;
- the Parong deposit consists of seven orebodies with total resources amounting to 3 867 tU, including 1 200 tU of inferred;
- the Khehoa-Khecao deposit consists of four orebodies with total resources amounting to 5 803 tU, including 1 125 tU inferred;
- the Dong Nam Ben Giang deposit consists of eight orebodies with total resources amounting to 1 556 tU, including 337 tU inferred;
- resources of the An Diem deposit amount to 1 853 tU, including 354 tU inferred.

Undiscovered conventional resources (prognosticated and speculative resources)

The results of geological exploration which have been conducted by the GDREE shows that, there are more than ten uranium occurrences and deposits located in the northern provinces (Lai Chau, Lao Cai, Yen Bai, Son La, Ha Giang, Cao Bang, Phu Tho and Thai Nguyen), in the highlands and in the central provinces.

Uranium deposits located in the Lai Chau province are associated with rare earth deposits. In the Cao Bang province, uranium mineralisation is associated with phosphate deposits, and in the Quang Nam province uranium is associated with sandstones and in coal deposits.

The undiscovered conventional uranium resources as of 31 December 2008 amounted to a total of 81 200 tU prognosticated and 321 600 tU speculative resources. Some of the prognosticated resources includes: 3 612 tU at Palua; 2 667 tU at Parong; 4 678 tU at Khehoa-Khecao; 1 219 tU at Dong Nam Ben Giang; and 1 499 tU at An Diemand.

Uranium production

No uranium has been produced in Viet Nam.

Future production centres

The objective of the current "Uranium Exploration Project" is to increase the resource base to a total of 5 500 tU_3O_8 (4 665 tU) inferred and 8 000 tU_3O_8 (6 780 tU) prognosticated as well as determining the feasibility of mining these deposits. The ITRR has carried out research on ore processing and has started to survey the environmental conditions of future mining operations. As of 31 December 2012, no production centre is planned.

Environmental activities and socio-cultural issues

Environmental activities, such as monitoring the environmental impacts resulting from exploration, are being carried out.

Uranium requirements

Viet Nam has a plan to develop a nuclear power plan that is expected to include 14 nuclear units with a total net nuclear electricity generating capacity of about 15 000 MWe to 16 000 MWe by the year 2030. To date, seven sites for the construction of NPP have been selected with each site having the potential to accommodate four to six units.

In March 2010, the Prime Minister of Viet Nam approved the overall plan for the implementation of the Ninh Thuan Nuclear Power Project, which includes the Phuoc Dinh and Vinh Hai NPPs.

The first nuclear plant will consist of two VVER-type PWRs with a total net nuclear electricity generating capacity of about 2 000 MWe, to be built in co-operation with Rosatom. This plant will be located in the Phuoc Dinh commune, Thuan Nam district, Ninh Thuan province. Construction of this plant is planned to begin in 2014 with operations commencing in 2020. The second nuclear plant, built in co-operation with Japan Atomic Power Co. is to have the same generating electricity capacity (2 x 1 000 MWe) and will be located in the Vinh Hai commune, Ninh Hai district, Ninh Thuan province. It is planned to be in operation by 2023. The expected annual reactor-related uranium requirements will be satisfied by imports and by domestic production.

Uranium exploration and development expenditures and drilling effort – domestic

(Vietnamese dong)

	2010	2011	2012	2013 (expected)
Industry* exploration expenditures	-	-	-	-
Government exploration expenditures	59 488 000 000	110 648 637 600	35 476 771 200	20 000 000 000
Industry* development expenditures	-	-	-	-
Government development expenditures	-	-	-	-
Total expenditures	**59 488 000 000**	**110 648 637 600**	**35 476 771 200**	**20 000 000 000**
Industry* exploration drilling (m)	-	-	-	-
Industry* exploration holes drilled	-	-	-	-
Government exploration drilling (m)	26 086.2	34 867.5	0	NA
Government exploration holes drilled	298	414	0	NA
Industry* development drilling (m)	-	-	-	-
Industry* development holes drilled	-	-	-	-
Government development drilling (m)	-	-	-	-
Government development holes drilled	-	-	-	-
Subtotal exploration drilling (m)	-	-	-	-
Subtotal exploration holes drilled	-	-	-	-
Subtotal development drilling (m)	-	-	-	-
Subtotal development holes drilled	-	-	-	-
Total drilling (m)	**26 086.2**	**34 867.5**	**0**	**NA**
Total number of holes drilled	**298**	**414**	**0**	**NA**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	0	1 200
Total	**0**	**0**	**0**	**1 200**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	0	0	0	1 200
Total	**0**	**0**	**0**	**1 200**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Heap leaching* from UG	0	0	0	1 200
Total	**0**	**0**	**0**	**1 200**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	0	2 800
Total	**0**	**0**	**0**	**2 800**

* *In situ* resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	0	2 800
Total	**0**	**0**	**0**	**2 800**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	0	2 800
Total	**0**	**0**	**0**	**2 800**

* *In situ* resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
NA	NA	81 200

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
NA	NA	321 600

Expected installed nuclear generating capacity to 2035

(MWe net)

2020		2025		2030		2035	
Low	High	Low	High	Low	High	Low	High
1 000	1 000	2 000	4 000	NA	NA	NA	NA

Expected annual reactor-related uranium requirements to 2030

(tonnes U)

2020		2025		2030		2035	
Low	High	Low	High	Low	High	Low	High
NA	NA	NA	NA	NA	NA	NA	NA

Zambia*

Uranium exploration and mine development

Historical review

Uranium was first observed in Zambia (then Northern Rhodesia) at the site of the Mindola copper mine in Kitwe, leading to the mining of this small deposit between 1957 and 1959. A total of 102 tU_3O_8 (86 tU) was produced. Although no uranium has been produced from that mine or from Zambia since then, exploration activity has only been carried out periodically by the government and by private companies.

* Report prepared by the Secretariat, based on previous Red Books and company reports.

Sporadic uranium exploration activities took place during the 1990s but primary attention was focused on copper. It was only in the mid-2000s that interest in uranium was stimulated by the dramatic rise in the spot market price for uranium.

The exploration environment in Zambia underwent a fundamental change in 1969. Prior to this date all mineral rights were in private hands, but in 1969 these rights reverted to the state. In 1969, the state also effectively nationalised mining by becoming a majority shareholder in all mining companies active in the country (principally copper). Financial realities, including a decline in copper prices, along with recommendations from external bodies such as the World Bank and International Monetary Fund, encouraged the state to enter into a process of privatisation. This became a reality in 1997 with the primary objective of encouraging foreign investment in the country.

Recent and ongoing uranium exploration and mine development activities

Denison completed extensive drilling in 2011 and 2012 on their Mutanga Project and updated the resource estimate to 18 923 tU at an average grade of 252 ppm U (0.0252% U). Airborne geophysics techniques used to locate anomalies for potential uranium mineralisation. Near-surface mineralisation at Dibwe East zones 1 and 2 is consistent over 4 km, with high-grade ore in its core. Future exploration activities are expected to be focused on field programmes including an extensive surficial geochemistry and surface radon surveys, geological mapping and airborne geophysics to assist in defining drill targets.

In mid-2011 Equinox Minerals was taken over by Barrick Gold Corp. for CAD 7.3 billion. At that time, a total of 4.2 Mt of uraniferous ore at a grade of 0.118% U_3O_8 (0.1% U) was stockpiled at the Lumwana copper mine which could be processed at a later date if Barrick decides to build a uranium mill for an estimated cost of USD 200 to 230 million. In 2012, drilling programmes at Lumwana were focused on a resource definition programme at Chimiwungo, reserve delineation at Chimiwungo and Malundwe, extension exploration drilling at Chimiwungo and condemnation drilling to test for economic mineralisation in areas of planned mining infrastructure. A total of 237 277 m of diamond drilling and 49 029 m of reverse circulation drilling was completed during 2012 in order to better define the limits of mineralisation and develop an updated, more comprehensive block model of the orebody for mine planning purposes. Total resources, including the uranium ore stockpiled at Malundwe, amounted to 7 492 tU at an average grade of 0.07% U. However, the orebody did not meet economic expectations. The drilling defined significant additional mineralisation, some at higher grades, much of it was deep and would require a significant amount of waste stripping, making it uneconomic based on the expected operating costs and current market copper prices. Activity continues on a number of key initiatives to lower costs, including improvements to operating systems and processes.

At the end of 2012, African Energy concluded baseline environmental studies for the Chirundu Uranium Project, the only work completed by African Energy on its uranium projects. African Energy is now focusing efforts on its coal projects in Botswana and intends to divest all uranium projects.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Only three properties in Zambia have reached the stage of development where NI 43-101 or JORC compliant resources have been published. Denison's Mutanga Project has a total of 75.4 Mt of measured, indicated and inferred ore at a grade of 0.025% U containing 18 923 tU including inferred resources at Dibwe East. African Energy's Chirundu Project, adjacent to Mutanga, has total measured, indicated and inferred resources of 18.7 Mt at a grade of 0.023% containing 4 270 tU. The third is the Lumwana copper mine, where resources are hosted by mica-quartz-kyanite schists of the Katangan Supergroup. Measured, indicated and inferred resources of 7 492 tU are contained within 11.2 Mt of ore.

Potential for the discovery of additional uranium resources exists in various parts of the country that have been poorly explored. Of particular interest is the Copperbelt where many copper orebodies have known associated uranium mineralisation.

Uranium production

Historical review

A total of 102 tU_3O_8 (86 tU) was produced at the Mindola mine in Kitwe during the late 1950s. Production ceased in 1960 and no uranium has been produced since.

Uraniferous ore was stockpiled at Lumwana while mining the higher-grade Malundwe copper deposit. As of March 2011, the stockpile amounted to 4.2 Mt of ore grading at 0.1% U.

Uranium production centre technical details

(as of 1 January 2013)

	Centre #1	Centre #2
Name of production centre	Lumwana	Mutanga
Production centre classification	Planned	Planned
Date of first production	NA	NA
Source of ore:		
Deposit name(s)	Malundwe-Chimiwungo	Dibwe-Mutanga
Deposit type(s)	Metasomatic (metamorphosed schists)	Sandstone
Recoverable resources (tU)	7 492	18 923
Grade (% U)	0.07	0.025
Mining operation:		
Type (OP/UG/ISL)	OP	OP
Size (tonnes ore/day)	2 800	NA
Average mining recovery (%)	NA	NA
Processing plant:		
Acid/alkaline	Acid	Acid
Type (IX/SX)	SX	HL
Size (tonnes ore/day) For ISL (mega or kilolitre/day or litre/hour, specify)		
Average process recovery (%)	93.1	NA
Nominal production capacity (tU/year)	650	NA
Plans for expansion		
Other remarks	Mine currently operated by Barrick: uranium bankable feasibility study completed by Equinox Minerals	Mine construction on hold until uranium price increases

Environmental activities and socio-cultural issues

Environmental impact assessments

African Energy has completed environmental baseline studies on their Chirundu Project near the Zimbabwe border, including the Njame and Gwabe deposits.

Waste rock management

Equinox Minerals original plans in 2003 were to excavate, stockpile and return the uraniferous ore to the Malundwe pit at the Lumwana copper mine following completion of mining as it was considered uneconomic at the time to recover the uranium. However, in 2006, with a uranium spot price in excess of USD 50 lb/U_3O_8 (USD 130/kgU) the project was re-evaluated. In January 2011, Equinox Minerals reported that the portion of the stockpile containing 0.09% U and 0.8% Cu may be treated at a later date, if and when a uranium plant is built. The stockpile is currently classified and expensed as "waste" in the copper project.

Environmental activities and socio-cultural issues

The Mines and Minerals Development Act (1995) makes provision for the preparation of a project brief when applying for a mining licence. This must include an environmental impact statement detailing all potential impacts of the project. Annual environmental audits must be carried out to ensure compliance and contributions must be made to an environmental management fund for rehabilitation.

Local inhabitants around the Mutanga Project were involved in public hearings organised by the Environmental Council of Zambia. Agreements were reached regarding the displacement of 107 families in 2 villages to allow for the construction of the mine infrastructure.

African Energy assisted the construction of a community health post at Sikoongo Village near their Chirunda Project.

Barrick have invested in a wide range of sustainable development initiatives in 2012, including funding for infrastructure (such as schools and health centres), literacy and agricultural programmes, community sports and recreation and an initiative to provide microcredit and small business loans to women.

Uranium requirements

Zambia has no nuclear generating capacity and no formal development plans.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Mining activities in general were regulated by the Mines and Minerals Act (1995), but until recently there was no legislation specifically relating to exploration for and mining of uranium. The act was repealed in 2008 following widespread criticism of what was perceived to be excessive scope for granting tax concessions. This act was replaced by the Mines and Minerals Development Act 2008, which ruled that no special agreements should be entered into by the government for the development of large-scale mining licences. It also effectively ended development agreements concluded under the previous act. The Mines and Minerals Development (Prospecting, Mining and Milling of Uranium Ores and Other Radioactive Mineral Ores) and Regulations of 2008 deal with the mining, storage and export of uranium. Mining and export licences will only be granted when the Radiation Protection Authority is satisfied that the operations pose no environmental and health hazards. Applicants for export licences will also have to prove the authenticity of the importers in terms of IAEA guidelines.

A study by the Council of Churches concluded that current legislation and enforcement was inadequate for uranium mining. They recommended that current regulations be revised to address the concerns of local communities and that educational and awareness programmes be initiated prior to any uranium exploration and mining activities.

In 2011, Zambia and Finland signed co-operating projects aimed at helping the southern African nation review regulations on uranium mining as well as the management of the mineral. The two projects are aimed at evaluating current regulations on uranium and other radioactive minerals as well as developing a modern geo-information infrastructure. These projects are designed to help the country evaluate, update and review regulations regarding the safety of uranium mining.

Uranium exploration and development expenditures and drilling effort – domestic

(CAD thousand)*

	2010	2011	2012	2013 (expected)
Industry** exploration expenditures		2 396	3 627	3 500
Government exploration expenditures				
Industry** development expenditures				
Government development expenditures				
Total expenditures				
Industry** exploration drilling (m)		15 296	18 160	0
Industry** exploration holes drilled		146	137	0
Government exploration drilling (m)				
Government exploration holes drilled				
Industry** development drilling (m)				
Industry** development holes drilled				
Government development drilling (m)				
Government development holes drilled				
Subtotal exploration drilling (m)		15 296	18 160	
Subtotal exploration holes drilled		146	137	
Subtotal development drilling (m)				
Subtotal development holes drilled				
Total drilling (m)		**15 296**	**18 160**	
Total number of holes drilled		**146**	**137**	

* Does not include Barrick's Lumwana's costs (copper-related).

** Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone			5 846	5 846
Metasomatite			6 469	6 469
Total			**12 315**	**12 315**

* *In situ* resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)			12 315	12 315
Total			**12 315**	**12 315**

* *In situ* resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from OP			12 315	12 315
Total			**12 315**	**12 315**

* *In situ* resources.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone			17 385	17 385
Metasomatite			1 023	1 023
Total			**18 408**	**18 408**

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)			18 408	18 408
Total			**18 408**	**18 408**

* *In situ* resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from OP			18 408	18 408
Total			**18 408**	**18 408**

* *In situ* resources.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Metasomatite	86	0	0	0	86	0
Total	**86**	**0**	**0**	**0**	**86**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Underground mining[1]	86	0	0	0	86	0
Total	**86**	**0**	**0**	**0**	**86**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	Total through end of 2012	2013 (expected)
Conventional	86	0	0	0	86	0
Total	**86**	**0**	**0**	**0**	**86**	**0**

Short-term production capabilities

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	0	0	0	0	0	0	650

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	650	0	0	0	650	0	0	0	650

Appendix 1. Members of the Joint NEA-IAEA Uranium Group participating in 2012-2013 meetings

Algeria	Ms A. Badani Mr A. Khaldi	Centre de Recherche Nucléaire de Draria, Draria
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	Ms Y. Liu	China National Nuclear Corporation, Beijing
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Egypt	Mr A. Abdelkhalek Khamies Mr M. Aly Mohamadin	Nuclear Materials Authority, Cairo
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Italy	Ms G. Abbate	ENEA, Bologna
Japan	Mr K. Hisatani	Japan Oil, Gas and Metals National Corporation, Tokyo
Jordan	Mr K. El-Kaysi	Jordan Energy Resources Incorporation, Amman
Kazakhstan	Mr Y. Demekhov Ms O. Gorbatenko *(Vice-Chair)* Mr D. Mubarakov	National Atomic Company "KAZATOMPROM", Astana

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Appendix 3. Glossary of definitions and terminology

Units

Metric units are used in all tabulations and statements. Resources and production quantities are expressed in terms of tonnes (t) contained uranium (U) rather than uranium oxide (U_3O_8).

1 short ton U_3O_8	=	0.769 tU
1% U_3O_8	=	0.848% U
1 USD/lb U_3O_8	=	USD 2.6/kg U
1 tonne	=	1 metric ton

Resource terminology

Resource estimates are divided into separate categories reflecting different levels of confidence in the quantities reported. The resources are further separated into categories based on the cost of production.

Definitions of resource categories

Uranium resources are broadly classified as either conventional or unconventional. Conventional resources are those that have an established history of production where uranium is a primary product, co-product or an important by-product (e.g. from the mining of copper and gold). Very low-grade resources or those from which uranium is only recoverable as a minor by-product are considered unconventional resources.

Conventional resources are further divided, according to different confidence levels of occurrence, into four categories. The correlation between these resource categories and those used in selected national resource classification systems is shown in Figure A3.1.

Reasonably assured resources (RAR) refers to uranium that occurs in known mineral deposits of delineated size, grade and configuration such that the quantities which could be recovered within the given production cost ranges with currently proven mining and processing technology, can be specified. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of deposit characteristics. Reasonably assured resources have a high assurance of existence. Unless otherwise noted, RAR are expressed in terms of quantities of uranium recoverable from mineable ore (see recoverable resources).

Inferred resources (IR) refers to uranium, in addition to RAR, that is inferred to occur based on direct geological evidence, in extensions of well-explored deposits, or in deposits in which geological continuity has been established but where specific data, including measurements of the deposits, and knowledge of the deposit's characteristics, are considered to be inadequate to classify the resource as RAR. Estimates of tonnage, grade and cost of further delineation and recovery are based on such sampling as is available and on knowledge of the deposit characteristics as determined in the best known parts of the deposit or in similar deposits. Less reliance can be placed on the estimates in this category than on those for RAR. Unless otherwise noted, inferred resources are expressed in terms of quantities of uranium recoverable from mineable ore (see recoverable resources).

Figure A3.1. Approximate correlation of terms used in major resources classification systems

<table>
<tr><td></td><td colspan="3">Identified resources</td><td colspan="3">Undiscovered resources</td></tr>
<tr><td>NEA/IAEA</td><td colspan="2">Reasonably assured</td><td>Inferred</td><td>Prognosticated</td><td colspan="2">Speculative</td></tr>
<tr><td rowspan="2">Australia</td><td colspan="2">Demonstrated</td><td rowspan="2">Inferred</td><td rowspan="2" colspan="3">Undiscovered</td></tr>
<tr><td>Measured</td><td>Indicated</td></tr>
<tr><td>Canada (NRCan)</td><td>Measured</td><td>Indicated</td><td>Inferred</td><td>Prognosticated</td><td colspan="2">Speculative</td></tr>
<tr><td>United States (DOE)</td><td colspan="2">Reasonably assured</td><td colspan="2">Estimated additional</td><td colspan="2">Speculative</td></tr>
<tr><td>Russian Federation, Kazakhstan, Ukraine, Uzbekistan</td><td>A + B</td><td>C1</td><td>C2</td><td>P1</td><td>P2</td><td>P3</td></tr>
</table>

The terms illustrated are not strictly comparable as the criteria used in the various systems are not identical. “Grey zones” in correlation are therefore unavoidable, particularly as the resources become less assured. Nonetheless, the chart presents a reasonable approximation of the comparability of terms.

Work to align the NEA/IAEA and national resource classification systems outlined above with the United Nations Framework Classification system remains under consideration. For a summary of recent efforts, see: www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc5_apr2014/ECE.ENERGY.GE.3.2014.L1_e.pdf.

Prognosticated resources (PR) refers to uranium, in addition to inferred resources, that is expected to occur in deposits for which the evidence is mainly indirect and which are believed to exist in well-defined geological trends or areas of mineralisation with known deposits. Estimates of tonnage, grade and cost of discovery, delineation and recovery are based primarily on knowledge of deposit characteristics in known deposits within the respective trends or areas and on such sampling, geological, geophysical or geochemical evidence as may be available. Less reliance can be placed on the estimates in this category than on those for inferred resources. Prognosticated resources are normally expressed in terms of uranium contained in mineable ore, i.e. *in situ* quantities.

Speculative resources (SR) refers to uranium, in addition to prognosticated resources, that is thought to exist, mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. The location of deposits envisaged in this category could generally be specified only as being somewhere within a given region or geological trend. As the term implies, the existence and size of such resources are speculative. SR are normally expressed in terms of uranium contained in mineable ore, i.e. *in situ* quantities.

Cost categories

The cost categories, in United States dollars (USD), used in this report are defined as: <USD 40/kgU, <USD 80/kgU, <USD 130/kgU and <USD 260/kgU. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant.

Note: It is not intended that the cost categories should follow fluctuations in market conditions.

Conversion of costs from other currencies into USD is done using an average exchange rate for the month of June in that year except for the projected costs for the year of the report, which uses the exchange rate of 1 January 2013 (Appendix 7).

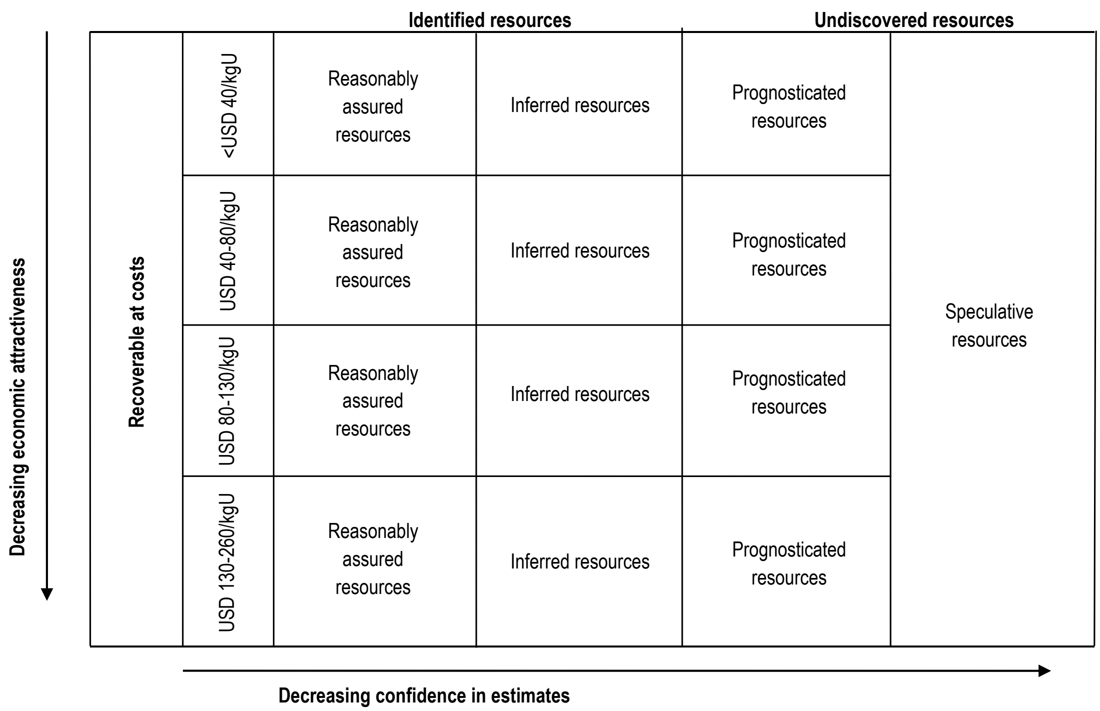
When estimating the cost of production for assigning resources within these cost categories, account has been taken of the following costs:

- the direct costs of mining, transporting and processing the uranium ore;
- the costs of associated environmental and waste management during and after mining;
- the costs of maintaining non-operating production units where applicable;
- in the case of ongoing projects, those capital costs that remain non-amortised;
- the capital cost of providing new production units where applicable, including the cost of financing;
- indirect costs such as office overheads, taxes and royalties where applicable;
- future exploration and development costs wherever required for further ore delineation to the stage where it is ready to be mined;
- sunk costs are not normally taken into consideration.

Relationship between resource categories

Figure A3.2 illustrates the inter-relationship between the different resource categories. The horizontal axis expresses the level of assurance about the actual existence of a given tonnage based on varying degrees of geologic knowledge while the vertical axis expresses the economic feasibility of exploitation by the division into cost categories.

Figure A3.2. NEA/IAEA classification scheme for uranium resources



Recoverable resources

RAR and IR estimates are expressed in terms of recoverable tonnes of uranium, i.e. quantities of uranium recoverable from mineable ore, as opposed to quantities contained in mineable ore, or quantities *in situ*, i.e. not taking into account mining and milling losses. Therefore both expected mining and ore processing losses have been deducted in most cases. If a country reports its resources as *in situ* and the country does not provide a recovery factor, the Secretariat assigns a recovery factor to those resources based on geology and projected mining and processing methods to determine recoverable resources. The recovery factors that have been applied are:

Mining and milling method	Overall recovery factor (%)
Open-pit mining with conventional milling	80
Underground mining with conventional milling	75
ISL (acid)	75
ISL (alkaline)	70
Heap leaching	70
Block and stope leaching	75
Co-product or by-product	65
Unspecified method	75

Secondary sources of uranium terminology

Mixed oxide fuel (MOX): MOX is the abbreviation for a fuel for nuclear power plants that consists of a mixture of uranium oxide and plutonium oxide. Current practice is to use a mixture of depleted uranium oxide and plutonium oxide.

Depleted uranium: Uranium where the ^{235}U assay is below the naturally occurring 0.7110%. Natural uranium is a mixture of three isotopes, uranium-238 – accounting for 99.2836%, uranium-235 – 0.7110%, and uranium-234 – 0.0054%. Depleted uranium is a by-product of the enrichment process, where enriched uranium is produced from initial natural uranium feed material.

Production terminology[1]

Production centres

A production centre, as referred to in this report, is a production unit consisting of one or more ore processing plants, one or more associated mines and uranium resources that are tributary to these facilities. For the purpose of describing production centres, they have been divided into four classes, as follows:

- *Existing* production centres are those that currently exist in operational condition and include those plants which are closed down but which could be readily brought back into operation.
- *Committed* production centres are those that are either under construction or are firmly committed for construction.

1. IAEA (1984), *Manual on the Projection of Uranium Production Capability,* General Guidelines, Technical Report Series No. 238, Vienna.

- *Planned* production centres are those for which feasibility studies are either completed or under way, but for which construction commitments have not yet been made. This class also includes those plants that are closed which would require substantial expenditures to bring them back into operation.
- *Prospective* production centres are those that could be supported by tributary RAR and inferred, i.e. "identified resources", but for which construction plans have not yet been made.

Production capacity and capability

Production capacity: Denotes the nominal level of output, based on the design of the plant and facilities over an extended period, under normal commercial operating practices.

Production capability: Refers to an estimate of the level of production that could be practically and realistically achieved under favourable circumstances from the plant and facilities at any of the types of production centres described above, given the nature of the resources tributary to them. Projections of production capability are supported only by RAR and/or IR. The projection is presented based on those resources recoverable at costs <USD 130/kgU.

Production: Denotes the amount of uranium output, in tonnes U contained in concentrate, from an ore processing plant or production centre (with milling losses deducted).

Mining and milling

In situ leaching (ISL): The extraction of uranium from sandstone using chemical solutions and the recovery of uranium at the surface. ISL extraction is conducted by injecting a suitable uranium-dissolving leach solution (acid or alkaline) into the ore zone below the water table thereby oxidising, complexing, and mobilising the uranium; then recovering the pregnant solutions through production wells, and finally pumping the uranium bearing solution to the surface for further processing. This process is sometimes referred to as *in situ* recovery (ISR).

Heap leaching (HL): Heaps of ore are formed over a collecting system underlain by an impervious membrane. Dilute sulphuric acid solutions are distributed over the top surface of the ore. As the solutions seep down through the heap, they dissolve a significant (50-75%) amount of the uranium in the ore. The uranium is recovered from the heap leach product liquor by ion exchange or solvent extraction.

In-place leaching (IPL): involves leaching of broken ore without removing it from an underground mine. This is also sometimes referred to as stope leaching or block leaching.

Co-product: Uranium is a co-product when it is one of two commodities that must be produced to make a mine economic. Both commodities influence output, for example, uranium and copper are co-produced at Olympic Dam in Australia. Co-product uranium is produced using either the open-pit or underground mining methods.

By-product: Uranium is considered a by-product when it is a secondary or additional product. By-product uranium can be produced in association with a main product or with co-products, e.g. uranium recovered from the Palabora copper mining operations in South Africa. By-product uranium is produced using either the open-pit or underground mining methods.

Uranium from phosphate rocks: Uranium has been recovered as a by-product of phosphoric acid production. Uranium is separated from phosphoric acid by a solvent extraction process. The most frequently used reagent is a synergetic mixture of tri-m-octyl phosphine oxide (TOPO) and di 2-ethylhexyl phosphoric acid (DEPA).

Ion exchange (IX): Reversible exchange of ions contained in a host material for different ions in solution without destruction of the host material or disturbance of electrical neutrality. The process is accomplished by diffusion and occurs typically in crystals possessing – one or two – dimensional channels where ions are weakly bonded. It also occurs in resins consisting of three-dimensional hydrocarbon networks to which are attached many ionisable groups. Ion exchange is used for recovering uranium from leaching solutions.

Solvent extraction (SX): A method of separation in which a generally aqueous solution is mixed with an immiscible solvent to transfer one or more components into the solvent. This method is used to recover uranium from leaching solutions.

Demand terminology

Reactor-related requirements: Refers to natural uranium acquisitions *not* necessarily consumption during a calendar year.

Environmental terminology[2]

Close-out: In the context of uranium mill tailings impoundment, the operational, regulatory and administrative actions required to place a tailings impoundment into long-term conditions such that little or no future surveillance and maintenance are required.

Decommissioning: Actions taken at the end of the operating life of a uranium mill or other uranium facility in retiring it from service with adequate regard for the health and safety of workers and members of the public and protection of the environment. The time period to achieve decommissioning may range from a few to several hundred years.

Decontamination: The removal or reduction of radioactive or toxic chemical contamination using physical, chemical, or biological processes.

Dismantling: The disassembly and removal of any structure, system or component during decommissioning. Dismantling may be performed immediately after permanent retirement of a mine or mill facility or may be deferred.

Environmental restoration: Clean-up and restoration, according to predefined criteria, of sites contaminated with radioactive and/or hazardous substances during past uranium production activities.

Environmental impact statement: A set of documents recording the results of an evaluation of the physical, ecological, cultural and socio-economic effects of a planned installation, facility, or technology.

Groundwater restoration: The process of returning affected groundwater to acceptable quality and quantity levels for future use.

Reclamation: The process of restoring a site to predefined conditions, which allows new uses.

Restricted release (or use): A designation, by the regulatory body of a country, that restricts the release or use of equipment, buildings, materials or the site because of its potential radiological or other hazards.

Tailings: The remaining portion of a metal-bearing ore consisting of finely ground rock and process liquids after some or all of the metal, such as uranium, has been extracted.

2. Definitions based on those published in OECD (2002), *Environmental Remediation of Uranium Production Facilities*, Paris.

Tailings impoundment: A structure in which the tailings are deposited to prevent their release into the environment.

Unrestricted release (or use): A designation, by the regulatory body of a country, that enables the release or use of equipment, buildings, materials or the site without any restriction.

Geological terminology

Uranium occurrence: A naturally occurring, anomalous concentration of uranium.

Uranium deposit: A mass of naturally occurring mineral from which uranium could be exploited at present or in the future.

Geologic types of uranium deposits[3]: uranium resources can be assigned on the basis of the following 15 major categories of uranium ore deposit types (arranged according to their approximate economic significance):

1. Sandstone deposits
2. Proterozoic unconformity deposits
3. Polymetallic Fe-oxide breccia complex deposits
4. Paleo-quartz-pebble conglomerate deposits
5. Granite-related
6. Metamorphite
7. Intrusive deposits
8. Volcanic-related deposits
9. Metasomatic deposits
10. Surficial deposits
11. Carbonate deposits
12. Collapse breccia-type deposits
13. Phosphate deposits
14. Lignite and coal
15. Black shale

Detailed descriptions with examples follow. Note that for Red Book reporting purposes only the major categories are used. However, descriptions of the sub-types for sandstone and Proterozoic unconformity deposits have also been included due to their importance.

1. *Sandstone deposits*: Sandstone-hosted uranium deposits occur in medium- to coarse-grained sandstones deposited in a continental fluvial or marginal marine sedimentary environment. Uranium is precipitated under reducing conditions caused by a variety of reducing agents within the sandstone, such as carbonaceous material, sulphides (pyrite), hydrocarbons and ferro-magnesian minerals (chlorite), bacterial activity, migrated fluids from underlying hydrocarbon reservoirs, and others. Sandstone uranium deposits can be divided into five main sub-types (with frequent transitional types between them):

   - *Basal channel deposits*: Paleodrainage systems consist of wide channels filled with thick, permeable alluvial-fluvial sediments. The uranium is predominantly associated with detrital plant debris in orebodies that display, in a plan view, an elongated lens or ribbon-like configuration and, in a section-view, a lenticular or, more rarely, a roll shape. Individual deposits can range from several hundred to 20 000 t of uranium, at grades ranging from 0.01% to 3%. Examples are the deposits of Dalmatovskoye (Transural Region), Malinovskoye (West Siberia), Khiagdinskoye

3. This classification of the geological types of uranium deposits was updated in 2011-2012 through a number of IAEA consultancies that included an update of the World Distribution of Uranium Deposits (UDEPO).

(Vitim District) in the Russian Federation, deposits of the Tono District (Japan), Blizzard (Canada) and Beverley (Australia).

- *Tabular deposits* consist of uranium matrix impregnations that form irregularly shaped lenticular masses within reduced sediments. The mineralised zones are largely oriented parallel to the depositional trend. Individual deposits can contain several hundred tons up to 150 000 tons of uranium, at average grades ranging from 0.05% to 0.5%, occasionally up to 1%. Examples of deposits include Hamr-Stráz (Czech Republic), Akouta, Arlit, and Imouraren (Niger) and those of the Colorado Plateau (United States).
- *Roll-front deposits*: The mineralised zones are convex in shape, oriented down the hydrologic gradient. They display diffuse boundaries with reduced sandstone on the down-gradient side and sharp contacts with oxidised sandstone on the up-gradient side. The mineralised zones are elongate and sinuous approximately parallel to the strike, and perpendicular to the direction of deposition and groundwater flow. Resources can range from a few hundred tons to several thousands of tons of uranium, at grades averaging 0.05% to 0.25%. Examples are Budenovskoye, Tortkuduk, Moynkum, Inkai and Mynkuduk (Kazakhstan); Crow Butte and Smith Ranch (United States) and Bukinay, Sugraly and Uchkuduk (Uzbekistan).
- *Tectonic/lithologic deposits* are discordant to strata. They occur in permeable fault zones and adjacent sandstone beds in reducing environments created by hydrocarbons and/or detrital organic matter. Uranium is precipitated in fracture or fault zones related to tectonic extension. Individual deposits contain a few hundred tons up to 5 000 tons of uranium at average grades ranging from 0.1-0.5%. Examples include the deposits of the Lodève District (France) and the Franceville basin (Gabon).
- *Mafic dykes/sills* in Proterozoic sandstones: mineralisation is associated with mafic dykes and sills that are interlayered with or crosscut Proterozoic sandstone formations. Deposits can be subvertical along the dyke's borders, sometime within the dykes, or stratabound within the sandstones along lithological contacts (Westmoreland District, Australia; Matoush, Canada). Deposits are small to medium (300-10 000 t) with grades low to medium (0.05-0.40%).

2. *Proterozoic unconformity deposits*: Unconformity-related deposits are associated with and occur immediately below and above an unconformable contact that separates Archean to Paleoproterozoic crystalline basement from overlying, redbed clastic sediments of Proterozoic age. In most cases, the basement rocks immediately below the unconformity are strongly hematised and clay altered, possibly as a result of paleoweathering and/or diagenetic/hydrothermal alteration. Deposits consist of pods, veins and semimassive replacements consisting of mainly pitchblende. They are preferentially located in two major districts, the Athabasca Basin (Canada) and the Pine Creek Orogen (Australia). The unconformity-related deposits include three sub-types:

   - *Unconformity-contact deposits*: Except for the low-grade Karku deposit (Russian Federation), these all occur in the Athabasca Basin (Canada). Deposits develop at the base of the sedimentary cover directly above the unconformity. They form elongate pods to flattened linear orebodies typically characterised by a high-grade core surrounded by a lower grade halo. Most of the orebodies have root-like extensions into the basement. While some mineralisation is open space infill, much of it is replacement style. Often, mineralisation also extends up into the sandstone cover within breccias and fault zones forming "perched mineralisation". Deposits can be monometallic (McArthur River) or polymetallic (Cigar Lake).

Deposits are medium to large to very large (1 000-200 000 t) and are characterised by their high grades (1-20%).

- *Basement-hosted deposits* are strata-structure bound in metasediments below the unconformity on which the basinal clastic sediments rest. The basement ore typically occupies moderately to steeply dipping brittle shear, fracture and breccia zones hundreds of metres in strike length that can extend down-dip for several tens to more than 500 m into basement rocks below the unconformity. Disseminated and vein uraninite/pitchblende occupies fractures and breccia matrix but may also replace the host rock. High-grade ore is associated with brecciated graphitic schists. These deposits have small to very large resources (300-200 000 t), at medium grade (0.10-0.50%). Examples are Kintyre, Jabiluka and Ranger in Australia, Millennium and Eagle Point in the Athabasca Basin and Kiggavik and Andrew Lake in the Thelon Basin (Canada).
- *Stratiform structure-controlled deposits*: low-grade (0.05-0.10%), stratabound, thin (1-5 m) zones of mineralisation are located along the unconformity between Archean, U-Th-rich granites and Proterozoic metasediments with minor enrichments along fractures. This type of deposit (Chitrial and Lambapur) has only been observed in the Cuddapah basin (India). Resources of individual deposits range between 1 000-8 000 t.

3. *Polymetallic iron-oxide breccia complex deposits*: This type of deposit has been attributed to a broad category of worldwide iron oxide-copper-gold deposits. Olympic Dam (Australia) is the only known representative of this type with significant by-product uranium resources. The deposit contains the world's largest uranium resources with more than 2 Mt of uranium. Deposits of this group occur in hematite-rich granite breccias and contain disseminated uranium in association with copper, gold, silver and rare earth elements. At Olympic Dam, this breccia is hosted within a Mesoproterozoic highly potassic granite intrusion that exhibits regional Fe-K-metasomatism. Significant deposits and prospects of this type occur in the same region, including Prominent Hill, Wirrda Well, Carrapeteena, Acropolis and Oak Dam as well as some younger breccia-hosted deposits in the Mount Painter area.
4. *Paleo-quartz pebble conglomerate deposits*: Deposits of this type contain detrital uranium oxide ores which are found in quartz pebble conglomerates deposited as basal units in fluvial to lacustrine braided stream systems older than 2 400-2 300 Ma. The conglomerate matrix is pyritic and contains gold, as well as other accessory and oxide and sulphide detrital minerals that are often present in minor amounts. Examples include deposits in the Witwatersrand basin, South Africa, where uranium is mined as a by-product of gold as well as deposits in the Blind River/Elliot Lake area of Canada.
5. *Granite-related deposits* include: *i)* true veins composed of ore and gangue minerals in granite or adjacent (meta-) sediments and *ii)* disseminated mineralisation in granite as episyenite bodies. Uranium mineralisation occurs within, at the contact or peripheral to the intrusion. In the Hercynian belt of Europe, these deposits are associated with large, peraluminous two-mica granite complexes (leucogranites). Resources range from small to large and grades are variable, from low to high.
6. *Metamorphite deposits* correspond to disseminations, impregnations, veins and shear zones within or affecting metamorphic rocks of various ages. These deposits are highly variable in sizes, resources and grades.
7. *Intrusive deposits* are contained in intrusive or anatectic igneous rocks of many different petrochemical compositions (granite, pegmatite, monzonite, peralkaline syenite and carbonatite). Examples include the Rossing and Rossing South (Husab) deposits (Namibia), the deposits in the Bancroft area (Canada), the uranium occurrences in the porphyry copper deposits of Bingham Canyon and Twin Butte

(United States), the Kvanefjeld and Sorensen deposits (Greenland) and the Palabora carbonatite complex (South Africa).

8. *Volcanic-related deposits* are located within and near volcanic calderas filled by mafic to felsic, effusive and intrusive volcanic rocks and intercalated clastic sediments. Uranium mineralisation is largely controlled by structures as veins and stockworks with minor stratiform lodes. This mineralisation occurs at several stratigraphic levels of the volcanic and sedimentary units and may extend into the basement where it is found in fractured granite and metamorphic rocks. Uranium minerals (pitchblende, coffinite, U6+ minerals, less commonly brannerite) are associated with Mo-bearing sulphides and pyrite. Other anomalous elements include As, Bi, Ag, Li, Pb, Sb, Sn and W. Associated gangue minerals comprise violet fluorite, carbonates, barite and quartz. The most significant deposits are located within the Streltsovska caldera in the Russian Federation. Other examples are known in China (Xiangshan District), Mongolia (Dornot and Gurvanbulag Districts), United States (McDermitt caldera), and Mexico (Pena Blanca District).

9. *Metasomatite deposits* are confined to Precambrian shields in areas of tectono-magmatic activity affected by intense Na-metasomatism or K-metasomatism which produced albitised or illitised facies along deeply rooted fault systems. In Ukraine, these deposits are developed within a variety of basement rocks, including granites, migmatites, gneisses and ferruginous quartzites which produced albitites, aegirinites, alkali-amphibolic, as well as carbonate and ferruginous rocks. Principal uranium phases are uraninite, brannerite and other Ti-U-bearing minerals, coffinite and hexavalent uranium minerals. The reserves are usually medium to large. Examples include Michurinskoye, Vatutinskoye, Severinskoye, Zheltorechenskoye, Novokonstantinovskoye and Pervomayskoye deposits (Ukraine), deposits of the Elkon District (Russian Federation), Espinharas and Lagoa Real (Brazil), Valhalla (Australia), Kurupung (Guyana), Coles Hill (United States), Lianshanguan (China), Michelin (Canada) and small deposits of the Arjeplog region in the north of Sweden.

10. *Surficial deposits* are broadly defined as young (Tertiary to Recent), near-surface uranium concentrations in sediments and soils. The largest of the surficial uranium deposits are in calcrete (calcium and magnesium carbonates) found mainly in Australia (Yeelirrie deposit) and Namibia (Langer Heinrich deposit). These calcrete-hosted deposits mainly occur in valley-fill sediments along Tertiary drainage channels and in playa lake sediments in areas of deeply weathered, uranium-rich granites. Carnotite is the main uraniferous mineral. Surficial deposits also occur less commonly in peat bogs, karst caverns and soils.

11. *Carbonate deposits* are hosted in carbonate rocks (limestone, dolostone). Mineralisation can be syngenetic stratabound or more commonly structure-related within karsts, fractures, faults and folds. The only example of a stratabound carbonate deposits is the Tumalappalle deposit in India which is hosted in phosphatic dolostone. At Mailuu-Suu, Kyrgyzstan and Todilto, United States. Another example includes deposits developed in solution collapse breccias occurring in limestone with intercalations of carbonaceous shale such as the Sanbaqi deposit, China.

12. *Collapse breccia-type deposits* occur in cylindrical, vertical pipes filled with down-dropped fragments developed from karstic dissolution cavities in underlying thick carbonate layers. The uranium is concentrated as primary uranium ore, mainly uraninite, in the permeable breccia matrix, and in the arcuate, ring-fracture zone surrounding the pipe. The pitchblende is intergrown with numerous sulphide and oxide minerals variably containing Cu, Fe, V, Zn, Pb, Ag, Mo, Ni, Co, As, and Se. Type examples are the deposits in the Arizona Strip north of the Grand Canyon and those immediately south of the Grand Canyon in the United States. Resources are small to medium (300-2 500 t) with grades around 0.20-0.80%.

13. *Phosphate deposits* are principally represented by marine phosphorite of continental-shelf origin containing syn-sedimentary, stratiform, disseminated uranium in fine-grained apatite. Phosphorite deposits constitute large uranium resources (millions of tons), but at a very low grade (0.005-0.015%). Uranium can be recovered as a by-product of phosphate production. Examples include the Land Pebble District, Florida (land-pebble phosphate) (United States), Gantour (Morocco) and Al-Abiad (Jordan). Another type of phosphorite deposits consists of organic phosphate, including argillaceous marine sediments enriched in fish remains that are uraniferous (Melovoye, Kazakhstan). Deposits in continental phosphates are not common.

14. *Lignite-coal deposits* consist of elevated uranium contents in lignite/coal mixed with mineral detritus (silt, clay), and in immediately adjacent carbonaceous mud and silt/sandstone beds. Pyrite and ash contents are high. Lignite-coal seams are often interbedded or overlain by felsic pyroclastic rocks. Examples are deposits of the south-western Williston basin, North and South Dakota (United States), Koldjat and Nizhne Iliyskoe (Kazakhstan), Freital (Germany), Ambassador (Australia) and the Serres basin (Greece).

15. *Black shale deposits* include marine, organic-rich shale or coal-rich pyritic shale, containing synsedimentary, disseminated uranium adsorbed onto organic material, and fracture-controlled mineralisation within or adjacent to black shale horizons. Examples include the uraniferous alum shale in Sweden and Estonia, the Chattanooga shale (United States), the Chanziping deposit (China), and the Gera-Ronneburg deposit (Germany).

Appendix 4. List of abbreviations and acronyms

AGR	Advanced gas-cooled reactor
AL	Acid leaching
ALKAL	Alkaline atmospheric leaching
BWR	Boiling water reactor
CANDU	*Can*adian *d*euterium *u*ranium
CEC	Commission of the European Communities
CWG	Crush-wet grind
DIP	Decision-in-principle
DOE	Department of Energy (United States)
EIA	US Energy Information Administration
EIA	Environmental impact assessment
EIS	Environmental impact statement
EPR	European pressurised water reactor
EU	European Union
EUP	Enriched uranium product
FLOT	Flotation
Ga	Giga-years
GDR	German Democratic Republic
GIF	Generation IV International Forum
GNSS	Global Nuclear Services and Supply
GWe	Gigawatt electric
ha	Hectare
HEU	Highly enriched uranium
HL	Heap leaching
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
IPL	In-place leaching
IR	Inferred resources
ISL	*In situ* leaching
IX	Ion exchange

JORC	Joint Ore Reserves Committee
kg	Kilogram
km	Kilometre
lb	Pound
LEU	Low-enriched uranium
LWR	Light water reactor
MAGNOX	Magnesium alloy graphite moderated gas-cooled reactor
MOX	Mixed oxide fuel
MWe	Megawatt electric
NEA	Nuclear Energy Agency
NPP	Nuclear power plant
OECD	Organisation for Economic Co-operation and Development
OP	Open-pit
PHWR	Pressurised heavy-water reactor
ppm	Parts per million
PR	Prognosticated resources
Pu	Plutonium
PWR	Pressurised water reactor
RAR	Reasonably assured resources
RBMK	Water-cooled, graphite-moderated reactor (Russian acronym)
SR	Speculative resources
SWU	Separative work unit
SX	Solvent extraction
t	Tonnes (metric tons)
Th	Thorium
tHM	Tonnes heavy metal
tUnat	Tonnes natural uranium equivalent
TOE	Tonnes oil equivalent
tU	Tonnes uranium
tU_3O_8	Tonnes triuranium octoxide
TVA	Tennessee Valley Administration
TWh	Terawatt-hour
U	Uranium
UG	Underground mining
US	United States
USSR	Union of Soviet Socialist Republics
VVER	Water-cooled, water-moderated reactor (Russian acronym)

Appendix 5. Energy conversion factors

The need to establish a set of factors to convert quantities of uranium into common units of energy appeared during recent years with the increasing frequency of requests for such factors applying to the various reactor types.

Conversion factors and energy equivalence for fossil fuel for comparison

1 cal	=	4.1868 J
1 J	=	0.239 cal
1 tonne of oil equivalent (TOE) (net, LHV)	=	42 GJ* = 1 TOE
1 tonne of coal equivalent (TCE) (standard, LHV)	=	29.3 GJ* = 1 TCE
1 000 m^3 of natural gas (standard, LHV)	=	36 GJ
1 tonne of crude oil	=	approx. 7.3 barrels
1 tonne of liquid natural gas (LNG)	=	45 GJ
1 000 kWh (primary energy)	=	9.36 MJ
1 TOE	=	10 034 Mcal
1 TCE	=	7 000 Mcal
1 000 m^3 natural gas	=	8 600 Mcal
1 tonne LNG	=	11 000 Mcal
1 000 kWh (primary energy)	=	2 236 Mcal**
1 TCE	=	0.698 TOE
1 000 m^3 natural gas	=	0.857 TOE
1 tonne LNG	=	1.096 TOE
1 000 kWh (primary energy)	=	0.223 TOE
1 tonne of fuelwood	=	0.3215 TOE
1 tonne of uranium: light water reactors	=	10 000-16 000 TOE
open cycle	=	14 000-23 000 TCE

* World Energy Council standard conversion factors (from WEC, 1998 Survey of Energy Resources, 18th Edition).

** With 1 000 kWh (final consumption) = 860 Mcal as WEC conversion factor.

Table 5A.1. Energy values for uranium used in various rector types[1]

Country	Canada	France	Germany		Japan		Russian Federation		Sweden		United Kingdom		United States	
Reactor type	CANDU	N4 PWR	BWR	PWR	BWR	PWR	VVER-1000	RBMK-1000	BWR	PWR	MAGNOX	AGR	BWR	PWR
Burn-up [Mw/day/tU]														
a) Natural uranium or natural uranium equivalent	7 770	5 848	5 665	5 230	5 532	4 694	4 855	4 707	6 250	5 780	5 900	NA	4 996	4 888
b) Enriched uranium	–	42 500	40 000	42 000	33 000	43 400	42 000	22 000	40 000	42 000	–	24 000	33 000	40 000
Uranium enrichment [% ^{235}U]	–	3.60	3.20	3.60	3.00	4.10	4.23	2.40	3.20	3.60	–	2.90	3.02	3.66
Tails assay [% ^{235}U]	–	0.25	0.30	0.30	0.25	0.30	0.25	0.25	0.25	0.25	–	0.30	0.30	0.30
Efficiency of converting thermal energy into electricity	30%	34.60%	33.50%	34.20%	33%	34%	33.30%	31.20%	34.00%	34.50%	26%	40%	32%	32%
Thermal energy equivalent of 1 t natural uranium [in 10^{15} joules][2]	0.671	0.505	0.49	0.452	0.478	0.406	0.419	0.406	0.540	0.500	0.512	0.360	0.432	0.422
Electrical energy equivalent of 1 t natural uranium [in 10^{15} joules][2]	0.201	0.175	0.164	0.155	0.158	0.140	0.139	0.127	0.184	0.173	0.133	0.144	0.138	0.135

1. Does not include Pu and U recycled. Does not take into account the requirement of an initial core load, which would reduce the equivalence by about 6%, if based on a plant life of about 30 years with a 70% capacity factor.

2. Does not take into account the energy consumed for ^{235}U enrichment in LWR and AGR fuel. The factor to be applied to the energy equivalent under the condition of 3% ^{235}U enrichment and 0.2% tails assay should be multiplied by 0.957.

NA = Not available.

Appendix 6. List of all Red Book editions (1965-2014) and national reports

Listing of Red Book editions (1965-2014)

OECD/ENEA	World Uranium and Thorium Resources, Paris, 1965
OECD/ENEA	Uranium Resources, Revised Estimates, Paris, 1967
OECD/ENEA-IAEA	Uranium Production and Short-Term Demand, Paris, 1969
OECD/ENEA-IAEA	Uranium Resources, Production and Demand, Paris, 1970
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1973
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1976
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1977
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1979
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1982
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1983
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1986
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1988
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1990
OECD/NEA-IAEA	Uranium 1991: Resources, Production and Demand, Paris, 1992
OECD/NEA-IAEA	Uranium 1993: Resources, Production and Demand, Paris, 1994
OECD/NEA-IAEA	Uranium 1995: Resources, Production and Demand, Paris, 1996
OECD/NEA-IAEA	Uranium 1997: Resources, Production and Demand, Paris, 1998
OECD/NEA-IAEA	Uranium 1999: Resources, Production and Demand, Paris, 2000
OECD/NEA-IAEA	Uranium 2001: Resources, Production and Demand, Paris, 2002
OECD/NEA-IAEA	Uranium 2003: Resources, Production and Demand, Paris, 2004
OECD/NEA-IAEA	Uranium 2005: Resources, Production and Demand, Paris, 2006
OECD/NEA-IAEA	Uranium 2007: Resources, Production and Demand, Paris, 2008
OECD/NEA-IAEA	Uranium 2009: Resources, Production and Demand, Paris, 2010
OECD/NEA-IAEA	Uranium 2011: Resources, Production and Demand, Paris, 2012
OECD/NEA-IAEA	Uranium 2014: Resources, Production and Demand, Paris, 2014

Index of national reports in Red Books

(The following index lists all national reports by the year in which these reports were published in the Red Books. A listing of all Red Book editions is shown at the end of this Index)

	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Algeria						1976	1977	1979	1982			
Argentina		1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Armenia												
Australia		1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Austria							1977					
Bangladesh											1986	1988
Belgium									1982	1983	1986	1988
Benin												
Bolivia							1977	1979	1982	1983	1986	
Bophuthatswana									1982			
Botswana								1979		1983	1986	1988
Brazil				1970	1973	1976	1977	1979	1982	1983	1986	
Bulgaria												
Cameroon							1977		1982	1983		
Canada	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Central African Republic				1970	1973		1977	1979			1986	
Chad												
Chile							1977	1979	1982	1983	1986	1988
China												
Colombia							1977	1979	1982	1983	1986	1988
Congo		1967										
Costa Rica									1982	1983	1986	1988
Côte d'Ivoire									1982			
Cuba												1988
Czech Republic												
Czech and Slovak Rep.												
Denmark (Greenland)	1965	1967		1970	1973	1976	1977	1979	1982	1983	1986	
Dominican Republic									1982			
Ecuador							1977		1982	1983	1986	1988
Egypt							1977	1979			1986	1988
El Salvador										1983	1986	
Estonia												
Ethiopia								1979		1983	1986	
Finland					1973	1976	1977	1979	1982	1983	1986	1988
France	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Gabon		1967		1970	1973				1982	1983	1986	
Germany				1970		1976	1977	1979	1982	1983	1986	1988

Index of national reports in Red Books (*continued*)

1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	
						2002	2004	2006	2008		2012	2014	**Algeria**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Argentina**
					2000	2002	2004	2006		2010	2012	2014	**Armenia**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Australia**
													Austria
													Bangladesh
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008				**Belgium**
1990													**Benin**
													Bolivia
													Bophuthatswana
										2010	2012	2014	**Botswana**
	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Brazil**
1990	1992	1994	1996	1998					2008	2010			**Bulgaria**
													Cameroon
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Canada**
													Central African Republic
												2014	**Chad**
	1992	1994	1996	1998	2000	2002	2004	2006	2008		2012	2014	**Chile**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**China**
1990			1996	1998					2008				**Colombia**
													Congo
1990													**Costa Rica**
													Côte d'Ivoire
	1992		1996	1998									**Cuba**
		1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Czech Republic**
1990													**Czech and Slovak Rep.**
1990	1992		1996	1998			2004			2010	2012	2014	**Denmark (Greenland)**
													Dominican Republic
													Ecuador
1990	1992	1994	1996	1998	2000		2004	2006	2008	2010			**Egypt**
													El Salvador
				1998			2004						**Estonia**
											2012		**Ethiopia**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Finland**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**France**
			1996	1998	2000	2002	2004	2006					**Gabon**
1990	1992	1994	1996	1998	2000	2002		2006	2008	2010	2012	2014	**Germany**

Index of national reports in Red Books (*continued*)

	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Ghana							1977			1983		
Greece							1977	1979	1982	1983	1986	1988
Guatemala											1986	1988
Guyana								1979	1982	1983	1986	
Hungary												
India	1965	1967		1970	1973	1976	1977	1979	1982	1983	1986	
Indonesia							1977				1986	1988
Iran, Islamic Republic of							1977					
Ireland								1979	1982	1983	1986	
Italy		1967		1970	1973	1976	1977	1979	1982	1983	1986	1988
Jamaica									1982	1983		
Japan	1965	1967		1970	1973	1976	1977	1979	1982	1983	1986	1988
Jordan							1977				1986	1988
Kazakhstan												
Korea, Republic of						1976	1977	1979	1982	1983	1986	1988
Kyrgyzstan												
Lesotho												1988
Liberia							1977			1983		
Libyan Arab Jamahiriya										1983		
Lithuania												
Madagascar						1976	1977	1979	1982	1983	1986	1988
Malawi												
Malaysia										1983	1986	1988
Mali											1986	1988
Mauritania												
Mexico				1970	1973	1976	1977	1979	1982		1986	
Mongolia												
Morocco	1965	1967				1976	1977	1979	1982	1983	1986	1988
Namibia								1979	1982	1983	1986	1988
Netherlands									1982	1983	1986	
New Zealand		1967					1977	1979				
Niger		1967		1970	1973		1977				1986	1988
Nigeria								1979				
Norway								1979	1982	1983		
Pakistan		1967										
Panama										1983		1988
Paraguay										1983	1986	
Peru							1977	1979		1983	1986	1988
Philippines							1977		1982	1983	1986	
Poland												

Index of national reports in Red Books *(continued)*

1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	
													Ghana
1990	1992	1994	1996	1998									**Greece**
													Guatemala
													Guyana
	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Hungary**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**India**
1990	1992	1994	1996	1998	2000	2002	2004	2006		2010	2012	2014	**Indonesia**
				1998	2000	2002	2004	2006	2008	2010	2012	2014	**Iran, Islamic Republic of**
	1992			1998									**Ireland**
	1992	1994	1996	1998	2000						2012	2014	**Italy**
													Jamaica
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Japan**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Jordan**
		1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Kazakhstan**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010			**Korea, Republic of**
			1996			2002							**Kyrgyzstan**
													Lesotho
													Liberia
													Libyan Arab Jamahiriya
		1994	1996	1988	2000	2002	2004	2006	2008				**Lithuania**
													Madagascar
					2000				2008	2010	2012	2014	**Malawi**
1990	1992	1994	1996	1998	2000	2002							**Malaysia**
												2014	**Mali**
1990													**Mauritania**
1990	1992	1994	1996	1998	2000						2012		**Mexico**
		1994	1996	1998						2010	2012	2014	**Mongolia**
1990				1998									**Morocco**
1990		1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Namibia**
1990	1992	1994	1996	1998	2000	2002							**Netherlands**
													New Zealand
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Niger**
													Nigeria
	1992		1996	1998									**Norway**
		1994		1998	2000								**Pakistan**
													Panama
													Paraguay
1990	1992	1994	1996	1998	2000		2004	2006	2008	2010	2012	2014	**Peru**
1990		1994	1996	1998	2000	2002	2004	2006					**Philippines**
					2000	2002			2008	2010	2012	2014	**Poland**

Index of national reports in Red Books *(continued)*

	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Portugal	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Romania												
Russian Federation												
Rwanda											1986	
Senegal									1982			
Slovak Republic												
Slovenia												
Somalia							1977	1979				
South Africa	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	
Spain	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Sri Lanka							1977		1982	1983	1986	1988
Sudan							1977					
Surinam									1982	1983		
Sweden	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Switzerland						1976	1977	1979	1982	1983	1986	1988
Syrian Arab Republic									1982	1983	1986	1988
Tajikistan												
Tanzania												
Thailand							1977	1979	1982	1983	1986	1988
Togo								1979				
Turkey					1973	1976	1977	1979	1982	1983	1986	1988
Turkmenistan												
Ukraine												
United Kingdom						1976	1977	1979	1982	1983	1986	1988
United States	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988
Uruguay							1977		1982	1983	1986	1988
USSR												
Uzbekistan												
Venezuela											1986	1988
Viet Nam												
Yugoslavia					1973	1976	1977		1982			
Zaire					1973		1977					1988
Zambia											1986	1988
Zimbabwe									1982			1988

Index of national reports in Red Books *(continued)*

1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Portugal**
	1992	1994	1996	1998	2000	2002							**Romania**
		1994		1998	2000	2002	2004	2006	2008	2010	2012	2014	**Russian Federation**
													Rwanda
													Senegal
		1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Slovak Republic**
		1994	1996	1998		2002	2004	2006	2008	2010		2014	**Slovenia**
													Somalia
	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**South Africa**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Spain**
													Sri Lanka
													Sudan
													Surinam
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Sweden**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008				**Switzerland**
1990		1994											**Syrian Arab Republic**
						2002							**Tajikistan**
1990										2010	2012	2014	**Tanzania**
1990	1992	1994	1996	1998	2000	2002		2006				2014	**Thailand**
													Togo
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Turkey**
							2004						**Turkmenistan**
		1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**Ukraine**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010		2014	**United Kingdom**
1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	**United States**
1990													**Uruguay**
	1992												**USSR**
		1994	1996	1998	2000	2002	2004	2006			2012		**Uzbekistan**
													Venezuela
	1992	1994	1996	1998	2000	2002	2004	2006	2008			2014	**Viet Nam**
1990	1992												**Yugoslavia**
													Zaire
1990	1992	1994	1996	1998							2012	2014	**Zambia**
	1992	1994	1996	1998									**Zimbabwe**

Appendix 7. Currency exchange rates

Country (currency abbreviation)	June 2010	June 2011	June 2012	January 2013
Algeria (DZD)	75.52	72.14	78.14	78.08
Argentina (ARS)	3.93	4.1	4.51	4.91
Armenia (AMD)	369	374	416.2	403.4
Australia (AUD)	1.144	0.954	0.996	0.965
Bangladesh (BDT)	68.73	74	81.4	79.5
Belgium (EUR)	0.811	0.699	0.805	0.754
Bolivia (BOB)	7.05	6.88	6.94	6.93
Botswana (BWP)	6.92	6.5	7.66	7.65
Brazil (BRL)	1.79	1.59	2.086	2.053
Bulgaria (BGL)	1.586	1.367	1.572	1.475
Cameroon (XAF)	531.981	458.514	527.389	494.592
Canada (CAD)	1.034	0.985	1.031	0.993
Central African Republic (XAF)	531.981	458.514	527.389	494.592
Chile (CLP)	535	466	502	470
China (CNY)	6.8	6.47	6.357	6.235
Colombia (COP)	1 900	1 781	1 801	1 771
Costa Rica (CRC)	517	499.1	493.8	493.1
Cuba (CUP)	1	1	1	1
Czech Republic (CZK)	20.78	17.04	20.68	18.89
Denmark (DKK)	6.035	5.213	5.975	5.621
Ecuador (USD)	1	1	1	1
Egypt (EGP)	5.66	5.94	6.058	6.188
Ethiopia (ETB)	13.52	16.9	17.72	18.11
Finland (EUR)	0.811	0.699	0.805	0.754
France (EUR)	0.811	0.699	0.805	0.754
Gabon (XAF)	531.981	458.514	527.389	494.592
Germany (EUR)	0.811	0.699	0.805	0.754
Ghana (GHS)	1.42	1.51	1.935	1.899
Greece (EUR)	0.811	0.699	0.805	0.754
Guatemala (GTQ)	8.02	7.79	7.86	7.95
Hungary (HUF)	231	1.88	231.8	219
India (INR)	46.28	44.93	56.8	54.93
Indonesia (IDR)	8 955	8 595	9 493	9 728
Iran, Islamic Republic of (IRR)	10 347.5	10 874	12 254	24 296
Ireland (EUR)	0.811	0.699	0.805	0.754
Italy (EUR)	0.811	0.699	0.805	0.754
Jamaica (JMD)	85.8	85.52	88.11	90.6
Japan (JPY)	89.4	80.84	79.31	86.07

Country (currency abbreviation)	June 2010	June 2011	June 2012	January 2013
Jordan (JOD)	0.708	0.708	0.708	0.708
Kazakhstan (KZT)	146.5	145.74	149.2	150.5
Korea, Republic of (KRW)	1 209	1 094	1 154	1 072
Lesotho (LSL)	7.6	6.84	8.42	8.491
Madagascar (MGA)	2 100	1 944	2 170	2 258
Malawi (MWK)	151.545	150.79	270	334.06
Malaysia (MYR)	3.2	3.02	3.196	3.059
Mali (XOF)	531.981	458.514	527.389	494.592
Mexico (MXN)	12.83	11.8	13.9	12.81
Mongolia (MNT)	1 374	1 267	1 338	1 396
Morocco (MAD)	8.92	7.92	874	8.411
Namibia (NAD)	7.6	6.84	8.42	8.491
Netherlands (EUR)	0.811	0.699	0.805	0.754
Niger (XOF)	531.981	458.514	527.389	494.592
Nigeria (NGN)	150.87	157.2	162.5	156.9
Norway (NOK)	6.406	5.453	6.06	5.562
Paraguay (PYG)	4 765	3 988	4 500	4 250
Peru (PEN)	2.83	2.76	2.67	2.55
Philippines (PHP)	46	43.49	42.36	41.1
Poland (PLN)	3.348	2.799	3.444	3.068
Portugal (EUR)	0.811	0.699	0.805	0.754
Romania (ROL)	3.44	2.94	3.576	3.334
Russian Federation (RUB)	30.6	28.06	33.06	30.24
Rwanda (RWF)	585	601.44	604.25	630.37
Slovak Republic (EUR)	0.811	0.699	0.805	0.754
Slovenia (EUR)	0.811	0.699	0.805	0.754
South Africa (ZAR)	7.6	6.84	8.42	8.491
Spain (EUR)	0.811	0.699	0.805	0.754
Sri Lanka (LKR)	113.1	109	133.7	126.9
Sudan (SDG)	2.35	2.88	5.3	5.969
Sweden (SEK)	7.714	6.462	7.066	6.488
Switzerland (CHF)	1.0874	0.833	0.966	0.911
Syrian Arab Republic (SYP)	46.9	47.3	67.91	74.37
Tanzania (TZS)	1 467	1 600	1 567	1 576
Thailand (THB)	32.36	30.62	31.88	30.64
Turkey (TRL)	1.55	1.61	1.83	1.79
Ukraine (UAH)	7.89	7.98	7.939	7.93
United Kingdom (GBP)	0.663	0.626	0.644	0.619
United States (USD)	1	1	1	1
Uruguay (UYU)	20.89	18.53	21.55	19.53
Uzbekistan (UZS)	1 595	1 711	1 885	1 980
Viet Nam (VND)	18 965	20 555	20 900	20 818
Zambia (ZMK)	5 050			5.19

Note: In national currency units per USD.

Source: United Nations Operational Rates of Exchange, United Nations Treasury.

Appendix 8. Groups of countries and areas with uranium-related activities

The countries and geographical areas referenced in this report are listed below. Countries followed by an asterisk (*) are OECD members.

North America

Canada*	Mexico*	United States*

Central and South America

Argentina	Bolivia	Brazil
Chile*	Colombia	Costa Rica
Cuba	Ecuador	El Salvador
Guatemala	Jamaica	Paraguay
Peru	Uruguay	Venezuela

Western Europe

Austria*	Belgium*	Denmark*
Finland*	France*	Germany*
Ireland*	Italy*	Netherlands*
Norway*	Portugal*	Spain*
Sweden*	Switzerland*	United Kingdom*

Central, Eastern and Southeast Europe

Armenia	Bulgaria	Croatia
Czech Republic*	Estonia*	Greece*
Hungary*	Lithuania	Poland*
Romania	Russian Federation	Slovak Republic*
Slovenia*	Turkey*	Ukraine

Africa

Algeria	Botswana	Central African Republic
Congo, Democratic Rep.	Egypt	Gabon
Ghana	Lesotho	Libya
Madagascar	Malawi	Mali
Morocco	Namibia	Niger
Nigeria	Somalia	South Africa
Zambia	Zimbabwe	

Middle East, Central and Southern Asia

Bangladesh	India	Iran, Islamic Republic of
Israel*	Jordan	Kazakhstan
Kyrgyzstan	Pakistan	Sri Lanka
Syria	Tajikistan	Turkmenistan
Uzbekistan		

Southeast Asia

Indonesia	Malaysia	Philippines
Thailand	Viet Nam	

Pacific

Australia*	New Zealand*

East Asia[1]

China	Japan*	Korea, Democratic People's Republic of
Korea, Republic of*	Mongolia	

The countries associated with other groupings of nations used in this report are listed below.

Commonwealth of Independent States (CIS) or Newly Independent States (NIS)

Armenia	Azerbaijan	Belarus
Georgia	Kazakhstan	Kyrgyzstan
Tajikistan	Turkmenistan	Moldavia
Russian Federation	Ukraine	Uzbekistan

European Union

Austria*	Belgium*	Bulgaria
Croatia	Cyprus	Czech Republic*
Denmark*	Estonia*	Finland*
France*	Germany*	Greece*
Hungary*	Ireland*	Italy*
Latvia	Lithuania	Luxembourg*
Malta	Netherlands*	Poland*
Portugal*	Romania	Slovak Republic*
Slovenia*	Spain*	Sweden*
United Kingdom*		

1. Includes Chinese Taipei.

Uranium 2014: Resources, Production and Demand

Uranium is the raw material used to fuel over 400 operational nuclear reactors around the world that produce large amounts of electricity and benefit from life cycle carbon emissions as low as renewable energy sources. Although a valuable commodity, declining market prices for uranium since the Fukushima Daiichi nuclear power plant accident in 2011, driven by uncertainties concerning the future of nuclear power, have led to the postponement of mine development plans in a number of countries and raised questions about continued uranium supply. This 25th edition of the "Red Book", a recognised world reference on uranium jointly prepared by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, provides analyses and information from 45 producing and consuming countries in order to address these and other questions. It includes data on global uranium exploration, resources, production and reactor-related requirements. It offers updated information on established uranium production centres and mine development plans, as well as projections of nuclear generating capacity and reactor-related requirements through 2035, incorporating policy changes following the Fukushima accident, in order to address long-term uranium supply and demand issues.

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International Atomic Energy Agency

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