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

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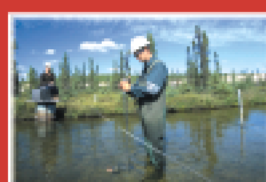
Uranium 2001: Resources, Production and Demand





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NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), Korea (12th December 1996) and the Slovak Republic (14 December 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 28 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

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, as well as
- 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 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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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 periodical 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 19th edition of the Red Book replaces the 1999 edition and reflects information available as of 1 January 2001.

The Red Book offers a comprehensive assessment of the uranium supply and demand situation worldwide up to the year 2020. It includes information and data on uranium resources in several categories of existence and economic attractiveness, uranium exploration and production, environmental aspects, installed nuclear capacity and related uranium requirements, uranium stocks and relevant uranium policies. Long-term projections of uranium demand, based on expert opinion rather than on information submitted by national authorities, are qualitatively discussed. Detailed national reports are also provided.

This publication has been prepared on the basis of data obtained through questionnaires sent by the NEA to its Member countries (20 countries responded) and by the IAEA for those states that are not OECD Member countries (27 countries responded). The opinions expressed in Parts I and II do not necessarily reflect the position of the countries or international organisations concerned. This report is published on the responsibility of the Secretary-General of the OECD.

Acknowledgement

The OECD Nuclear Energy Agency (NEA), Paris, and the International Atomic Energy Agency (IAEA), Vienna, would like to acknowledge the co-operation of those organisations (see Annex 2), which replied to the questionnaire.

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EXECUTIVE SUMMARY

Uranium 2001 – Resources, Production and Demand, presents results of the 2001 review of world uranium supply and demand and provides a statistical profile of the world uranium industry as of 1 January 2001. This is the 19th edition of what has become known as the "Red Book", which first appeared in 1965. It contains official data provided by 45 countries along with unofficial data for two countries on uranium exploration activities, resources, production and reactor-related requirements. For the first time, a report for Tajikistan is included. Projections of nuclear generating capacity and reactor-related uranium requirements through 2020 are provided. In addition, a perspective on uranium supply and demand through 2050 is presented.

Exploration

Worldwide exploration expenditures in 2000 totalled about USD 87 million, a decrease of over 50% from the recent high of over USD 178 million reached in 1997. Exploration was concentrated in areas with potential for unconformity-related deposits and ISL-amenable sandstone deposits. Exploration was largely focused in close proximity to known resources, with limited expenditures being directed toward "grass roots" exploration. In addition, in 2000, over 95% of expenditures were concentrated on domestic exploration, representing an over 84% decrease in exploration abroad compared to 1997 levels. The decline in exploration spending is expected to continue in 2001 with expenditures projected to total about USD 55 million, a 37% decrease from the 2000 total.

Resources

Total Known Conventional Resources (RAR & EAR-I) in both the ≤USD 80/kgU (about 3 107 000 tonnes U) and ≤USD 130/kgU (about 3 933 000 tonnes U) categories were little changed in 2001 compared to their 1999 levels. However, Known Resources in the ≤USD 40/kgU increased by about 66% compared to those reported in 1999, largely because Australia reported resources in this cost category for the first time. Total Undiscovered Conventional Resources (EAR-II & Speculative Resources) are estimated at about 12 271 000 tonnes U (tU) in 2001. There were no significant changes in Undiscovered Resources among any of the countries reporting resources.

The fact that resource totals remained relatively unchanged between 1999 and 2001 suggests that new discoveries or transfer of resources to higher confidence categories approximately kept pace with production.

Production

Uranium production in 2000 totalled 36 112 tU compared to 32 179 tU in 1999, an increase of about 12%. A total of 21 countries reported production in 2000 compared to 23 producing countries in 1998 with Argentina, Belgium and Gabon ceasing production and Brazil restarting production. Australia and Kazakhstan had the most significant gains in production between 1998 and 2000, with increases of about 55% and 47%, respectively. Conversely, the United States and Niger had the largest decreases in output at about 16% and 22%, respectively. Production in 2001 is expected to increase slightly compared to that in 2000. Production is planned to end in France and Portugal during 2001, but this loss of capacity is expected to be offset by increased production elsewhere. In 2000, underground mining accounted for 43% of total production; open pit mining, 28%; *in situ* leach mining, 15%; with co-product and by-product recovery from copper and gold operations and other unconventional methods accounting for most of the remaining 14%.

Environmental aspects of uranium production

The growing awareness of the importance of the environmental aspects of uranium production is very apparent from the increasing number of countries reporting environmental-related cost information and activities in their individual country reports. The reports mostly focus on decommissioning and reclamation of inactive sites, though there is also information on ongoing reclamation at active sites. Additional information on the environmental aspects of uranium production can be found in a separate report produced by the joint NEA/IAEA Uranium Group titled *Environmental Remediation of World Uranium Production Facilities*, Paris, OECD, 2002.

Uranium demand

At the end of 2000, a total of 438 commercial nuclear reactors were operating with a net generating capacity of about 360 GWe with uranium requirements estimated at about 64 014 tU. The world nuclear capacity is projected to grow in the high demand case to about 464 GWe net or to slightly decline in the low case to about 334 GWe net by the year 2020. Accordingly, world reactor-related uranium requirements are projected to rise in the high case to about 80 249 tU or to decrease in the low case to about 58 010 tU by the year 2020.

Within these broad projections there is significant regional variation. Nuclear energy capacity and attendant uranium requirements are expected to grow significantly in the Central, Eastern and South East Europe region (increasing up to 97% in the high case); the East Asia region (80-90% increases projected); and the Middle East, Central and South Asia region (113-394% increases projected). In the Central and South America and African regions capacity and requirements are projected to remain essentially unchanged in the low case or increase as much as 250% in the high case. Nuclear capacity and requirements are expected to hold approximately steady or decline in North America and Western Europe and Scandinavian regions. However, there is great uncertainty as to the projections in these regions as there is ongoing debate on the magnitude of the future role of nuclear energy to meet energy requirements.

Several factors, including a potential increased emphasis on plant security, security of supply and the importance given in the future to the role of nuclear energy in the debate on global warming, may likely have a significant impact on these projections. Concerns about longer-term security of supply of fossil fuels and the heightened awareness that nuclear power plants are environmentally clean with respect to acid rain and greenhouse gas emissions might contribute to even higher than projected growth in uranium demand over the long-term.

Supply and demand relationship

At the end of 2000, world uranium production (36 112 tU) provided about 56% of world reactor requirements (64 014 tU). The rest of the requirements were met by secondary sources including civilian and military stockpiles, uranium reprocessing and re-enrichment of depleted uranium. However, by 2025, secondary sources will decline in importance and provide only about 4-6% of requirements, depending on the demand projections used.

The uranium market over the mid-term remains uncertain due to a lack of information on the nature and extent of secondary supplies. The increasing availability of new supplies from the conversion of warhead material, together with recent increases in commercial inventories, implies a continuing oversupplied, low-priced market. It is expected that low production levels and the draw down of civilian and military inventories may continue for several years. The low prices for uranium have impacted the production sector resulting in consolidations, mine closures, and deferment of investment and projects. Production and exploration are likely to remain low until sufficient evidence exists that secondary supplies, particularly inventories, are being exhausted, or that significant new requirements are emerging.

As currently projected, uranium production capabilities including existing, committed, planned and prospective production centres supported by Known Conventional Resources (RAR and EAR-I) recoverable at a cost of ≤USD 80/kgU cannot satisfy projected future world uranium requirements in either the low or high demand cases. Thus, in the near-term, secondary sources, i.e. excess commercial inventories, the expected delivery of LEU derived from HEU warheads, re-enrichment of tails and spent fuel reprocessing, will continue to be necessary to ensure adequate supplies.

In the longer-term, when supplies from excess stockpiles are no longer available, reactor requirements will need to be met through the expansion of existing production capacity, together with the development of additional production centres or the introduction of alternate fuel cycles. However, significant and sustained near-term increases in uranium market prices will be needed to stimulate timely development of that resource base. Because of the long lead-times necessary to discover new resources and develop new production capabilities, there exists the potential for uranium market distortions to develop as secondary sources become exhausted. Significant new exploration and development activities will likely be needed within the next two decades if adequate resources are to remain available at stable prices. Improved information on the nature and extent of world uranium inventories and other secondary sources will be necessary to permit the more accurate forecasting that would permit timely production decisions.

Conclusions

World electricity use is expected to continue growing over the next several decades to meet the needs of an increasing population and anticipated sustained economic growth. Nuclear electricity generation will continue to play a significant role, although the magnitude of that role remains uncertain.

Ultimately, the future of nuclear energy and, thus the demand for uranium will likely be determined by the resolution of the tension between several major competing themes: the continued growth in electricity demand, the competitiveness of nuclear energy in increasingly open electricity markets, and the need to minimise impacts on the environment. If it can be demonstrated that nuclear energy is clean, economically competitive, safe, and that acceptable solutions for wastes exist, then it is likely that a period of strong growth in nuclear power will ensue. If that case cannot be made satisfactorily then nuclear power will likely decline slowly in importance. Whichever path is taken the total projected uranium resource base, including known and undiscovered resources, is adequate to meet future requirements.

DEFINITIONS AND TERMINOLOGY

Only minor changes have been made to the NEA/IAEA resource terminology and definitions since the modifications that were introduced in the December 1983 edition of the Red Book. An exception was the introduction in the 1993 Red Book edition of a new lower-cost category, i.e., resources recoverable at USD 40/kgU or less. This category was introduced to reflect a production cost range that is more relevant to current uranium market prices.

Resource estimates

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. *All resource estimates are expressed in terms of metric tons (t) of recoverable uranium (U) rather than uranium oxide (U_3O_8).* Estimates refer to quantities of uranium recoverable from mineable ore, unless otherwise noted (see Recoverable Resources below).

a) 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, either, 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 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.

Estimated Additional Resources – Category I (EAR-I) 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 deposits' 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.

Figure 1. **Approximative correlations of terms used in major resources classification systems**

	KNOWN CONVENTIONAL RESOURCES			UNDISCOVERED CONVENTIONAL RESOURCES		
NEA/IAEA	REASONABLY ASSURED		ESTIMATED ADDITIONAL I	ESTIMATED ADDITIONAL II	SPECULATIVE	
Australia	REASONABLY ASSURED		ESTIMATED ADDITIONAL I	UNDISCOVERED		
Canada (NRCan)	MEASURED	INDICATED	INFERRED	PROGNOSTICATED	SPECULATIVE	
France	RESERVES I	RESERVES II	PERSPECTIVE I	PERSPECTIVE II		
Germany	PROVEN	PROBABLE	POSSIBLE	PROGNOSTICATED	SPECULATIVE	
United States (DOE)	REASONABLY ASSURED		ESTIMATED ADDITIONAL		SPECULATIVE	
Russian Federation, Kazakhstan, Ukraine, Uzbekistan	A + B	C 1	C 2	P1	P2	P3

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.

Estimated Additional Resources – Category II (EAR-II) refers to uranium, in addition to EAR-I, 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 EAR-I.

Speculative Resources (SR) refers to uranium, in addition to EAR-II, 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.

b) Cost categories

The cost categories, in United States dollars (USD), used in this report are defined as: USD 40/kgU or less, USD 80/kgU or less, and USD 130/kgU or less.

NOTE: It is not intended that the cost categories should follow fluctuations in market conditions.

Conversion of projected 2001 costs from other currencies into USD was done using the exchange rate of 1 January 2001. For past years, conversion of other currencies into USD was done using an average exchange rate for the month of June in that year. See Annex 6 for a complete list of the currency exchange rates used to prepare this report. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant.

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 which remain unamortised.
- 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 were not normally taken into consideration.

c) Relationship between resource categories

Figure 2 illustrates the inter-relationship between the different resource categories. The horizontal axis expresses the level of assurance about the actual existence of given tonnages based on varying degrees of geologic knowledge while the vertical axis expresses the economic feasibility of exploitation by the division into cost categories.

The dashed lines between RAR, EAR-I, EAR-II and SR in the highest cost category indicate that the distinctions of level of confidence are not always clear. The shaded area indicates that known conventional resources (i.e., RAR plus EAR-I) recoverable at costs of USD 80/kgU or less are distinctly important because they support most of the world's EXISTING and COMMITTED production centres. RAR at prevailing market prices are commonly defined as "Reserves".

Because resources in the EAR-II and SR categories are undiscovered, the information on them is such that it is not always possible to divide them into different cost categories and this is indicated by the horizontal dashed lines between the different cost categories.

d) Recoverable resources

Resource 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*. Therefore both expected mining and ore processing losses have been deducted in most cases. Deviations from this practice are indicated in the tables. *In situ* resources are recoverable resources in the ground not taking into account mining and milling losses.

e) Types of resources

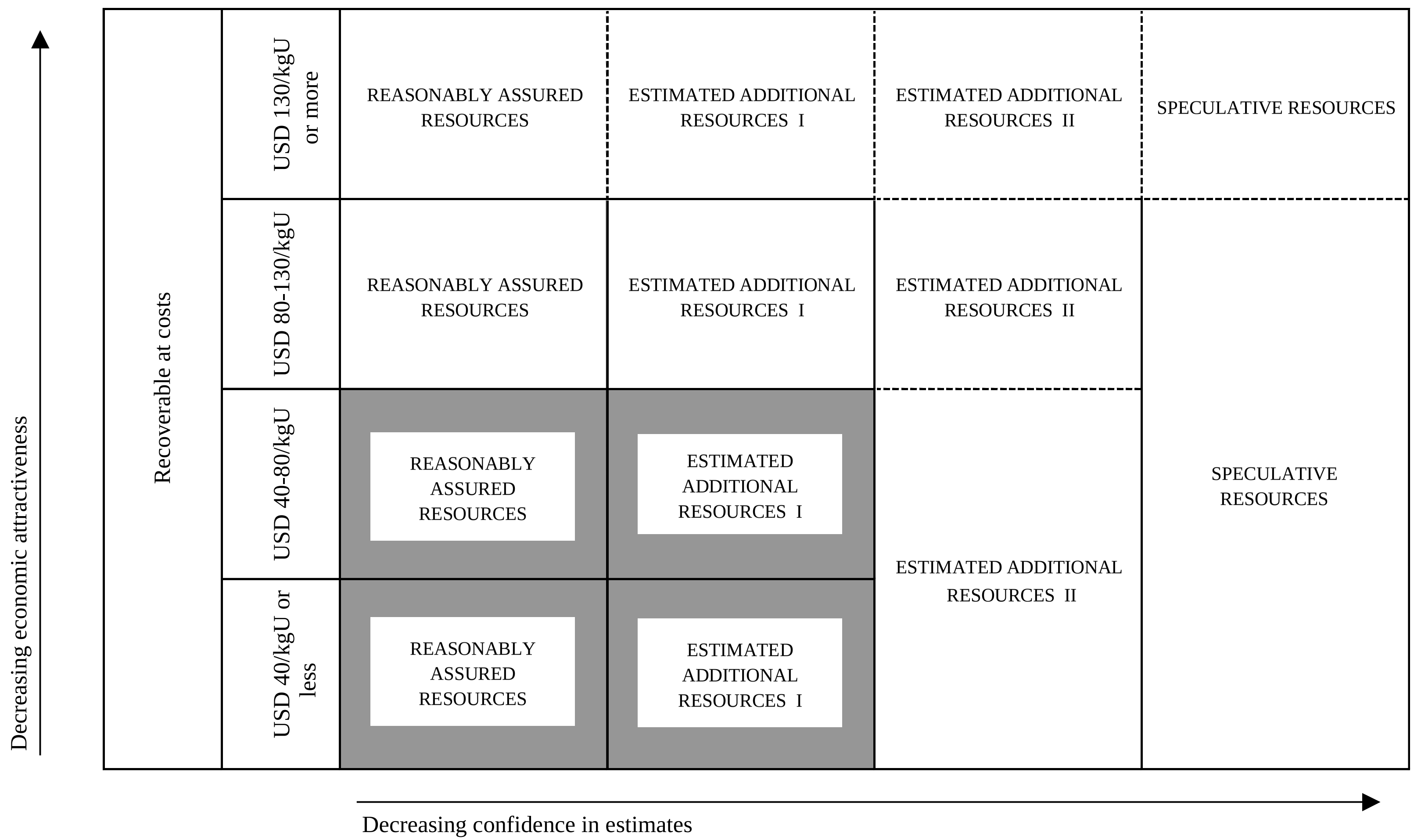
To obtain a better understanding of the uranium resource situation, reference is made to different geologic types of deposits that contain the resources, as follows:

Geologic types of uranium deposits

The major uranium resources of the world can be assigned on the basis of their geological setting to the following 15 ore types (see Annex 3 for a more detailed discussion of uranium deposit types):

1. Unconformity-related deposits.
2. Sandstone deposits.
3. Quartz-pebble conglomerate deposits.
4. Vein deposits.
5. Breccia complex deposits.
6. Intrusive deposits.
7. Phosphorite deposits.
8. Collapse breccia pipe deposits.
9. Volcanic deposits.
10. Surficial deposits.
11. Metasomatite deposits.
12. Metamorphic deposits.
13. Lignite.
14. Black shale deposits.
15. Other types of deposits (phosphates, monazite, coal, etc.).

Figure 2. **NEA/IAEA Classification scheme for uranium resources**



PRODUCTION TERMINOLOGY[1]

a) 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 the uranium resources that are tributary to them. For the purpose of describing production centres, they have been divided into four classes, as follows:

i) 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.

ii) COMMITTED production centres are those that are either under construction or are firmly committed for construction.

iii) 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.

iv) PROSPECTIVE production centres are those that could be supported by tributary RAR and EAR-I, i.e., "known resources", but for which construction plans have not yet been made.

b) 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 EAR-I. The projection is presented based on those resources recoverable at costs up to USD 80/kgU.

DEMAND TERMINOLOGY

REACTOR-RELATED REQUIREMENTS refer to natural uranium acquisitions *not* necessarily consumption.

UNITS

Metric units are used in all tabulations and statements. Resources and production quantities are expressed in terms of metric tons (t) contained uranium (U) rather than uranium oxide (U_3O_8).

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1. *Manual on the Projection of Uranium Production Capability* (1984), General Guidelines, Technical Report Series No. 238, IAEA, Vienna, Austria.

1 short ton U_3O_8	=	0.769 tU
USD/lb U_3O_8	=	USD 2.6/kgU
1 metric ton	=	1 tonne

GEOLOGICAL TERMS

a) Uranium occurrence

A naturally occurring, anomalous concentration of uranium.

b) Uranium deposit

A mass of naturally occurring mineral material from which uranium could be exploited at present or in the future.

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 ultimate goal of decommissioning is unrestricted release or reuse of the site. The time period to achieve this goal may range from a few to several hundred years.

Decontamination The removal or reduction of radioactive or toxic chemical contamination through a physical, chemical, or biological process.

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 Cleanup 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.

Reclamation The process of restoring a site to predefined conditions, which allows new uses.

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2. Definitions taken from *Environmental Remediation World Uranium Production Facilities* (2002), OECD, Paris.

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.

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.

I. URANIUM SUPPLY

This Chapter summarises the current status of world-wide uranium resources, exploration and production. In addition, production capabilities in reporting countries for the period ending in the year 2020 are presented and discussed. The last section of the chapter describes environmental issues relating to uranium mining and milling and decommissioning of production facilities.

A. URANIUM RESOURCES

Known conventional resources

Known Conventional Resources (KCR) consist of Reasonably Assured Resources (RAR) and Estimated Additional Resources Category I (EAR-I) recoverable at a cost of USD 130/kgU or less (≤USD 130/kgU). Relative changes in different resource and cost categories of KCR, between this edition and the 1999 edition of the Red Book are given in Table 1. As shown in Table 1, KCR in the ≤USD 130/kgU category remain virtually unchanged between 1999 and 2001. The most significant change in resources occurred in the ≤USD 40/kgU category. This change came about largely because Australia reported resources in this low-cost category in 2001, whereas it did not do so in 1999. Current estimates of RAR and EAR-I on a country by country basis are presented in Tables 2 and 3, respectively. In addition to the resources listed in Tables 1, 2 and 3, China reported 73 000 tU as KCR. Yet, since it included no further resource or cost classification, China's resources could not be included in Tables 1, 2 and 3. Similarly, India reported 78 030 tU as KCR of which 54 470 tU are classified as RAR and 23 560 tU as EAR-I. However, since no cost classification was reported, India's KCR are not included in Tables 1, 2 and 3.

Table 1. **Changes in known conventional resources 1999-2001**
(1 000 tonnes U)

Resource category	**1999**	**2001**	**Changes**
KCR (Total)			
≤USD130/kgU	3 954	3 933	-21
≤USD80/kgU	3 002	3 107	+105
≤USD40/kgU*	>1 254	>2 086	>+832
RAR			
≤USD130/kgU	2 964	2 853	-111
≤USD80/kgU	2 274	2 242	-32
≤USD40/kgU*	>916	>1 534	>+618
EAR-I			
≤USD130/kgU	990	1 080	+90
≤USD80/kgU	728	865	+137
≤USD40/kgU*	>338	>552	>+214

* Resources in the cost categories of ≤USD 40/kgU are higher than reported, however several countries have indicated that either detailed estimates are not available, or the data are confidential.

Table 2. **Reasonably assured resources (RAR)**
(in 1 000 tonnes U, as of 1 January 2001)

COUNTRY	Cost Ranges				
	≤ USD 40/kgU	USD 40-80/kgU	≤ USD 80/kgU	USD 80-130/kgU	≤ USD 130/kgU
Algeria (a) (b)	–	–	26.00	0.00	26.00
Argentina	2.64	2.44	5.08	2.00	7.08
Australia	654.00	13.00	667.00	30.00	697.00
Brazil (a) (b)	56.10	105.90	162.00	0.00	162.00
Bulgaria (a) **	2.22	5.61	7.83	0.00	7.83
Canada	277.99	36.57	314.56	0.00	314.56
Central African Republic (b) *	–	–	8.00	8.00	16.00
Chile (b) (e)	NA	NA	NA	NA	NA
Congo, Democratic Republic of (a) (b)*	–	–	1.80	0.00	1.80
Czech Republic	0	2.37	2.37	0.00	2.37
Denmark (b) *	0	0	0	27.00	27.00
Finland	0	0	0	1.50	1.50
France (b)	0.19	0.00	0.19	0.00	0.19
Gabon**	4.83	0.00	4.83	0.00	4.83
Germany (b)	0.00	0.00	0.00	3.00	3.00
Greece *	1.00	0.00	1.00	0.00	1.00
India (e)	NA	NA	NA	NA	NA
Indonesia (a)	0.00	0.47	0.47	6.33	6.80
Italy (b) *	–	–	4.80	0.00	4.80
Islamic Republic of Iran (a)	0	0	0	0.49	0.49
Japan (b)	0.00	0.00	0.00	6.60	6.60
Kazakhstan (a) (b)	317.23	115.56	432.79	162.04	594.83
Malawi (a) **	–	–	11.70	0.00	11.70
Mexico (a) (b) *	0	0	0	1.70	1.70
Mongolia (a) **	10.60	51.00	61.60	0.00	61.60
Namibia (a)	61.83	82.04	143.87	31.24	175.10
Niger (a)	10.91	18.69	29.60	0.00	29.60
Peru (a) *	–	–	1.79	0.00	1.79
Portugal	–	–	7.45	0.00	7.45
Romania	–	–	–	–	4.55
Russian Federation (a) (f)	63.00	75.00	138.00	0.00	138.00
Slovenia (b)	0	2.20	2.20	0	2.20
Somalia (a) (b) *	–	–	0	6.60	6.60
South Africa	119.20	111.90	231.10	59.90	291.00
Spain	0	2.46	2.46	2.46	4.92
Sweden (b)	0	0	0	4.00	4.00
Thailand	–	–	–	–	0.01
Turkey (a)	0.00	9.13	9.13	0.00	9.13
Ukraine (a)	19.25	23.35	42.60	38.40	81.00
United States	NA	–	104.00	244.00	348.00
Uzbekistan (a)	90.08	0	90.08	25.27	115.35
Viet Nam (a) (b)	0.00	0.00	0.00	1.34	1.34
Zimbabwe (a) *	NA	NA	1.80	0	1.80
Total (c)	> **1 691.07**	> **657.69**	**2 516.10**	**661.87**	**3 182.52**
Total adjusted (d)	> **1 534.10**	> **556.65**	**2 242.45**	**589.77**	**2 853.30**

(a) *In situ* resources.
(b) Assessment not made within last 5 years or not reported in 2001 responses.
(c) Totals related to cost ranges ≤USD 40/kgU and USD 40-80/kgU are higher than reported in the tables because certain countries do not report resource estimates, mainly for reasons of confidentiality.
(d) *In situ* resources (indicated by footnote "a") were adjusted to estimate recoverable resources using recovery factors provided by countries. If no factors were provided the Secretariat, taking into account the geology and most likely mining and processing method(s), estimated them. Reported *in situ* resources were then multiplied by the individual recovery factors on a country-by-country basis to determine the adjusted total.
(e) Cost data not provided, therefore reported resources were not included in this table.
(f) Secretariat estimate.
– No resources reported.
NA Data not available.
* Data from previous Red Book.
** Data from previous Red Book depleted for production.

Table 3. **Estimated additional resources (EAR) – Category I**
(in 1 000 tonnes U, as of 1 January 2001)

COUNTRY	Cost Ranges				
	≤ USD 40/kgU	USD 40-80/kgU	≤ USD 80/kgU	USD 80-130/kgU	≤ USD 130/kgU
Argentina	2.03	0.35	2.38	6.18	8.56
Australia	185.00	11.00	196.00	37.00	233.00
Brazil (a) (b)	–	–	100.20	0	100.20
Bulgaria (a) (b) *	2.20	6.20	8.40	0.00	8.40
Canada	102.81	19.58	122.39	0	122.39
Chile (b) (e)	–	–	–	–	NA
Congo, Democratic Republic of (a) (b) *	–	–	1.70	0	1.70
Czech Republic	0	0.31	0.31	0.00	0.31
Denmark (b) *	–	–	0	16.00	16.00
France (b)	0.00	0.00	0.00	11.74	11.74
Gabon *	1.00	–	1.00	–	1.00
Germany (b)	0	0	0	4.00	4.00
Greece *	–	–	6.00	0	6.00
Hungary (a) (b)*	0	0	0	18.40	18.40
India (a) (e)	–	–	–	–	NA
Indonesia (a)	0.00	0.00	0.00	1.70	1.70
Islamic Republic of Iran (a)	0.00	0.00	0.00	0.88	0.88
Italy (b) *	–	–	0	1.30	1.30
Kazakhstan (a) (b)	113.20	82.70	195.90	63.40	259.30
Mexico (a) (b) *	–	–	0	0.70	0.70
Mongolia (a) (b) *	11.00	10.00	21.00	0	21.00
Namibia (a)	70.55	20.27	90.82	16.70	107.51
Niger (a)	11.17	14.36	25.53	0.00	25.53
Peru (a) *	–	–	1.86	0	1.86
Portugal	0.00	0.00	0.00	1.45	1.45
Romania	–	–	–	–	4.69
Russian Federation (a) (f)	17.20	19.30	36.50	0	36.50
Slovenia (b)	–	–	5.00	5.00	10.00
Somalia	–	–	0	3.40	3.40
South Africa	48.10	18.70	66.80	9.60	76.40
Spain	0	0	0	6.38	6.38
Sweden	0	0	0	6.00	6.00
Thailand	–	–	–	–	0.01
Ukraine (a)	–	20.00	20.00	30.00	50.00
Uzbekistan (a)	46.80	0	46.80	9.97	56.71
Viet Nam (a) (b)	NA	NA	1.10	5.64	6.74
Total (c)	> **611.06**	> **222.77**	**949.69**	**255.44**	**1 209.76**
Total adjusted (d)	> **552.04**	> **186.95**	**864.85**	**225.15**	**1 079.78**

(a) *In situ* resources.

(b) Assessment not made within last 5 years or not reported in 2001 responses.

(c) Subtotal and totals related to cost ranges ≤USD 40/kgU and USD 40-80/kgU are higher than reported in the tables because certain countries do not report resource estimates, mainly for reasons of confidentiality.

(d) *In situ* resources (indicated by footnote "a") were adjusted to estimate recoverable resources using recovery factors provided by countries. If no factors were provided the Secretariat, taking into account the geology and most likely mining and processing method(s), estimated them. Reported *in situ* resources were then multiplied by the individual recovery factors on a country-by-country basis to determine the adjusted total.

(e) Cost data not provided, therefore reported resources were not included in this table.

(f) Secretariat estimate.

* Data from previous Red Book(s).

– No resources reported.

NA Data not available.

Distribution of known conventional resources by categories and cost ranges

Table 4 summarises the most significant changes between 1999 and 2001 in Known Conventional Resources. Australia, Canada, Ukraine and Uzbekistan all gained resources in the categories shown in Table 4, while the Czech Republic and Niger experienced net reductions in resources. Distribution of RAR and EAR-I among countries with major resources are shown in Figures 3 and 4, respectively.

RAR recoverable at costs ≤USD 130/kgU (adjusted for estimated mining and milling losses) decreased by about 111 000 tU, or about 4% compared to the previous edition. Overall, reported increases in resources were insufficient to offset losses resulting from 1999 and 2000 production (about 68 291 tU) during the reporting period. Similar observations held true for RAR recoverable at ≤USD 80/kgU. In contrast, RAR recoverable at ≤USD 40/kgU increased by about 618 000 tU, largely because Australia reported resources in this category for the first time.

EAR-I recoverable at ≤USD 130/kgU increased by about 90 000 tU, with Australia and Canada accounting for nearly 65% of the increase. EAR-I recoverable at ≤USD 80/kgU increased by about 137 000 tU, with Australia, Canada, Niger and Russia accounting for 75% of the increase. In the ≤USD 40/kgU cost category, EAR-I increased by about 214 000 tU, with Australia, which reported resources in this category for the first time, accounting for about 85% of the increase.

Availability of resources

In order to estimate the availability of resources for near-term production, countries were asked to report the percentage of KCR (RAR and EAR-I), recoverable at costs of ≤USD 40/kgU and ≤USD 80/kgU, that are tributary to existing and committed production centres. Of a total of 21 producing countries, 11 provided estimates. Other countries did not report mainly for reasons of confidentiality. Resources tributary to existing and committed production centres in the 11 countries that submitted data total 1 525 590 tU at ≤USD 40/kgU, and 1 931 400 tU at ≤USD 80/kgU.

Table 4. **Major conventional resource changes**
(in 1 000 tonnes U)

Country	Resource category	1999	2001	Changes	Reasons
Australia	RAR ≤USD 40/kgU	0	654	+654	Australia did not previously report resources in this category
	EAR-I ≤USD 40/kgU	0	185	+185	Australia did not previously report resources in this category
	RAR ≤USD 80/kgU	607	667	+60	Re-assessment of Ranger, Jabiluka and Westmoreland deposits
	EAR-I ≤USD 80/kgU	147	196	+49	Re-assessment of Ranger, Jabiluka and Westmoreland deposits
	RAR USD 80-130/kgU	109	30	-79	Reassessment
	EAR-I USD 80-130/kgU	47	37	-10	Reassessment

Table 4. **Major conventional resource changes** (cont'd)
(in 1 000 tonnes U)

Country	Resource category	1999	2001	Changes	Reasons
Canada	EAR-I ≤USD 40/kgU	87.01	102.81	+15.8	Reassessment of McArthur River resources
Czech Republic	EAR-I USD 80-130/kgU	21.55	0	-21.55	Re-evaluation of Hamr and Osecna-Kotel deposits
Niger	RAR ≤USD 40/kgU	43.59	10.91	-32.68	Re-evaluation
Ukraine	RAR ≤USD 40/kgU	0	19.25	+19.25	Exploration results within the Vatutinskoye and Michurinskoye deposits
Uzbekistan	RAR ≤USD 40/kgU	65.62	90.08	+24.46	Re-evaluation
	EAR-I ≤USD 40/kgU	39.85	46.80	+6.95	Re-evaluation

Figure 3. **Distribution of reasonably assured resources (RAR) among countries with major resources**

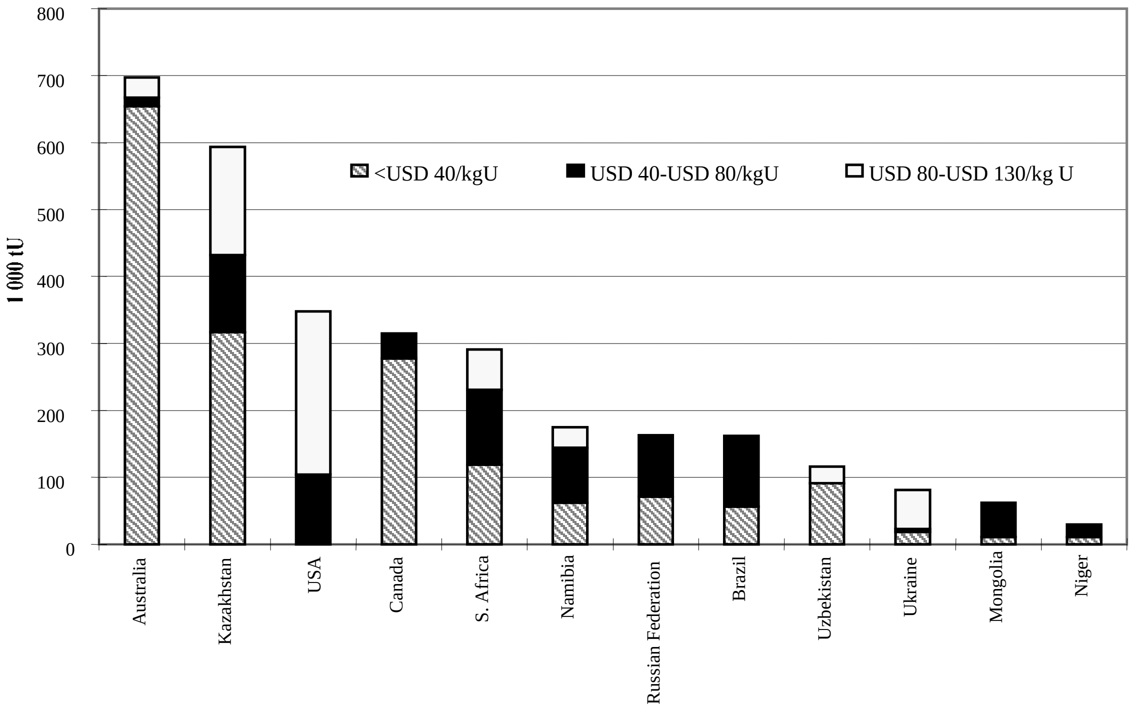
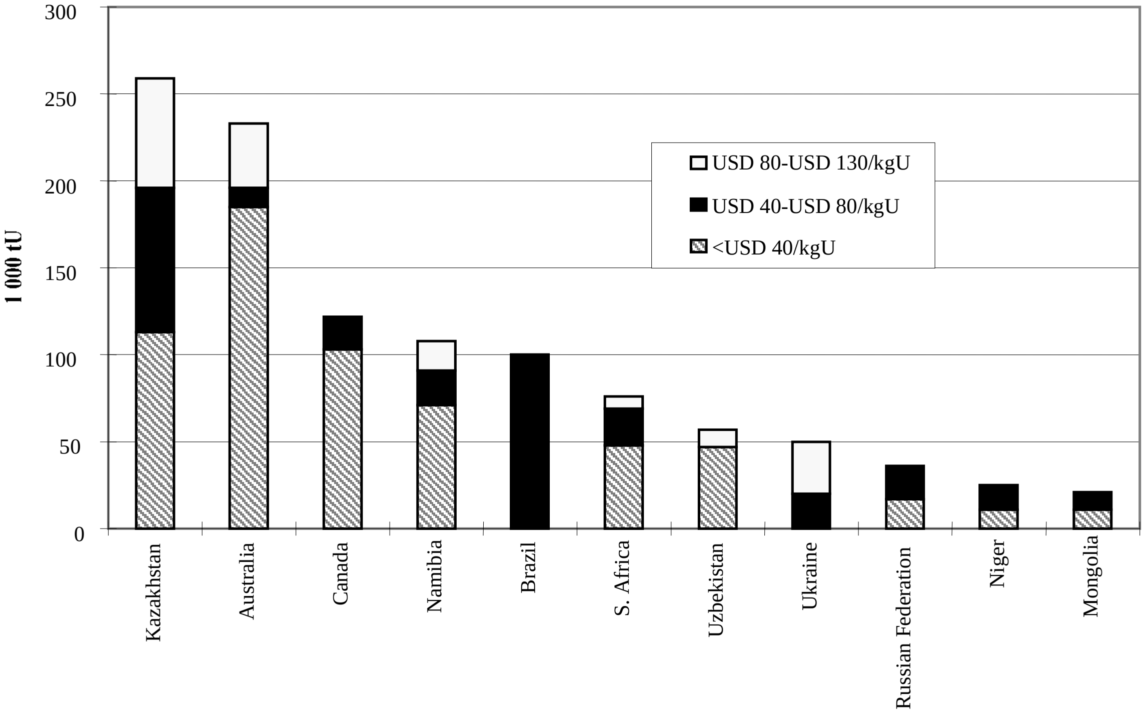


Figure 4. **Distribution of estimated additional resources – Category I (EAR-I) among countries with major resources**



Undiscovered conventional resources

Undiscovered Conventional Resources include Estimated Additional Resources – Category II (EAR-II) and Speculative Resources (SR). EAR-II refers to uranium resources that are expected to occur in well-defined geological trends of known ore deposits, or mineralised areas with known deposits. SR refers to uranium resources that are thought to exist in geologically favourable, yet unexplored areas. Therefore EAR-II are assigned a higher degree of confidence than SR. Almost all EAR-II and SR are reported as *in situ* resources. Both categories of undiscovered conventional resources are reported in Table 5. A number of countries, e.g. Australia, did not report undiscovered conventional resources for the 2001 Red Book, with some specifying that they do not perform systematic evaluations of this type of resources, though countries, such as Australia, are considered to have significant resource potential in sparsely explored areas.

Only a few countries report EAR-II recoverable at ≤USD 40/kgU. Therefore, this category is not included in Table 5. Compared to the last edition only minor changes have been reported in both EAR-II and Speculative Resources. EAR-II are estimated to total about 2.3 million tU recoverable at ≤USD 130/kgU, and about 1.5 million tU at ≤USD 80/kgU.

It should be noted that the USA does not report EAR-I and EAR-II separately. Instead, all EAR reported by the USA are classified as EAR-II; an unknown portion, however, belongs to EAR-I.

Table 5. **Reported undiscovered conventional resources**
(in 1 000 tonnes U, as of 1 January 2001)*

COUNTRY	Estimated Additional Resources Category II		Speculative Resources		
	Cost Ranges		Cost Ranges		
	<USD 80/kgU	<USD 130/kgU	<USD 130/kgU	Cost Range Unassigned	Total
Argentina	0	1	NA	NA	NA
Brazil	120	120	0	500	500
Bulgaria (a)	2	2	16	0	16
Canada	50	150	700	0	700
Chile (c)	NA	NA	NA	2	2
China (a)	NA	NA	NA	1 770	1 770
Colombia (a)	NA	11	217	NA	217
Czech Republic	1	1	0	179	179
Denmark	NA	NA	50	10	60
Gabon (a)	2	2	0	0	0
Germany	0	0	0	74	74
Greece (a)	6	6	0	0	0
Guatamala	NA	18	NA	NA	0
Hungary (a)	0	18	0	0	0
India (a) (c)	NA	NA	0	17	17
Indonesia	0	0	0	4	4
Iran, Islamic Republic of	0	4	4	5	9
Italy (a)	NA	NA	NA	10	10
Kazakhstan	290	310	500	0	500
Mexico (a)	NA	3	NA	10	10
Mongolia (a)	0	0	1 390	NA	1 390
Niger	16	16	0	200	200
Peru (a)	7	20	20	6	26
Portugal	0	2	5	0	5
Romania	NA	3	3	0	3
Russian Federation	56	105	550	450	1 000
Slovenia	0	1	NA	NA	NA
South Africa (a)	35	148	NA	1 113	1 113
Ukraine	0	4	0	231	231
United States (d)	839	1 273	858	482	1 340
Uzbekistan	56	85	0	145	145
Venezuela (a)	NA	NA	0	163	163
Viet Nam	0	7	100	130	230
Zambia (a)	0	22	0	0	0
Zimbabwe (a)	0	0	25	0	25
Total (reported by countries)**	**1 480**	**2 332**	**4 438**	**5 501**	**9 939**

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

** Totals do not represent a complete account of world undiscovered conventional resources. Totals may not equal sum of components due to independent rounding.

NA Data not available.

(a) Data from previous Red Book.

(b) Mineable resources.

(c) Cost data not provided, therefore, reported EAR-II resources were not included on this table.

(d) USA reports all EAR-I and EAR-II as EAR-II.

Worldwide reporting of SR is incomplete, with only 28 countries reporting SR compared to 43 that reported RAR. The estimated total for countries reporting SR recoverable at ≤USD 130/kgU is about 4.44 million tU, essentially unchanged compared to the 1999 total. About 5.50 million tU of additional SR are reported without an estimate of production costs, bringing total reported SR to about 9.94 million tU.

Unconventional resources and other materials

No specific compilation of unconventional resources is provided in this report, as only a few countries reported relevant information.

Uranium resources and sustainability

The extensive uranium resources believed to exist throughout the world and their effective management through the use of efficient fuel cycle strategies and advanced technologies will allow these resources to be used for many generations to come.

Uranium is widely dispersed within the earth's crust and in the oceans. As specified in this report, estimates of uranium resources are classified into conventional and unconventional categories. Current estimates of conventional resources of uranium (known and undiscovered) total about 16.2 million tU or nearly 250 years of supply at today's rate of usage (around 64 000 tU/year). There are additional resources classified as unconventional, in which uranium exists at very low grades, or is recovered as a minor by-product. Unconventional resources include about 22 million tonnes that occur in phosphate deposits and up to 4 billion tonnes contained in seawater. Based on current technology, however, the unconventional resources have very high recovery costs. For example, research in Japan indicates that the cost to extract uranium from seawater is estimated at USD 300/kgU or approximately 10-15 times the spot market price for natural uranium at the end of 2000.

In the long-term, natural uranium requirements will depend on future fuel cycle strategies and reactor technologies adopted. Fuel cycle strategies that reduce uranium consumption per kWh include lowering enrichment plant tails assays (thereby recovering more of the ^{235}U present in natural uranium but at higher energy costs); and recycling uranium and plutonium recovered from the reprocessing of spent fuel (thereby reducing the need for fresh natural uranium). By reprocessing spent fuel about 30% of the potential energy in the initial fuel can be re-utilised in thermal reactors.

The introduction of fast reactors (e.g. liquid metal cooled fast reactors) could further reduce total uranium requirements. Plutonium breeding allows fast reactors to extract 60 times as much energy from uranium as do thermal reactors. Other advanced technologies could be developed in the future, that could extend the useful life of the conventional uranium resources over several centuries, including other new reactor types. While there are technologies that could potentially extend the life of the world's uranium resources, the full impact that these technologies will have on uranium requirements is still very uncertain. Therefore, it is incumbent that the adequacy of the world's known and speculative resources also be assessed based on current or known technology. A report published in 2001 by the IAEA, titled *Analysis of Uranium Supply to 2050*, addresses the adequacy of different resource categories and is summarised in the demand analysis section.

B. URANIUM EXPLORATION

Worldwide uranium exploration continues to be unevenly distributed geographically, with the majority of exploration expenditures being concentrated in areas considered to have the best likelihood for the discovery of economically attractive deposits. Following a continuous decrease of domestic exploration activities for more than ten years, a low of about USD 70 million was reached in 1994. As shown in Table 6, the trend in decreasing exploration expenditures was interrupted beginning in 1995 and extending through 1997. In 1997, a total of 25 countries reported domestic exploration expenditures of about USD 153 million, or almost 38% higher than in the previous year. In 1998, however, the decline in exploration expenditures resumed when only 22 countries reported domestic exploration activities costing about USD 132 million. That decline continued into 2000, when expenditure totals declined to about USD 83 million.

Domestic exploration expenditures totalled about USD 83.29 million in 2000, a decrease of about USD 48.36 million or 37% compared to the 1998 total. Six countries, Australia, Canada, India, the Russian Federation, the United States and Uzbekistan, accounted for 94% of domestic exploration expenditures in 2000. However, all of these countries except India reported decreases in exploration expenditures compared to their 1998 totals. It is also important to note that about 70% of Uzbekistan's expenditure total, or USD 10.08 million was spent on development-related activities. Iran and Ukraine were the only other countries besides India to report increases in domestic exploration expenditures between 1998 and 2000 (see Table 6).

China does not report exploration expenditures. It does, however, report that it has an active exploration programme. Canada was the only country to report non-domestic exploration expenditures in 2000 (see Table 7).

The trends in domestic and non-domestic exploration expenditures for selected countries are depicted in Figure 5. As noted in both Figure 5 and Tables 6 and 7, the decline in exploration expenditures is expected to continue in 2001. Domestic exploration expenditures are expected to drop to about USD 52 million in 2001, only about 62% of the 2000 total, which is about 26% below the last low-mark in 1994. Similarly, non-domestic exploration expenditures are expected to experience a sharp drop to only USD 3 million, 83% below the 1998 level.

Current activities and recent developments

North America. **Canada** continued to be the world's leader in domestic exploration spending, with annual expenditures in 1999 and 2000 of about USD 33 million and 30.7 million, respectively. Nearly 65% of Canada's expenditure total is attributable to projects awaiting production approvals. Basic "grass-roots" expenditures were of the order of USD 12 million annually, well over 90% of which was spent in Saskatchewan. Canada's 2001 exploration expenditures are expected to decline by about 51% compared to the 2000 level.

Exploration expenditures in the **USA** in 1999 totalled about USD 8.97 million a decline of about 60% compared to 1998 expenditures. Preliminary data indicate that this trend continued with 2000 expenditures totalling only about 75% of the 1999 level. Of the 1999 expenditure total about USD 7.89 million are attributable to surface drilling and about USD 1 million are attributable to "other exploration" activities.

Central and South America. Exploration in Central and South America in 2000 continued at a virtual standstill with none of the countries reporting any exploration expenditures. **Argentina** reported conducting a limited exploration drilling program of 15 holes and 1 438 metres. However, it assigned no cost figures to this program.

Western Europe and Scandinavia. Domestic exploration in the area continued to decline with no countries reporting exploration expenditures in 2000 compared to about USD 1.15 million in 1998.

Table 6. **Industry and government uranium exploration expenditures (domestic) in countries listed – USD 1 000 in year of expenditure**

COUNTRY	Pre-1994	1994	1995	1996	1997	1998	1999	2000	2001 (expected)
Argentina	47 804	700	950	0	0	0	NA	NA	NA
Australia	439 521	4 904	5 942	11 841	18 038	12 030	6 260	4 390	NA
Bangladesh	453	NA	NA	NA	NA	NA	NA	NA	NA
Belgium	1 685	0	0	0	0	0	0	0	0
Bolivia	9 368	NA	NA	NA	NA	NA	NA	NA	NA
Botswana	640	NA	NA	NA	NA	NA	NA	NA	NA
Brazil	189 920	0	0	0	0	0	0	0	513
Canada	1 014 732	26 087	32 353	28 467	42 029	41 096	33 000	30 667	15 000
Central African Rep.	20 000	NA	NA	NA	NA	NA	NA	NA	NA
Chile	8 222	94	218	143	154	196	178	154	NA
Colombia	23 935	0	0	0	0	NA	NA	NA	NA
Costa Rica	361	NA	NA	NA	NA	NA	NA	NA	NA
Cuba	466	228	142	86	50	NA	NA	NA	NA
Czechoslovakia	312 560	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Czech Republic	579	468	282	201	163	90	64	44	50
Denmark	4 350	0	0	0	0	0	0	0	0
Ecuador	2 055	NA	NA	NA	NA	NA	NA	NA	NA
Egypt	39 680	3 245	3 264	6 528	7 418	7 976	NA	NA	NA
Finland	14 777	0	0	0	0	0	0	0	0
France	886 899	6 217	2 882	7 960	1 742	1 040	0	0	0
Gabon	89 111	1 050	939	1 338	343	0	0	0	0
Germany	144 765	0	0	0	0	0	0	0	0
Ghana	90	NA	NA	NA	NA	NA	NA	NA	NA
Greece	16 660	154	148	273	290	NA	NA	NA	NA
Guatemala	610	NA	NA	NA	NA	NA	NA	NA	NA
Hungary	3 700	0	0	0	0	0	0	0	0
India	197 286	9 363	9 536	9 250	11 183	12 812	12 090	14 368	13 098
Indonesia	12 851	648	574	695	632	114	217	61	82
Iran, Islamc Republic of	NA	NA	NA	NA	NA	857	1 000	1 700	4 500
Ireland	6 800	0	0	0	0	0	0	NA	NA
Italy	75 060	NA	NA	NA	NA	NA	NA	NA	NA
Jamaica	30	NA	NA	NA	NA	NA	NA	NA	NA
Japan	8 640	0	0	0	0	0	0	0	0
Jordan	482	10	30	100	100	150	NA	NA	NA
Kazakhstan	5 025	1 290	113	242	160	0	0	0	0
Korea, Republic of	4 670	0	0	0	0	0	0	0	0
Lesotho	21	NA	NA	NA	NA	NA	NA	NA	NA
Madagascar	5 243	NA	NA	NA	NA	NA	NA	NA	NA

Table 6. **Industry and government uranium exploration expenditures (domestic) in countries listed – USD 1 000 in year of expenditure** (cont'd)

COUNTRY	Pre-1994	1994	1995	1996	1997	1998	1999	2000	2001 (expected)
Malaysia	9 237	399	163	0	245	188	186	66	32
Mali	51 637	NA	NA	NA	NA	NA	NA	NA	NA
Mexico	24 910	0	0	0	0	0	0	0	0
Mongolia	108	700	1 650	2 560	3 135	NA	NA	NA	NA
Morocco	2 752	NA	NA	NA	NA	NA	NA	NA	NA
Namibia	15 886	0	2 044	0	0	0	0	0	0
Niger	200 674	1 481	1 665	427	1 653	754	471	604	897
Nigeria	6 950	NA	NA	NA	NA	NA	NA	NA	NA
Norway	3 180	0	0	0	0	0	0	0	0
Paraguay	25 510	NA	NA	NA	NA	NA	NA	NA	NA
Peru	4 179	4	0	0	0	0	0	NA	NA
Philippines	3 387	30	30	19	19	13	11	5	4
Portugal	17 014	106	130	114	154	102	18	19	0
Romania	NA	2 998	2 448	1 776	1 198	934	549	157	348
Russian Federation	12 538	4 197	5 581	4 281	10 052	8 650	6 870	7 990	8 010
Somalia	1 000	NA	NA	NA	NA	NA	NA	NA	NA
South Africa	108 993	NA	NA	NA	NA	NA	NA	NA	NA
Spain	138 814	891	0	1 388	0	10	0	0	0
Sri Lanka	33	NA	NA	NA	NA	NA	NA	NA	NA
Sweden	46 870	0	0	0	0	0	0	0	0
Switzerland	3 868	0	0	0	0	0	0	0	0
Syria	1 068	NA	NA	NA	NA	NA	NA	NA	NA
Thailand	10 686	116	119	0	0	0	0	NA	NA
Turkey	20 581	0	0	0	200	1 200	0	0	0
Ukraine	NA	NA	NA	1 376	1 611	1 940	1 606	2 107	2 482
United Kingdom	2 600	0	0	0	0	0	0	0	0
United States	2 657 800	4 329	6 009	10 054	30 426	21 724	8 968	6 694	NA
Uruguay	231	NA	NA	NA	NA	NA	NA	NA	NA
USSR	247 520	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Uzbekistan*	NA	472	6 197	22 067	21 954	19 652	19 392	14 152	6 850
Viet Nam	1 391	137	161	208	227	120	120	110	110
Yugoslavia	1 006	NA	NA	NA	NA	NA	NA	NA	NA
Zambia	170	4	NA	NA	NA	NA	NA	NA	NA
Zimbabwe	6 902	0	0	0	0	NA	NA	NA	NA
TOTAL (a)	**7 216 546**	**70 322**	**83 570**	**111 394**	**153 176**	**131 648**	**91 000**	**83 288**	**51 976**

(a) Of available data only.
xxxx National entity not in existence or politically redefined.
NA Data not available.
* Includes maintenance expenditures since 1996.

Table 7. **Non-domestic uranium exploration expenditures (abroad) in countries listed USD 1 000 in year of expenditure**

COUNTRY	Pre-1994	1994	1995	1996	1997	1998	1999	2000	2001 (expected)
Belgium	4 500	0	0	0	0	0	0	0	0
Canada	–	1 449	1 471	3 650	3 986	3 000	3 000	4 000	3 000
France	634 722	30 959	10 245	6 808	8 972	8 777	7 120	NA	NA
Germany	390 424	2 646	2 951	3 137	4 000	NA	NA	0	0
Japan	353 621	12 923	14 771	7 533	4 752	2 280	1 390	NA	NA
Korea, Rep. of	22 137	175	178	511	603	445	NA	NA	NA
Spain	20 400	0	0	0	0	0	0	0	0
Switzerland	29 030	627	0	0	0	0	0	0	0
United Kingdom	61 263	0	0	0	0	0	0	0	0
United States	228 770	NA	NA	422	3 050	3 616	NA	NA	NA
TOTAL	**1 744 867**	**48 779**	**29 616**	**22 061**	**25 363**	**18 118**	**11 510**	**4 000**	**3 000**

– No expenditures reported.

NA Data not available.

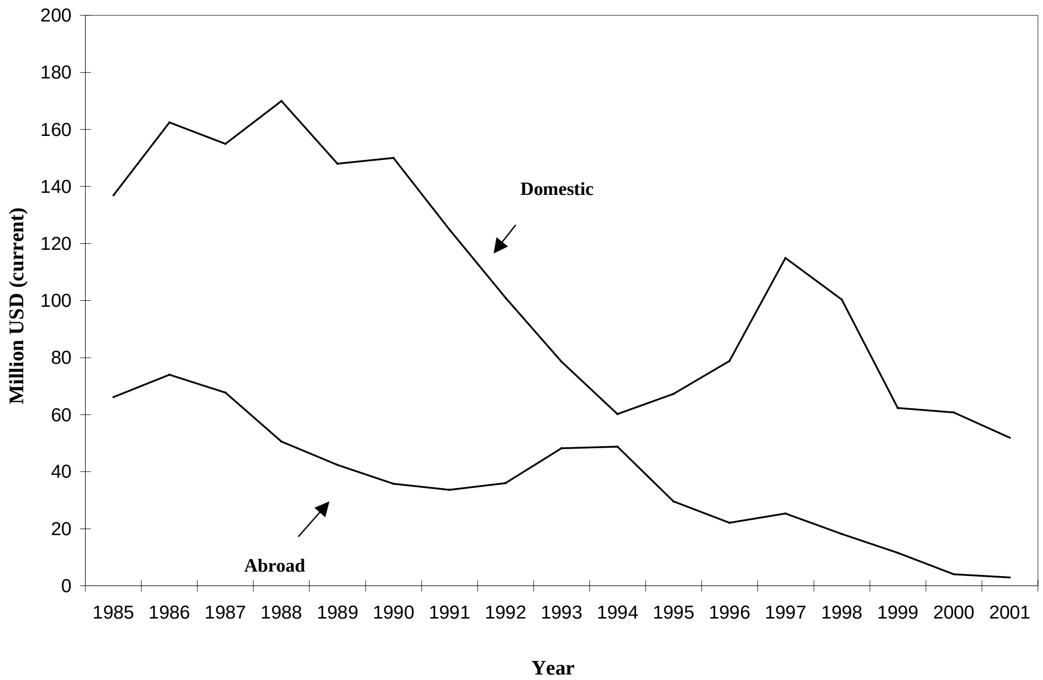
Central, Eastern and South East Europe. No field work was undertaken in the **Czech Republic**, and only archiving and processing of previously obtained data continued. In **Romania**, drilling programmes continued in favourable areas; however, there was a downward trend in both expenditures and drilling footage. The **Russian Federation** has concentrated its exploration activities on sandstone deposits amenable to *in situ* leaching (ISL) and on unconformity-related deposits. Major drilling programmes continued in the Transural District, the West Siberian District and in the Vitim Region. **Turkey**, which reported about USD 1.2 million in 1998, reported no exploration expenditures in 2000. **Ukraine** continued exploration within and on the slopes of the Ukrainian shield. Exploration expenditures in 2000 totalled about USD 2.1 million compared to about USD 1.9 million in 1998 and about USD 1.6 million in 1999.

Africa. **Niger** was the only African country to report exploration expenditures in 1999 and 2000. Expenditures totalled about USD 471 000 in 1999 and about USD 604 000 in 2000. **Egypt,** which reported almost USD 8 million in 1998 did not submit information for this edition.

Middle East, Central and South Asia. In **India** active programmes are being conducted in several provinces. Annual drilling was between 28 and 32 km in 1999 and 2000 compared to 30 km in 1998. Exploration expenditures were about USD 12.1 million and USD 14.4 million in 1999 and 2000, respectively. India’s exploration activities focused on Proterozoic basins, Cretaceous sandstones and several other geologic environments. Because of its large resource base, reconnaissance exploration has been suspended in **Kazakhstan.** In **Uzbekistan**, exploration was primarily focused on drilling in established ore fields and delineation of new resources. In 1999 and 2000, exploration expenditures totalled about USD 5.7 million and USD 4.1 million, respectively. In addition, development expenditures of USD 13.7 million and USD 10.1 million were reported in 1999 and 2000, respectively. A total of 2 964 exploration and development drills holes were completed in 1999 followed by 3153 drill holes in 2000.

South East Asia. Exploration activities in **Indonesia**, the **Philippines** and **Vietnam** were maintained at a low level. This work was done to evaluate previously discovered mineralisation.

Figure 5. **Trend in uranium exploration expenditures for selected countries (excluding China, Cuba, NIS and Eastern Europe)***



* Data for 2001 represents expected values.

Pacific. Exploration continued in several regions of **Australia** with annual expenditures of about USD 6.3 million in 1999 and about USD 4.4 million in 2000. These totals compare with exploration expenditures totalling about USD 12 million in 1998. Annual drilling programmes of 33 km and 19 km were reported for 1999 and 2000, respectively, compared to 78 km in 1998. The main focus of exploration continues to be on unconformity-related deposits in Arnhem Land (NT) and the Paterson Province (WA), as well as for sandstone and calcrete deposits in South and Western Australia.

East Asia. **China** continues exploration for sandstone-type deposits amenable to *in situ* leaching in the Xinjiang and Inner Mongolian Autonomous Regions and in Northern China. **Japan** has no domestic exploration programme. Mining interests previously held by the Japanese government outside of Japan are being transferred to the private sector. Exploration continues in **Mongolia**, although no details have been reported. The **Republic of Korea** has no domestic exploration and it has sold its interests in joint ventures in Canada and the USA.

C. URANIUM PRODUCTION

Worldwide uranium production decreased almost 8% from 34 886 tU in 1998 to 32 179 tU in 1999, and then increased by over 12% to 36 112 tU in 2000. In the OECD countries, production decreased from 19 017 tU in 1998 to 17 303 tU in 1999, but then increased to 20 894 tU in 2000. Production in selected countries and reasons for major changes between 1998 and 2000 are listed in Table 8. Historical uranium production on a country-by-country basis is given in Table 9 and shown in Figures 6 and 7.

Present status of uranium production

Uranium production in **North America** decreased by about 4% from 1998 to 2000, but the region still contributed about 34% of the world total in 2000. **Canada** remained the leading world producer. Since 1997, all production has come from mines in Saskatchewan, following closure of the Stanleigh mine in Ontario in 1996. In the **USA**, about 75% of the production came from four ISL operations, with the remainder from other sources including underground mining operations and mine water treatment.

Argentina was the only producing country in **South America** in 1999, but it reported no production in 2000, having placed the Sierra Pintada mill on standby status. **Brazil** resumed uranium production in 2000 with the opening of the Lagoa Real conventional mine/mill complex.

Production in **Western Europe** decreased from 771 tU in 1998 to 593 tU in 2000, representing about 1.6% of total world production. **France** produced 416 tU and 296 tU, respectively, in 1999 and 2000 with production ending in early 2001. **Spain**'s production remained stable at 255 tU in 2000 but essentially ceased in 2001. The remaining production in Western Europe was either from clean-up operations (**Germany**), or small open pit operations (**Portugal**).

Uranium production in **Central, Eastern and South East Europe** was virtually unchanged with production in 1998, 1999 and 2000 totalling 4 282, 4 321 and 4 363, respectively. This region contributed about 12% of world production in 2000. The **Czech Republic** reportedly produced 612 tU in 1999 and 507 tU in 2000. Annual production in **Hungary** was about 10 tU from reclamation of the Mecsek mine. In **Romania,** production was reported as 89 tU in 1999 and 86 tU in 2000. Production in the **Russian Federation** steadily increased from a reported 2 530 tU in 1998 to about 2 610 tU and 2 760 tU, in 1999 and 2000, respectively. Most of Russia's production came from the Krasnokamensk mine, though it also produced between 50 and 150 tU at the Dalmatovskoe ISL operation in the Transural district. **Ukraine** reported annual production of 1 000 tU in 1999 and 2000.

Three countries in **Africa**, Namibia, Niger and South Africa contributed about 18% of world production in 2000. Production in Africa declined steadily from 8 184 tU in 1998 to 6 524 tU and 6 464 tU in 1999 and 2000, respectively. **Niger's** output declined from 3 714 tU in 1998 to 2 911 tU in 2000. **South Africa** showed a similar decline from 965 tU in 1998 to 838 tU in 2000. **Namibia's** production held steady with about 2 780 tU and 2 715 tU in 1998 and 2000, respectively. The future of uranium production in South Africa depends on the price of gold. Namibia and Niger could either maintain production at current levels, or increase it, if market conditions improve. **Gabon**, a long-time producer ceased uranium production in 1999 and began mill decommissioning.

In the **Middle East, Central and South Asia** production increased steadily between 1998 and 2000. Production from this region totalled 4 128 tU in 2000, or about 11% of the world total, compared to 3 426 tU in 1998. The increase is largely due to higher output in **Kazakhstan** where production increased from 1 270 tU in 1998 to 1 870 tU in 2000. **Uzbekistan's** production also increased during the same time period from 1 926 tU in 1998 to 2 028 tU in 2000. **India** and **Pakistan** do not report production information. Their 2000 output is estimated to have remained constant at about 207 tU and 23 tU, respectively, the same as 1998 production.

Australia is the only producing country in the **Pacific** region. Its production increased steadily from 4 894 tU in 1998 to 5 984 tU in 1999 and 7 579 tU in 2000. Increased output at both the Ranger and Olympic Dam operations contributed to the overall increases in production.

In **East Asia, China,** the region's only producing country, does not report official production figures. Its production for both 1999 and 2000 is estimated at 700 tU.

Table 8. **Production in selected countries and reasons for major changes**

Country	Production (tU)		Reasons for changes in production since 1998
	1998	2000	
Argentina	7	0	The San Rafael/Sierra Pintata production centre was placed on standby status in 1998.
Australia	4 894	7 579	Ranger increased output by 329 tU in 2000 and Olympic Dam increased production by 2 366 tU, having completed expansion of capacity from 1 500 to 3 885 tU/year.
Belgium	15	0	The uranium recovery circuit at the Prayon-Rupel Technologies phosphate processing plant was closed in 1999.
Brazil	0	80	The Lagoa Real production centre began operations in 1999.
Canada	10 922	10 683	The McArthur River and McClean Lake mines began operation in 1999. Output from these operations failed to offset declining production from the Key Lake and Rabbit Lake mines.
Gabon	725	0	Uranium production came to an end in 1999. Decommissioning of the Mounana mill is nearly complete.
Kazakhstan	1 270	1 870	In response to improved sales opportunities.
United States	1 810	1 522	Reduced as the result of placing of two *in situ* leach operations on stand by status, and discontinuing operation of the uranium by-product circuits at two phosphate processing plants. Two conventional uranium mills that operated during1998-1999 were also place on standby status.
Niger	3 714	2 911	Reduced output at Arlit and Akouta.

Table 10 shows the ownership of world-wide uranium production in 2000, within the 21 countries with production. Domestic mining companies controlled about 62% of 2000 production compared to about 74% of 1998 output. Government-owned and privately owned domestic mining companies shared about equally in the portion of 2000 output that was domestically controlled. Of the remaining approximately 40% of 2000 production, 17% was controlled by government-owned companies and 21% by private companies.

Changes in employment levels at existing uranium production centres of reporting countries are shown in Table 11. Though the data are incomplete, they show a steady reduction in employment associated with uranium production, during a time when world-wide annual output held relatively steady. The over 26% decrease in employment between 1994 and 2000 reflects increasing efficiency within the industry in response to increased competition from within the industry and from secondary supply sources.

Production techniques

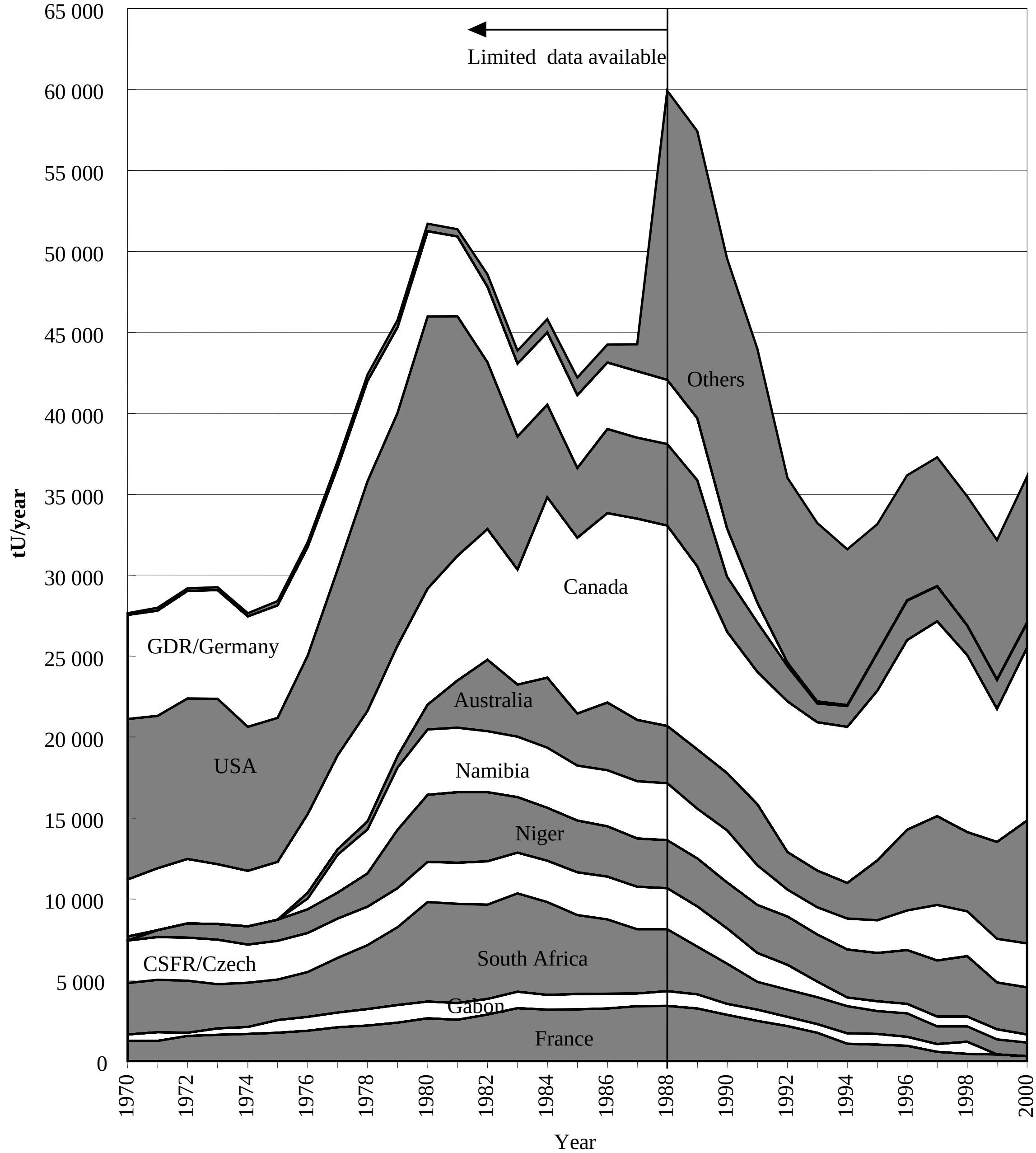
Uranium is produced by open pit and underground mining and ore processing (milling) and other techniques including *in situ* leaching (ISL), co-product or by-product recovery associated with copper, gold and phosphate operations, and heap/stope leaching.

Table 9. **Historical uranium production**
(tonnes U)

COUNTRY	Pre-1998	1998	1999	2000	Total to 2000	Expected 2001
Argentina	2 498	7	4	0	2 509	0
Australia	72 700	4 894	5 984	7 579	91 157	7 700
Belgium	671	15	0	0	686	0
Brazil	1 030	0	0	80	1 110	250
Bulgaria	16 720	0	0	0	16 720	0
Canada	310 704	10 922	8 214	10 683	340 523	11 250
China*	5 445 (a)	590	700	700	7 435 (a)	700
Congo, Democratic Republic of	25 600	0	0	0	25 600	0
Czech Republic	105 351	610	612	507	107 080	501
Finland	30	0	0	0	30	0
France	72 500	452	416	296	73 664	120
Gabon	27 147	725	0	0	27 872	0
Germany	5 375	30	29	28	5 462	20
GDR	213 380	xxxx	xxxx	xxxx	213 380	0
Hungary	21 000	10	10	10	21 030	10
India*	6 652	207	207	207	7 273	207
Japan	84	0	0	0	84	0
Kazakhstan	83 672	1 270	1 560	1 870	88 372	2 250
Mexico	49	0	0	0	49	0
Mongolia	535	0	0	0	535	0
Namibia	63 942	2 780	2 690	2 715	72 127	2 702
Niger	72 321	3 714	2 907	2 911	81 853	2 910
Pakistan*	768	23	23	23	837	23
Poland	660	0	0	0	660	0
Portugal	3 674	19	10	14	3 717	3
Romania	17 422 *	132	89	86	17 729 *	85
Russian Federation	106 123	2 530	2 610 *	2 760 *	114 023 *	2 910 *
Slovenia	382	0	0	0	382	0
South Africa	150 607	965	927	838	153 337	1 160
Spain	4 196	255	255	255	4 961	30
Sweden	200	0	0	0	200	0
Ukraine	7 000 (b)	1 000	1 000	1 000	10 000 (b)	1 000
United States	348 691	1 810	1 773	1 522 (c)	353 796	1077 c)
Uzbekistan	89 645	1 926	2 159	2 028	95 758	2 350
Yugoslavia	380	0	0	0	380	0
OECD	945 885	19 017	17 303	20 894	1 003 099	20 711
TOTAL	**1 834 656**	**34 886**	**32 179**	**36 112**	**1 937 822**	**37 258**

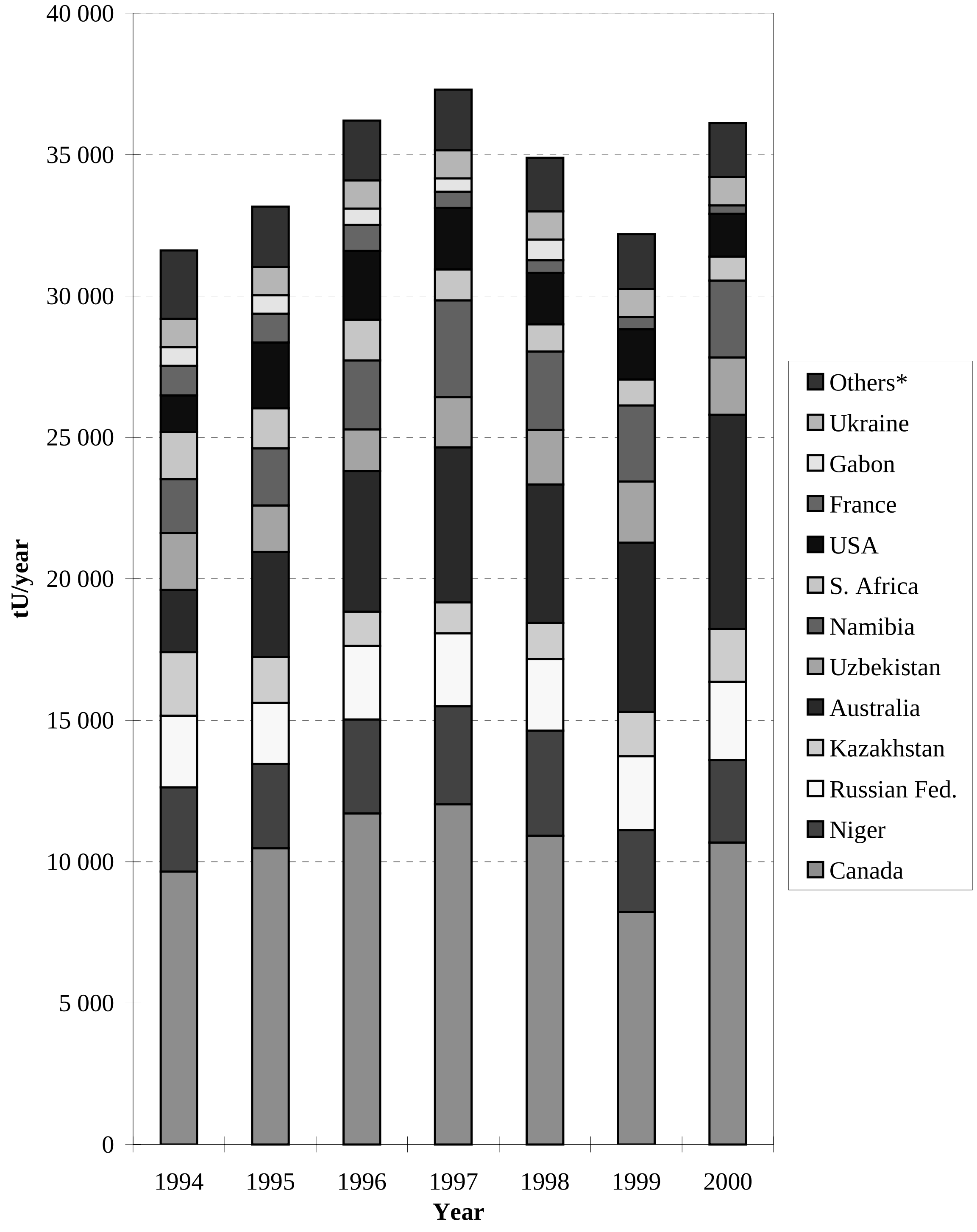
NA Not available.
* Secretariat estimate.
(a) Production in China since 1990.
(b) Production in Ukraine since 1992.
(c) Provisional data.
xxxx National entity not in existence or politically redefined.

Figure 6. **Historical uranium production**



Note: "Others" data correspond to other remaining producers. Only partial data are available on other producers before 1988. The peak in 1988 is thus a function of reporting of newly available data and not representative of a large increase in production.

Figure 7. **Recent world uranium production**



* "Others" includes the remaining producers.
Values for China, India and Pakistan in "Others" are estimated.

Historically, "conventional" production involved ore extraction by open pit and underground mining followed by processing of the ore in a conventional uranium mill. However, in the past two decades, ISL mining, which uses either acid or alkaline solutions to extract the uranium, has become increasingly important and is now considered a "conventional" mining method. The solutions are injected into, and recovered from, the ore-bearing zone through wells constructed from the surface. ISL technology is currently only being used to extract uranium from sandstone deposits. The distribution of production by type of mining or "material sources" for 1998 through 2000 is shown in Table 12. "Other" includes recovery of uranium as a by-product or co-product of gold, copper and phosphate operations, stope/block leaching, heap leaching and treatment of mine waters as part of reclamation and decommissioning. Stope/block leaching involves leaching of broken ore without removing it from an underground mine, while heap leaching is done once the ore is extracted using conventional mining, and moved to a surface leaching facility.

As shown in Table 12, open pit and underground mining and conventional milling remained the dominant technologies for producing uranium, accounting for between 70 and 80% of uranium production in 1998 through 2000. The relative contribution of open pit mining decreased largely as a result of depletion of reserves at Key Lake which was not entirely offset by increased output from Ranger in Australia and opening of the McClean Lake mine in Saskatchewan, both of which are open pit operations. Underground mining's contribution increased largely as a result of the start of production at McArthur River in Canada. The increased contribution of the "Other" category is attributable to increased production at Olympic Dam in Australia where uranium is recovered as a co-product of copper mining and processing. The increase in production at Olympic Dam more than offset the fact that recovery of uranium as a by-product of phosphate operations in Belgium and the USA was terminated in 1998-1999.

Open pit and underground mining and conventional milling are expected to continue to account for a majority of the world's uranium production. ISL technology could maintain its relative share if planned new projects in Australia (Honeymoon), Kazakhstan (Inkai and Moynkum), Russia (Dalmatovskoe and Khiagda) and Uzbekistan (Sugraly) are brought into production. Further increases in capacity at Olympic Dam, which will depend on copper prices and demand, would ensure a continued important role for the "Other" category.

The availability of secondary supply including HEU, inventory draw down, and re-enrichment of depleted tails from enrichment has limited demand for newly produced uranium thus keeping uranium market prices at historic lows in recent years. As a consequence development of new production centres has been limited to high-grade unconformity-related deposits and sandstone deposits amenable to ISL mining technology. Australia and Canada are the only countries with known unconformity-related resources. In Canada, the McArthur River and McClean Lake mines began operation in 1999. Development of the Cigar Lake deposit has been delayed until 2005 because of limited demand and low uranium prices.

In Australia, extensive development work was completed on the Jabiluka unconformity-related deposit. Following completion of this first stage of development, the Jabiluka project was placed on a stand-by and environmental maintenance basis in 2000 while the company planned the future development of the project together with the nearby Ranger mining operation. The Beverley project in South Australia began production in 2000 using ISL technology. Development of the Honeymoon ISL project in South Australia is underway with commercial-scale production expected to begin in 2002.

Table 10. **Ownership of uranium production based on 2000 output**

COUNTRY	Domestic Mining Companies				Foreign Mining Companies				TOTAL
	Government-owned		Private-owned		Government-owned		Private-owned		
	tU/year	%	tU/year	%	tU/year	%	tU/year	%	
Australia	0	0	4 061	54	196	3	3 321	44	7 578
Brazil	80	100	0	0	0	0	0	0	80
Canada	563	5	5 698	53	4 249	40	173	2	10 683
China*	700	100	0	0	0	0	0	0	700
Czech Republic	507	100	0	0	0	0	0	0	507
France	296	100	0	0	0	0	0	0	296
Germany	28	100	0	0	0	0	0	0	28
Hungary	10	100	0	0	0	0	0	0	10
India	207	100	0	0	0	0	0	0	207
Kazakhstan	1 770	100	0	0	0	0	100	100	1 870
Namibia	81	3	0	0	271	10	2 362	87	2 714
Niger*	966	33	0	0	1 030	35	916	32	2 912
Pakistan*	23	100	0	0	0	0	0	0	23
Portugal	0	0	14	100	0	0	0	0	14
Romania	86	100	0	0	0	0	0	0	86
Russian Federation	2 760	100	0	0	0	0	0	0	2 760
South Africa*	0	0	838	100	0	0	0	0	838
Spain	0	0	255	100	0	0	0	0	255
Ukraine	1 000	100	0	0	0	0	0	0	1 000
United States	0	0	325	21	421	28	776	51	1 522
Uzbekistan	2 028	100	0	0	0	0	0	0	2 028
TOTAL	**11 105**	**31**	**11 191**	**31**	**6 167**	**17**	**7 648**	**21**	**36 111**

* Secretariat estimate.

Table 11. **Employment in existing production centres of countries listed**
(in person-years)

COUNTRY	1994	1995	1996	1997	1998	1999	2000	2001 (expected)
Argentina	180	120	100	80	80	80	70	62
Australia (a)	412	413	464	468	501	565	526	596
Belgium	5	5	5	6	6	6	5	5
Brazil	408	390	305	280	180	110	110	110
Bulgaria	NA	NA	NA	NA	NA	NA	NA	NA
Canada (b)	1 370	1 350	1 155	1 105	1 134	1 076	1 026	1 000
China	9 100	8 000	8 500	8 500	8 500	8 500	8 500	8 000
Czech Republic	5 400	4 500	3 600	3 580	3 410	3 300	3 180	2 850
France	496	468	441	141	144	NA	NA	NA
Gabon	263	276	259	150	NA	NA	NA	NA
Germany (c)	4 613	4 400	4 200	3 980	3 615	3 149	3 115	3 100
Hungary	1 766	1 250	1 300	900	0	0	0 *	0 *
India	3 898	NA	NA	4 000	4 000	4 000	4 000	4 000 *
Kazakhstan	8 050	6 850	6 000	5 100	4 800	4 600	4 100	4 000
Namibia	1 246	1 246	1 189	1 254	1 104	1 009	902	900
Niger	2 104	2 109	2 070	2 033	2 012	1 830	1 732	1 691
Portugal	46	52	56	57	61	54	50	0
Romania	6 500	6 000	5 000	4 550	3 300	2 800	2 150	2 070
Russian Federation	14 400	14 000	13 000	12 900	12 800	12 700 *	12 500 *	12 300 *
Slovenia (c)	145	140	115	105	NA	NA	NA	NA
South Africa	NA	NA	NA	NA	160	160	160	160
Spain	185	183	178	172	148	135	106	64
United States	452	535 (d)	689 (d)	793 (d)	911 (d)	649 (d)	401 (d)	NA
Uzbekistan	6 688	7 378	8 201	8 230	8 165	7 734	7 331	7 300
TOTAL	**67 727**	**59 665**	**56 827**	**58 384**	**55 031**	**52 457**	**49 964**	**48 208**

NA Data not available.
* Secretariat estimate
(a) Olympic Dam does not differentiate between copper, uranium, silver and gold production. Employment has been estimated for uranium related activities.
(b) Data as of end of year, for mine site employment only.
(c) Employment related to decommissioning and rehabilitation.
(d) Does not include 528 persons-years in 1994, 573 in 1995, 429 in 1996, 303 in 1997, 209 in 1998, 199 in 1999 and 226 in 2000 for employment in reclamation work relating to exploration, mining, milling and processing.

Table 12. **Percentage distribution of world production by material source**

Material source	**1998** (%)	**1999** (%)	**2000** (%)
Open pit	39	35	28
Underground	40	36	43
ISL	13	17	15
Other*	8	12	14

* Co-product or by-product of copper, gold and phosphate mining, stope/block leaching, heap leaching and mine water recovery.

Projected production capabilities

To assist in developing projections of future uranium availability, member countries were asked to provide projections of their production capability through 2020. Table 13 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 80/kgU or less category through 2020 for all countries that either are currently producing uranium or have the potential to produce in the future.

A total of 8 countries, including the major producers (Australia, Canada, Kazakhstan, Niger, South Africa, USA and Uzbekistan) plus Brazil reported their production capability based on RAR and EAR-I in the USD 40/kgU or less cost category. This includes a first time report in this category for Australia. Therefore, a majority of the production capability through 2005 in Table 13 is based on resources recoverable at costs of USD 40/kgU or less. In the A-II category, these proportions are: 2001 (78%), 2002 (79%), 2005 (64%), 2010 (48%), 2015 (44%) and 2020 (45%); and in the B-II category they are: 2001 (77%), 2002 (80%), 2005 (61%), 2010 (44%), 2015 (41%) and 2020 (43%). The lower percentages beginning in 2010 reflect both depletion of low-cost resources and the fact that some of the countries do not report production capability after 2005.

Uranium producing countries not reporting projected production capabilities include China, India, Pakistan and Romania (after 2001). Projections of future production capability for India, Pakistan and Romania are made based on reports that these countries intend to meet their future domestic reactor requirements. China reports capability to meet only its short-term requirements unless new resources are discovered.

In 2001, reported production capability of existing and committed production centres, was about 45 310 tU. For comparison, 2000 uranium production was 36 112 tU, or about 80% of the 2001 production capability. In 2001, with projected plant capacity utilisation at about 84%, existing and committed capability was about 70% of 2001 world uranium requirements (see Table 15). Total production capability for 2001, including planned and prospective centres, is about 46 230 tU. This is greater than the capability level for 2001 (between 43 750 tU and 47 220 tU) projected in the 1999 Red Book.

In 2002, production from existing and committed centres is expected to increase by about 2 282 tU or about 5% compared to projected output in 2001. An increase of 1 990 tU in Canadian capacity accounts for about 87% of the projected capacity increase. Smaller capacity increases in Argentina, Russia, South Africa and Uzbekistan account for the remainder of the projected capacity increase in 2002.

The uranium production industry will continue to experience moderate change during the next 10 to 20 years. By 2005, existing and committed capability could increase to about 48 319 tU, or about 73% of projected requirements, depending on the development of nuclear power during the next 5 years. However, additions of planned and prospective centres would make available an additional 7 755 tU per year. The addition of planned and prospective production centres by 2005 would increase total capability to 56 074 tU, which would still fall short of the projected requirements by almost 10 000 tU.

The expected closure of existing mines due to resource depletion would cause existing and committed capability to slowly decrease to 46 119 tU by 2010, a decline of about 4.5% compared to projected output in 2005. Existing and committed capability would cover about 64% and 71% of projected requirements in 2010, for the high and low demand cases, respectively. Annual capability is expected to continue to decline to about 42 914 tU and 40 939 tU by 2015 and 2020, respectively. The projected continued reduction in existing and committed capability indicates that output in 2020 will be adequate to cover only 51% to 71% of world requirements in the high and low cases, respectively. Addition of planned and prospective production centres would increase coverage to about 94% of projected requirements in 2020 for the low case but only cover about 68% of projected requirements in the high case.

Two important conclusions are apparent in the preceding analysis. Current and planned capacity based on resources recoverable at a cost of less than USD 40/kgU (low-cost resources) are adequate to cover about 57% of 2001 uranium requirements. Between 2010 and 2020, low-cost total production capability (existing, committed, planned and prospective) will be adequate to cover between 33% and 43% of the high and low case requirements, respectively. However, even with the addition of resources recoverable at between USD 40 and USD 80/kgU, total production capability in 2020 will still only satisfy between 68% and 94% of the high and low case requirements, respectively. Resources recoverable at higher costs and/or additional non-primary supply would be necessary to fill the potential production shortfall indicated by these projections. Significant additional material would likely come from alternative supplies including fuel reprocessing, excess inventory draw down, re-enrichment of depleted tails from enrichment, and low enriched uranium (LEU) obtained from the blending of highly enriched uranium (HEU) from warheads and from government stockpiles. It is probable that LEU from HEU weapons material would be the second largest supply source after production.

Changes in production facilities

Existing and committed production capability has changed very little between 1999 (45 807 tU) and 2001 (45 310 tU). The addition of new production centres and expansion of existing capacity in 1999 and 2000, largely offset the closing of production centres. The character of the industry has changed somewhat by the replacement of smaller and higher cost facilities with larger and more cost effective facilities.

Some of the changes that occurred in uranium production facilities in the 1999-2000 period and changes that are expected in the next few years include:

Facility closures

- 1999: **Canada** (Eagle Point Mine placed on standby, 3 900 tU);
  Gabon (Mounana, 540 tU);
  United States (Kingsville Dome and Rosita placed on standby, 500 tU; Sunshine Bridge Phosphate, 160 tU).
- 2000: **United States** (Christensen Ranch, 250 tU).
- 2001: **Canada** (Rabbit Lake mill placed on standby, 3 900 tU);
  France (Jouac, 600 tU);
  Portugal (Urgeiriça, 170 tU);
  United States (Canon City mill placed on standby, 210 tU).
- 2002: **Canada (**Cluff Lake, 1 900 tU);
  South Africa (Palabora uranium circuit, 90 tU).

Table 13. **World uranium production capability to 2020**
(in tonnes U/year, from resources recoverable at costs up to USD 80/kgU, except as noted)

COUNTRY	2001		2002		2005		2010		2015		2020	
	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	0	0	40	40	120	120	120	500	120	500	NA	NA
Australia	9 400	9 400	9 400	10 300	9 400	10 300	8 200	11 600	8 200	11 600	8 200	11 600
Brazil	250	250	250	250	340	665	340	665	340	665	340	665
Canada	14 300	14 300	16 290	16 290	16 150	16 150	18 450	18 450	16 150	16 150	13 850	13 850
China (b) (e)	700	700	700	700	740	1 560	740	1 560	740	1 560	740	1 560
Czech Republic	660	660	550	550	110	110	84	84	87	87	80	80
France	0	120	0	0	0	0	0	0	0	0	0	0
India (a) (b) (d)	210	210	210	210	210	560	210	860	210	860	820	1 670
Kazakhstan	2 250	2 250	2 250	2 250	3 200	3 300	3 500 (b)	4 500 (b)	3 500 (b)	4 500 (b)	3 500 (b)	4 500 (b)
Mongolia (c)	0	0	0	0	150 (b)	1 100 (b)	150 (b)	1 100 (b)	150 (b)	1 100 (b)	150 (b)	1 100 (b)
Namibia (b)	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000
Niger	2 910	2 910	2 960	2 960	2 960	2 960	NA	NA	NA	NA	NA	NA
Pakistan (b) (d)	23	23	23	23	30	110	30	110	30	300	30	300
Portugal	NA	0	NA	0	170	NA	170	NA	150	NA	NA	NA
Romania	100	100	100	100	100	100	200	300	200	300	300	400
Russian Federation (b)	3 000	3 100	3 000	3 200	3 000	4 000	3 000	5 000	3 000	5 000	3 000	5 000
South Africa (c)	1 157	1 157	1 319	1 319	1 439	1 439	1 225	1 225	537	537	429	429
Ukraine	1 000	1 000	1 000	1 000	1 000	1 000	1 500	1 500	2 000	2 000	2 000	2 000
United States	3 000	3 700	3 000	3 700	2 700	6 100	1 700	6 900	1 000	5 000	1 000	5 000
Uzbekistan	2 350	2 350	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500
TOTAL	**45 310**	**46 230**	**47 592**	**49 392**	**48 319**	**56 074**	**46 119**	**60 854**	**42 914**	**56 659**	**40 939**	**54 654**

A-II Production capability of existing and committed centres supported by RAR and EAR-I recoverable resources.
B-II Production capability of existing, committed, planned and prospective centres supported by RAR and EAR-I recoverable resources.

NA Data not available.

(a) From resources recoverable at costs of USD 130/kgU or less.

(b) Secretariat estimate.

(c) From resources recoverable at costs of USD 40/kgU or less.

(d) Projections for India and Pakistan are based on the countries' stated plans to produce to meet domestic requirements.

(e) Projections are based on China's report of enough capability to meet its short- term requirements.

New mines opening

- 1999: **Canada** (McArthur River, 6 900 tU; McClean Lake, 2 300 tU);
- **Brazil** (Lagoa Real, 250 tU).
- 2000: **Australia** (Beverley, 850 tU).

Expansion of existing facilities

- 1999: **Australia** (Olympic Dam expansion from 2 290 tU to 3 900 tU and Ranger mill expansion from 3 000 tU to 4 240 tU);
  Canada (Key Lake mill from 4 615 tU to 6 923 tU).

New mines planned

- 2002: **Australia** (Honeymoon, 850 tU);
  Kazakhstan (Katco-Moynkum, 700 tU; Inkai, 700 tU);
  Russian Federation (Dalmatovskoe, 700 tU).
- 2005: **Canada** (Cigar Lake, 6 900 tU to be processed though McClean Lake and Rabbit Lake mills).

D. ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

This section presents an overview of radiation safety and environmental protection practised by the uranium mining industry (additional information can be found in the individual country reports). These practices are in general, directed toward four main areas of emphasis: (1) Rehabilitation of mine and mill sites no longer in operation, in many instances where project operators no longer exist and where legal provisions for proper decommissioning and rehabilitation were insufficient. (2) Environmental protection and environmental monitoring at ongoing and planned operations, as well as the decommissioning of recently closed sites. (3) Updating or establishing legislation and a regulatory framework that is consistent with recently introduced international standards. (4) Overlaid on the latter two activities is the increased use of environmental assessments as a planning tool for evaluating all phases of uranium operations prior to the approval, start-up or closure of an operation. A joint OECD/NEA-IAEA report on "Environmental Activities in Uranium Mining and Milling" containing more detailed information from participating countries was published by the OECD/NEA in 1999, and a new joint OECD/NEA-IAEA report *Environmental Remediation of World Uranium Production Facilities* has been published in February 2002.

North America. Environmental activities within **Canada's** uranium mining industry focused on environmental assessment, environmental management and decommissioning. Environmental assessments required by the *Canadian Environmental Assessment Act (CEAA)* are in various stages of preparation or review for five projects. The nature of the activities and the companies involved are as follows: (1) Licensing of historic mines in the Elliot Lake region by Rio Algom; (2) Suspension of operations at COGEMA Resources Inc.'s (CRI) Cluff Lake production centre; (3) Renewal of CRI's McClean Lake operating license which includes a request to increase annual production capacity from 2 308 tU to 3 077 tU; (4) CRI and Cigar Lake Mining Corporations request to dispose of potentially acid generating waste from the Cigar Lake mine at McClean Lake; (5) Cigar Lake Mining Corporation and Cameco Corporation's proposal to process approximately 57% of Cigar Lake ore at the Rabbit Lake mill. Environmental management in Canada centres around the mining companies' compliance with regulatory requirements. Canadian uranium producers have committed over USD 100 million to environmental management at existing mines. The McClean Lake mine received ISO 14001 certification in 2001, the first North American uranium mine to do so. Decommissioning efforts in Canada have been centred in the Elliot Lake area where Canadian mining companies have committed over USD 50 million toward decommissioning of the area's mines and mills. In addition, uranium producers have posted letters of credit totalling over USD 100 million for decommissioning and closure of operating uranium mines and mills.

In the **USA**, since no conventional mills were operating and half the other production facilities were on standby at the end of 2000, decommissioning was the main focus of environmental efforts. A 1995 US study found that, on average, reclamation of uranium mill tailings accounted for approximately 54% of overall decommissioning costs for conventional uranium mill sites. Total decommissioning costs averaged USD 14.1 million per site. This includes USD 7.7 million for tailings reclamation, USD 2.3 million for groundwater restoration, USD 0.9 million for mill dismantling, and USD 3.2 million for indirect costs. For *in situ* leach sites, the average decommissioning cost was USD 7.0 million including USD 2.8 million for groundwater restoration, USD 0.9 million for well field reclamation, USD 0.6 million for dismantling of buildings and plant structures, USD 1.2 million for reclaiming evaporation ponds, disposal wells, radiometric surveys, etc., and USD 1.4 million for indirect costs. Remediation of mill tailing sites resulting from the US Government's uranium procurement program during and following World War II is ongoing. Cleanup costs for 22 former uranium ore processing sites involved in this procurement programme are largely borne by the US Government. Surface cleanup at these sites is expected to cost approximately USD 1.476 billion; groundwater cleanup will cost an additional USD 147 million.

Central and South America. In **Argentina**, hydrogeochemical studies were performed to define baseline conditions at the Cerro Solo U-Mo deposit. In addition, as part of the Sierra Pintada feasibility study, studies are being implemented to improve surface and groundwater monitoring and waste and tailings management. In **Brazil**, site monitoring and development of a decommissioning plan for the Poços de Caldas mine and mill complex are ongoing. The environmental impact assessment of the Lagoa Real production centre, which began operating in 1999, was completed and has become part of the operating plan for the mine-mill complex.

Western Europe and Scandinavia. In **France**, efforts are focused on closed mining and milling sites. Total expenditures for decommissioning the Forez, Hérault, La Crouzille, Vendée and other sites amounted to almost FRF 675 million (USD 113 million) to the end of 1998, with an additional FRF 90 million (USD 14.4 million) budgeted in 1999. In **Germany,** uranium mining ended in 1990 and WISMUT GmbH has been actively carrying out major decommissioning and restoration activities since then. By the end of 1998, about 90% of underground rehabilitation work had been completed. Remediation of waste rock piles, stabilisation of mine spoil, chemical processing of uranium ores at the milling facilities, rehabilitation of tailings and disposal facilities, demolition of production plants and buildings, water treatment, and monitoring of air and water quality in the vicinity of these facilities are ongoing. By the end of 2000, approximately 6.7 billion DEM (USD 3.3 billion) of the estimated 13 billion DEM (USD 6.2 billion) required to complete all decommissioning and remediation needs had been spent. In **Spain**, restoration of twelve closed uranium mines in the Extremadura region was completed in 2000. Restoration of six additional uranium mines in the Andalucia region was also completed in 2000. The decommissioning plan for the Elefante heap leaching plant was approved by the Regulatory Authorities in 2001. In **Sweden,** decommissioning and rehabilitation of the Ranstad mine is now complete at an estimated cost of 150 million SEK (USD 15 million). Monitoring of the site is ongoing. In **Portugal**, decommissioning the Urgeiriça, Castelejo, Cunha Baixa, Sevilha and Quinta do Bispo mines continues. Studies are being carried out to characterise the local geochemical and hydrochemical setting and to establish mitigation measures for the waste piles of the Cunha Baixa mine and the Quinta do Bispo heap leaching operation. Production of uranium concentrates was scheduled to be suspended in early 2001 at Urgeiriçia. Therefore, environmental activities will now become the main emphasis within the uranium industry. The budget to provide for these activities is estimated at between USD 35 and 40 million.

Central, Eastern and South East Europe. Uranium mining and milling in the **Czech Republic** led to serious environmental impacts that will require significant resources over the next several years to mitigate. With reduced uranium production, this is now the central DIAMO activity. Remediation of the tailings impoundments at the Stráz pod Ralskem and Mydlovary processing plants is the top environmental priority. In addition, remediation of the Dolní Rozínka tailings impoundment, which is still in use, will present significant financial and technical challenges. Efforts are also being focused on decommissioning the Hamr, Olší, Jasenice-Pucov, Zadní Chodov, Okrouhlá Radoun and Licomerice-Brezinka mines, and remediation of the Stráz ISL operation. In **Hungary**, remediation of the tailings ponds and construction of waste water treatment facilities in the Mecsek region were the most important environmental activities. Demolition of the ore processing plant began in 1999, and the remediation programme will continue until the end of 2002. Uranium mining and processing activities in **Poland** ended more than 25 years ago. The companies responsible for the associated environmental problems no longer exist, so remediation activities are entirely government funded. Only a limited number of serious impacts have been identified in Poland, the most important of which is the tailings pond in Kowary. A remediation programme has been developed to construct drainage systems and cover the tailings pond. In addition, a remediation programme for uranium production activities in the Lower Silesia region is currently being prepared by local authorities. In **Romania**, environmental protection related to uranium production is currently focused on increasing water treatment capabilities in the Eastern Carpathians, Apuseni and Banat Mountains. These programmes also include increasing tailings impoundment capacities, processing and closure of ore storage areas at various mines, and the long-term stabilisation, reclamation and revegetation of waste dumps and surrounding environs. In **Ukraine**, although no mines are currently being decommissioned, a programme is being conducted by VostGOK to clean up and rehabilitate sites in Zheltiye Vody contaminated by uranium mill tailings. In addition, a State Programme for Improvement of Radiation Protection at Facilities of the Atomic Industry of Ukraine has been established.

Africa. In **Gabon,** following the March 1999 termination of all uranium mining, the Government initiated a programme to rehabilitate seven sites comprising the Mounana mining and milling operational area. Rehabilitation of the Mounana site involves dismantling the mill and related facilities (which has been completed), closure of tailings impoundments, site clean-up and revegetation. The programme objective is to assure a residual radiological impact that is as low as is reasonably achievable, while insuring the physical stability of the impoundments, and to the extent possible, provide for the future utilisation of the affected area. A long-term programme for monitoring and surveillance of the tailings impoundment will also be implemented. In **Namibia** environmental activities are currently governed by policy directives, but an Environmental Act and an Integrated Pollution Control and Waste Management Bill are in preparation. An associated Environmental Fund will be established to ensure that financial resources are available for mine rehabilitation. Cumulative environmental management costs in Namibia have totalled over 44 million ZAR (USD 8.5 million), including 1.8 million ZAR (USD 252 000) in 2000. **South Africa** has strict environmental legislation that ensures that areas contaminated by radioactivity are suitably rehabilitated, in particular where uranium plants are or were located. Environmental issues related to gold/uranium mining in the Witwatersrand district include dust pollution, surface and groundwater contamination and residual radioactivity. Closed gold-uranium plants are currently being decommissioned. Although the by-product status of all uranium production in South Africa makes it impossible to allocate environmental costs specifically to uranium mining activities, the mining industry in general expends considerable resources on environmental aspects in all stages of their activities.

Middle East, Central and South Asia. In **Kazakhstan**, environmental efforts are focused on wastes associated with closed uranium production facilities, as well as on the environmental impacts of ISL mining. All uranium mine and mill sites were inventoried in 1997 and 1998, and it was determined that out of 100 waste storage sites only 5 or 6 are of significant environmental concern, mainly related to the uncontrolled use of waste materials for construction by local inhabitants. A study of the long-term impact of ISL operations on aquifers is being conducted in conjunction with the International Atomic Energy Agency. In addition, an investigation of self-remediation of ISL aquifers is being conducted. In **Uzbekistan**, the focus is also on areas affected by past conventional mining and milling, as well as the environmental impacts associated with ISL operations. Navoi Mining and Metallurgical Complex has implemented a step-by-step programme for evaluating and, where necessary, reclaiming areas impacted by over thirty years of uranium production. For example, at Navoi's hydrometallurgical plant a system of wells has been installed to monitor and control potential groundwater contamination from the tailings impoundment. About 17% of the tailings impoundment surface had been covered by the end of 2000; the entire surface is expected to be covered by 2012. An investigation of self-remediation of ISL aquifers is also being conducted in Uzbekistan. In **India**, management of the environmental impact of uranium production is the responsibility of the Health Physics Group of the Bhabha Atomic Research Centre in Bombay. This Group monitors radiation, radon and dust contamination at uranium production facilities as well as operating an Environmental Survey Laboratory at Jaduguda.

Pacific Area. In **Australia**, mineral rights are vested with the Crown. In the Alligator Rivers region, the land is owned by the traditional Aboriginal owners. The Ranger Project Area and Jabiluka mineral lease are on Aboriginal lands. The Kakadu National Park, which surrounds the project area and mineral lease, is Aboriginal land leased back to the Commonwealth Government's Director of National Parks and Wildlife. The Commonwealth Government's Office of the Supervising Scientist (OSS) has the responsibility for supervising environmental management and research within the Alligator Rivers region, which includes the Ranger (operating), Jabiluka (under development) and Nabarlek (closed) mines. The OSS has consistently attested to the high level of environmental protection achieved within its jurisdictional area and noted that mining operations have had a negligible impact on the surrounding environment. Rehabilitation of the Nabarlek mine area is nearly complete. Perhaps the biggest environmental challenge facing Ranger is the ultimate transfer of approximately 18 million m^3 of tailings from the tailings dam to mined-out pits 1 and 2 in order to comply with below ground level disposal. Construction at the Jabiluka mine commenced in June 1998 following a comprehensive joint Commonwealth-Northern Territory environmental impact assessment process. The project has, however, been placed on care and maintenance status pending resolution of where the ore will be processed, either at Ranger or a stand alone mill at Jabiluka. The South Australia Government has responsibility for regulating the Olympic Dam and Beverley mines. Both projects are required to submit publicly available annual environmental reports. Southern Cross Resources Australia Pty Ltd's plan to develop an ISL uranium mine at Honeymoon was delayed by a request for additional detailed information on aquifer hydrogeology by the Commonwealth Environment Minister, however, development has been approved with production scheduled to begin in 2002.

East Asia. China, has used its many years of experience in uranium production to develop new regulations to control, monitor and reduce the environmental impacts of uranium production. These regulations have led to backfilling of waste rock and tailings into mined out areas, treatment of mine water and used process water, and covering waste and tailings piles to reduce radon release. Extra high voltage electrostatic filters have been installed at the Fuzhou and Hengyang ore processing plants to reduce the release of fly dust. In addition to the environmental measures introduced at operating production centres, five small uranium mines have been completely decommissioned; seven other mines or mine-mill complexes are in various stages of decommissioning.

II. 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. It should be noted that uranium demand is defined as acquisitions of natural uranium and thus the data provided are not necessarily consistent with actual consumption. Also the data for 2001 and beyond are estimates and the actual figures for acquisitions and/or consumptions will often differ.[3]

A. CURRENT NUCLEAR GENERATING CAPACITY PROGRAMMES AND COMMERCIAL REACTOR-RELATED URANIUM REQUIREMENTS

World (360.2 GWe net as of 1 January 2001). At the end of 2000, world-wide use of nuclear energy continued to grow at a rate equivalent to the average rate experienced over the past decade. In 1999, nuclear energy supplied about 6.8% [1] of the world's total primary energy and about 17% of the world's electricity. A total of 438 commercial nuclear reactors were operating with a net generating capacity of about 360 GWe. Distribution of nuclear generating capacity is shown in Figure 8 and Table 14.

In 1999, four new power plants were connected to the grid, one each in France, India, the Republic of Korea, and the Slovak Republic. Six new reactors were connected to their national grids during 2000: one each in Brazil, the Czech Republic, and Pakistan; and three in India. At the end of 2000, there were a total of 33 reactors reported under construction (about 29.5 GWe net): one each in Argentina, the Czech Republic, and Romania; two each in India, Iran and the Slovak Republic; three in Russia; four each in the Republic of Korea and Ukraine; five in Japan and eight in China. During 1999 and 2000 three reactors were shutdown, one each in Kazakhstan, Sweden, and Ukraine representing an installed capacity of about 1.6 GWe net.

World annual uranium requirements were estimated at about 64 014 tU in 2000 and about 64 329 tU in 2001 (see Figure 9 and Table 15).

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3. The Euratom Supply Agency publishes detailed reactor consumption information. For the period 1996 through 2000, these data show that average fuel loaded was 18 360 tU per year compared to an average projection of requirements of 20 360 tU per year over the same period. Similarly, deliveries to users averaged 15 640 tU per year for 1996 through 2000 while projected "net requirements" (reactor requirements reduced by stockpile usage and recycling) were 17 620 tU per year over the same period. These data suggest that uranium requirements estimates may be prone to overestimation.

Table 14. **Installed nuclear generating capacity* to 2020**
(MWe net)

COUNTRY	2000	2001	2005	2010		2015		2020	
				Low	High	Low	High	Low	High
Argentina	940	940	940	940	1 630	940	1 630	600	1 292
Armenia	408	408	408	0	408	0	600	600	1 200
Bangladesh	0	0	0	0	0	0	100 a)	0 a)	100 a)
Belarus	0	0	0	0	0	0 a)	0 a)	0 a)	1 000 a)
Belgium	5 713	5 713	5 713	5 713	5 713	5 713	5 713	3 966 a)	5 713 a)
Brazil	1 875	1 875	3 120	3 120	3 120	3 120	3 120	1 855 a)	8 000 a)
Bulgaria	3 538 a)	3 538 a)	3 538 a)	2 314 a)	3 538 a)	1 906 a)	2 722 a)	953 a)	2 314 a)
Canada	15 500	15 500	15 500	15 500	16 700 b)	15 500	24 000 b)	14 500	26 100 b)
China (c)	2 100	2 100	8 700	12 700	14 700	18 000	23 000	22 000	26 000
Cuba	0	0	0	0	0	0	600 a)	0	600 a)
Czech Rep.	1 632	2 544	3 456	3 456	3 472	3 456	3 472	3 456	3 472
Egypt	0	0	0	0	0	0	600 a)	0 a)	600 a)
Finland	2 600	2 600	2 600	2 600	2 600	2 600	2 600	2 600	2 600
France	63 200	63 200	63 200	63 200	63 200	63 200	63 200	63 200	63 200
Germany	21 300	21 300	21 300	NA	NA	NA	NA	NA	NA
Hungary	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800
India	2 503	2 503	2 503	7 209	7 209	12 011 a)	12 011 a)	4 726 a)	9 653 a)
Indonesia	0	0	0	0	0	0	900 a)	0 a)	900 a)
Iran	0	0	915	915 a)	915 a)	915 a)	2 111 a)	915 a)	2 111 a)
Italy	0	0	0	0	0	0	0	0 a)	3 000 a)
Japan	43 700 a)	43 700 a)	48 000 a)	59 900 a)	59 900 a)	59 900 a)	59 900 a)	59 900 a)	59 900 a)
Kazakhstan	0	0	0	0	0	0 a)	600 a)	0 a)	600 a)
Korea, DPR	0	0	0 a)	950 a)	1 900 a)	1 900 a)	1 900 a)	1 900 a)	1 900 a)
Korea, Rep.	13 716	13 716	17 716	22 529	22 529	26 050	26 050	26 050	26 050
Lithuania	2 760	2 760	1 380	1 380	1 380	0	1 380	0 a)	1 380 a)
Malaysia	0	0	0	0	0	0 a)	0 a)	0 a)	600 a)
Mexico	1 370	1 370	1 370	1 370	1 370	1 370	1 370	1 370	1 370
Morocco	0	0	0	0	0	0 a)	600 a)	0 a)	600 a)
Netherlands	449	449	0	0	0	0	0	0	0
Pakistan	425 a)	425 a)	425 a)	600 a)	725 a)	600 a)	600 a)	600 a)	2 000 a)
Philippines	0	0	0	0	0	0	0	0 a)	600 a)
Poland	0	0	0	0	0	0 a)	1 000 a)	0 a)	1 000 a)
Romania	650	650	650	1 300	1 950	1 300	1 950	1 950	2 600
Russian Federation	21 242 a)	21 242 a)	26 000 a)	21 242 a)	36 000 a)	17 500 a)	46 000 a)	17 500 a)	57 000 a)
Slovak Republic	2 430	2 430	2 430	1 620	3 240	1 620	2 430	810	1 620
Slovenia	672	672	672 a)	672 a)	672 a)	672 a)	672 a)	672 a)	672 a)
South Africa	1 842	1 842	1 842	1 800 a)	1 900 a)	1 800 a)	2 300 a)	1 800 a)	2 700 a)
Spain	7 500	7 500	7 500	7 500	7 730	7 500	7 730	7 500	7 730
Sweden	9 400	9 400	9 400	8 800	9 400	8 800	9 400	8 800	9 400
Switzerland	3 200	3 200	3 200	3 200	3 200	2 115	3 200	2 115	3 200
Thailand	0	0	0	0	0	0	0	0 a)	600 a)
Turkey	0	0	0	0	0	0 a)	2 000 a)	0 a)	2 000 a)
Ukraine	12 880	11 880	13 800	14 800	15 800	14 800	15 800	15 800	17 800
United Kingdom	12 490	12 490	12 000	10 000	10 000	7 000	7 000	4 000	4 000
United States	97 480	97 480	97 480	90 620	96 860	65 570	94 250	55 300	88 530
Viet Nam	0	0	0	0	0	0	700 a)	0	1 400 a)
OECD TOTAL	303 480	304 392	312 665	297 808	307 714	272 194	315 115	255 367	310 685
WORLD TOTAL	360 199	360 111	385 042	375 234	407 045	355 142	442 495	333 514	463 691

* Capacity installed at end of year.

(a) Secretariat estimate.

(b) Based on Natural Resources Canada analyses.

(c) The following data for Chinese Taiwan are included in the World total but not in the totals for China 4 884 MWe in 2000 and 2001, 7 484 MWe for 2005 and the low and high cases of 2010 and 2015, and 6 276 and 8 784 MWe for 2020 low and high cases, respectively.

Figure 8. **World installed nuclear capacity: 360.2 GWe net**
(as of 1 January 2001)

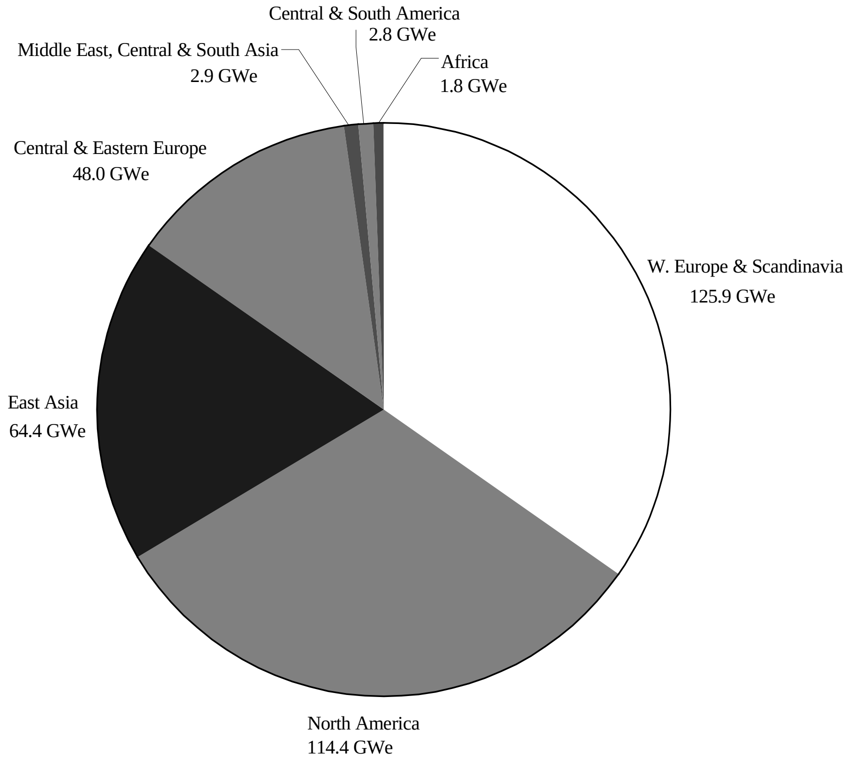


Figure 9. **World uranium requirements: 64 329 tU**
(as of 1 January 2001)

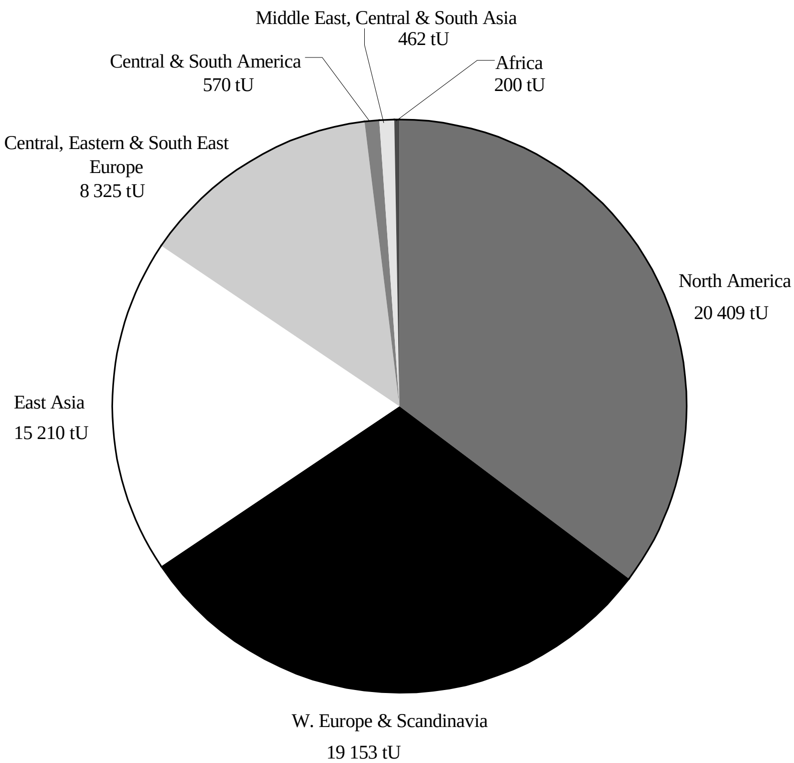


Table 15. **Annual reactor-related uranium requirements to 2020**
(tonnes U)

COUNTRY	2000	2001	2005	2010		2015		2020	
				Low	High	Low	High	Low	High
Argentina	120	120	120	95	250	95	205	60	205
Armenia	89	89	89	0	89	0	91	91	180
Bangladesh	0	0	0	0	0	0 a)	0 a)	0 a)	17 a)
Belarus	0	0	0	0	0	0	0	0 a)	170 a)
Belgium	1 050	1 050	1 050	1 050	1 050	1 050	1 050	730 a)	1 050 a)
Brazil	450	450	1 040	470	810	470	810	460 a)	1 980 a)
Bulgaria	840 a)	840 a)	840 a)	550 a)	840 a)	455 a)	650 a)	230 a)	550 a)
Canada	1 800	1 800	1 800	1 800	1 900 b)	1 800	2 800 b)	1 800	3 000 b)
China (c)	380	380	1 500	2 200	2 600	3 200	4 100	3 900	4 600
Cuba	0	0	0	0	0	0 a)	105 a)	0 a)	105 a)
Czech Rep.	722	512	605	680	690	680	690	680	690
Egypt	0	0	0	0	0	0 a)	105 a)	0 a)	105 a)
Finland	500	500	500	500	500	500	500	500	500
France	8 879	8 568	8 568	8 168	8 168	8 168	8 168	8 168	8 168
Germany	3 350	3 200	3 100	NA	NA	NA	NA	NA	NA
Hungary	368	311	370	370	370	370	370	370	370
India	397	397	397	1 000	1 000	1 327 a)	1 327 a)	820 a)	1 670 a)
Indonesia	0	0	0	0	0	0 a)	155 a)	0 a)	155 a)
Iran	0	0	155	155 a)	155 a)	155 a)	360 a)	155 a)	360 a)
Italy	0	0	0	0	0	0	0	0	510 a)
Japan	7 500	11 100	9 100	11 900	11 900	11 600	11 600	11 600 a)	11 600 a)
Kazakhstan	0	0	0	0	0	0 a)	102 a)	0 a)	102 a)
Korea, DPR	0	0	0	160 a)	325 a)	325 a)	325 a)	325 a)	325 a)
Korea, Rep.	3 400	2 900	3 000	4 200	4 200	4 300	4 300	4 300	4 300
Lithuania	240	240	240	240	240	0	240	0 a)	240 a)
Malaysia	0	0	0	0	0	0	0	0	100 a)
Mexico	187	189	346	173	173	170	170	170 a)	170 a)
Morocco	0	0	0	0	0	0 a)	100 a)	0 a)	100 a)
Netherlands	84 a)	10	0	0	0	0	0	0	0
Pakistan	65 a)	65 a)	65 a)	90 a)	110 a)	90 a)	90 a)	90 a)	305 a)
Philippines	0	0	0	0	0	0	0	0 a)	100 a)
Poland	0	0	0	0	0	0 a)	170 a)	0 a)	170 a)
Romania	100	100	100	200	300	200	300	300	400
Russian Federation	4 000 a)	4 000 a)	5 000 a)	4 000 a)	6 500 a)	3 000 a)	8 000 a)	3 000 a)	10 000 a)
Slovak Rep.	63	63	63	42	84	42	63	21	42
Slovenia	120	120	120 a)	120 a)	120 a)	120 a)	120 a)	120 a)	120 a)
South Africa	200	200	200	210 a)	220 a)	210 a)	270 a)	210 a)	315 a)
Spain	1 400	1 700	1 100	1 500	1 500	1 500	1 500	1 500	1 500
Sweden	1 500	1 500	1 500	1 400	1 600	1 400	1 600	1 400	1 600
Switzerland	360	375	265	585	585	390	585	390	585
Thailand	0	0	0	0	0	0	0	0	100 a)
Turkey	0	0	0	0	0	0	400 a)	0	400 a)
Ukraine	2 200	2 050	2 350	2 500	2 650	2 500	2 650	2 650	2 950
United Kingdom	2 250	2 250	2 400	1 850	1 850	1 139	1 139	750 a)	750 a)
United States	20 570	18 420	18 670	17 440	19 740	11 510	15 940	12 150	17 860
Viet Nam	0	0	0	0	0	0	120 a)	0	240 a)
OECD TOTAL	**53 983**	**54 448**	**52 437**	**51 658**	**54 310**	**44 619**	**51 045**	**44 529**	**53 265**
WORLD TOTAL	**64 014**	**64 329**	**65 923**	**64 918**	**71 789**	**58 036**	**72 540**	**58 010**	**80 249**

(a) Secretariat estimate.

(b) Based on Natural Resources Canada analyses.

(c) The following data for Chinese Taiwan are included in the World total but not in the totals for China: 830 tU/year in 2000 and 2001, 1270 tU/ year in 2005, 1 270 tU/year in the low and high cases in 2010 and 2015 and 1 070 tU/ year and 1 490 tU/ year in the low and high cases of 2020, respectively.

Figure 10. **Projected installed nuclear capacity to 2020 low and high projections**

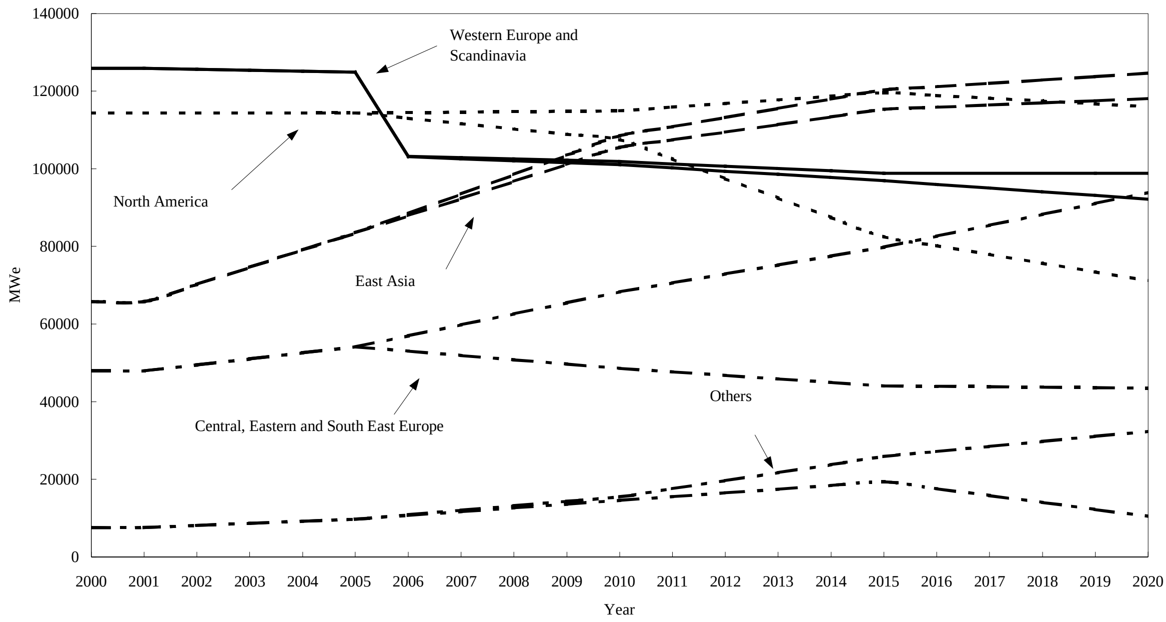
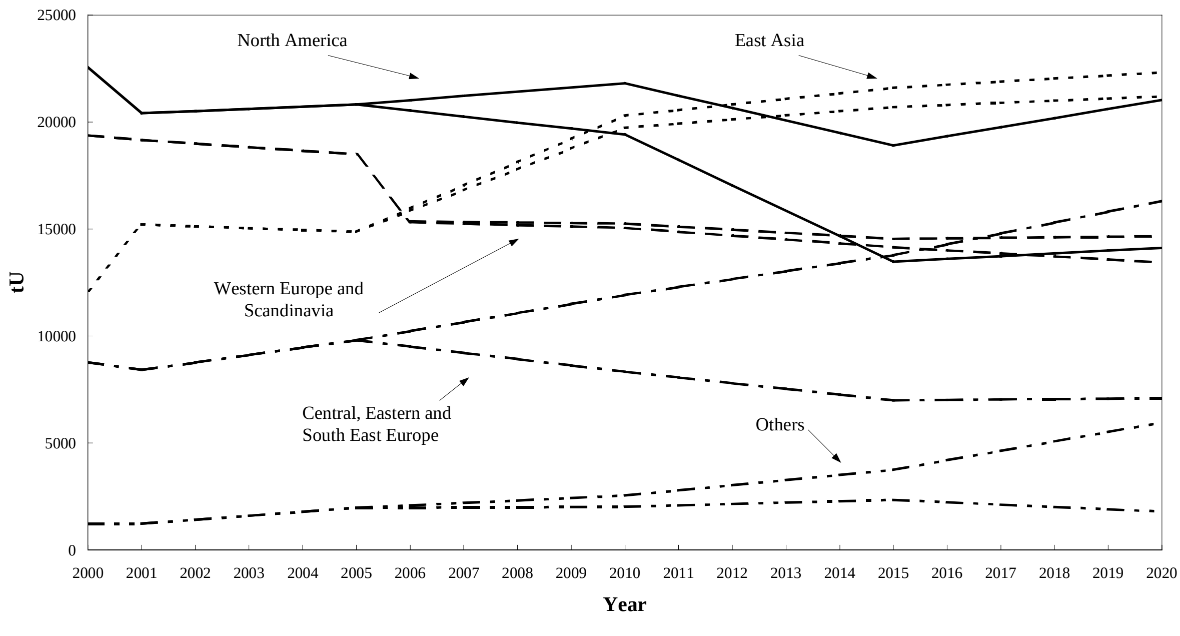


Figure 11. **Annual reactor uranium requirements to 2020 low and high projections**



OECD (303.5 GWe net as of 1 January 2001). The countries constituting the OECD contain about 84% of the world's nuclear electricity generating capacity. A total of 12 reactors are under construction in OECD countries, with a capacity of about 8.7 GWe. The period between 1999 and 2000 was marked by improved operating efficiency with several countries setting record generating rates (France, Republic of Korea, Spain, Switzerland, United States); increases in capacity through new construction (Czech Republic, Japan, Korea, Slovak Republic) and the granting of significant capacity upgrades to existing plants (Switzerland, United States); and the extensions of licensed operating periods (United States). The debate over the role of nuclear energy in meeting increased energy demands while meeting environmental commitments emerged as a factor that may have significant impact on the future of nuclear energy, particularly in Europe.[4]

The OECD reactor-related uranium requirements were 53 983 tU for 2000 and were expected to be about 54 448 tU in 2001.

North America (114.4 GWe net as of 1 January 2001). In the **United States**, record levels of power generation were achieved in the last two years with 753.9 billion kWh being produced in 2000 following the previous record of 728.1 billion kWh set in 1999. The annual net capacity factor for 2000 was 89.1%. Two trends have emerged that will have impacts on short and long-term uranium requirements: license renewals and capacity upgrades. In 2000, license renewal applications were granted for five power plants that extended their operation for 20 years beyond the original shutdown dates at each plant and five additional applications were received. In addition, 28 more applications are expected to be submitted by 2004. Plant capacity upgrades emerged as a trend with regulatory authorities expecting to process 46 applications totalling 1.6 GWe through 2005. Additionally, significant interest is reported to be emerging both in government and industry to commence construction of a new power plant or re-start construction of a suspended plant. In **Canada,** following an independent performance assessment in 1997, seven nuclear reactors were shutdown for refurbishment (four at Pickering-A site and three at Bruce-A site). Plans are to return six of the seven reactors to service by 2003 (all but 1 reactor at Bruce-A).

Annual requirements for North America were about 22 557 tU in 2000 and were expected to decrease to 20 409 tU in 2001.

Central and South America (2.8 GWe net as of 1 January 2001). At the beginning of 2001, there were four nuclear units operating in two countries of the region – two each in Argentina and Brazil. **Brazil** saw the completion and connection to the grid of its second power plant, the 1.2 GWe Angra-2 plant in 2000. Increased demand for power in Brazil is resulting in consideration of construction of a third nuclear power plant, though a decision is not expected before 2003. The uranium requirements for Central and South America were about 570 tU in 2000 and were expected to remain the same in 2001.

Western Europe and Scandinavia (125.9 GWe net as of 1 January 2001). **France** and **Belgium** continue to produce more than 50% of their electricity from nuclear reactors with nuclear's share of total electrical generation over 76% and over 56%, respectively, in 2000. In 1999, **France** connected the Civaux-2 reactor (1 450 MWe) to the grid. **France**, **Spain**, and **Switzerland** achieved record generation of electricity in 2000 with several other countries at or near previous highs. Any significant change in the position of nuclear energy in the generation mix in this region is unlikely over the near-term but remains uncertain over the longer-term. Reviews and evaluations of the role of nuclear power in meeting growing demands for energy while meeting environmental commitments were conducted or initiated by the **European Commission** [2], **Belgium** [3], **Finland, France**[4]**,** and the **United Kingdom** [5]. **Sweden** remains committed to its phase out of nuclear energy, though in 2000 it delayed the planned closure of the Barseback-2 reactor until suitable replacement sources of power can be obtained. Conversely, progress toward the phase out of nuclear energy usage in **Germany** continues to be made with maximum duration of plant life and maximum generation limits being agreed upon by the government and industry. Overall, the trend for the long-term will be downward as Germany’s plans are fully implemented.

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4. See, for example, the European Commission *Green Paper: Towards an European strategy for the security of energy supply* (2000), Com(2000)769, 29 November 2000.

The reactor-related uranium requirements for Western Europe and Scandinavia in 2000 were about 19 373 tU and are expected to decrease slightly to 19 153 tU in 2001.

Central, Eastern and South East Europe (48.0 GWe net as of 1 January 2001). The past two years in this region were marked by a strong interest in the growth of nuclear energy. **Russia** connected the Rostov-1 plant (950 MWe net) to the grid in 2001, its first since 1993. Russia looks to expand the use of nuclear energy having announced plans for construction of several new reactors plus plans to extend the life of its older VVER-440 plants. Significant growth continues in **Ukraine** with four plants under construction. In 2000, the Chernobyl-3 plant was permanently shutdown. The **Czech Republic** connected the Temelin-1 (912 MWe net) plant to the grid in 2000, continued construction of the Temelin-2 plant (912 MWe net) and announced a life extension for its Dukovany plants. **Romania** has made completion of the Cernavoda-2 plant (650 MWe net) a national priority and is considering the potential for new construction. **Turkey** decided to delay any plans to construct a nuclear plant for at least a decade due to financial conditions.

Overall, there are eleven reactors under construction in the region (one in the Czech Republic, one in Romania, three in the Russian Federation, two in the Slovak Republic and four in Ukraine) representing a total capacity of 9.0 GWe net. Reactor-related uranium requirements in 2000 for this region were about 8 742 tU and were expected to decrease to 8 325 tU in 2001.

Africa (1.8 GWe net as of 1 January 2001). Nuclear capacity remains constant in Africa. The region's only two reactors are located in **South Africa**. However, South Africa is actively developing the Pebble Bed Modular Reactor, a high-temperature, helium-cooled reactor. Annual reactor-related uranium requirements were about 200 tU/year in 2000 and were expected to remain the same in 2001.

Middle East, Central and South Asia (2.9 GWe net as of 1 January 2001). This region continued to exhibit strong growth in nuclear energy during the past several years. In 2000, the region saw four reactors connected to national grids and construction was initiated on two more. In **India**, fourteen commercial reactors are presently operating with a total capacity of 2.5 GWe. Two PHWR units, with a total capacity of 900 MWe, are under construction in India. Additionally, Indian reactors achieved record levels of generation in 1999. **Pakistan** connected the Chasnupp-1, a 300 MWe PWR, to the grid in 2000. Plans to construct a second reactor at the Chasnupp site, were also reported. Two reactors are under construction in **Iran** with start up of the first expected in 2002. Initial planning to develop nuclear power was begun in **Bangladesh** with announced plans to construct a new plant. Additionally, the **Arab League** and **Egypt** have expressed interest in developing nuclear energy programmes. Reactor-related uranium requirements for the Middle East, Central and South Asia region were about 462 tU in 2000 and were expected to remain the same in 2001.

East Asia (64.4 Gwe net as of 1 January 2001). East Asia remains the strongest nuclear growth region in the world with 17 reactors under construction. In **Japan,** there are 52 operating reactors (about 43.7 Gwe net) and five nuclear units under construction (4.9 Gwe net). Plans are to have 66 reactors operational by 2010. The government and industry are maintaining a strong focus on the development of an indigenous closed fuel cycle industry and plan to initiate the use of MOX fuel in 16-18 reactors by 2010. The **Republic of Korea** has 16 operating reactors (about 13.7 Gwe net) and 4 units (3.8 Gwe net) under construction. Announced plans in Korea call for 26 plants by 2011. In 2000, Korea's nuclear plants generated a record level of electricity. **China** has three operating reactors (about 2.1 Gwe net) and eight units under construction (about 6.6 Gwe net) with several additional plants in the early planning stages. In the **Democratic People's Republic of Korea**, two nuclear reactors are planned for construction using Western technology. The 2000 reactor-related uranium requirements for the East Asia region were 12 110 tU, and for 2001 they were expected to increase to about 15 210 tU.

South East Asia (0 GWe net). This region has no current commercial nuclear capacity. However, **Indonesia, Thailand, and Vietnam** are considering the construction of nuclear reactors to satisfy their expected increasing electricity demand.

Pacific (0 GWe net). This region has no commercial nuclear capacity. **Australia** has one small research reactor. Australian Government policy prohibits development of nuclear power, thus no domestic demand for uranium is anticipated. The Government of **New Zealand** also has a policy prohibiting the development of nuclear power.

B. PROJECTED NUCLEAR POWER GROWTH AND RELATED URANIUM REQUIREMENTS

Projections of nuclear capacity and reactor-related uranium requirements are based on official responses from Member countries and States to questionnaires circulated by the Secretariat. However, for countries that did not provide this information, projections from the IAEA Secretariat are used. Because of the uncertainty in nuclear programmes in the years 2010, 2015 and 2020, high and low values are given, unless a single projection was provided in the official response.

World-wide

Installed nuclear capacity is projected to grow from about 360 GWe net at the beginning of 2001 to about 464 GWe net in the high case or to slightly decline in the low case to about 334 GWe net by the year 2020. The different trends depicted in these two cases reflect the uncertainties that exist in relation to the life expectancy of operating nuclear units and potential nuclear capacity additions. In the high case, the increase represents about 29% growth from current capacity or an annual growth rate of about 1.4% for the forecasting period. The low projection shows a net decrease of about 26 GWe by 2020 representing about a 7% decline for the forecasting period. Several factors, including a potential increased emphasis on plant security, security of supply and importance given in the future to the role of nuclear energy in the debate on global warming, may likely have an impact on these projections.

Nuclear capacity projections vary considerably from region to region (see Figure 10). Table 14 summarises projected nuclear electricity generating capacity on a country by country basis. The **East Asia** region is projected to experience the largest increase in nuclear capacity. By the year 2020, this region is projected to have incorporated between about 52 GWe and 58 GWe of new capacity (79-89% increases). **Central and Eastern Europe** will follow, with a high case forecast of up to 45.8 GWe of new capacity by 2020 (an over 95% increase). Other regions potentially experiencing growth include the **Middle East and South Asia**, **Central and South America**, **South East Asia** and **Africa**. The capacity in **North America** would experience a reduction in the low case of about 43 GWe, and in the high case a slight increase of about 1.6 GWe by 2020. In **Western Europe,** nuclear capacity is expected to decline as plans to phase out nuclear energy in Germany are implemented. However, specific schedules for that phase out have not yet been finalised so specific forecasts are impractical.

World reactor-related uranium requirements are expected to rise in the high case to about 80 249 tU or to decrease in the low case to 58 010 tU by the year 2020 (see Table 15 and Figure 11) from the 2000 value of 64 014 tU.

As in the case of world nuclear capacity, uranium requirements will vary considerably from region to region (see Figure 11). In contrast to the rest of the world, **North America** and the **Western Europe and Scandinavia** region will either remain fairly constant or experience declines in uranium requirements through the year 2020. The increase in uranium requirements will be largest in the **East Asia** region, where expected nuclear capacity expansion will almost double the 2000 uranium needs by the year 2020.

Reactor-related requirements over the short-term are fundamentally determined by installed nuclear capacity, or more specifically kilowatt-hours of operation. As noted, the majority of the anticipated near-term capacity is already operating, thus short-term requirements may be predicted with greater certainty. Other factors that affect near-term uranium requirements include: plant life extensions and retirements; plant efficiency; fuel-cycle length; discharge burnup; the ratio between natural uranium and enrichment prices;[5] plant power upgrades; and the extent of reprocessing and the use of mixed-oxide fuels.

A number of countries are considering new construction, which would lead to an increase in their uranium requirements. However, several factors are influencing the decisions on the installation of new nuclear generating capacity, particularly in Europe and North America, that must be resolved before there are likely to be any new significant building programmes. These factors include:

- Projected steady or low-growth of base load electricity demand.
- The high initial capital requirements.
- The lack of sufficient financial resources in developing countries.
- Problems with public acceptance.
- Uncertainties over final waste disposal.
- Recognition of the role that nuclear power plays in meeting international environmental commitments.
- Economically competitive alternative technologies for electricity generation in increasingly competitive energy markets.

While these factors tend to retard new construction, the strong performance and economic competitiveness of existing plants, chiefly because of low operating, maintenance, and fuel costs, makes retention of these plants desirable.

As discussed earlier, there is a trend especially in the United States, to extend the lives of existing power plants. As the number of plants granted extensions increases, the projections of uranium demand in the future will also increase. In 2000, for example the United States Nuclear Regulatory Commission granted license renewal applications for five power plants extending power plant operations for 20 years beyond the original shutdown dates at each plant and five additional applications were received. Up to 28 additional applications may be submitted by 2004 in the United States and it is generally expected that most plants in the United States will ultimately seek license renewal. Additionally, Russia has plans to extend the service lives of its 12 older VVER-440 plants.

Uranium demand is also directly influenced by changes in the performance of installed nuclear power plants and fuel cycle facilities, even if the installed base capacity remains the same. Over the past decade there has been a trend toward higher nuclear plant energy availability factors and capacity

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5. 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 enricher is dependent on many factors including the ratio between natural uranium and enrichment prices.

factors worldwide. In 2000, the world average nuclear energy availability factor was at a record high level of 82.1% up from the 79.2% of 1998. This continues a steady upward trend since 1990 when the factor was 72.9% [6]. This trend has been largely influenced by the increasing use of higher burn-up fuel that has allowed the periodicity of refueling outages to be increased. Additionally, the efficiency of the outages has improved as shown by the decrease in outage lengths reported by a number of utilities. For example, in the United States the median duration of refueling outages has steadily decreased from 76 days in 1990 to only 35 days in 2000, more than a 50% reduction [7].

C. URANIUM SUPPLY AND DEMAND RELATIONSHIPS

Uranium supply and demand are in balance and there have been no supply shortages. There are several different sources of supply of which the largest is the primary production of uranium that, over the last several years, satisfied some 50% to 60% of world requirements. The remainder has been provided from secondary sources such as, uranium derived from military HEU, re-enrichment of tails, reprocessing of spent fuel or stockpiles (including utilities excess inventory drawdown).

Primary production has been less than requirements since 1990. There are a number of significant factors at play here. These include the relatively rapid introduction into the market of new supplies from secondary, or non-production sources, as well as major changes within the uranium production industry. The availability of information regarding the amount of uranium held in inventory by utilities, producers and governments has increased, with a proportionate decrease in the uncertainty regarding these inventories. However, uncertainty still exists regarding the magnitude of these inventories, especially in the Russian Federation and the availability of secondary supplies from other sources.

From the beginning of commercial exploitation of nuclear power in the early-1960s through the mid-1980s, the portion of the world uranium market for which accurate information was available was characterised by uranium production consistently exceeding commercial requirements (see Figure 12). This was mainly the consequence of a lower than expected nuclear electricity generation growth rate and high levels of production for military purposes. Although limited information is available it also appears that production substantially exceeded reactor requirements in Eastern Europe and the former Soviet Union extending to 1994. The political and economic reorganisation of this region in the early-1990s resulted in major steps toward development of an integrated commercial world uranium market. As a consequence there has been greater availability of uranium supplies from the former Soviet Union including the successor republics of Kazakhstan, the Russian Federation, Ukraine and Uzbekistan.

This over-production situation, that lasted through 1990 (see Figure 12), along with the availability of secondary sources resulted in uranium spot prices trending downward until 1994 when they reached their lowest level in 20 years. Between 1990 and 1994 there were significant reductions in many sectors of the world uranium industry including exploration, production and production capability. This decreasing supply situation combined with growing demand for uranium and the bankruptcy of an important uranium trading company resulted in a modest recovery in uranium prices from October 1994 through mid-1996. This trend, however, has since reversed and uranium prices have continued the downward trend through mid-2000. Overall, the increasingly, and better, informed perception of plentiful inventories and supplies has maintained a downward pressure on uranium prices.

In 2000, 21 nations produced uranium of which the 10 leading producers (Australia, Canada, Kazakhstan, Namibia, Niger, the Russian Federation, South Africa, Ukraine, USA and Uzbekistan) provided over 90% of the world's uranium mine output. In comparison, 32 nations currently consume uranium in commercial reactors. Figure 13 shows the uneven distribution between countries producing uranium and those consuming uranium. In 2000, world uranium production (36 112 tU) provided about 56% of the world reactor requirements (64 014 tU). In OECD countries, the 2000 production of 20 894 tU provided about 39% of the demand of 53 983 tU. The rest of the requirements were provided by secondary sources including civilian and military stockpiles, uranium reprocessing and re-enrichment of depleted uranium.

Secondary sources of supply

The uranium market at the end of 2000 was characterised by the availability of sources of supply beyond primary production, i.e., secondary sources, including:

- Natural and enriched uranium stocks and inventories, both civilian and military in origin.
- Uranium produced by recycling and reprocessing of spent reactor fuels.
- Uranium produced by re-enrichment of depleted uranium tails.

Given their importance to the current market in the near-term, a more detailed discussion of these sources is provided.

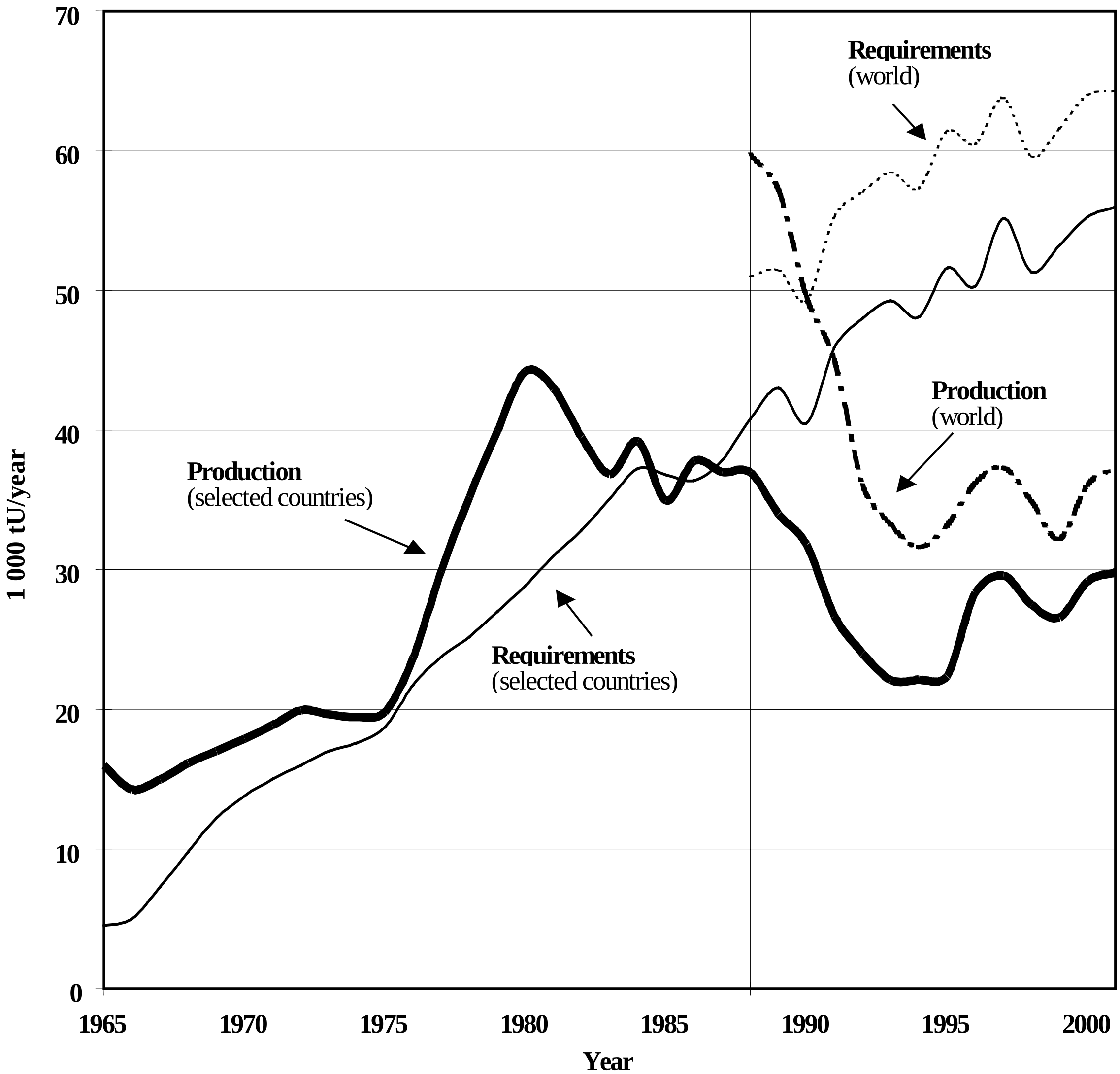
1. Natural and enriched uranium stocks and inventories

A major source of supply comes from the drawdown of accumulated stockpiles. The civilian inventories include strategic stocks, pipeline inventory and excess stocks available to the market. Few countries have provided detailed information on the size of the uranium stockpiles that are held by producers, consumers or governments. Utilities are believed to hold the majority of commercial stocks. Many utilities either hold or have policies that require carrying the equivalent of one to two years of natural uranium requirements.

It appears, from available information, that uranium stocks are significant but declining. In its report *The Global Nuclear Fuel Market 2001* the World Nuclear Association reported the year-end 2000 commercial inventory of uranium at 140 000 tU down from its estimate of 168 500 tU in their 1998 report [8].

The Euratom Supply Agency reports that from 1992-2000, over 105 400 tonnes of natural uranium or feed contained in enriched uranium products (in tU) were imported by European Union operators from the NIS. Of this, 43 100 tU were delivered to EU utilities leaving a balance of 62 300 tU. Yet, since 1996 imports have declined trending more in line with deliveries to utilities. It was concluded the "the total inventories of natural uranium in the EU have increased significantly during the period 1992-97 but started decreasing slightly in 1998-1999; this trend continued in 2000" [9]. Judging by the level of production in Kazakhstan, Uzbekistan and the other NIS during the period in question, a large portion of the imports to the European Union is likely to have originated in the Russian Federation.

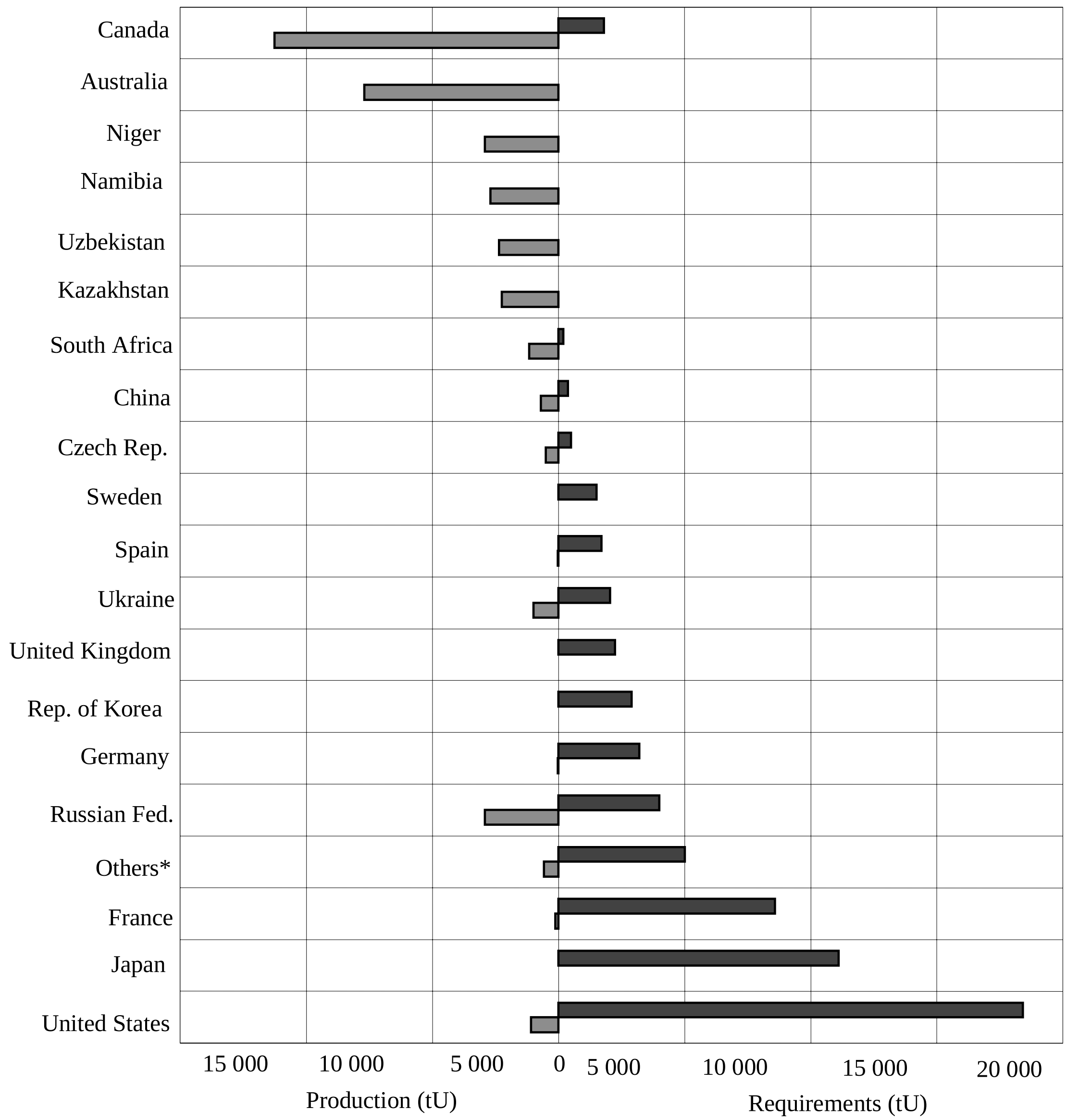
Figure 12. **Historical uranium production and reactor requirements in selected countries* (1965-2001) and world (1988-2001)**



* Selected countries excludes the following: Bulgaria, China, Cuba, the Czech Republic (and preceding states), Former GDR, Hungary, Kazakhstan, Mongolia, Romania, Russian Federation, Slovenia, Ukraine, Former USSR, Uzbekistan, and Yugoslavia.

Note: Prior to the late-1980s uranium production and requirements for a number of countries including the Former Soviet Union, Eastern Europe, and the People's Republic of China were not officially reported to nor estimated by the Secretariat. Beginning in 1988 sufficient information was officially submitted or available from other sources to permit a global estimation of production and requirements.

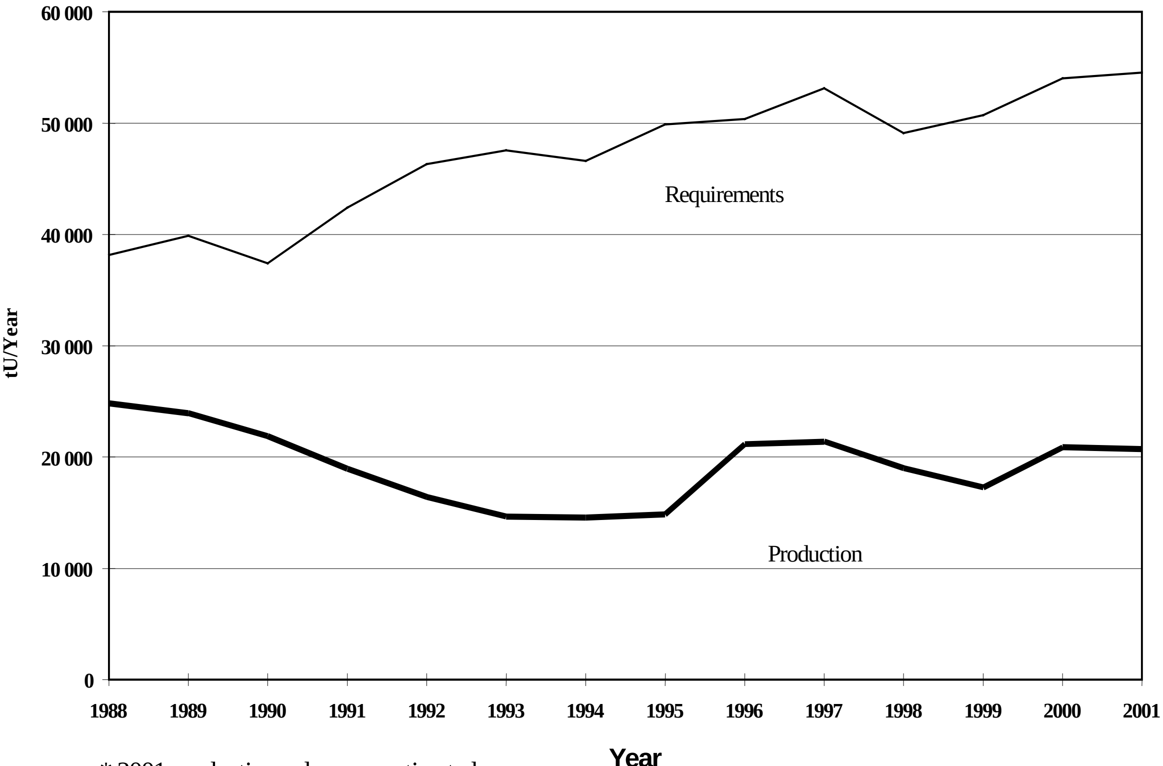
Figure 13. **Estimated 2001 uranium production and reactor-related requirements**



"Others" producers include: Brazil, Hungary, India, Pakistan, Portugal, Romania.

"Others" consumers include: Argentina, Armenia, Belgium, Brazil, Bulgaria, Finland, Hungary, India, Lithuania, Mexico, the Netherlands, Pakistan, Romania, the Slovak Republic, Slovenia, Switzerland.

Figure 14. **OECD uranium production and requirements***



* 2001 production values are estimated.

In the USA, the year-end commercial uranium inventory of all types decreased from about 52 500 tU in 1998, to about 48 890 tU in 1999, and further to about 43 210 tU in 2000 [10]. United States government inventories of natural uranium increased from about 9 410 tU in 1998 to about 20 410 tU in 1999 and remained constant at that level through 2000. The US government maintains no inventory of enriched uranium having transferred its inventory to USEC, Inc. in 1997 as part of the privatisation process.

Reports of comparable inventory levels are not available for the rest of the world. However, available information suggests that no significant excess inventories are held in Eastern Europe and Central Asia, outside of the Russian Federation. The inventory of enriched uranium product and natural uranium held by the Russian Federation has not yet been officially reported.

In addition to civilian inventories, large amounts of uranium derived from military applications in both the USA and the Russian Federation are becoming available for commercial applications, resulting in a significant impact on the market. Highly Enriched Uranium (HEU) and natural uranium held in various forms by the military sector could total a few years supply of natural uranium equivalent for commercial applications. While the rate at which this material may enter the civilian market is still uncertain, recent developments serve to reduce this uncertainty. Significant amounts of uranium from the conversion of nuclear weapons material are expected to enter the civilian market at least through 2013 as the result of purchase agreements between three western corporations and the governments of the USA and the Russian Federation.

Highly Enriched Uranium from the Russian Federation

In February 1993, the United States and Russia signed *The Agreement between the Government of the United States and the Government of the Russian Federation Concerning the Disposition of Highly Enriched Uranium from Nuclear Weapons*, which subsequently became known as the "Russian HEU Agreement". Under the agreement, the United States was to purchase 500 tU of Russian HEU over a 20-year period at annually negotiated prices. Blending down the HEU into LEU is being done in Russia. The US Executive Agent is the United States Enrichment Corp (USEC). The delivery schedule was revised to specify 6 tU in 1995, 12 tU in 1996, 18 tU in 1997, 24 tU in 1998, and 30 tU per year in 1999 and the following years. In 1999, USEC ordered 898 tU (derived from about 31 t HEU). This included 9.5 t of HEU that was ordered but delayed in 1998, when deliveries were suspended by Russia and not resumed until March 1999. The delayed 1998 deliveries were filled by June 1999, and 1999 deliveries then began in July of that year.

In 1999, given the decline in the market for uranium, deliveries ordered by USEC at the agreement-specified fixed-price, applicable since November 1996, were above the then-current market price. As a result, discussions were begun at that time with Russia to adopt a market-based-price structure, and MINATOM and TENEX committed to pursuing a mutually acceptable pricing arrangement.

Combined deliveries of natural uranium to USEC under the Russian agreement through 1999 totaled 24 484 tU. Of this amount, 16 520 tU were transferred to the US Department of Energy (DOE) and 7 964 tU natural uranium were available for purchase by Cameco-Cogéma-Nukem and GNSS or alternatively could be returned to Russia.

In May 2000, USEC and TENEX reached an agreement in principle to amend the HEU contract and adopt market-based payment terms starting in calendar year 2002. USEC will purchase, in calendar 2002-2004, additional deliveries beyond the 30 tU per year specified in the original agreement in order to make up the delivery shortfall of 9 tU that Russia did not make in previous years. Approval by the US Government is required to execute the new agreement.

Under the Russian HEU Agreement, from 1994 through 30 June 2001, 3 575 t of LEU derived from 122 t of Russian HEU has been delivered to USEC. This amount, represents about 24% of the original 500 t HEU covered by the so-called "Megatons to Megawatts" agreement, and is equivalent to some 4 880 nuclear warheads.

In March 1999, The United States and Russia signed a government-to-government agreement to facilitate the return to Russia of certain quantities of the Russian natural uranium component from HEU-to-LEU shipments. DOE is also to purchase the Russian natural uranium component of its 1997-1998 LEU shipments, agreeing to hold the material from the market for a 10-year period. At the same time, Russia also signed a long-term, market-based-price contract to sell the natural uranium component of the HEU-to-LEU shipments to a Cameco-Cogéma-Nukem consortium.

United States Highly Enriched Uranium

The United States has committed to the disposition of about 174 tonnes of surplus HEU with over 155 tonnes planned to be blended down for use as LEU fuel in research and commercial reactors. About 15 tonnes of this HEU, in the form of uranium hexafluoride, has already been converted. The remainder will be converted over the next several years, through approximately 2015. Both sides of the HEU blending point will be available for safeguard monitoring by the IAEA. About 48 tonnes of HEU will be transferred to USEC for down blending to LEU with this transfer set for completion by 2005.

The DOE and Tennessee Valley Authority (TVA) signed a letter of intent in April 1999, whereby TVA would utilise LEU derived from blending down US surplus HEU. About 38 tonnes of HEU are considered part of this programme with the TVA. This LEU is considered "off-specification" because it contains ^{236}U in excess of the specifications established for commercial nuclear fuel. TVA plans to fuel its nuclear reactors with the off-specification LEU derived from US HEU by 2003.

An additional 25 tonnes of HEU will be kept under IAEA safeguards until blended down to make research reactor fuel, while an additional 31 tonnes of HEU is not ready for disposition and final plans are not yet made.

Plutonium

On 4 January 2000 the DOE announced its decision to dispose of up to 50 tonnes of surplus plutonium through immobilisation of up to 17 tonnes and the use of up to 33 tonnes as mixed oxide fuel. It is planned that a MOX fuel fabrication facility located near Aiken, South Carolina will produce MOX fuel beginning in 2007 for irradiation in three specially licensed commercial reactors. These reactors are the Catawba Nuclear Station near York, South Carolina; the McGuire Station near Huntsville, North Carolina; and the North Anna Power Station near Mineral, Virginia. The 33 tonnes Pu would produce MOX fuel that would displace about 6 500 tU (natural equivalent) which is equivalent to about 2-3% of total estimated US reactor fuel requirements over the period 2007-2022.

Under an agreement signed in September 2000 between the United States and the Russian Federation, each country will render 34 tonnes of weapon-grade plutonium into a form unusable for nuclear weapons within the next 25 years. While the US plans to convert some plutonium into fuel and dispose of the rest geologically, Russia plans to convert all 34 tonnes into fuel.

The agreement foresees large-scale international funding, including the US paying at least USD 200 million towards building plants to store and salvage the plutonium, but impending cost growth could slow down implementation.

Russia must adapt its nuclear power plants to use plutonium-based MOX fuel or sell the fuel to other countries. It will not be possible for Russia to burn the MOX fuel quickly enough in its own VVER reactors to meet the time scale the US would prefer. Leasing the fuel for use in western European reactors already licensed to burn MOX would enable Russia to meet the preferred time table as well as to raise funds to help with the disposition programme. Russia would be obliged to repatriate spent MOX fuel.

A special international G-8 group has been considering the financing by donor countries of a MOX-fabrication plant. BNFL would be in a position to help Russia convert plutonium into MOX fuel, should Russia's plans not materialise to buy Siemens AG facilities in Hanau, Germany.

In view of the long time scale and the amounts involved, this secondary source may not have as an important effect on the market as the material derived from highly enriched uranium.

2. Uranium produced by recycling and reprocessing of spent reactor fuels.

Another, potentially substantial source of fissile material lies in the constituents of spent fuel from power reactors. As of January 1999, over 210 000 tonnes of heavy metal have been discharged from power reactors. About 133 000 tonnes remain in storage as spent nuclear fuel. The remainder has been reprocessed. The quantity of accumulated spent fuel is 20 times the present total annual reprocessing capacity [11]. To date, no country has licensed a permanent geological repository for spent fuel. The majority of the spent fuel is currently stored at reactor sites in special holding pools. In some countries such as France, Japan, the Russian Federation, Germany, Belgium, Switzerland, Korea, and the United Kingdom, spent fuel has been viewed as a national energy resource. In some of these countries, the use of recycled material is already taking place. There are 32 reactors world-wide licensed to use MOX fuel, and facilities for the fabrication of this type of fuel exist in Belgium, France and the UK and are being constructed in Japan [12].

Use of MOX improves the overall efficiency of the fuel cycle but it has not yet dramatically altered world uranium demand because the quantities involved are yet rather small. This supply source was estimated by the IAEA to potentially contribute up to 3 500 tU in 2000 and could potentially contribute up to 4 000 and 5 000 tU (natural equivalent), respectively, in 2005 and 2010 [13]. It should be noted that this supply from reprocessing is based on projections by the IAEA of MOX fuel fabrication capacities. Therefore it represents a maximum level of use. The Euratom Supply Agency reported that the use of MOX during 2000 in the European Union reduced natural uranium requirements only by an estimated 1 100 tU [9] compared with total western European and Scandinavian uranium requirements of 19 373 tU. This, at the present time, also represents total world MOX use because MOX use is currently limited to Europe, though Japan remains committed to introducing its use in 16-18 of its reactors by 2010.

3. Uranium produced by re-enrichment of depleted uranium tails

The world's depleted uranium stocks represent a major reserve of uranium that can displace primary production of uranium. The use of re-enrichment of depleted uranium is determined by economics. As of 1999, re-enrichment was only economic in centrifuge enrichment plants that had spare capacity and where operating costs are low. The 1999 depleted uranium stockpile of 1.2 million tU (assumed assay of 0.3% ^{235}U) could provide up to 452 000 tU of equivalent natural uranium.[6] This would be sufficient for about 7 years of operation of the world's nuclear reactors at 2000 uranium requirement levels.

Deliveries of re-enriched tails represent a significant source of uranium for the European Union. Having begun there in 1997 they remained a small source through 1998 (<1% of total supply) but have since grown. In 2000, about 1 100 tU of re-enriched uranium was delivered to utilities representing almost 7% of the fuel loaded into reactors that year [9]. Additionally, the Euratom Supply Agency concluded 4 new supply contracts for the delivery of about 600 tU as re-enriched tails over the period 2001-2005 [9]. There are indications that re-enriched tails are supplied to users outside of the European Union (and outside the United States because of trade restrictions).

Uranium market developments

Some of the largest influences in uranium trade have arisen as a result of policies in the USA and in the European Community on sales of uranium produced in the Newly Independent States (NIS).

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6. OECD Nuclear Energy Agency, *Management of Depleted Uranium* (2001), Paris, France. This total assumes 1.2 million tonnes U at 0.3% assay re-enriched to produce 336 000 tU of equivalent natural uranium, leaving 864 000 tU of secondary tails with an assay of 0.14%. These secondary tails could then also be re-enriched providing a further 106 000 tU equivalent leaving 758 000 tU of tertiary tails with an assay of 0.06%.

Restrictions in the United States

Since 1991, the United States has restricted uranium imports from the former Soviet Union. At the end of 1998, agreements were in place with Kazakhstan, Kyrgystan, Russia, and Uzbekistan to limit imports from those republics in exchange for a suspension of the antidumping investigations by the US Department of Commerce (DOC).

The original suspension agreement with Russia had required that under a specific quota, an import of Russian-origin uranium or separative work units (SWU) in a US market transaction must be matched with a quantity of newly produced US-origin uranium or SWU. The previous ratio had been 1:1 for US- to Russian-origin natural uranium.

In early 1999, Kazakhstan requested termination of its uranium import suspension agreement. As a result of the required subsequent case review, a negative determination for Kazakhstan was issued in July 1999 signifying that unlimited imports of uranium would not likely lead to material injury to the US uranium industry.

In August 1999, a further review was undertaken by the US Government to determine whether termination of the suspension agreements on uranium from Russia and Uzbekistan and revocation of the antidumping duty order on uranium from Ukraine would likely lead to continuation or recurrence of material injury. As a consequence of this review, in August 2000, the determination was made that termination of the suspended agreement on uranium from Russia would likely lead to continuation or recurrence of material injury in the United States. However, it was determined that revocation of the antidumping duty orders on uranium from Ukraine and on uranium from Uzbekistan would not likely lead to continuation or recurrence of material injury to an industry in the United States within a reasonably foreseeable time.

Policy measures in the European Union

The Euratom Supply Agency (Euratom), established under the provisions of Chapter VI of the Euratom Treaty, must ensure through a common supply policy that all users in the European Community (EC) receive a regular and equitable supply of ores and nuclear fuels. These supply provisions contain no "community preference" for community production [14].

In order to ensure regular and reliable supply, the Agency policy aims at avoiding over-dependence of the European Union (EU) on any single source of supply (diversity of sources), and at ensuring market-related prices in order to avoid supply disruption in the event that supply sources are reduced for political or other reasons. The policy does not involve a system of quantitative import limits, but rather the exercise by the Agency of its exclusive right under the Treaty to conclude contracts in such a way as to assure long-term security of supply.

In practical terms:

- Diversity of sources means that EU users should not depend, on average, for more than *about one quarter of their natural uranium needs and for more than around one fifth of their enrichment needs* from the NIS and Russia, respectively.
- Market-related prices means prices covering production cost in a market economy environment and compatible with prices offered by the best market economy producers.

Since 1998, Euratom has been following closely how material from two secondary sources, namely the feed component of the HEU deal between the Russian Federation and the United States and re-enrichment in the Russian Federation of tails material arising from enrichment in the European Community, are introduced into the market.

Because the arrangements were expected to improve market stability and predictibility, Euratom welcomed the agreement signed on 24 March 1999, between the US and Russian, as well as, the related purchase option contract between Minatom and western uranium suppliers (Cameco from Canada, Cogéma from France and Nukem from Germany). Under this agreement a major part of the HEU feed component (9 000 tU per year) can be purchased by the western suppliers, and the remainder must be either sold under the US quota limitation, stockpiled, or used for blending. Following consultations with all the parties concerned, Euratom will allow EU users to freely acquire HEU feed, through specific or open origin contracts without affecting their normal NIS entitlements.

With regard to equivalent natural uranium from re-enrichment of western-origin tails material, Euratom announced [15], following a recommendation of its Advisory Committee, that such material can be freely sold if it is further enriched in the EU. Euratom expects that this material could provide a supply on the order of 1 000 to 2 000 tU per year as equivalent natural uranium. Part of this is sold to EU users and the remainder is exported. The impact of the sales of re-enriched tails is being monitored, and the policy could be revised if a need arises. The Agency is contemplating an amendment to the policy in the sense of allowing further purchases of fresh production of natural uranium from Kazakhstan and Uzbekistan by the EU utilities.

Euratom's policy[7] was clearly confirmed by the European Court of First Instance and Court of Justice in the Kernkraftwerke Lippe-Ems case [16]. In this case Euratom had refused the unconditional conclusion of a contract for the supply of natural uranium to a German user, because it would have resulted in an excessive level of dependence on the NIS and because of the low price. The Court underlined the tasks and role of Euratom and insisted on its broad margin of discretion. The Courts accepted that three legal obstacles allowed Euratom to oppose the contract: the excessive level of dependence which could jeopardise the security of supply (diversification), the price which was not a "market related price" as prescribed by Article 14 of the EU/USSR Agreement [17] of 1989, and the risk that allowing an individual company more than its proportional share would create a privileged position forbidden by Article 52 of the Euratom Treaty.

Spot market activities

Though the uranium spot market represents a relatively small portion of total annual uranium transactions worldwide it still remains an important indicator of the general uranium market.

Some national and international authorities (e.g. Australia, Canada, US, EU) make available spot price indicators which reasonably illustrate term contract price trends. Additionally, spot price indicators for immediate or near-term delivery are regularly provided by industry sources such as the Ux Consulting Company LLC (UxC) and others. Figure 15 shows a comparison of historical annual average delivered prices reported by various sources and clearly depicts the overall decreasing trend in world uranium prices that has characterised the market since 1982.

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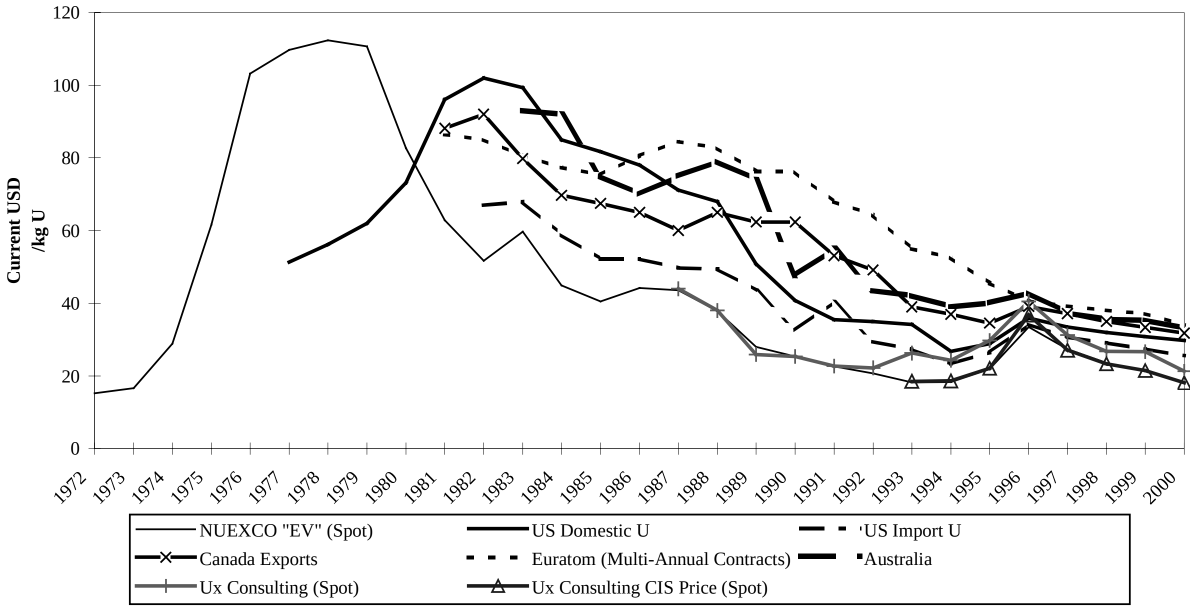
7. For political endorsement see statements in the European Parliament quoted in the 1997 Red Book, p. 80, see also European Commission, *Green paper: For a European Union energy policy* (1995), p. 107 and *White paper: An energy policy for the European Union* (1995), p. 23.

Figure 15. **Development of uranium prices**



Notes:

1) NUEXCO Prices refer to the “Exchange Value”. The values for 1992-1998 refer to the unrestricted market.

2) Euratom prices refer to deliveries during that year under multiannual contracts.

Sources: Australia, Canada, Euratom, United States, NUEXCO (TradeTech), Nukem, Ux Consulting Company, LLC.

Outlook to 2020

Uranium demand over the short-term is fundamentally determined by nuclear capacity. Although there are uncertainties related to potential changes in world nuclear capacity, short-term uranium requirements are fairly predictable. Most of the nuclear capacity that is projected to exist in 2020 is already in operation or under construction; there is only a limited degree of uncertainty regarding construction lead times and implementation of plans for new units in some countries. There continues to be high levels of new construction in East Asia, and in the Middle East, Central, and South Asia regions. Significant new construction is also planned in Central, Eastern, and Southern Europe. There are early indications that new construction may be initiated in North America by 2020. Conversely, in Western Europe and Scandinavia it appears that there will be a decline in capacity as Germany’s plans to phase out nuclear power are fully implemented, despite expected offsets from construction in other parts of that region.

Improvements and modifications to nuclear reactor technology may also affect requirements, though the impact will likely take time to have a major impact. The trend to higher burn-up fuel tends to reduce uranium requirements. For example, improving burnup from 40 to 50 GW-day/tU decreases uranium requirements by 4-5% [18]. This improvement in technology has allowed the extension of the period between refuelings. This coupled with the shortening of the time needed to perform these refuelings has raised availability factors significantly over the past decade. This tends to increase uranium requirements as reactors provide more electricity. The trend to upgrade the power levels and extend the lives of operating reactors using various means leads to higher uranium requirements.

The uranium market over the mid-term remains uncertain due to a lack of information on the nature and extent of secondary supplies. The increasing availability of supplies from the conversion of warhead material, together with recent increases in the commercial inventory, implies a continuing oversupplied, low-priced market. The low prices of uranium have caused a reduction in exploration and production and a growing reliance on secondary supplies. This situation is reducing the prospects of a market recovery in the short-term.

The low prices for uranium have impacted the production sector resulting in consolidations, mine closures, and deferment of investment and projects. Production and exploration are likely to remain low until sufficient evidence exists that secondary supplies, particularly inventories, are being exhausted, or that significant new requirements are emerging. However, given the long-lead times required to increase primary production the potential exists for supply and demand imbalances. Improved information on the nature and extent of world uranium inventories and other secondary sources is necessary to permit more accurate forecasting that would permit timely production decisions.

As shown in Figure 16, production capability for all uranium producing countries, based on Existing, Committed, Planned and Prospective production centres supported by RAR and EAR-I recoverable at a cost of USD 80/kgU or less, cannot satisfy future world uranium requirements in either the low case or the high case. Thus, in the near-term, secondary sources, i.e. excess commercial inventories, the expected delivery of LEU derived from HEU warheads, re-enrichment of tails and spent fuel reprocessing are necessary to ensure adequate supplies.

In the longer-term, beginning around 2020, when secondary supplies decline to lower levels, reactor requirements will need to be met through the expansion of existing production capabilities, together with the development of additional production centres or the introduction of alternate fuel cycles. The lead-time for the development of new uranium production facilities is several years. Additionally, developing new uranium projects has become more difficult because of increasingly demanding radiation safety and environmental regulations, as well as the additional time required to meet licensing, permitting and environmental review procedures. Thus it will be important that decisions to pursue exploration and development of new resources and production capabilities be made in the near-term. Any extended production shortfall in the absence of secondary sources could destabilise the uranium market and lead to potential temporary shortfalls and/or significant upward pressure on uranium prices.

Analysis of uranium supply to 2050

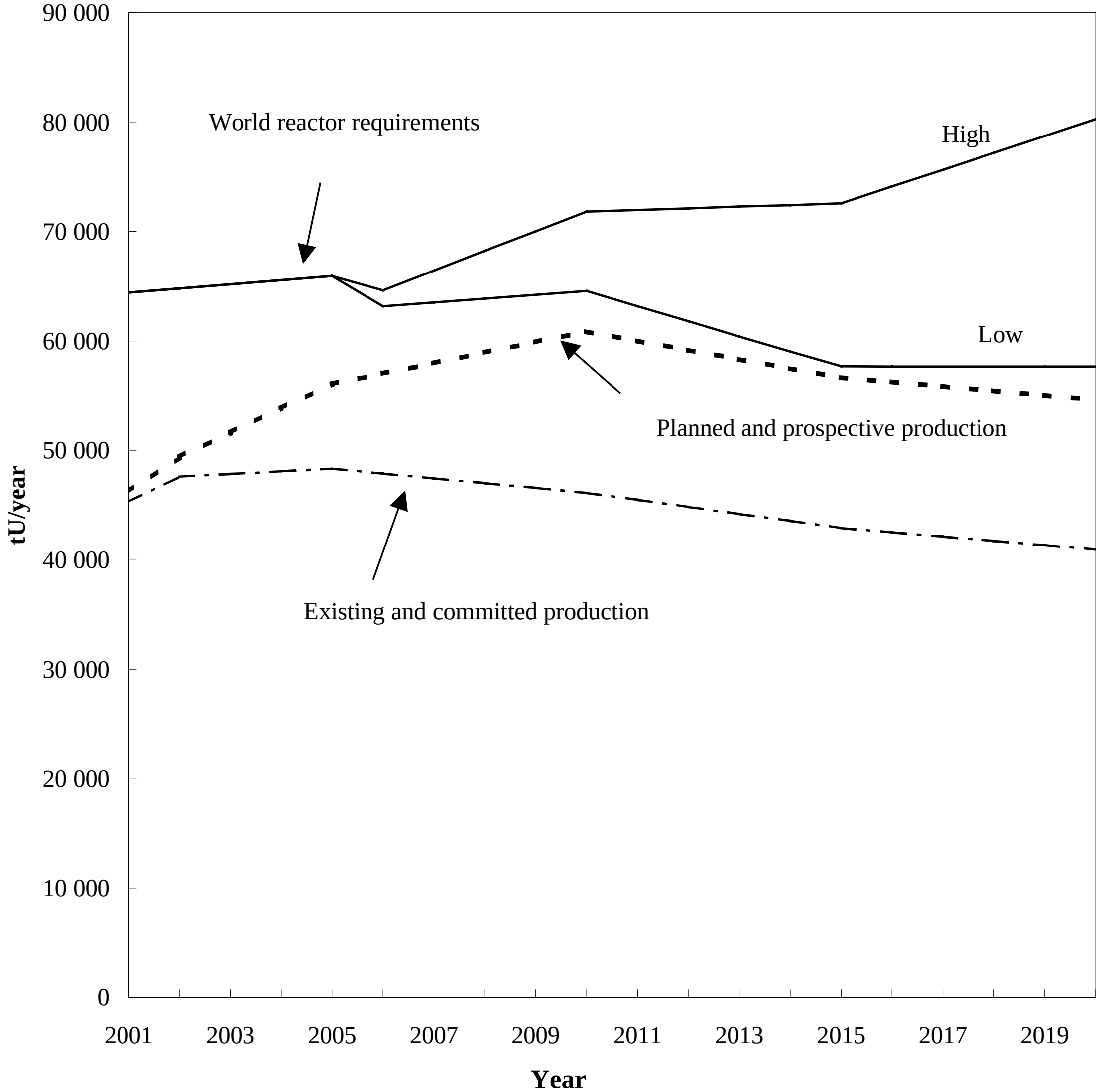
Nuclear power is expected to be an important part of the world-wide energy mix for at least the next 50 years and probably well beyond. Its future, however, will only be assured if there is an adequate supply of uranium available to sustain the nominal growth rate of 1 to 3% projected by many analysts.

In 1999, the IAEA assembled a team of consultants to evaluate the adequacy of supply to meet reactor uranium requirements (demand) through 2050, and to characterise the level of confidence that can be placed in the projected supply. The results were published by the IAEA in 2001 [19].[8] It is assumed in this study that uranium-fueled reactors will continue to be the dominant reactor type for the foreseeable future. The following steps were taken in completing the study:

- Establish annual world-wide reactor demand.
- Identify all sources of uranium potentially available to fill reactor demand
- Determine the most likely contribution that each source will make toward satisfying annual demand.

8. This publication was prepared and published under the auspices of the IAEA without the formal participation of the Uranium Group.

Figure 16. **Annual world uranium production capability through 2020***
compared with projected world reactor requirements

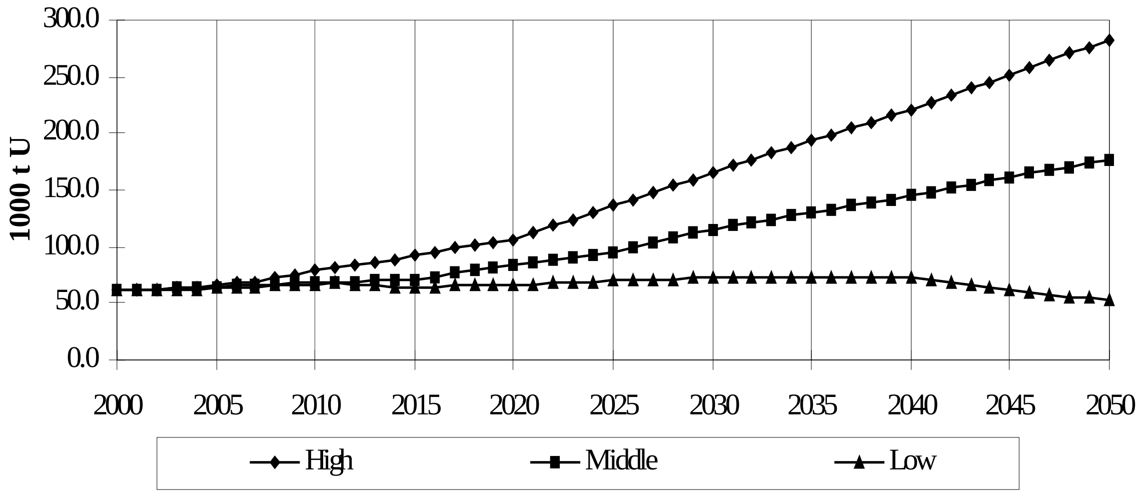


Source: Tables 13 and 15.

* Includes all current and identified potential uranium production centres.

Three uranium demand cases were considered that cover a broad range of assumptions as to world-wide economic growth and related growth in energy and nuclear power. The middle case assumes medium economic growth for the world's economy with sustained growth for nuclear power. The high case assumes a high economic growth rate accompanied by significant growth for nuclear power, while the low case assumes medium economic growth and a phase-out of nuclear power by 2100. Figure 17 shows the annual requirements for the three demand cases.

Figure 17. **Projections of annual uranium requirements 2000 to 2050**



The cumulative uranium requirements between 2000 and 2050 for the three cases are as follows:

High case	7 577 300 tU
Middle case	5 394 100 tU
Low case	3 390 000 tU

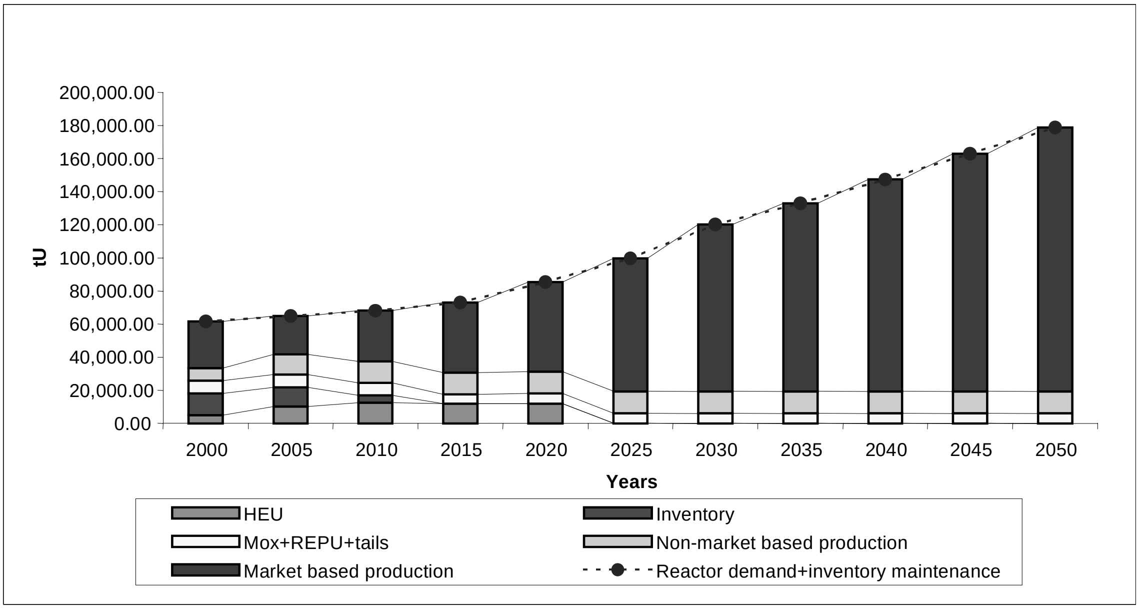
The projected growth of annual uranium requirements is underscored by comparing requirements in 2000, 2020 and 2050 in the three demand cases:

	Low (tU)	**Middle** (tU)	**High** (tU)
2000	62 000	62 000	62 000
2020	60 233	83 300	106 500
2050	52 000	177 000	283 000

Uranium supply is broadly classified into two categories – secondary and primary supply. Secondary supply includes highly enriched uranium (HEU), natural and low enriched uranium (LEU) inventories, mixed oxide fuel (MOX), reprocessed uranium (RepU) and re-enrichment of depleted uranium (tails). Secondary supply was projected to cover 42% of demand in 2000. By 2025, this contribution is projected to drop to 6% and 4% of demand in the middle and high demand cases, respectively.

Primary supply is divided into production that is not constrained by, or controlled by, market conditions such as production in the Commonwealth of the Independent States (CIS), China and various small national programmes, and production which is market-based. Once the three demand cases were established, the first step in assessing the balance between supply and demand was to project the annual availability of each of the components of secondary supply between 2000 and 2050. Secondary supply was then subtracted from projected annual reactor requirements (demand) to determine total primary supply requirements. Projections were then made as to the annual availability of non-market based supply (CIS, China and national programmes) which was subtracted from total primary supply requirements to determine annual market-based production requirements. Figure 18 shows the relative contributions of secondary supply and market based and non-market based primary supply. The increasing importance of market-based production is quite apparent.

Figure 18. **Uranium supply-demand relationship, 2000-2050 – Middle demand case**

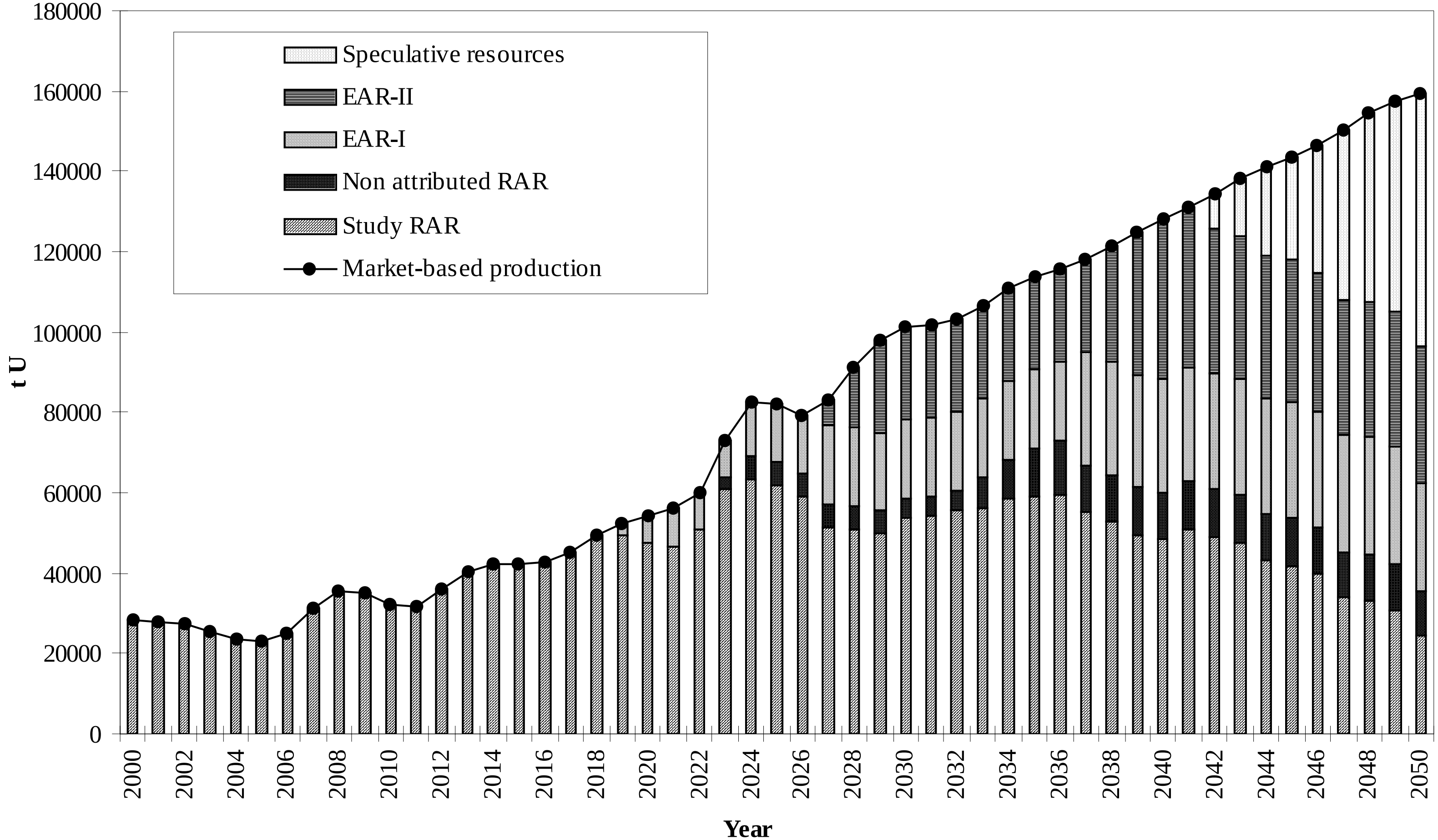


Once market-based production requirements had been established, the focus of the report turned to the adequacy of uranium resources to meet those annual requirements. The participating consultants supplied detailed information on the resources of known deposits throughout the world and their estimated production costs and capacities. This information is supplemented with 1999 Red Book information to establish total Reasonably Assured Resources (RAR), the highest confidence resource category. RAR are grouped according to production costs into the following categories: Low-cost (≤USD 34/kgU), low-medium cost (USD 34-52/kgU), high-medium cost (USD 52-78/kgU), high-cost (USD 78-130/kgU) and very high-cost (>USD 130/kgU). The cost categories used in this study differ from those used in the Red Book for two reasons. First, it was felt that the lower cost categories better reflected near-term market conditions. Secondly, based on the consensus of the participating consultants, the low-cost category separated a small number of the lowest cost operating and planned production centres from a much larger group of deposits with projected costs in the low-medium range.

Annual production capacity was estimated for production centres to which RAR are attributed. Licensing and development lead times were considered when estimating availability of output from each production centre.

Annual market-based production requirements were assumed to be met first by the lowest cost production centre producing at projected nominal capacity. Remaining demand will be filled by progressively higher cost producers until annual demand is satisfied. Production from higher cost projects is deferred until they are cost competitive. A similar assessment is made for lower confidence resources including EAR-I and EAR-II. When production based on RAR is no longer sufficient to satisfy market based production requirements, the lowest cost EAR-I are assumed to be brought into production. Similarly, when production based on the combination of RAR+EAR-I (known resources) falls short of satisfying market based requirements, EAR-II are called upon to fill the shortfall. Figure 19 shows the contribution that each resource category is expected to make to satisfy market based production requirements through 2050 for the middle demand case. The report emphasizes the role that undiscovered resources (EAR-II and Speculative Resources) will need to play in satisfying market based production shortfalls from known resources in the latter part of the study period.

Figure 19. **Resources contribution by confidence level through EAR-II and speculative resources – Middle demand case**



Based on the above methodology, the report reached the following conclusions:

- Cumulative market-based production requirements to 2050 are projected to total 4 158 280 tU in the middle demand case, and 6 406 190 and 1 917 990 tU in the high and low demand cases, respectively.
- Low and low-medium cost RAR (≤USD 52/kgU) are adequate to meet market-based production requirements through 2019 in the middle demand case. Inclusion of high-cost RAR extends coverage to 2028.
- Production based on known resources (RAR+EAR-I) in the low and low-medium cost categories is adequate to meet market-based production requirements through 2021 in the middle demand case. Total known resources in all cost categories extend coverage to 2034.
- Known resources plus EAR-II are adequate to satisfy market-based production requirements through 2041 in the middle demand case.
- RAR are adequate to cover market-based production requirements in the low demand case through 2050.
- Total known resources are nearly adequate to satisfy cumulative market-based production requirements. However, because of production timing and capacity constraints, not all resources will be utilized by 2050. Therefore, cumulative production derived from known resources will be adequate to satisfy only 80% of total market-based production requirements in the middle demand case, despite the fact that resources nearly equal demand.
- In the high demand case, RAR through EAR-II are adequate to cover market-based production requirements only through 2029. The cumulative deficit between market-based production requirements and projected production derived from RAR through EAR-II in the high demand case could total 2.059 million tU. Speculative and/or unconventional resources would be required to satisfy this deficit.
- A cumulative shortfall of 844 500 to 2 950 350 tU is projected between market-based production requirements and production in the middle and high demand cases, respectively. Therefore, to ensure a stable supply of relatively low-cost uranium needed to ensure the future of nuclear power, major exploration expenditures will have to be made within the next 5 to 10 years, which will only happen if near-term demand and market prices support such expenditures. To have the greatest impact on reducing the projected deficits, discoveries need to be made early enough that they can accommodate long environmental review and development lead times, and still contribute to fulfilling production requirements in a timely manner.
- Each of the components of secondary and primary supply has risks and uncertainties – both negative and positive. Sensitivity studies were included in the report to address a wide range of uncertainties.
- Environmental opposition to uranium development could limit or significantly delay availability of low-cost market-based production. Therefore, a sensitivity study was included that shows the impact on supply-demand relationships if resources potentially subject to environmental or political opposition are removed from the resource base.
- The base case for HEU assumes that 250 t of Russian HEU and 55 t of US HEU will be available that is in excess of current agreements, which will extend availability of uranium derived from HEU to 2023, 10 years beyond the current US-Russian Agreement. A

sensitivity analysis was included to show the effect of limiting HEU availability to the current agreement (low HEU case) as well as extending availability to 2040 (high HEU case).

- A sensitivity study was also included that shows potential changes in production requirements imposed by limiting the use of MOX and reprocessed uranium, and the availability of depleted uranium (tails).

Every effort was made in the report to arrive at realistic production scenarios that consider all aspects of uranium production, including cost, technical feasibility, and environmental and political risk. These production scenarios were intended to characterise the uranium production industry throughout the next 50 years based on a range of potential demand scenarios. They address adequacy of supply at different confidence levels, and they can indirectly be used to broadly project market price trends. They are not, however, intended to be absolute forecasts of the future. In addition, they assume that there will be no new uranium resources discovered or announced in the period through 2050.

D. THE IMPACT OF RECENT DEVELOPMENTS ON THE LONG-TERM PERSPECTIVE

Concerns about longer-term security of supply of fossil fuels and the heightened awareness that nuclear power plants are environmentally clean with respect to acid rain and greenhouse gas emissions might contribute to even higher than projected growth in uranium demand over the long-term.

World electricity use is expected to continue growing over the next several decades to meet the needs of an increasing population and sustained economic growth. Electricity is expected to remain the fastest growing form of end-use energy worldwide through 2020 [20]. The growth of electricity consumption will be strongest in developing nations. Consumption of electricity in non-OECD countries is expected to reach 2.5 times its present level in 2020 [21]. Nuclear electricity generation will continue to play a significant role in the future growth of electricity consumption in some regions. In 2020, the International Energy Agency projects that global production of nuclear electricity will account for 5% of primary energy production [22]. Other institutions have projected even larger contributions by nuclear to growing world energy demand and as yet, they do not reflect the result of the ongoing debate on the role of nuclear energy in meeting global emissions targets.

Technology developments will likely shape the future of nuclear energy and uranium requirements. For example, reprocessing is a technology that is currently available which could make a significant impact on uranium requirements in the long-term, assuming that it is fully implemented. Implementing a programme to recycle all plutonium in light water reactors would reduce uranium requirements by 17% [21]. Other technologies under development that could also make noticeable impacts if they are implemented include tandem cycle reactors, such as the PWR-CANDU concept, which re-burns PWR spent fuel in CANDU reactors and thereby reduces CANDU uranium requirements by about 40%. Other potential technologies, e.g. fast breeder reactors, high-temperature gas-cooled reactors, thorium fuel cycles and new extraction and enrichment technologies could effectively extend uranium resources for centuries. Several major international technology development programmes have commenced whose goals could lead to major advances in nuclear technologies by 2030.

Ultimately, the long-term future of nuclear energy will likely be determined by the resolution of the tension between several major competing themes; the continued growth in demand for electricity, the competitiveness of nuclear energy in increasingly open electricity markets, and the need to minimise the impact on the environment, namely through the reduction of emissions of greenhouse gases. If it can be demonstrated that nuclear energy is clean, economically competitive, safe, and that acceptable solutions to waste issues exist, then it is likely that a period of strong growth will ensue. If that case cannot be made satisfactorily then nuclear power will likely decline slowly in importance.

Uranium resources are sufficient for the present use paradigm for many decades and already new technologies and fuel cycles are identified, including the ability to recover uranium from seawater, that would allow nuclear fission to be an almost limitless supply of energy without emission of greenhouse gases. Thus, in the long-term the impact of recent developments points to a strong potential for nuclear energy as the world economies and populations continue to grow, yet this potential is dependent on the resolution of the environmental and political discussions now underway. Because of the long lead-times necessary to discover new resources and develop new production capabilities, there exists the potential for supply-demand imbalances to develop as secondary sources become exhausted. Significant new exploration and development activities will likely be needed over the next few decades if adequate resources are to remain available at stable prices.

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III. NATIONAL REPORTS ON URANIUM EXPLORATION, RESOURCES, PRODUCTION, DEMAND AND THE ENVIRONMENT

INTRODUCTION

Part III of the report presents the national submissions on uranium exploration, resources and production. These reports have been provided by the official government organisations (Annex 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 the Red Book. 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 Red Book 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 publications: "World Distribution of Uranium Deposits" (STI/PUB/997), together with the "Guidebook to accompany the IAEA Map: World Distribution of Uranium Deposits" (STI/PUB/1021). The location of 582 uranium deposits is given on a geologic base map at the scale 1:30 000 000. The guidebook (which is available at no cost with purchase of the map) and map provide information on the deposit: type, tectonic setting, age, total resources, average uranium grade, production status and mining method. They may be ordered from:

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• Algeria •

URANIUM EXPLORATION

Historical review

Uranium exploration began in Algeria in 1969. The Precambrian shield of the Hoggar and its Tassilian sedimentary cover were considered to have a geological environment favourable for uranium mineralisation. Initial exploration, carried out by means of ground radiometric surveys, found several radioactive anomalies (Timgaouine, Abankor and Tinef). In 1971, an aerial radiometric survey was performed over the entire country – an area of 2 380 000 km^2. After evaluation of the data from that survey, several prospecting teams were involved in ground follow-up work and in verifying anomalies. This led to the discovery of a large number of promising areas for further uranium exploration: Eglab, Ougarta and southern Tassili (Tin-Séririne basin) where the Tahaggart deposit was discovered. Follow up of the aerial radiometric survey also led to identification of the Tamart-N-Iblis and Timouzeline sectors as areas for future uranium exploration. At the same time, the search for uranium entered a phase (1973-1981) which focused primarily on the exploitation of reserves and evaluation of the deposits already discovered. A second phase (1984-1987) was characterized by a marked slowdown in the search effort; however, investigation of the flanks of the known deposits and in neighbouring regions revealed other potential mineralised areas (e.g. Tesnou zone in the northwest and north of Timgaouine). These are currently being evaluated. In the Tin-Séririne basin (Tassili south of the Hoggar), geological mapping has resulted in characterization of the distribution of uranium mineral deposits in the Palaeozoic sedimentary sequences.

Recent and ongoing uranium exploration and mine development activities

From 1984 to 1997, uranium exploration focused mainly on investigation of three types of deposits:

- Granite-related deposits.
- Sandstone and continental black shale deposits.
- Unconformity-related deposits.

Exploration activities were, therefore, oriented towards collecting basic geological, geochemical and geophysical data in two known provinces:

- The uranium-bearing province of the western Hoggar (Pharusian chain).
- The uranium-bearing province on the border between Algeria and Niger.

Uranium anomalies discovered in these areas have been evaluated and the elements of the corresponding deposits have been characterised as to mineralisation, geochemistry, grade, morphology and extent.

Exploration activities slowed down beginning in 1998, and from 1998 to 2001 no exploration or prospecting activity was carried out in the field.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Algeria's Reasonably Assured Resources comprise two geological types: Upper Proterozoic unconformity-related deposits and vein deposits. The first category includes deposits associated with weathering profiles (regolith) and deposits associated with the basal conglomerate and sandstone of the sedimentary cover, which are located primarily in the Tin-Sériríne basin in the southern Hoggar. Deposits of the second (vein) type are located in veins in primary fractures associated with faults across granite batholiths. This type of deposit includes the Timgaouine, Abankor, El-Bema and Aït-Oklan deposits in the southwestern Hoggar.

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

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	26 000	26 000

* As *in situ* resources.

Algeria did not report any information on uranium production, uranium requirements, national policies relating to uranium, uranium stocks or uranium prices.

• Argentina •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration activities in Argentina began in 1951-1952. The Huemul sandstone deposit was found in 1954, while exploring for red bed copper mineralisation. The Tonco district with the sandstone deposits Don Otto and Los Berthos was discovered by an airborne geophysical survey conducted in 1958. During the late 1950s and the early 1960s, airborne surveys also led to the discovery of the Los Adobes sandstone deposit in Patagonia.

During the 1960s, the Schlagintweit and La Estela vein deposits were found by ground exploration in granitic terraine. The resources hosted in these deposits were subsequently mined in the production centres of Los Gigantes and Las Estela, respectively. In 1968, an airborne survey led to discovery of the Dr. Baulies deposit, which occurs in volcaniclastic sediments, in the Sierra Pintada district in Mendoza Province.

Argentina

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. An airborne survey carried out in 1978 in Patagonia contributed to the discovery of the small Laguna Colorada deposit located in a volcanic environment.

During the 1980s, an airborne survey conducted over granitic terrain identified a number of strong anomalies. Subsequently in 1986, ground exploration identified the vein Las Termas mineralisation. At the end of the 1980s, a nation-wide exploration programme was started to evaluate those geological units that were believed to have uranium potential.

In 1990, exploration was initiated in the vicinity of the Cerro Solo deposit in Patagonia. Through 1998, more than 56 000 m were drilled to test the potential of the favourable portions of the paleochannel structure. The results include the delineation of additional ore bodies containing resources of several thousand tonnes. In addition to this work, assessment of the favourable geological units and exploration of Las Termas mineralisation continued.

Recent activities within the industry are as follows:

- A prefeasibility study was completed for the Cerro Solo U-Mo deposit, Chubut Province, and preliminary testing of the host paleochannel structure potential was carried out, mainly based on the information obtained in the 56 800 m of drilling performed in the 1990s.
- Assessment continued of favourable geological units within the country, on a regional scale, as well as exploration of the Las Termas mineralisation, Catamarca Province.
- Updating of the feasibility study for the Sierra Pintada Production Center, Mendoza Province, has been initiated and it will be the basis for decisions regarding future mining-milling activities in the area.

Recent and ongoing uranium exploration and mine development activities

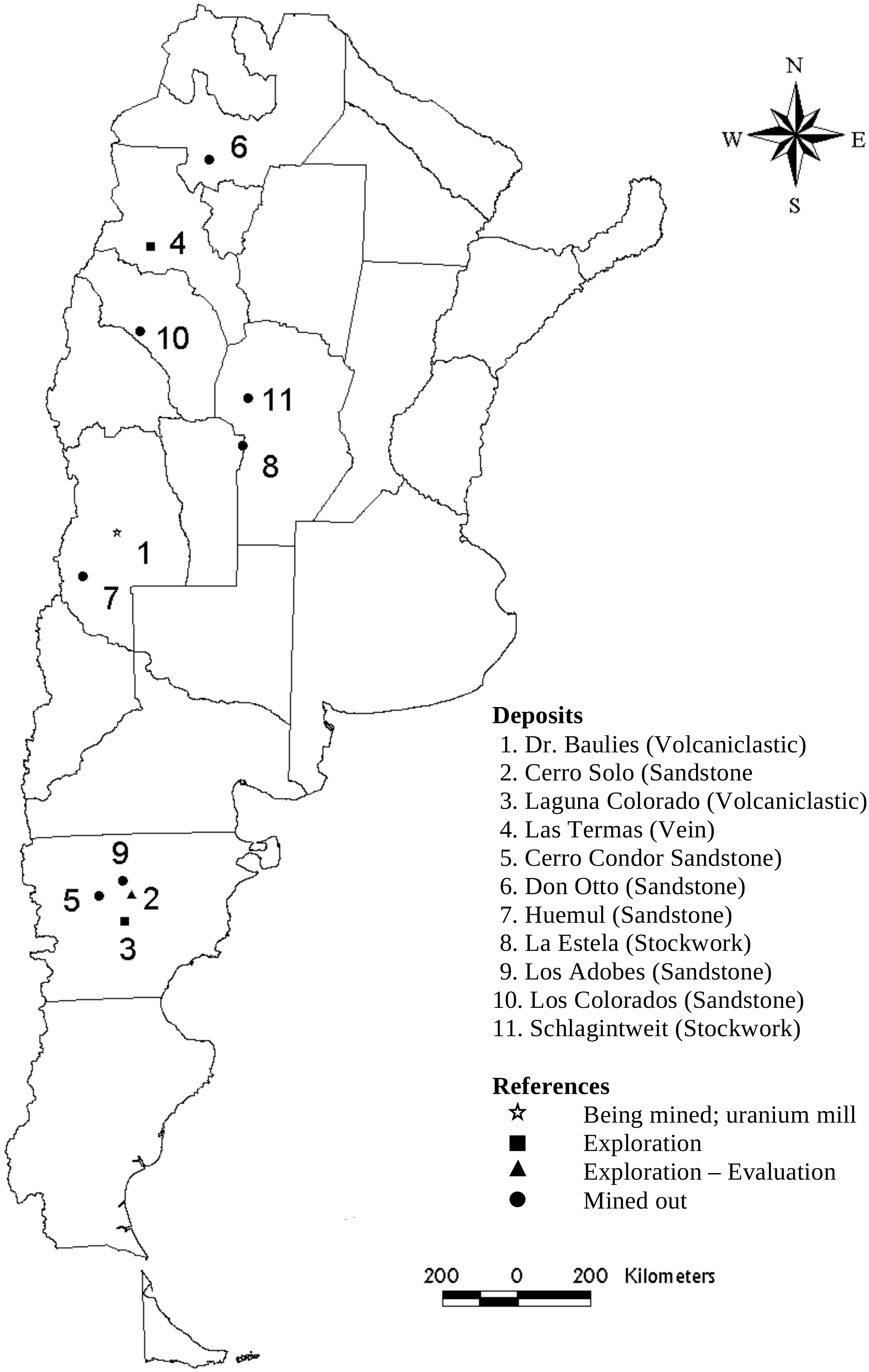
During 1999 and 2000, ongoing exploration programmes continued, both at regional and local scales. Regional assessment of the country's overall uranium potential is still in progress, and areas of interest were selected to develop geological studies at a more detailed scale. Consideration of different metallogenetic models is an important part of this effort.

Airborne gamma-ray spectrometric data (old CNEA and recently acquired Argentinean Geological Survey data) are being interpreted to help in uranium (and other elements) exploration and geological mapping. A technical co-operation programme by the IAEA was approved to support these activities.

The final feasibility study of the Cerro Solo Uranium-Molybdenum Deposit and exploration of the surrounding areas in the Chubut Province was completed, and the deposit was offered for public auction, both national and international; the tender presentation period was concluded in March 2001.

The reassessment project that is being performed in the Sierra Pintada Production Centre was accelerated during 2000. An evaluation drillhole programme, laboratory scale series of tests for improving the treatment methods, resources evaluation, and a survey of environmental conditions were performed.

Uranium deposits of Argentina



Uranium drilling statistics

	1998	1999	2000	2001 (expected)
Government exploration drilling (m)	0	0	1 438	0
Number of exploration holes drilled by government organisations	0	0	15	0

URANIUM RESOURCES

Known conventional uranium resources (RAR & EAR-I)

Changes in known resources compared with the 1999 Red Book are the result of new estimates for the Sierra Pintada deposit, after updating the database and including data obtained in evaluation of the drillhole programme performed in 2000.

Compared with the previous estimate, RAR recoverable at costs below USD 80/kgU and below USD 130/kgU decreased from 5 240 to 5 080 tU, and from 7 480 to 7 080 tU, respectively. However, the updated evaluation added 6 110 tU EAR-I below USD 130/kgU, increasing the total to 8 560 tU.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
2 640	5 080	7 080

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
2 030	2 380	8 560

* As recoverable resources adjusted for mining and processing losses (25%).

Undiscovered conventional resources (EAR-II & SR)

EAR-II below USD 130/kgU (*in situ*) are estimated at 1 440 tU, unchanged from the 1999 total. These resources occur in the La Volanta deposit, Cerro Solo area.

Estimated additional resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
0	1 440

URANIUM PRODUCTION

Historical review

Argentina has been producing uranium since the mid-1950s. A total of seven commercial scale production centres were in operation at different times through 2000. In addition, a pilot plant operated from about 1953-1970.

Between the mid-1950s and 1999, cumulative uranium production totalled 2509 tU. Since 1996, all production has come from the San Rafael centre. Production data are given in the following table.

Los Colorados mine and mill complex, located in La Rioja province started production in 1993, and was shut down at the end of 1995. Los Colorados was owned and operated by Uranco S.A., a private company. Ore was mined from a small sandstone deposit and treated in the attached IX recovery plant that was relocated to Los Colorados from La Estela project. The closure of the Los Colorados operation resulted in a change in the ownership structure of uranium production in Argentina. Since 1996, the uranium mining industry has been wholly owned by the Government Agency CNEA.

Historical uranium production (tonnes U)

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Processing plant	702	0	0	0	702	0
Heap leaching	1 796	7	4	0	1 807	0
Total	2 498	7	4	0	2 509	0

Status of production capability

The Sierra Pintada Production Centre, Mendoza Province, Argentina’s only active uranium mining-milling facility, is on a stand-by basis. No uranium concentrates were produced in the period 1998-2000, using the conventional methods applied in the Centre. However, retreatment of yellow-cake to comply with specifications yielded 34 tU in the final product during this period, but this material is not included in the production table. Additional activity was devoted to testing uranium extraction from uranium dioxide purification process wastes.

Ongoing studies in support of updating the Sierra Pintada feasibility study include improving the mining and treatment methods, and investigating mining waste and tailings management.

Studies carried out by the treatment development group have advanced knowledge about new leaching conditions and using different bacteria to reduce the processing costs. Biological treatment is also being considered to reduce effluent management costs, mainly for nitrate elimination.

Uranium production centre technical details
(as of 1 January 2001)

Name of production centre	Complejo Minero Fabril San Rafael
Production centre class	existing
Operational status	stand by
Start-up date	September 1979
Source of ore • Deposit names • Deposit type(s) • Reserves (active resources) • Grade (% U)	 Sierra Pintada Volcaniclastic 2 440 tU 0.19
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 open pit 700 90
Processing plant (Acid/ Alkaline): • Type (IX/SX/AL) • Size (tonnes ore/day)for ISL kilolitre/day or litre/hour) • Average process recovery (%)	 AL/IX 700 85
Nominal production capacity (tU/year)	120
Plans for expansion	NA
Other remarks	NA

Ownership structure of the uranium industry

At present, all of Argentina's uranium industry is government owned.

Employment in the uranium industry

Employment at the Sierra Pintada Centre is expected to decrease to 62 persons in 2001.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
80	80	70	62

Short-term production capability
(tonnes U/year)

2001				2002				2005			
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	40	40	0	0	120	120

2010				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	500	120	500	0	500	120	500	NA	NA	NA	NA

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Under the auspices of "Innovative Strategies for the Preservation of Water Quality in Mining Areas of Latin America", an INCO-DC Project of the European Union, hydrogeochemical studies were performed in order to define baseline conditions prior to any mining work in the Cerro Solo U-Mo deposit area.

The Sierra Pintada's ongoing project for updating the feasibility study emphasises good environmental practices. Improvement of surface and underground water monitoring and studies of mining waste and mill tailings management are short-term objectives.

URANIUM REQUIREMENTS

Argentina's uranium requirements have been modified due to the uncertainty in the date of completion of the Atucha II nuclear power plant. Currently available information on installed nuclear electricity generating capacity and related uranium requirements are summarised in the following tables.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
940	940	940	940	1 630	940	1 630	600	1 292

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
120	120	120	95	250	95	205	60	205

Supply and procurement strategy

The National Atomic Energy Commission's ongoing projects for restarting uranium production in Argentina in the mid-term, described in different sections of this report, reflect a policy aimed at finding equilibrium between market opportunities and reduction of supply and price uncertainties.

NATIONAL POLICIES RELATING TO URANIUM

There are no restrictions that preclude local and foreign private companies from participating in uranium exploration and production. The legal framework issued in the 1994-95 period, regulates these activities to ensure environmental practices that conform to international standards.

URANIUM STOCKS

As of 1 January 2001, total uranium stocks held by the CNEA amounted to 110 tU.

Total uranium stocks
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	110	0	0	0	110
Producer	0	0	0	0	0
Utility	NA	0	0	0	NA
Total	110	0	0	0	110

URANIUM PRICES

Information on uranium prices is not available.

• Armenia •

Armenia did not report any information on uranium exploration and mine development, uranium production, environmental activities and socio-cultural issues, national policies relating to uranium or uranium prices. There is no stockpile of natural uranium material in Armenia.

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 remained the same and are based on the operation of one VVER-440 unit of the Metsamor nuclear power plant. High-level forecast requirements are given taking into account the designed life-time for this reactor facility, which has an installed capacity of about 408 MWe.

The long-term requirements depend on the country's policy in the nuclear energy sector. According to the development plan for the Armenian energy sector, it is envisaged to construct, as a possible option, two new nuclear units with the capacity of about 600 MWe each.

Capacity projections are given in the following tables.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
408	408	408	0	408	0	600	600	1 200

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
89	89	89	0	89	0	91	91	180

Supply and procurement strategy and stockpiles

The nuclear fuel for the Metsamor reactor is supplied by the Russian Federation.

Armenia’s supply and procurement strategy has remained the same during the past two years, and as there have been no changes in uranium requirements, the country's uranium supply position is based on the same fuel procurement from the Russian Federation.

• Australia •

URANIUM EXPLORATION

Historical review[1]

Exploration for uranium in Australia can be divided into two distinct periods: 1947 to 1961, and 1966 to the present. During the first period, the Australian Government introduced measures to encourage exploration, including a system of rewards for the discovery of uranium ore. There was active exploration, particularly by prospectors in most Australian mineral fields and many of the discoveries were made by prospectors equipped with Geiger counters. Several of the deposits discovered during this period produced uranium, the largest being Mary Kathleen, Rum Jungle and Radium Hill.

Uranium requirements for defence purposes decreased in the early 1960s and uranium demand fell sharply. As a result, there was virtually no exploration for uranium between 1961 and 1966.

The second phase of uranium exploration in Australia commenced in 1966. This revival was encouraged by the announcement in 1967 of a new export policy designed to encourage exploration for new deposits. Most of this exploration was undertaken by companies with substantial exploration budgets, utilising the more advanced geological, geochemical and geophysical techniques now available. Several major discoveries were made through the use of airborne multi-channel gamma ray spectrometers. These discoveries resulted in large increases in Australia's low-cost (<USD 80/kgU) RAR from 6 200 tU in 1967 to 622 000 tU in 1996. The major uranium deposits which were discovered during the second phase of exploration included:

Unconformity related deposits[2]

Alligator Rivers uranium field:	Ranger (1969), Nabarlek (1970), Koongarra (1970), Jabiluka (1971).
Paterson Province:	Kintyre (1985).

Breccia complex deposit

Stuart Shelf:	Olympic Dam (1975).

Surficial deposits

Calcrete deposits in tertiary sediments overlying the Yilgarn Block:	Yeelirrie (1971), Lake Way (1972), Lake Maitland (1972).

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1. For a summary of the history of uranium exploration in Australia, please refer to Lambert I., McKay A. & Miezitis Y. (1996), *Australia's Uranium Resources: Trends, Global Comparisons and New Developments.* Bureau of Resource Sciences, Canberra. See also: McKay A. & Miezitis Y. (2001), *Australia's Uranium Resources, Geology & Development of Deposits.* AGSO-Geoscience Australia, Australia Mineral Resource Report 1, http://www.ga.gov.au/pdf/RR0076.pdf.

2. Year of discovery shown in parentheses.

Sandstone deposits

Frome Embayment uranium field:	Beverley (1970), East Kalkaroo (1971), Honeymoon (1972).
Westmoreland/Pandanus Creek uranium field:	Junnagunna (1976).
Ngalia Basin:	Bigrlyi (1970), Walbiri (1970).
Amadeus Basin:	Angela (1973), Pamela (1973).
Carnarvon Basin:	Manyingee (1974).
Officer Basin:	Mulga Rock (1978).

Volcanic deposits

Georgetown/Townsville uranium field:	Maureen (1971), Ben Lomond (1976).

Following the uranium exploration boom in Australia during the late 1970s exploration expenditure declined sharply from the peak level of AUD 35 million (AUD[3] 94 million) in 1980 to AUD 14 million (AUD[3] 28 million) in 1983. This sharp fall in exploration was due to decreases in uranium prices and energy conservation policies in response to the oil shocks of the 1970s.

In 1983, the Labour Government introduced what became known as the “three mines” policy. Under this policy, exports of uranium were permitted only from the Nabarlek, Ranger and Olympic Dam mines. Despite the dampening effect of the “three mines” policy on uranium exploration, the discovery of the Kintyre deposit in the Paterson Province, Western Australia, in 1985 led to an increase in exploration expenditure from 1985 to 1988. Exploration subsequently declined from 1989 onwards to an historic low of AUD 6.7 million in 1994 (AUD[3] 7.6 million). This decline was due to the fall in spot market prices from 1976 onwards, excess uranium inventories in Western world countries, and the sales of uranium from the former USSR countries.

From 1994 onwards, uranium exploration expenditure has increased to AUD 19.37 million in 1998 (AUD[3] 20.3 million). Australia has been one of the few countries where expenditure increased. These increases were due to the abolition of the “three mines” policy by the Liberal/National Party Coalition following its election to government in 1996, and improved prices for uranium during 1996.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration expenditure in Australia decreased progressively from AUD 19.37 million in 1998, to AUD 9.61 million in 1999, and AUD 7.59 million in 2000. This decline was due mainly to:

- Following the decision in 1999 to develop the Beverley project, expenditure on this project in 1999 and 2000 was not attributed to exploration.
- Several companies ceased uranium exploration in Australia during this period.

The main areas where uranium exploration was carried out during 1999 and 2000 included:

- Arnhem Land (Northern Territory) – exploration for unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie Sandstone.
- Paterson Province (Western Australia) – exploration for unconformity-related deposits in Palaeoproterozoic metasediments of the Rudall Metamorphic Complex which host the Kintyre orebody.

3. Expenditures in 2000 AUD.

- Frome Embayment (South Australia) – exploration for sandstone uranium deposits.
- Westmoreland area (northwest Queensland) – exploration for sandstone uranium deposits in Proterozoic sediments of the McArthur Basin.
- Olympic Dam area (South Australia) – exploration for breccia complex deposits.
- Mount Isa Inlier (northwest Queensland) – exploration at the Valhalla deposit where mineralisation is in a brecciated sequence of Proterozoic ferruginous shales, tuffaceous sediments and basalts, which show hematite and sodic alteration.

During 1997 and 1998, Acclaim Uranium NL (an Australian exploration company) carried out a major drilling and exploration programme at the Langer Heinrich calcrete deposit in Namibia. No further exploration was undertaken in 1999 and 2000.

Uranium exploration expenditures and drilling effort – domestic

	1998	**1999**	**2000**	**2001** (expected)
Industry expenditures AUD (million) USD (million)	 19.37 12.03	 9.61 6.26	 7.59 4.39	 not reported not reported
Industry surface drilling (m)	78 085	33 134	19 293	not reported
Number of industry holes drilled	not reported	not reported	not reported	not reported

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Over the two-year period from 1 January 1999 to 1 January 2001, estimates of Australia's uranium resources in the RAR and EAR-I categories have changed as follows:

- RAR recoverable at costs of <USD 80/kg U have increased by 60 000 tU.
- EAR-I recoverable at costs of <USD 80/kg U have increased by 49 000 tU.
- RAR recoverable at costs in the range USD 80-130/kg U have decreased by 79 000 tU.
- EAR-I recoverable at costs in the range USD 80-130/kg U have decreased by 10 000 tU.

These changes were due to:

- Reassessments of the resources for the Ranger No. 3, Jabiluka, Olympic Dam and Westmoreland ore bodies.[4]
- Improved metallurgical recoveries achieved by the Ranger mill (86.8% in 1998 to 91.6% in 2000), that have increased the estimates of recoverable resources for the Ranger No. 3 Orebody.
- Low-cost RAR were also reduced by uranium production from Ranger and Olympic Dam mines which totalled 13 563 t U for 1999 and 2000.

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4 . The latest estimates for these ore bodies were calculated by the mining companies.

Uranium deposits and prospects in Australia

At Olympic Dam, copper is the main product, uranium is a co-product, and gold and silver are by-products.

Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
654 000	667 000	697 000

Estimated additional resources – Category I
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
185 000	196 000	233 000

Deductions for anticipated mining and ore processing losses are determined for each deposit. The percentage of losses for mining and ore processing are dependent upon mining methods (or proposed methods for undeveloped deposits), metallurgical processes (or proposed processes for undeveloped deposits), and mineralogy of the ore and gangue.

For the Ranger and Olympic Dam deposits, the latest figures for mining and ore processing losses, as reported by the companies, were used to calculate recoverable resources.

90% of the known uranium resources recoverable at costs below USD 40/kgU and 85% below USD 80/kgU are tributary to existing production centres.

Undiscovered conventional resources (EAR-II & SR)

Estimates are not made of Australia's uranium resources within the EAR-II & SR Categories. Recent geological mapping has shown that the Granites-Tanami Inlier (Northern Territory) has Archaean gneissic domes and Palaeoproterozoic metasediments similar to the Alligator Rivers region and is considered to be favourable for Proterozoic unconformity-related deposits.

URANIUM PRODUCTION

Historical review

Production of uranium in Australia commenced in 1954. During the period 1954 to 1971, some 7 732 tU were produced to fulfil contracts with the UK Atomic Energy Authority or the Combined Development Agency (a joint UK-US defence purchasing agency). The major production was from two mines, Rum Jungle in the Northern Territory and Mary Kathleen in Queensland. The remainder of the production was from a number of small deposits in the South Alligator Valley in the Northern Territory and from Radium Hill in South Australia. Production ceased when the existing contracts were completed although at Rum Jungle production continued until the orebodies were mined and the production in excess of that required to meet contracts was stockpiled.

The second phase of uranium production in Australia commenced in 1976 with the re-start of production from Mary Kathleen. Production commenced at Nabarlek (Northern Territory) in June 1980; at Ranger (Northern Territory) in August 1981; and at Olympic Dam (South Australia) in September 1988. The Nabarlek orebody was mined in 1979 and stockpiled for later treatment. Production ceased in 1988 when the final portions of the stockpile were processed.

Historical uranium production (tonnes U)

	Pre-1998	1998	1999	2000	Total through 2000	2001 (expected)
Total*	72 700	4 894	5 984	7 579	91 157	7 700**

* Uranium is produced as a co-product of copper mining at Olympic Dam, where production pre-1998 totals 10 685 tU, and production in 1998, 1999, and 2000 was 1 460 tU, 2 713 tU and 3 816 tU, respectively.

** In 2001, the Beverly ISL operation contributed to Australia's total production. For confidentiality reasons this ISL production is not reported separately.

Status of production capability

Commercial operations commenced at the Beverley *in situ* leach operation during November 2000. Australia now has three uranium mining operations – Olympic Dam, Ranger and Beverley. Australia's total production for 2000 was a record high of 8 937 t U_3O_8 (7 579 tU), of which Olympic Dam produced 4 500 t U_3O_8 (3 816 tU) and Ranger produced 4 437 t U_3O_8 (3 763 tU). Beverley reported nil production for the year. Australia's total production for 2000 was 27% higher than in 1999.

Olympic Dam

Olympic Dam production for 2000 was 41% higher than for the previous year. In terms of annual production, it is now the world's second largest uranium mine. This increase in production resulted from the major expansion of the project, which was completed in 1999 at a final cost of AUD 1.94 billion. The expansion has increased annual production capacity to 200 000 t of refined copper, 4 600 t U_3O_8 (3 901 tU) and commensurate increases in gold and silver output.

On 21 October 2001, WMC suffered its second fire within the past two years in the solvent extraction area of the Olympic Dam processing plant. WMC stated that uranium oxide production is expected to be reduced by 1 500 t over the following twelve months because of the fire.

Ranger

Mining of the Ranger No.3 Orebody continued, with 2.4 Mt of ore and 4.5 Mt of overburden being mined in 2000. Energy Resources of Australia (ERA) Ltd reported that mining of the No. 3 Orebody is expected to be completed in 2007, which will meet the requirements for this open pit to be utilised as a tailings repository from 2008. It is anticipated that processing of Ranger ore will be completed by 2010.

In January 2000, the new Authority to Operate at Ranger came into force, which allows Ranger to continue to operate for a further 21 years. As a condition of this Authority, new environmental requirements (ERs) for Ranger were put in place. These new ERs reflect the changes in technology and build upon the knowledge gained from mining in the region over the past 20 years. These will enable management of environmental issues that will allow the high level of protection currently being achieved to continue.

Australia

In August 2000, Rio Tinto Ltd gained a majority ownership of ERA Ltd through the take-over of North Ltd. ERA Ltd is the operating company for Ranger and Jabiluka.

Uranium production centre technical details
(as of 1 January 2001)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4	Centre # 5
Production centre name	Ranger	Olympic Dam	Beverley	Jabiluka	Honeymoon
Production centre class	existing	existing	existing	committed	planned
Operational status	mine and processing plant operating	mine and processing plant operating	ISL mining and processing plant operating	mine construction commenced June 1998	government approvals yet to be obtained
Start-up date	1981	1988	2000	~2008	NA
Source of ore					
• Deposit name	Ranger 1, No. 3 orebody	Olympic Dam orebody	Beverley orebody	Jabiluka, orebody	Honeymoon & East Kalkaroo orebodies
• Deposit type	unconformity-related	Breccia complex	sandstone	unconformity-related	sandstone (d)
Mining operation					
• Type (OP/UG/ISL)	OP	UG	ISL	UG	ISL
• Size (t/ore/year)	2.4 million (a)	4 million	NA	450 000 (c)	NA
• Average mining recovery (%)	100	NA	65	NA	65
Processing plant (acid/alkaline):	acid	acid		acid	
• Type (IX/SX/AL)	CWG, AL, SX	CWG, FLOT, SX, AL	IX, AL	CWG, SX, AL	SX, AL
• Size (t/ore/year) for ISL (kilo-litre/ day or litre/hour)	2 million	9 million	NA 450 litres/sec	450 000	NA 220 litres/sec
• Average process recovery (%)	92	66 (b)	NA	NA	NA
Nominal production capacity (tU/year)	4 660	3 930	848	2 290	848
Plans for expansion	(a)	NA	NA	NA	NA

a) Expansion of the milling capacity to 2.0 million tonnes ore per year (4 660 tpa U) was completed in August 1997. Under an agreement with the Commonwealth Government, ERA can increase production to 5 090 tpa U when the company considers it commercially viable to do so.

b) Source: WMC Holdings Report to the Securities and Exchange Commission Washington DC, 1992.

c) Jabiluka Mill Alternative: For the Jabiluka mill, ERA proposes to mill 450 000 t of ore/annum (2 700 tpa U_3O_8 or 2290 tpa U) through to the end of stage 1. For stage 2 it is proposed to increase production to 900 000 tpa ore of a lower grade corresponding to an average output of around 4 000 tpa U_3O_8 (3 392 tpa U).

d) Honeymoon deposit has an average grade times thickness of 0.71 m%.

Beverley

Commercial operations commenced at the Beverley mine (South Australia) in November 2000. Beverley is Australia's first uranium mine to utilise *in situ* leaching (ISL). Annual production is planned to be approximately 1 000 t U_3O_8, (848 tU) and ion exchange technology is used in the uranium recovery plant.

Jabiluka

Construction of the decline, interim water management pond and surface facilities were completed in 1999. During 2000, the Jabiluka site was on stand-by and environmental maintenance.

As part of the environmental impact assessment for the project, ERA investigated two milling options for the Jabiluka ore. These options are:

- Ranger Mill Alternative (RMA) whereby the ore is transported by truck to the existing Ranger mill for processing.
- The Jabiluka Mill Alternative, whereby the ore is processed in a mill to be constructed on the Jabiluka lease.

The company's preferred option is the RMA because it will have the least environmental and social impact in the region. The Northern Land Council, which negotiates on behalf of the Aboriginal Traditional Owners, advised ERA that it would not consider any proposal in relation to trucking ore from the Jabiluka mine to the Ranger mill until at least January 2005. The company subsequently reported that it would now focus on refining the best outcomes that can be delivered by developing a milling operation at Jabiluka. However, in view of continuing depressed market conditions and ERA's undertaking not to have Jabiluka and Ranger be in full production simultaneously, Jabiluka is likely to remain on stand-by and environmental maintenance for the foreseeable future.

Short-term production capability
(tonnes U/year)

2001				**2002**				**2005**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
9 400	9 400	9 400	9 400	9 400	10 300	9 400	10 300	9 400	10 300	9 400	10 300

2010				**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
8 200	11 600	8 200	11 600	8 200	11 600	8 200	11 600	8 200	11 600	8 200	11 600

Ownership structure of the uranium industry

In August 2000, Rio Tinto gained control of 68.39% of Energy Resources of Australia Ltd (ERA) through the take-over of North Ltd. As of August 2000, ERA Ltd, which is the operating company for the Ranger mine and mill and the Jabiluka project, was owned by the following companies:

Company	Percentage of issued capital controlled
Rio Tinto Limited	68.39
Other "A" class shareholders	6.51
Cameco	6.45
UG Australia Developments Pty Ltd	4.19
Interuranium Australia Pty Ltd	1.98
Cogéma Australia Pty Ltd	1.31
OKG Aktiebolag	0.54
Japan Australia Uranium Resources Development Co Ltd	10.64

The Olympic Dam project is wholly owned by WMC Limited.

The Beverley mine is wholly owned by Heathgate Resources Pty Ltd, a wholly owned subsidiary of General Atomics (USA).

Ownership of uranium production in 2000

DOMESTIC				FOREIGN				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	4 061	53.6	196	2.6	3 321	43.8	7 579	100

Employment in the uranium industry

Employment in Australia's production centres was marginally lower in 2000 but will increase in 2001 following the start-up of the Beverley mine.

Employment in existing production centres
(person-years)

1998	1999	2000	**2001** (expected)
501	565	526	596

Future production centres

Honeymoon ISL project

The resources recoverable by ISL methods for Honeymoon and nearby deposits owned by Southern Cross Resources Australia Pty Ltd are:

Deposit or prospect	Resource category	Resources (t U_3O_8)	Grade (% U_3O_8)
Honeymoon (including Honeymoon extension)	measured	3 700	0.156
East Kalkaroo	indicated	900	0.14
Goulds Dam	inferred	18 000	0.098

The Honeymoon deposit has a roll-front shape and occurs at an oxidation-reduction interface within coarse-grained sands of Tertiary age, along the lateral margins of a bend in a palaeochannel. The deposit is between 100 m and 120 m below surface.

In May 1996, the project was acquired by Southern Cross Resources Incorporated. Refurbishment of the solvent extraction plant (which was built by the previous owners) commenced in the latter part of 1997, and it was commissioned in early 1998.

In April 1998, approval was granted by the South Australian Department of Primary Industries and Resources for the company to carry out field leach trials. These used sulphuric acid and an oxidant to mobilise the uranium from the basal aquifer. The oxidants tested were oxygen gas, hydrogen peroxide and ferric sulphate [$Fe_2(SO_4)_3$]. Both solvent extraction and ion exchange (resin) techniques were investigated; however, the results obtained using solvent extraction were far superior, because the extremely high chloride content of the groundwater prevented the ion exchange process from working effectively.

Southern Cross Resources proposes to develop a commercial ISL uranium operation, based on the Honeymoon and East Kalkaroo deposits. The nominal production rate is planned to be 1000 tU_3O_8 (848 tU) per year. As noted above, uranium will be recovered in the processing plant using solvent extraction technology.

The commercial ISL operation will produce considerable quantities of liquid wastes. The various options for disposal of these liquid wastes were outlined in the draft EIS. The company's preferred method for disposal is to re-inject the liquid wastes into the Basal Sand via disposal wells. The company claims that return of these liquids to the Basal Sands will have negligible impact on the ground water because of its already high natural levels of salinity, and contamination with uranium and radium.

Salinity levels in the palaeochannel aquifer are high. Total dissolved solids (TDS) vary from 10 000 to 20 000 mg/litre with the salinity levels increasing with depth. On the basis of TDS alone, the ground water in the palaeochannel is generally not suitable for watering livestock. The TDS of the water in the Basal Sand is beyond the tolerance for stock watering. The water in the Upper Sand is generally unsuitable for stock watering and is near the upper limit for sheep on dry feed.

Formal approval of the project was announced in November 2001 following an assessment of the environmental impact statement and additional hydrogeological investigations.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Regulatory activities

Northern Territory

The Commonwealth Government has responsibility for supervising environmental management of uranium mining in the Alligator Rivers Region (ARR), which is Commonwealth land. The Ranger mine, Jabiluka mine (on care and maintenance after initial development work) and Nabarlek mine (mined out and nearing completion of remediation work) are within this region. The Northern Territory Government has responsibility for day to day regulation of mining activities, with the responsibilities determined by a suite of legislation and agreements between the two governments to minimise the environmental impacts from uranium mining.

Environmental supervision and oversight of operations in the ARR are provided by the Supervising Scientist, a statutory officer of the Commonwealth Government, who derives authority from the *Environment Protection (Alligator Rivers Region) Act*. While the Supervising Scientist is not the regulator his opinion must be sought and considered by the Northern Territory supervising authorities whenever decisions are being made in relation to potential environmental impacts of mining and milling.

The Commonwealth's Office of the Supervising Scientist (OSS), has overseen the environmental aspects of uranium mining operations in the ARR since mining commenced at Nabarlek (1979) and Ranger (1980). It is also carrying out this role in relation to the development of Jabiluka. The Supervising Scientist, supported by the Environmental Research Institute of the Supervising Scientist (ERISS), co-ordinates and supervises measures for the protection and restoration of the environment of the ARR from the effects of uranium mining. The OSS measures environmental performance at the mines, including the rehabilitation of Nabarlek, through twice-yearly audit processes.

South Australia

The South Australian Government has responsibility for regulating the Olympic Dam and Beverley projects. Olympic Dam is principally regulated under site specific South Australian State Government legislation – the *Roxby Downs (Indenture Ratification) Act 1982 as amended* (the Indenture). Beverley is regulated under a range of South Australian legislation applicable to mining, including mining of radioactive substances.

The Department of Primary Industries and Resources regulates day to day mining activities, with the Department of Human Services responsible for radiation protection issues.

Environmental impact assessment

New environment legislation

Comprehensive new national environment legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), came into effect on 16 July 2000 to improve the protection of Australia's environment and conserve its biodiversity.

The EPBC Act constitutes the most fundamental reform of Australia's environmental law since the early 1970s. The EPBC Act replaced a number of Acts including the *Environment Protection (Impact of Proposals) Act 1974* (EPIP Act) under which uranium mining projects have been previously assessed. The Act sets clear timelines for decisions and streamlines government approvals processes.

A key purpose of the environmental legislation was to provide greater certainty and transparency for State/Territory governments and key stakeholders in the operation of the legislation. The role of the Commonwealth is limited to specific situations where the proposed activity has significant implications for matters of national environmental significance (NES). NES matters include all nuclear actions, for example uranium mining projects.

Projects that commenced under former legislation (the EPIP Act), or projects that were being assessed under former legislation as of 1 July 2000, or had received agreement to assessment under former legislation prior to 1 July 2000, are not affected by the new legislation unless the activity changed significantly. The EPIP Act continues to apply to such projects, including projects undergoing assessment such as the Honeymoon uranium project in South Australia (see below).

Recent environmental impact assessment processes

Olympic Dam

The expansion of Olympic Dam project in 1999 was subject to an environmental impact assessment process involving both the Commonwealth and South Australian governments. Environmental approvals resulting from this assessment allow the project to further expand subject to no substantial change in the technology of mining practice, no change to tailings management systems and no change in water extraction from the Great Artesian Basin beyond that already approved by South Australia.

Beverley

Development of the Beverley project was approved by both the Commonwealth and South Australian governments in March 1999, following completion of a joint assessment of the Environmental Impact Statement.

As part of the assessment process the Commonwealth Environment Minister required the company to carry out further work to confirm that there is no hydraulic connection between the Beverley aquifer and other surrounding aquifers, including the Great Artesian Basin aquifer. This was necessary in order for approvals to be granted for the disposal of liquid wastes by re-injection into the Beverley aquifer.

The Bureau of Rural Sciences (BRS) was commissioned to carry out an independent assessment of the available hydrological data, including the additional work completed by the company. The BRS assessment demonstrated that the Beverley aquifer is isolated from the Great Artesian Basin aquifer and other surrounding ground water. Consequently it will be feasible to contain liquid waste in the northern part of the Beverley aquifer, where it will remain isolated from the biosphere throughout time. This option offers significant advantages over other disposal options, such as evaporation of liquids in large surface ponds.

Honeymoon

Southern Cross Resources Australia Pty Ltd (SCR) is proceeding with its proposal to develop the Honeymoon uranium project. The company plans to produce up to 1 000 tU_3O_8 (848 tU) per year using the ISL mining method. The proposal has been subject to a joint Commonwealth/South Australian environmental impact statement (EIS) process under the EPIP Act.

SCR released a draft EIS for public comment on 7 June 2000 and on 22 November 2000 released an EIS Response Supplement to address comments that were received during the public comment phase.

The draft EIS and the Response Supplement were assessed jointly by South Australian State Government agencies, and the Commonwealth Government Department of the Environment and Heritage.

In February 2001, the Commonwealth Environment Minister announced that before he could make a final decision on the proposal, further detailed information was required on the hydrology of the Honeymoon aquifers. With reference to the disposal of waste liquids by re-injection into the Basal Sands aquifer, the Minister stated that he must be confident about the characteristics of any migration of re-injected waste, and also that detrimental environmental consequences would not occur. This required further testing of aquifer boundaries, their associated ground water chemistry, and the effectiveness of monitoring wells.

For the additional work, the company was required to:

- Carry out pump tests and stratigraphic drilling to assess the hydrogeological boundaries and characteristics of the aquifer and confining beds, including any leakage between the aquifers.
- Characterise the chemical processes, which may occur in any liquid waste plume, to determine the chemical and physical changes and the probable rate of return to values comparable to the natural groundwater in the aquifer.
- Demonstrate the effectiveness of the monitoring system to detect possible excursions as a result of: ISL operations, liquid waste injection into the Basal Sand aquifer, and groundwater extraction from the Upper Sand aquifer.

Jabiluka

Assessment of the Jabiluka proposal was completed in August 1998 when environmental clearance was given to ERA's proposal to mill uranium ore at Jabiluka provided 100% of the mill tailings are placed back underground. This followed environmental clearance granted in August 1997 to ERA's preferred Jabiluka proposal to process Jabiluka ore at the Ranger mill, subject to over 70 requirements to ensure the protection of World Heritage and Ramsar values, flora and fauna and cultural heritage, including sacred sites.

The Jabiluka project has been subject to considerable scrutiny by the World Heritage Committee in view of its proximity to the Kakadu National Park. In April 1999, the Supervising Scientist's assessment of the Jabiluka project was submitted to the Committee. The overall conclusion drawn was that the natural World Heritage values of Kakadu National Park are not threatened by the development of the Jabiluka mine. An Independent Scientific Panel (ISP) was convened by the International Council of Science Unions (ICSU) at the request of the World Heritage Centre to review the Supervising Scientist's report. The ISP report was provided to the Supervising Scientist in May 1999. The Supervising Scientist provided a supplementary report to the World Heritage Centre addressing the issues raised in the ISP review.

In July 1999, UNESCO's World Heritage Committee was planning to consider whether the World Heritage values of Kakadu National Park are "in danger" as a result of the Jabiluka development. The World Heritage Committee met in July 1999, and resolved not to inscribe Kakadu as “World Heritage in danger”. In making its decision, the World Heritage Committee asked the Independent Scientific Panel (ISP) to continue to work with the Supervising Scientist and the International Union for the Conservation of Nature (IUCN) to resolve any remaining scientific issues.

The ISP visited the region accompanied by a representative from the IUCN in July 2000. When the ISP reported back to the World Heritage Bureau it found that the Supervising Scientist had identified and analysed with a high degree of certainty all the principal risks to the natural values of the Kakadu World Heritage site, that these risks have been shown to be very small or negligible, and that the development of the Jabiluka Mill Alternative should not threaten the natural World Heritage values of Kakadu National Park. The World Heritage Committee when it met in November 2000, decided that the mine and mill proposal at Jabiluka does not threaten the natural values of Kakadu National Park.

Monitoring

Ranger

The Ranger mine remains the only operating mine in the Northern Territory. The Nabarlek mine ceased production in 1988 and is currently in the final stages of rehabilitation. The long-term issues of final revegetation development and monitoring and site stewardship have yet to be resolved. Environmental monitoring of the site is continuing, being carried out by the Northern Territory Department of Mines and Energy (NTDME).

The environmental monitoring programme at Ranger is one of the most comprehensive in the world. The company sets out the programme it wishes to implement as an application under the authorisation process described above. The final programme covers routine sampling of surface and ground waters at fixed locations with the analytical programme tuned to the circumstances of the site. For example, bores may be designated primary, tertiary or secondary depending on their location in relation to any known or anticipated seepage plume or contaminant front. Also included in the routine programme are air quality and radiological sampling, soil sampling and vegetation assessment in irrigation areas used for mine water disposal, and creek side biological monitoring during the wet season when creeks are flowing. Additional elements of the programme are event related and include specific chemical and biological programmes associated with water releases from on-site containments. The final programme, including sampling locations and frequencies and analytical programmes, is set down in the authorisation to operate.

Jabiluka

The Jabiluka project site and lease area are subject to an intensive monitoring programme. The programme has been developed by the company in discussion with the major stakeholders and is set down in an Authorisation issued by the Northern Territory Minister under the provisions of the *Uranium Mining (Environment Control) Act.* To date, there has been no evidence of adverse impact away from the project site.

Australia

Olympic Dam

The Indenture requires the operator (WMC Ltd) to draft and implement an Environmental Management Programme which must be revised and submitted for State Government approval every three years. Since mid-1998, WMC has implemented a new ISO 14001 compliant Environmental Management System following its approval by the South Australian Government. This system is documented in an Environmental Management Manual (EMM) and seven Environmental Management Programmes (EMPs) that focus on those aspects and impacts associated with the project which have most risk of causing environmental degradation, including groundwater, tailings management and radiation. The current EMM has been approved to operate for the three years to 28 February 2002, while the EMPs are reviewed and issued annually following government approval.

WMC submits a publicly available annual environment report on activities covered by each EMP. No major issues were identified in the report released for the year ended 28 February 2000.

Since 1996, WMC's environmental management and monitoring arrangements have also been subject to independent annual auditing. To date, none of these audits has identified any significant omissions or variations in methodology that might result in significantly increased environmental risk.

Beverley

Before operations commenced at Beverley the company was required to submit and obtain approval of a three year Environmental Management and Monitoring Plan (EMMP). The Plan, approved by the South Australian Government in November 2000, encompasses comprehensive monitoring of surface hydrology, hydrogeology, vegetation and general landscape, radiation and airborne emissions, meteorology and waste management. The Plan also provides for triennial independent audits of the environmental programme.

Monitoring results will be reported in a publicly available annual environmental report. The first annual report will report on results for calendar 2001.

Tailings impoundment

Ranger

A prime environmental requirement for all uranium mines in the ARR is that tailings are returned to a repository below ground level at the end of operations. In the case of Ranger this will be the mined-out pits No. 1 and No. 3. When milling began at Ranger in 1980, tailings were deposited into a purpose built tailings dam located about 1 km west of the mill. The dam was built to be a water retaining structure, with a rolled clay core surrounded by graded filter zones, and subject to all the statutory design and performance requirements and legal obligations for such structures. The dam is approximately 1 km square and has been extended in height in four stages; the last phase lifted the crest of the core to an elevation 44.5 m above sea level but only about 25 m above ground level. Tailings were deposited sub-aqueously initially as a radon emanation reduction measure. This practice ceased after trials in 1986 showed that the same level of radon control could be obtained from keeping the tailings moist. Thus sub-aerial deposition was practised until the completion of mining in Pit No. 1 in 1996. Approximately 18 million m^3 of tailings were placed in the dam. Sub-aerial deposition resulted in better settled density, less separation of finer particles and a more uniform material in the dam.

Once pit No. 1 had been prepared as a tailings repository, deposition was transferred to that location. Initially the system was sub-aqueous deposition from a series of spigots around the perimeter of the pit, but in a few months beaches began to form and could be seen above the decant pond. Unfortunately, a succession of above-average, wet-seasons have resulted in an accumulation of excess water in the pit and deposition is now essentially sub-aqueous again. However, in 1999, a trial was begun to examine use of a central deposition method using a discharge line on a pontoon. This was successful and is now the only tailings deposition technique in use. To try and improve settled density of tailings in No. 1 pit the company has conducted trials on various thickened paste technologies but, as yet, none has been proven good enough to adopt.

In preparation for the relocation of tailings at the time of the mine's final rehabilitation a trial relocation of 1 million m^3 was undertaken in 1999 using a suction cutter dredge floating on the decant pond in the dam and piping the slurry to pit No. 1. While the physical transfer of tailings was successful the method proved inadequate for final use as being too slow and leading to settled densities in the pit which only just met the regulatory minimum of 1.2 t per m^3. As a result the company has abandoned plans to use dredges and is currently looking at a truck and shovel option as the method to use. Studies will continue.

Jabiluka

It has been proposed that should mining and milling take place on the Jabiluka site all tailings will be contained underground primarily as cemented backfill to stopes and all remaining tailings would be placed in special silos, custom built in the inert sandstone located above the mineralised host rock. The use of thickened paste tailings for both these later activities is being investigated.

Olympic Dam

Tailings impoundment at Olympic Dam has increased significantly following completion in 1999 of a major expansion to the project that has increased production of copper from 85 000 tpa to over 200 000 tpa, plus production of associated uranium, gold and silver. Tailings production has increased from 2.7 million tpa to over 7 million tpa.

The course fraction of tailings is used in backfilling underground. The retention system for fine tailings continues to use the traditional paddock method, with an additional two tailings cells constructed to contain the increased tails production from the project's expansion. The paddocks now cover an area of about 360 ha and are supplemented by four evaporation ponds used for evaporation of tailings liquor.

Waste rock management

Ranger

Waste rock at Ranger is stockpiled in seven classes based on the degree of uranium mineralisation. Clean waste is that rock containing less than 0.02% U_3O_8 by weight; all rocks with higher levels of mineralisation are required to be managed in such a manner that run-off cannot pass directly to the offsite environment. Waste is stockpiled in separate dumps according to grade in order to facilitate mixing of intermediate grades for blending into the mill and to allow lower grades to be placed directly for later incorporation into the final rehabilitated land form. All waste other than clean waste must be covered in rehabilitation works to reduce radon emanations. The present procedure is to place 1 m of clean waste over low-grade mineralised material (between 0.02 and 0.12% U_3O_8); the rock is placed in 2 nominal 500 mm layers. The first is compacted by the passage of machinery. The second is ripped to improve water and air infiltration and so improve the conditions for plant growth.

Jabiluka

Clean waste rock is defined as rock containing less than 0.02% U_3O_8 and is at present all Kombolgie sandstone. This material is stockpiled within the fenced project area and precautions are taken to ensure that any sediment developed by weathering and carried away by runoff is trapped on the site. All rock excavated from below the unconformity at the base of the sandstone has been treated as mineralised material. The rocks are predominantly schists, which along with uranium mineralisation contain varying, but small amounts, of reactive sulphides and thus present a potential threat in terms of generating acid drainage. Both these types of wastes have been stored on a custom-built pad. The pad has been built with a double skin lined base and an under drainage system that drains to the interim water management pond (IWMP), a no-release containment. The rock pile has been covered with a cover made from heavy duty plastic material. This is so that rainfall will not run-off or infiltrate the pile and so lead to possible weathering products or contaminated water moving to other parts of the site. The cover has been custom built to withstand severe weather events, up to gale force.

Olympic Dam

There are two separate sets of ore and waste rock (mullock) handling facilities: those associated with the Whenan Shaft and those associated with the Robinson Shaft. Waste rock is crushed separately underground. This is then hoisted to the surface via waste rock skips in the shafts. On reaching the surface, the waste rock is carried by truck to the back-fill plant or to the waste rock stockpile.

After final extraction of the primary stopes is complete, the stopes are backfilled with cemented aggregate fill (CAF). CAF consists of crushed waste rock and mill tailings with the addition of Portland cement. Backfill is introduced directly into the stope from the surface through 300 mm diameter boreholes.

Effluent management

Ranger

Runoff and seepage from all stockpiles other than clean waste has to be contained on site until it can be discharged in a controlled manner. Approved strategies include spray irrigation onto bushland plots within the lease area; polishing of water by passage through a constructed wetland filter prior to irrigation or direct discharge to a creek under controlled conditions of flow and after appropriate pre-release testing based on both biological and chemical tests. All run off waters are passed through some form of containment or sediment trap to reduce sediment movement off site.

Jabiluka

Run-off water from clean waste rock is passed through silt control fences and structures before discharging to natural water courses. Run-off from undisturbed areas of bushland within the project area is similarly allowed to discharge to water courses. Underground seepage into the workings and run-off from areas where contamination from mineralised material could occur is contained in the interim water management pond (IWMP). The water management system in place is the one approved for the first phase of construction. As the project has been placed on a care and maintenance footing, the system has had to be adapted to be capable of accommodating the rainfall associated with a wet season having a return period of 10 000 years. During the wet season only surface run-off is allowed to enter the IWMP. Underground seepage remains in the workings. When the level of the IWMP reaches the authorised maximum operating level excess water can be pumped underground. This water is disposed of by treatment through a Reverse Osmosis plant and then being used to irrigate revegetation areas within the project boundary fence. None of this water is permitted to run-off from the site.

Olympic Dam

In contrast to Ranger and Jabiluka, Olympic Dam is located in an arid region. The high cost of water creates a strong incentive to minimise water use and, wherever possible, all process wastewater is recycled in the process plant to recover valuable mineral constituents and reduce water consumption. Stormwater collected in the bunded parts of the metallurgical plant continue to be recovered and pumped into the process water system. Stormwater run-off from other impervious areas within the plant is directed to unlined sumps and allowed to infiltrate and evaporate. Collection and use of this water is undertaken following major rain events, although this is infrequent owing to the low level of rainfall in the region.

Site rehabilitation

Ranger

When mining and milling are complete the Ranger site will be rehabilitated so that it may be incorporated into the surrounding Kakadu National Park without requiring it to be managed in a manner significantly different from the main Park. Throughout the life of the mine progressive rehabilitation has been encouraged by the authorities. Although the final details of the engineering design criteria, and hence the final land form, have yet to be finalised the goal and objectives of rehabilitation in terms of vegetation, radiological and erosion considerations have been agreed between all the major stakeholders. The area rehabilitated each year at the site has varied between 1 and 10 ha according to operational conditions. Some areas are now more than 10 years old and provide valuable data on the success of both revegetation techniques as well as assessment philosophies.

Jabiluka

All areas that were cleared in Jabiluka’s initial construction phase but are no longer needed for operational purposes have been revegetated using natural species endemic to the area. The establishment of the vegetation has been helped by the availability of irrigation water from the reverse osmosis plant. All non-essential buildings, equipment and personnel have been removed from the site and ground disturbance is minimised.

Olympic Dam

A decommissioning plan for the project area has not yet been developed because of the very long operational life of the project and the desirability of including in the plan the results of ongoing research into rehabilitation procedures.

Beverley

Rehabilitation of the Beverley mine will be a continuing process and will commence as soon as possible after ISL operations in each area are completed. Interim and final closure criteria in relation to long-term rehabilitation will be developed in consultation with the appropriate State authorities.

Social and/or cultural issues

Ranger is located on a project area granted under the *Atomic Energy Act* that forms a "window" wholly surrounded by the World Heritage listed Kakadu National Park. For this reason it is vital that the mine should have no adverse environmental impact off site that could lead to damage outside the project area. Also the land belongs to Traditional Aboriginal Owners and is held under Native Title. All actions on the lease are undertaken with the knowledge of the Traditional Owners.

An evaluation of the social and cultural impacts of Ranger was included in the Kakadu Regional Social Impact Study which was carried out in connection with the proposed development of the Jabiluka uranium mine project. The study was completed in 1997 and the final reports made a substantial number of recommendations for activities in the fields of education, employment, housing, business development, health, sport and recreation. The reports also put forward suggestions for the development of a women's resource centre as well as discussing considerations of the economic and political future for the Aboriginal people of the area as well as for the town of Jabiru. Various local and national organisations have created appropriate committees and working groups to implement the recommendations. Some success has already been achieved, in particular the establishment of an Aboriginal Health Service and provision of funds for relevant programmes at the Jabiru Area School. A status report on outcomes was published in June 2000.

Olympic Dam

WMC has implemented an Indigenous Peoples Policy with employment throughout Australia (including at Olympic Dam) of Community Relations Officers who are responsible for ensuring ongoing community relations. In accordance with this policy, WMC has actively entered into consultation about Aboriginal heritage with all native title claimant groups and other relevant Aboriginal groups. It is the company's policy to avoid all ethnographic sites and to avoid disturbing archaeological sites whenever possible.

Beverley

Before developing Beverley, Heathgate Resources finalised mining agreements with a number of Aboriginal claimants who had lodged native title claims encompassing the Beverley project area. Under these agreements, Heathgate is committed to make grants and royalty payments, endeavour to achieve at least 20% Aboriginal employment among the Beverley workforce and train all Heathgate employees and contractors in Aboriginal culture and heritage. The total amount paid to Aboriginal communities had reached almost USD 400 000 by early 2001 and the Aboriginal employment target was being met.

The approved Environmental Management and Monitoring Plan provides that site clearances (if required) of areas of Aboriginal significance will be undertaken by representatives of Native Title Claimants. All heritage clearances will be done in accordance with South Australian and Commonwealth legislation relating to Aboriginal heritage.

URANIUM REQUIREMENTS

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

NATIONAL POLICIES RELATING TO URANIUM

Following its election in March 1996, the Liberal/National Coalition Government removed the former Government's policy which restricted the development of new uranium mines in Australia (i.e. the "three mines" policy). The current government's policy is to approve new uranium mines and exports subject to strict environmental, heritage and nuclear safeguards requirements being met. Where Aboriginal interests are involved, the Government is committed to ensuring full consultation with the affected Aboriginal communities.

Uranium export contracts remain subject to Government approval but are no longer scrutinised for pricing purposes.

In November 1996, the Government announced that, following removal of the "three mines" policy, the foreign investment policy applying to the mining sector generally would also now apply to the uranium sector. This means that foreign investment above the notification thresholds in the uranium sector will be subject to a "national interest" test and that no special investment restrictions will apply. The establishment of a new uranium mine involving investment of AUD 10 million or more, or the acquisition of substantial interest in an existing uranium mine valued at AUD 5 million or more require prior approval and no objections will be raised unless the proposal is considered contrary to the national interest. No significant changes have occurred in the last two years.

URANIUM STOCKS

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

URANIUM PRICES

Average annual export prices for Australian uranium have been:

Year	**Average annual export price** (AUD/kgU)
1990	61.08
1991	71.01
1992	57.43
1993	60.28
1994	53.06
1995	55.74
1996	53.96
1997	48.93
1998	57.28
1999	54.32
2000	57.37

• Belgium •

URANIUM EXPLORATION

Historical review

Until 1977, just a few uranium occurrences were known in Belgium. These were mainly connected with black shales of the Upper Visean-Namurian, in the Dinant Basin, and of the Revinian, in the Stavelot mountains, and also with breccia, in Visean and Frasnian chalk, in the Visé mountains.

From 1977 to 1979, there was renewed interest in uranium exploration, leading to a study of the uranium occurrences in the Visé mountains and a study on the uranium content of the phosphates in Cretaceous formations in the Mons Basin.

From 1979 to 1981, the European Communities and the Ministry of Economic Affairs financed a general reconnaissance survey for uranium in the areas of Paleozoic formations in Belgium. The Geological Service co-ordinated three types of exploration, covering an area of approximately 11 000 km^2: carborne radiometric survey, geochemical survey on alluvial deposits, and hydrogeochemical survey. The Belgian universities of Mons, Louvain (UCL), and Brussels (ULB), respectively, were entrusted with the work. The general report was published in 1983.

From 1981 to 1985, this research was conducted chiefly at the Mons Laboratory, with the aim of studying the geological environment of the main anomalies discovered in the course of general exploration (Visean-Namurian and Lower Devonian).

From 1985 to 1988, an exploration programme financed by the Underground Resources Service (Walloon Region) led to the discovery of anomalies and deposits (over 1% uranium equivalent at certain points) in schistose sandstone formations of the Lower Devonian and surface formations in Upper Ardenne.

Strategic and tactical uranium exploration was pursued in the Lower Devonian, in the Belgian Ardenne and on the basis of isolated anomalies discovered during preliminary carborne prospecting. This project was jointly financed by the EEC and the Geological Service of Belgium, during 1979-1982. Different geochemical and geophysical methods were used (radon in spring water, ground radon survey, gamma spectrometry) for indications discovered during the second phase, as well as trenching and shallow drilling (about 10 m). Deeper core sampling and drill hole-logging surveys were conducted on a regional basis by the Geological Service.

Currently, it is estimated that none of the areas investigated are of economic interest. Although the occurrences are numerous and varied, the uranium content of each indication showing more than 100 ppm amounts to less than one tonne.

The uranium content of phosphates in the Mons Basin has also been evaluated, and a new estimate of the P_2O_5 resources in the Basin put unconventional uranium resources at approximately 40 000 tU. This includes approximately 2 000 tU of resources in areas suitable for phosphate mining, although the contents are below 10% P_2O_5 and 100 ppm uranium equivalent.

URANIUM RESOURCES

Belgium has no known conventional resources (RAR & EAR-I). No undiscovered conventional resources (EAR-II & SR) have been identified.

URANIUM PRODUCTION

In September 1998, Prayon-Rupel Technologies decided to stop recovering uranium from imported phosphates. Since 1999, the facility is in the process of being decontaminated and dismantled. The work is expected to be terminated at the end of June 2001.

Historical uranium production (tonnes U)

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Other methods e.g. mine water treatment, environmental restoration.	671	15	0	0	686	0
Total	671	15	0	0	686	0

Uranium production centre technical details
(as of 1 January 2001)

Name of production centre	PRT
Production centre class	existing
Operational status	decommissioning
Start-up date	1980
Source of ore: • Deposit name • Deposit type	phosphates from Morocco
Mining operation: • Type (OP/UG/*in situ*) • Size (tonnes ore/year) • Average mining recovery (%)	none
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/year) • Average processing ore recovery (%)	DEPA-TOPO Process 130 000 TP_2O_5/year
Nominal production capacity (tU/year)	45
Plans for expansion	none

Ownership structure of the uranium industry

The 45 tonnes of uranium production capacity is 100% owned by PRAYON RUPEL TECHNOLOGIES (PRT), a private company. All uranium production is sold to SYNATOM, the Belgian nuclear fuel cycle company.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
6	6	5	5*

* Until the end of June 2001, corresponding to the end of the decontamination and dismantling activities by PRT.

Future production centres

No new uranium production capability is currently foreseen in Belgium over the 1999-2020 period.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

The installed nuclear generating capacity in Belgium is unchanged at 5 713 MWe (net). There was no change in uranium requirements as well as no change in the supply and procurement strategy.

Installed nuclear generating capacity to 2020
(MWe net)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
5 713	5 713	5 713	5 713	5 713	5 713	5 713	3 966*	5 713*

* Secretariat estimate.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 050	1 050	1 050	1 050	1 050	1 050	1 050	730*	1 050*

* Secretariat estimate.

NATIONAL POLICIES RELATED TO URANIUM

None reported.

Information on uranium stocks and on uranium prices are not available for reasons of confidentiality.

• Brazil •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Systematic prospecting for radioactive minerals began in 1952 by the Brazilian National Research Council. 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 US Government to assess the Brazilian uranium potential. After the creation of the National Nuclear Energy Commission (CNEN) a mineral exploration department was organised with the support of the French CEA in 1962.

In the 1970s, CNEN's exploration for radioactive minerals increased due to the availability of more 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 in 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 an increase of NUCLEBRAS's 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, INB’s uranium exploration activities came to a halt according to the Brazilian nuclear development programme reorganisation of 1988.

Recent and ongoing uranium exploration and mine development activities

After the Brazilian nuclear programme reorganisation in 1988, uranium activities were entrusted to “Urânio do Brasil S.A.”, the subsidiary to the holding company Industrias Nucleares do Brasil – INB, responsible for the nuclear fuel cycle activities. Following the 1994 reorganisation Urânio do Brasil activities were transferred to INB.

In 1995, feasibility studies for the mining project Lagoa Real were initiated and completed in 1996. Lagoa Real began operations in mid-2000.

Since 1991, no uranium exploration programme has been carried out and the total expenditure of the Brazilian exploration programme since NUCLEBRAS is estimated at about USD 150 million.

URANIUM RESOURCES

Brazil's conventional known and undiscovered 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 (metasomatic).
- Lagoa Real, Espinharas and Campos Belos (metasomatic-albititic).
- Others including the Quadrilátero Ferrifero with the Gandarela and Serra des Gaivotas deposits (quartz pebble conglomerate).

Known conventional uranium resources (RAR & EAR-I)

Brazil's reported known conventional resources were estimated prior to 1992. As of 1 January 2001, the known resources of Brazil total 262 200 tU as *in situ* resources recoverable at below USD 80/kgU. Of this total, 162 000 tU are RAR recoverable at costs below USD 80/kgU of which in turn 56 100 tU belong to the below USD 40/kgU cost category. The remaining 100 200 tU are EAR-I recoverable at costs below USD 80/kgU.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
56 100	162 000	162 000

* As *in situ* resources.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	100 200	100 200

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

The estimates of undiscovered resources, which remain unchanged since 1992, are summarised in the following tables.

Estimated additional resources – Category II*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	120 000	120 000

* As *in situ* resources.

Speculative resources*
(tonnes U)

Cost range	Cost range	Total
<USD 130/kg U	Unassigned	
0	500 000	500 000

* As *in situ* resources.

URANIUM PRODUCTION

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 liquidated and its assets transferred to Urânio do Brasil S.A. With the dissolution of Urânio do Brasil in 1994, the ownership of uranium production is 100% controlled by Industrias Núcleares do Brasil S.A (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 2 years on stand-by the Poços de Caldas production centre was shut down in 1997. A decommissioning programme started in 1998.

Under INB management, the Lagoa Real production centre began operations in mid-2000. Nominal capacity is expected to be reached in 2001.

Historical uranium production (tonnes U)

	Pre-1998	1998	1999	2000	Total through 2000	2001 (expected)
Processing plant	1 030	0	0	0	1 030	0
Heap leaching	0	0	0	80	80	250
Total	1 030	0	0	80	1 110	250

Status of production capability

After the closure of the Poços de Caldas centre in 1997, production at Lagoa Real started in 1999.

Ownership structure of the uranium industry

The Brazilian uranium industry is 100% government-owned, through the state-owned company Industrias Nucleares do Brasil – INB. This company controls the Lagoa Real operating facilities, referred to as Uranium Concentrate Unit, and is managing the decommissioning of mining areas in the Poços de Caldas Unit. Studies are being carried out to develop other uses for its industrial facilities.

Uranium production centre technical details
(as of 1 January 2001)

Name of production centre	Poços de Caldas	Lagoa Real	Itataia
Production centre class	existing	existing	planned
Operational status	shutdown	in operation	feasibility
Start-up date	1981	1999	NA
Source of ore: • Deposit names • Deposit types • Reserves (active resources) • Grade (% U)	Cercado Mine Collapse Breccia Pipe	Cachoeira Quebradas Metasomatic 12 700 tU 0.26% U	Itataia Phosphorite 67 700 tU 0.08% U
Mining operation: • Type • Size (tonnes ore/day) Average mining recovery (%)		OP 1 000 90	OP NA 50
Processing Plant (Acid/Alkaline): • Type (IX/SX/AL) • Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour) Average process recovery (%)	AL/SX 25 000 80	AL/SX 1 000 80	Flot./AL/SX NA 70
Nominal production capacity (tU/year)	425	250	325
Plans for expansion	no	yes	NA
Other remarks	closed 1997	started up in 2000	by product

Employment in the uranium industry

The Lagoa Real Production Centre is using expert personal from the Poços de Caldas Unit.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
180	110	110	110

Future production centres

In the planned Itataia production centre, uranium would be recovered as a by-product together with phosphate from apatite and collophanite bearing episyenites. Development of the uranium-phosphate Itataia project will depend on numerous factors including the markets for both products. A production startup date has not been set. A projection of production capability through the year 2020 is shown in the following table.

Short-term production capability
(tonnes U/year)

2001				**2002**				**2005**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
250	250	250	250	250	250	250	250	340	665	340	665

2010				**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	665	340	665	340	665	340	665	340	665	340	665

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Government Policies and Regulations

Government policies and regulations pertaining to nuclear energy are established by *Comissão Nacional de Energia Nuclear* – CNEN (National Commission for Nuclear Energy). General regulations are provided in *Diretrizes Básicas de Radioproteção* (Radioprotection Basic Directives) – NE-3.01 – date 1 August 1988 and a specific regulation about tailings ponds decommissioning: *Segurança de Sistema de Barragem de Rejeito Contendo Radionuclídeos* (Safety of Radionuclide Bearing Tailings Pond Systems) – Ne-1.10 – dated 27 November 1980.

In the absence of specific regulations, ICRP and IAEA recommendations are used.

Poços de Caldas

The Poços de Caldas Mining and Industrial Complex (CIPC) is located in the district of Caldas in the southwest of the Minas Gerais state. Prior to the recent start up of the Lagoa Real production centre, it was the only facility in Brazil owned by Indústrias Nucleares do Brasil S.A. (INB), engaged in the production of uranium concentrate (yellowcake) in the form of ammonium diuranate (ADU).

The mine is an open pit with a surface diameter of 1 000 m and an average depth of 120 m. Some 47×10^6 m^3 of overburden, ore and waste have been mined from the pit.

About 10×10^6 m^3 of the overburden material was used in embankment structures for several CIPC installations and civil engineering works, and the rest of the removed material was deposited in two pre-selected areas both having an area of about 2.0×10^6 m^2.

Brazil

Uranium mining activities between 1982 and 1996 generated about 45×10^6 m^3 of waste rock. This material is characterised by soluble uranium below 200 ppm U_3O_8 which was discarded over a total of 172 ha of natural land. Among the five waste rock piles (WRP) formed, two of these, named 4 and 8 are considered of major environmental importance because of their large volume of acid drainage. This acidification is promoted by the oxidation of pyrite. The remaining waste rock is disposed of in different areas, designed for this purpose, around the mine pit, and in the period from 1993 until 1996, the waste rock has been stored inside the mine pit.

Pile 4 contains 12.4×10^6 m^3 of waste rock and mine scouring material distributed over a surface area of 0.57 km^2 with a maximum embankment height of 90 m. These waste rocks came mostly from mining of the "B-ore body", which was basically contained within a mass of breccia in a pipe configuration, which originated from the syenitic intrusion commonly seen in the mine area. The matrix exhibited a tinguaite texture impregnated by hydrothermal materials like pyrite, fluorite, uranium minerals, molybdenum and zirconium, and minor amounts of galena, sphalerite and barite. Kaolin frequently fills the fractures or is disseminated into porous zones of breccias. The uranium present in the matrix was either of primary origin linked to ascendant hydrothermal processes that permeated the breccia body or from secondary reconcentration due to the action of redox processes.

The mill, when in full operation, processed 2 500 t of ore per day and the solid and liquid tailings were routed to a waste pond system where approximately 2.0×10^6 m^3 (2.2×10^6 t) of solid wastes are contained with an estimation of an additional 120×10^3 m^3 to be disposed of. The upper surface of the tailing pond is about 200×10^3 m^2.

Since the beginning of operations in 1982, control actions have been undertaken to minimise the environmental impact of these piles, as follows:

- The annual average volume of waters chemically treated is about 900×10^3 m^3.
- In 1994, about 2.0×10^6 m^3 of acid drainage water were treated requiring USD 610 000 for operational costs. Although the tailings management system has been considered effective, INB has been searching for a long-term solution for the mine pit, WRPs, and tailings disposal pond.
- The search for adequate disposal sites was primarily focused on substrate stability followed by economical considerations based upon distance and topography. Pile 4 was constructed over the Consulta Creek valley in an area near the mine pit, since geological and geotechnical features assessed by field examination have not shown instabilities or possibility of embankment rupture. Turf or soft soil is not present along the banks of the creek and its tributaries. The valley is formed exclusively by a continuous surface of saprolite, an altered soil derived from hard, highly resistant alkaline rocks. Over this surface lies a 0.3 m thick layer of limonitic gravels, clay and sand.
- Before filling the valley with the waste rock, deep drains were constructed of waste rocks covered by transition material and clays on the bottom surface for water drainage. To ensure the physical stabilisation of the deposit and reduction of alteration in the Consulta waters, about 500 m of the creek watercourse lying inside the area of the waste rock deposition was diverted to a downstream point. The pile surface was lined with a 30-cm layer of compacted clay to prevent rainwater from percolating through the waste rocks. Final pile slope ranged from 0.5 to 1%, with pluvial waters flowing down this platform being conveyed to the environment through drainage channels. Alternatives for reforestation have been under experimentation in order to stabilise the deposit to protect against wind and rain erosion and, to a certain degree, against the penetration of humidity into the waste rock pile.

- Monitoring of the Consulta waters showed a significant increase of uranium and more stable elements leached by waters draining from the waste rock pile. These waters are usually acidified by the oxidation of pyrites found in the waste rocks, having the following radiological and chemical characteristics: ^{226}Ra=0.30, ^{228}Ra=0.20, ^{238}U=79.3 in ($Bq.l^{-1}$), and Mn=80, Al=170, Fe=2.1, Ca=95, SO_4=1300, F=100 in (mg. l^{-1}), and pH=3.5.
- Permissible limits for water to be released into the environment at the monitoring site are ^{226}Ra=1.0, ^{228}Ra=1.0, ^{238}U=1.0, in (Bq. l^{-1}) and Mn=1.0, Al=0.2, F=1.4 in ($mg.l^{-1}$). It follows that a drastic reduction of U, Mn, Al, and F content is necessary, which has been accomplished by piping such waters to the lime treatment station. The precipitated solids go either to the chemical processing plant or to the tailings pond, while the overflow liquid is sent to the solid settling ponds before being discharged into the environment.

The main objective of this study is to determine the chemical characterisation of CIPC waste rock piles, one of the most important pieces of information related to the final stabilisation, in such a way that the treatment of effluents can be minimised in the future.

The goal of the Environmental Protection and Control Programme of the Poços de Caldas area is stabilisation of potential pollutant areas, reintegrating them into their original land-forms or adjusting them to other forms of land reclamation.

Lagoa Real/Caetité Unit

Decommissioning has been an important consideration in planning and designing the Lagoa Real Project. Several courses of action have already been devised for the enterprise.

Flooding the pit by diverting Cachoeira Creek to its original watercourse will provide for restoration of the mine area. Pit levels above the waterline will be covered with vegetation. Revegetation of the embankments and areas of the pit will be performed following the end of the mining operations in each specific area.

The waste rock piles and solid wastes (leached ore) will be covered with an impermeable compacted clay layer and vegetation.

The leaching facilities include two distinct areas: the ore heaps and uranium leachate basins. Regarding the heaps, the first action will be the removal of the protective layer and dumping it in the waste rock piles. All the surface area will be monitored and if values above background are found it will be covered with inert material followed by a layer of organic soil and followed in turn by revegetation. The leachate basins will be drained and the liquid will be treated with lime, sent to the liquid effluent basins and covered with inert, organic soil and vegetation.

Decommissioning of the containment basins will follow the same procedures as for the leachate basins.

The other units, buildings, structures and equipment will be catalogued, monitored, decontaminated and assessed for alternative uses.

For the production phase, an Operational Environmental and Radiological Monitoring Programme has been carried out since 1990.

URANIUM REQUIREMENTS

Brazil's present uranium requirements for the Angra I nuclear power plant, a 630 MWe PWR, are about 120 tU/year. With the completion and start-up of the Angra II nuclear power plant halfway through 2000, a 1 245 MWe PWR, the uranium requirements increased by 310 tU/year after the first core. In addition, start-up of Angra III (similar to the Angra II nuclear power plant) operation is expected around 2004.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 875	1 875	3 120	3 120	3 120	3 120	3 120	1 855*	8 000*

* Secretariat estimate.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
450	450	1 040	470	810	470	810	460*	1 980*

* Secretariat estimate.

NATIONAL POLICIES RELATING TO URANIUM

After the total implementation of the Caetité/Lagoa Real centre, INB's focus is turning to the Itataia deposits in Ceará State. Although this is the largest uranium reserve in Brazil, at the moment mining activities are economically dependent on exploitation of the associated phosphate. This means that although uranium extraction is considered to be in the low-cost category, project viability is dependent on the production of phosphoric acid. These activities are thus dependent on setting up partnerships with private enterprise interested in this market.

There is a co-operation agreement between INB and a Brazilian mining industry to process concentrates of tantalite/columbite minerals, and to produce uranium concentrate as a by-product. The uranium resources associated with tantalite/columbite concentrate are not included in the resources Brazil reports for the Red Book.

Brazil, through INB, is interested in joint venture projects with national or international partners in order to participate in the uranium global market. Some international uranium producers are studying data about the deposits at Rio Cristalino (State of Pará), and other areas, in order to initiate a commercial agreement.

URANIUM STOCKS

Total uranium stocks
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	81	0	0	0	81
Total	81	0	0	0	81

URANIUM PRICES

None reported.

• Canada •

URANIUM EXPLORATION

Historical review

Uranium exploration in Canada began in 1942, with the focus of activity traceable through several distinct phases from Great Bear Lake, Northwest Territories, to Beaverlodge, Saskatchewan, to Blind River/Elliot Lake, Ontario, and back to Saskatchewan's Athabasca Basin in the late 1960s. These latter two areas have been Canada's most prolific, supporting all domestic uranium production until the closure of the Stanleigh mine at the end of June 1996. Following this closure, that brought to an end over 40 years of uranium production in the Elliot Lake area of Ontario, Saskatchewan is Canada's sole producer of uranium.

Recent and ongoing activities

As in previous years, uranium exploration remains concentrated in areas favourable for the occurrence of deposits associated with Proterozoic unconformities, most notably in the Athabasca Basin of Saskatchewan, but also in the Thelon Basin of Nunavut.

In 2000, overall Canadian uranium exploration expenditures amounted to about USD 31 million, while uranium exploration and surface development drilling amounted to 77 000 m, down from about 89 000 m in 1999. As in recent years, most of the overall exploration expenditures can be attributed to advanced underground exploration, deposit appraisal activities, and care and maintenance expenditures associated with those Saskatchewan projects awaiting production approvals. Basic "grass roots" uranium exploration, therefore, likely reached USD 12 million in 2000, up from about USD 9.5 million in 1999. In recent years, the number of companies with major exploration programmes in Canada has declined.

Well over 90% of the combined exploration and surface development drilling in 1999 and 2000 took place in Saskatchewan. In 2001, total combined uranium drilling is expected to decline to about 70 000 m.

The top three operators, accounting for nearly all of the USD 31 million expended in 2000 were: Cameco Corporation, Cigar Lake Mining Corporation and Cogéma Resources Inc. Expenditures by Cogéma Resources Inc. include those of Urangesellschaft Canada Limited.

Uranium exploration continues in essentially the same areas as in the recent past, with geophysical and geochemical surveys and surface drilling focussed on the extensions of mineralised zones, and on deeper targets in frontier areas of Saskatchewan's Athabasca Basin. Similarly, in Nunavut, exploration was carried out on the Kiggavik Trend and along the western edge and northeastern portion of the Thelon Basin.

Uranium exploration and development expenditures and drilling effort – domestic
(CAD million)

	1998	**1999**	**2000**	**2001** (expected)
Industry exploration expenditures	22	14	18	18
Government exploration expenditures	<0.1	<0.1	<0.1	<0.1
SUBTOTAL Exploration expenditure	22	14	18	18
SUBTOTAL Development expenditures	38	35	28	5
TOTAL EXPENDITURES (CAD million)	60	49	46	23
TOTAL EXPENDITURES (USD million)	41	33	31	15
Industry exploration drilling (m)	89 000	86 000	76 000	69 000
Number of industry exploration holes drilled	NA	NA	NA	NA
Government exploration drilling (m)	0	0	0	0
Number of government exploration holes drilled	0	0	0	0
SUBTOTAL Exploration drilling	89 000	86 000	76 000	69 000
SUBTOTAL Exploration holes	NA	NA	NA	NA
SUBTOTAL Development drilling	6 000	3 000	1 000	1 000
SUBTOTAL Development holes	NA	NA	NA	NA
TOTAL DRILLING (m)	95 000	89 000	77 000	70 000
TOTAL NUMBER OF HOLES	NA	NA	NA	NA

Uranium exploration and development expenditures – abroad
(CAD million)

	1998	**1999**	**2000**	**2001** (expected)
Industry exploration expenditures	4	4	5.5	5
Government exploration expenditures	0	0	0	0
SUBTOTAL Exploration expenditures	4	4	5.5	5
SUBTOTAL Development expenditures	0	0	0	0
TOTAL EXPENDITURES (CAD million)	4	4	5.5	5
TOTAL EXPENDITURES (USD million)	3	3	4	3

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

As of 1 January 2001, Canada's total known uranium resources (i.e., recoverable at a cost of USD 80/kgU or less) amounted to about 437 000 tU, compared to 417 000 tU as of 1 January 2000. This upward adjustment of almost 5% is mainly due to McArthur River resources that, as a result of an extensive underground drilling programme, were increased by over 50%. As of 1 January 2001, uranium resources recoverable at a cost of USD 40/kgU or less were estimated to be 380 800 tU, up slightly from the 1999 value of 372 000 tU.

The bulk of Canada's known uranium resources occur in Proterozoic unconformity-related deposits of the Athabasca Basin, Saskatchewan, and the Thelon Basin, Nunavut. These deposits host their mineralisation at the unconformity boundary, or above and/or below it, in either monometallic or polymetallic mineral assemblages. Pitchblende prevails in the monomineralic deposits, whereas uranium-nickel-cobalt assemblages prevail in the polymetallic assemblages. The average grade varies from less than 1% uranium to those grading between 2% and 5% uranium, although parts of some deposits exceed 20% uranium.

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.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
277 990	314 560	314 560

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
102 810	122 390	122 390

* Mining loses (~20%) and ore processing losses (~3%) were used to calculate known conventional resources.

Undiscovered conventional resources (EAR-II & SR)

The 1 January 2001 assessment did not result in any change to EAR-II and SR tonnages reported as of 1 January 1993.

Estimated additional resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kg U	<USD 130/kg U
50 000	150 000

Speculative resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
700 000	0	700 000

All of the RAR & EAR-I resources recoverable at less than USD 40/kgU are at existing or committed production centres, and 90% of RAR and EAR-I resources recoverable at less than USD 80/kgU are at existing or committed production centres.

URANIUM PRODUCTION

Historical review

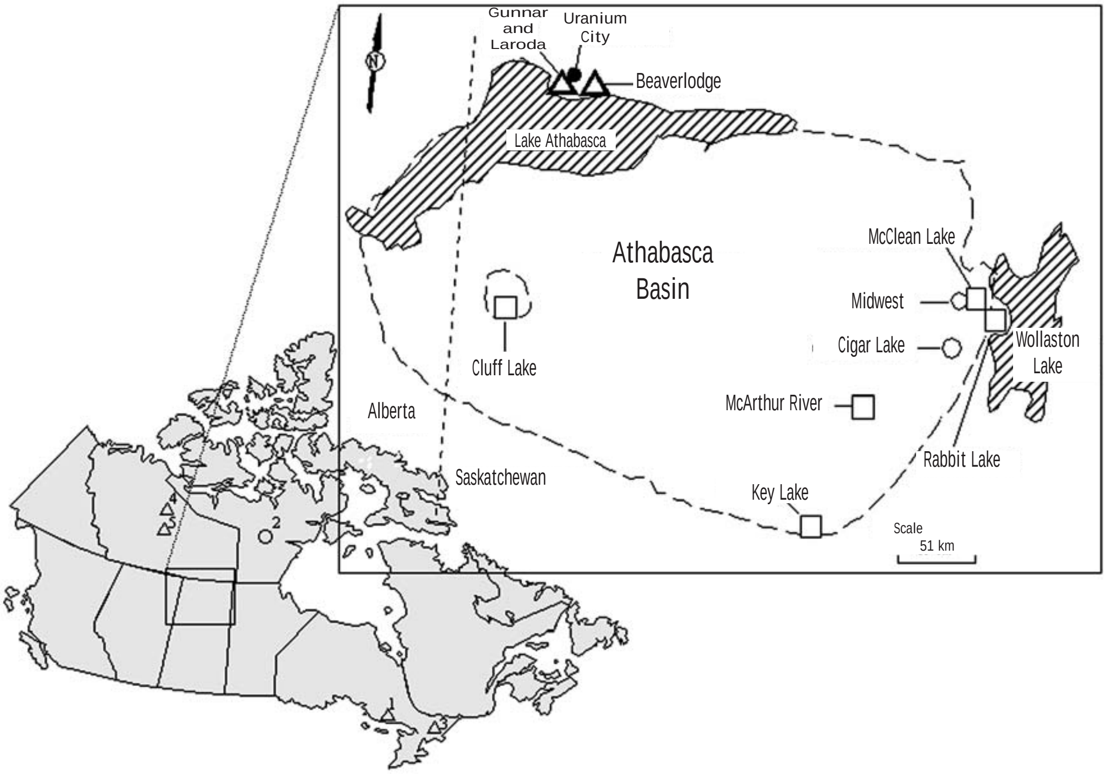
Canada's uranium industry began in the Northwest Territories with the 1930 discovery of the Port Radium pitchblende deposit. Exploited for radium from 1933 to 1940, the deposit was re-opened in 1942 in response to demand for uranium for British and United States defence programmes. A ban on private exploration and development was lifted in 1947, and by the late 1950s some twenty uranium production centres had started up in five producing districts. 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. Annual output grew steadily throughout the 1980s, as Canada's focus of uranium production shifted increasingly from east to west. In the early 1990s, the poor markets and low prices led to the closure of three of four Ontario production centres. The last remaining Ontario uranium production centre closed in mid-1996.

Status of production capability

Overview

The decline in production capability from Canada's existing operations in the early 1990s, due to the closure of several Elliot Lake facilities, has been compensated for by the opening of new operations in Saskatchewan, where all Canadian uranium projects are now located. At present, Canadian uranium output remains below full capability. Low uranium prices and the transition to the new high-grade uranium mines stimulated production cutbacks in 1999. As a result, Canadian production, which in 1997 exceeded 12 000 tU, declined to 10 922 tU in 1998 and 8 214 tU in 1999. However, in 2000, production rebounded to 10 683 tU, as the new McClean Lake and McArthur River facilities were successfully brought into production.

Uranium Mines in Canada



□ **Producing operations**
Rabbit Lake
Cluff Lake
Key Lake
McClean Lake
McArthur River

○ **Projects under development**
Midwest
Cigar Lake
Kiggavik (2)

∆ **Past producing operations**
Beaverlodge et al
Gunnar & Lorado et al
Agnew Lake (1)
Madawaska et al (3) [Bancroft]
Port Radium (4)
Rayrock [Marian River] (5)
Quirke/Panel/Denison/Stanleigh et al [Elliot Lake] (1)

Historical uranium production (tonnes U)

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Processing plant	310 704	10 922	8 214	10 683	340 523	11 250
Total	310 704*	10 922	8 214	10 683	340 523	11 250

* Primary output. In 1996 and earlier, an additional 50 tU was recovered at Elliot Lake from Cameco's refinery / conversion facility by-products. With the closure of Rio Algom's Stanliegh operation at Elliot Lake in mid-1996, by-products from Cameco's refinery / conversion facilities in Ontario are no longer processed in Canada.

Saskatchewan

The Rabbit Lake facility, owned and operated by Cameco Corp., produced 2 705 tU and 2 790 tU in 1999 and 2000, respectively. This sharp decline from 1998 production of 4 491 tU is the result of the production cutbacks implemented by Cameco in November 1998, which included the suspension of mining operations and a reduced milling rate at Rabbit Lake. In August 2000, Cameco announced that it would be extending the temporary shutdown of mining at Rabbit Lake through 2001. As a result, when the existing ore stockpile is depleted (expected in June 2001), the mill will be placed on standby for approximately one year, depending on market conditions. Cameco is re-evaluating the mining plan at the Rabbit Lake Eagle Point mine to achieve further efficiencies and, in 2001, is expected to seek regulatory approval to re-open the Rabbit Lake operation based on the revised mining plan.

The Key Lake facility, operated by Cameco, is a joint venture between Cameco (83%) and Cogéma Resources Inc. (CRI; 17%). Mining at Key Lake was completed in 1997. In 1999, in spite of a four month long shutdown for retrofitting required to process McArthur River ore, the Key Lake mill maintained its standing as the world's largest uranium production centre, producing 3 715 tU from stockpiled ore. In January 2000, the first high-grade ore from the McArthur River mine was delivered to the Key Lake mill. To facilitate processing, high-grade McArthur River ore is blended down with stockpiled Key Lake special waste to produce a blend grading of 3.4% U. In 2000, a total of 4 142 tU was produced in this fashion (402 tU from Key Lake special waste and 3 740 tU from McArthur River ore).

Cameco is the operator of the McArthur River mine, a joint venture between Cameco (70%) and CRI (30%). Mine commissioning, which began in December 1999, proceeded smoothly. Using innovative techniques, such as freezing the ore body and, for radiation protection purposes, using remotely operated raise boring techniques and underground crushing, grinding and slurry production circuits, 3 740 tU were produced from high-grade McArthur River ore in 2000. Slurry produced underground is pumped to the surface to automated loading stations, then delivered by truck some 80 km to the Key Lake mill. All McArthur River ore will be milled at Key Lake.

The McClean Lake uranium production centre, operated by CRI, is a joint venture between CRI (70%), Denison Mines Ltd. (22.5%), and OURD (Canada) Co. Ltd., a subsidiary of Overseas Uranium Resources Development Corporation of Japan (7.5%). Production began in July 1999. Mill start-up proceeded smoothly, and by 31 December 1999, 560 tU had been produced. In 2000, the annual licensed uranium production capacity of 2 308 tU was reached by November. In its 2001 application to renew the operating licence, CRI has requested an increase in the McClean Lake annual production capacity of some 770 tU (to a total of 3 077 tU per year). In 1999 and 2000, ore from the previously mined-out JEB open pit and from the Sue C open pit fed the McClean Lake mill. Mining of the Sue C open pit is ongoing in 2001. Two ore bodies adjacent to the Sue C deposit, Sue A and Sue B, will be mined by open pit next.

The Cluff Lake production centre is owned and operated by CRI. In 1999, Cluff Lake production amounted to 1 234 tU, with the mill operating on a continuous schedule to process stockpiled low-grade ore. In 2000, production amounted to 1 443 tU, as the mill, operating on an alternate week basis, processed a blend of low-grade Dominique-Janine extension pit ore and higher grade ore from the West Dominique-Janine mine. With allowable capacity remaining in the tailings management area (TMA), higher ore grades, lower production costs and improved productivity, CRI is planning to continue operations at Cluff Lake into 2002. Although the higher than expected ore grades have resulted in fewer tailings, production at the site remains limited by the capacity of the TMA. Because of the significant capital expense required to build a new TMA, CRI's August 1998 decision to suspend operations indefinitely at Cluff Lake has not changed.

Given current market conditions and the time required for licensing and construction, production is not scheduled to begin until 2005 at the Cigar Lake mine. The Cigar Lake mine is a joint venture between Cameco (50.025%), CRI (37.1%), Idemitsu (7.875%) and TEPCO (5%) that is operated by the Cigar Lake Mining Corporation. In 1999, the prototype freeze-drill system was tested. In 2000, the new jet boring system was tested in waste rock and in frozen ore, capital costs were re-evaluated, freeze hole patterning and the construction of concrete segments were tested, and the mine layout was revised. An application for a mine site preparation licence was submitted to regulatory agencies early in 2001, with a decision on that licence expected in mid-2001.

Uranium production centre technical details
(as of 1 January 2001)

	Centre #1	Centre #2	Centre #3	Centre #4
Name of production centre	Key Lake	Rabbit Lake	Cluff Lake	McClean Lake
Production centre class	existing	existing	existing	existing
Operational status	operating	operating	operating	operating
Start-up date	1983	1976	1980	1999
Source of ore: • Deposit names • Deposit type(s) • Reserves (active resources) • Grade (% U)	Deilmann, unconformity	Collins Bay and Eagle Point unconformity	Dominique Janine/Peter unconformity	Sue A-C, JEB & McClean unconformity
Mining operation: • Type (OP/UG/ISL) • Size (t ore/day) • Average mining recovery (%)	stockpile	UG NA 90 (estimated)	UG NA 85 (estimated)	OP, UG NA 90 (estimated)
Processing plant (Acid/ Alkaline): • Type (IX/SX/AL) • Size (t ore/day) for ISL (kilolitre/day or litre/hour) • Average process recovery (%)	AL – SX 750 97	AL – SX 1 920 97	AL – SX 800 98	AL – SX 300 97

	Centre #1	Centre #2	Centre #3	Centre #4
Nominal production capacity (tU/year)	5 400	3 900	1 900	2 300
Plans for expansion	relates to McArthur River	relates to Cigar Lake		relates to Cigar Lake, Midwest
Other remarks	McArthur River ore feeds mill	Eagle Point mining suspended 31/03/1999	operations to be suspended in 2002	

Uranium production centre technical details (cont'd)
(as of 1 January 2001)

	Centre #5	Centre #6	Centre #7	Centre #8
Name of production centre	McArthur River	Cigar Lake	Midwest	Kiggavik
Production centre class	existing	planned	planned	planned
Operational status	operating	environmental assessment completed in 1998	environmental assessment completed in 1998	feasibility study ongoing
Start-up date	1999	2005	2003	unknown
Source of ore • Deposit names • Deposit type(s) • Reserves (active resources) • Grade (% U)	P2N et al. unconformity	Cigar Lake unconformity	Midwest unconformity	Kiggavik, Andrew Lake unconformity
Mining operation: • Type (OP/UG/ISL) • Size (t ore/day) • Average mining recovery (%)	UG NA NA	UG NA NA	UG NA NA	OP NA NA
Nominal production capacity (tU/year)	6 900	6 900 (est)	2 300 (est)	1 200 (est)
Plans for expansion				
Other remarks				

Ownership structure of the uranium industry

On 25 August 2000, Billiton Plc and Rio Algom Ltd., announced that they had reached an agreement whereby Billiton would acquire the entire issued share capital of Rio Algom for a total of about USD 1.13 billion. Rio Algom recommended that shareholders accept this offer and in November 2000, Rio Algom became a wholly owned subsidiary of Billiton.

In late 2000, JCU (Canada) was established as a subsidiary of Japan-Canada Uranium Co. Ltd. to transfer the rights to explore for uranium at 14 projects that were acquired from PNC Exploration (Canada) Ltd. The transfer results from the decision of Japanese Nuclear Cycle Development Institute, the parent company of PNC, to withdraw from North American uranium exploration by the end of March 2001, following the Japanese Government's decision to vacate the uranium exploration field.

In March 2001, Redstone Resources Inc. purchased a 20.7% share of the Midwest Uranium Project, as Denison Mines Ltd. reduced its interest by 5.04% and CRI by 15.66%. Following this transaction, the Midwest joint venture structure is 54.8% CRI, 20.7% Redstone Resources Inc., 20% Tenwest Uranium Ltd. (a wholly owned subsidiary of Denison Mines Ltd.), and 4.5% OURD (Canada) Co. Ltd.

Ownership of uranium production in 2000

DOMESTIC				FOREIGN				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
563	5.3	5 698	53.3	4 249	39.8	173	1.6	10 683	100

Employment in the uranium industry

Direct employment in Canada's uranium industry totalled 1 076 in 1999 and 1 026 in 2000 (1 983 in 2000, if head office and contract employees are included). This slight decline from 1997 and 1998 employment levels is the product of workforce losses resulting from running the Cluff Lake and Rabbit Lake mills at reduced capacity exceeding workforce additions required to bring the McClean Lake and McArthur River projects into production. Employment is expected to decline marginally in 2002 as production at Cluff Lake is suspended. Employment levels are not expected to increase until construction begins at the Cigar Lake and Midwest mines.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
1 134	1 076	1 026	1 000

Future production centres

The uranium mining projects in Saskatchewan that have cleared the environmental review process and are poised to enter into production will simply extend the lives of the existing production centres. Cigar Lake ore will feed the McClean Lake and Rabbit Lake mills, with Midwest ore providing additional feed for the McClean Lake mill. Beyond these Saskatchewan projects, Kiggavik in Nunavut is the only other project currently envisaged as an additional production centre in Canada, but it is unlikely to proceed in the near future.

Short-term production capability
(tonnes U/year)

2001				2002				2005			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
14 300	14 300	14 300	14 300	16 290	16 290	16 290	16 290	9 225	9 225	16 150	16 150

2010				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
9 225	9 225	18 450	18 450	6 925	6 925	16 150	16 150	6 925	6 925	13 850	13 850

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Environmental assessments

In 1995, Rio Algom Ltd. decided to request licences for the historic mines in the Elliot Lake region (Spanish American, Milliken, Lacnor, Nordic, Buckles and Pronto) that are not currently licensed by the Canadian Nuclear Safety Commission (CNSC). This triggered an environmental assessment under the *Canadian Environmental Assessment Act* (*CEAA*). In support of its licence application, Rio Algom submitted a screening report environmental assessment to the CNSC in 2000. Review and revision of this report is ongoing, with licensing anticipated in 2002.

Cogéma Resources Inc. (CRI) is currently preparing an environmental assessment under the *CEAA* of its plan to suspend operations at Cluff Lake. Early in 2001, a Comprehensive Study (CS) that outlines, among other issues, the decommissioning plan as well as options and mitigation measures, was submitted to the CNSC for preliminary review. Development of this CS has already involved public consultation, and additional public consultation on the CS and the decommissioning plan will take place once the CS is finalised.

In its 2001 operating licence application renewal to the CNSC, CRI requested that the McClean Lake annual production capacity be increased by about 770 tU (from 2 308 tU to 3 077 tU). The requested amendment to increase production requires a screening environmental assessment under the *CEAA*. This environmental assessment is being prepared for the 9 August 2001, CNSC hearing on the McClean Lake operating licence.

In late-2000, CRI and the Cigar Lake Mining Corporation submitted a screening environmental assessment under the *CEAA* of the preferred option to dispose of potentially acid generating waste rock from the Cigar Lake mine in the mined-out Sue C open pit at McClean Lake. The environmental assessment is now being reviewed by regulatory agencies.

A Comprehensive Study environmental assessment under the *CEAA* of the proposal to mill approximately 57% of the Cigar Lake ore at the Rabbit Lake mill is expected to be submitted to regulators in 2002. Subject to regulatory approvals and mutually agreeable business arrangements among the joint venture partners, ore from Cigar Lake could provide feed to the Rabbit Lake mill for some 10 to 14 years.

Environmental management

In the process of following recommendations by environmental assessment panels, as well as federal and provincial regulatory requirements, uranium mining companies operating in Canada devote significant resources and effort to environmental protection. To date, Canadian uranium producers have committed over USD 100 million to the environmental management of existing uranium mines, over USD 20 million in 2000 alone.

Beyond this financial and operational commitment to environmental protection, uranium producers contribute in other ways to the sustainable development of Canadian uranium resources. These contributions include training and employment of northern Saskatchewan residents (whose numbers have grown to over 50% of mine site employees), business opportunities for northern residents (more than USD 115 million of goods and services were purchased from businesses in northern Saskatchewan in 2000), support and training for local environmental monitoring committees, and assistance in the development of a northern Saskatchewan community health and vitality database.

After two years of preparation, the McClean Lake uranium facility received ISO 14001 certification for its environmental management system, the first uranium mine in North America to do so.

Decommissioning

To date, uranium mining companies in Canada have committed over USD 50 million to the decommissioning of the Elliot Lake mine sites; over USD 3 million in 2000 alone. In addition, uranium producers have posted letters of credit amounting to over USD 100 million for the decommissioning and closure of the uranium mining and milling sites currently in operation.

Decommissioning of the Elliot Lake uranium mines and mills continued through 1999 and 2000. All systems at Denison Mines Ltd.'s former mine sites are operating better than anticipated. Tailings management area monitoring and treatment of water discharged from these areas is ongoing. In 2000, additional activities included treatment of runoff, surface drainage alteration, and the use of bio-solids to improve the vegetation cover on the Stanrock tailings basin.

Denison Mines and Rio Algom released the first report of the Serpent River Watershed Monitoring Program (SRWMP) in January 2000. This comprehensive monitoring programme gathers information to assess the recovery of the watershed that hosted uranium mining for over 40 years. Data collected to date indicate that water quality in the Serpent River watershed continues to improve and that the river meets drinking water guidelines and provides healthy fish habitat.

Rio Algom and its predecessor companies operated a total of nine Elliot Lake uranium mines and, since 1985, has dismantled and remediated these sites. In reclaiming the Quirke and Panel tailings areas, the primary environmental issues were preventing or controlling the long-term production of acid rock drainage and the contamination of water by radioactive materials. After Rio Algom's proposal to cover these tailings with water was supported by a public review panel and approved by governments and regulators, dams and dikes were built to create ponds to submerge the tailings. Since the tailings are no longer exposed to air, the formation of acid generated in the waste rock is limited. The water also acts as a barrier to radiation releases. Water flowing from these sites is being treated and will continue to be until water quality meets discharge criteria without treatment. At that time, these sites will enter a phase of long-term monitoring with care and maintenance.

Since the local topography around some of Rio Algom's historic sites does not allow for the safe flooding of tailings, these areas have been vegetated to control dust and surface runoff, with the runoff and seepage from the sites collected for treatment. These historic sites (Spanish American, Milliken, Lacnor, Nordic, Buckles and Pronto) are not presently under CNSC license and, although uranium mining and milling ceased at these facilities more than 30 years ago, Rio Algom is currently in the process of obtaining CNSC licences for these sites.

URANIUM REQUIREMENTS

On 1 April 1999, Ontario Hydro, once North America's largest power company, was split into five separate entities. The two largest of the successor companies are Ontario Power Generation Inc., the entity that will run the province's 80 generating stations (including 19 CANDU reactors), and Ontario Hydro Services Co., which will run the province's 29 000-kilometre transmission network.

Ontario Power Generation (OPG) is continuing to implement its five-year CAD 1.76 billion "Integrated Improvement Plan" (IIP) to regain its status as one of the world's nuclear performance leaders. This expenditure applies to the 12 operating nuclear units at the Pickering B, Bruce B and Darlington stations. OPG reports that progress has been made and that the IIP is expected to be completed on schedule.

In early 1999, OPG expressed its intent to restart the four reactors at the Pickering A Nuclear Generating Station. The Canadian Nuclear Safety Commission (CNSC) determined that before a decision on the application could be made, an environmental assessment of the proposal was required under the *Canadian Environmental Assessment Act*. After reviewing the assessment the CNSC announced on 16 February 2001, that the restart of the Pickering A units would not cause significant adverse environmental effects. On 30 March 2001, the CNSC renewed the Pickering Station A and B operating licences for a term of 27 months, ending 30 June 2003.

In July 2000, OPG announced the proposed lease of the 8 unit Bruce nuclear station to Bruce Power Inc. The lease covers the period to 2018, with an option to extend for up to another 25 years. Bruce Power is a joint venture of British Energy Plc, Cameco Corporation, the Power Workers' Union and The Society of Energy Professionals. The deal was completed in May 2001 after the CNSC issued operating licences for the Bruce A and B stations. Bruce Power anticipates having two Bruce A reactors back on-line in 2003.

Hydro-Québec has decided to undertake a detailed assessment of a 25-year life extension (beyond 2008) of the Gentilly 2 nuclear power station. The study, conducted by Atomic Energy Canada Ltd. (AECL), will include a comprehensive engineering evaluation of the required rehabilitation work and the associated costs. Preliminary analyses indicate that the refurbishment of Gentilly 2 would be fully competitive when compared to other electricity generating options.

In 2001, the New Brunswick government released a new energy policy which includes deregulation of the electricity market through a gradual and controlled approach. This new policy does not, however, provide a clear indication on government support for a 25-year life extension (beyond 2008) of the Point Lepreau nuclear generating station, or whether the Point Lepreau station would be privatised along with other conventional generation facilities.

Supply and procurement strategy

From the late-1960s through to 1995, Ontario Hydro purchased >99% of its uranium requirements through long-term contracts with Canadian suppliers. In 1996, this pattern was broken with the import of 150 tU from Australia. This increased to about 250 tU in 1997, as a result of long-term contracts with Australian suppliers. Ontario Hydro also entered into a long-term contract with a US uranium broker for the supply of 100 tU/year beginning in 1997. Through these and other long-term contracts, OPG has filled about 90% of its uranium requirements to the end of 2000 (about one-third from foreign suppliers). The remaining 10% of its requirements are being met with spot market purchases.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
15 500	15 500	15 500	15 500	16 700*	15 500	24 000*	14 500	26 100*

* Based on Natural Resource Canada analysis.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 800	1 800	1 800	1 800	1 900*	1 800	2 800*	1 800	3 000*

* Based on Natural Resource Canada analysis.

NATIONAL POLICIES RELATING TO URANIUM

The *Nuclear Safety and Control Act* and associated regulations were brought into force on 31 May 2000. On that date, the Canadian Nuclear Safety Commission (CNSC) replaced the Atomic Energy Control Board (AECB). The revamped law and regulations, the first major overhaul of Canada's nuclear regulatory regime since 1946, reflect the increased focus on health, safety, security and environmental protection in recent years. The CNSC regulatory regime includes new requirements, such as lower radiation dose limits and strengthened security requirements, as well as increased penalties for non-compliance.

On 25 April 2001 the Government of Canada introduced legislation in the House of Commons entitled "*An Act Respecting the Long-term Management of Nuclear Fuel Waste*." The legislation calls for nuclear utilities to form a waste management organisation that would report regularly to the Government of Canada. This organisation would provide recommendations to the Government on the long-term management of nuclear fuel waste. The legislation would also require that the utilities establish a trust fund to finance implementation of the approach, which would ensure that Canadian taxpayers are not exposed to this financial liability over the long term.

On 7 June 2001 the Canadian government passed legislative amendments to ease, but not eliminate, the foreign share ownership restrictions specified in the *Eldorado Nuclear Limited Reorganization and Divestiture Act*, Cameco's governing legislation. The amendments raise the limits on non-resident share ownership from 5% to 15% and aggregate share ownership voting rights from 20% to 25%. These changes allow Cameco to attract new investment capital and forge new strategic alliances.

URANIUM STOCKS

The Canadian government does not maintain any stocks of natural uranium and data are not available for producers and utilities. 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

Uranium export price* statistics

	1994	1995	1996	1997	1998	1999	2000
Average price CAD/kg U	51	47	53.60	51.30	51.10	49.10	47.70
Average exchange rate	1.366	1.373	1.364	1.384	1.483	1.486	1.485
Average price USD/lb U_3O_8	14	13	15.10	14.20	13.30	12.70	12.40
Percentage spot deliveries	<1%	2%	1%	<1%	<2%	<1%	<1%

* Average price of all deliveries under export contract.

• Chile •

URANIUM EXPLORATION

Historical review

Uranium exploration activities in Chile started in the early 1950s. Over the next few years the US Atomic Energy Commission, working in co-operation with several Chilean state organisations, discovered uranium mineralisation associated with hydrothermal and high temperature vein-type copper deposits, copper-molybdenum tourmaline breccia pipes, and pegmatitic dykes.

Little follow-up work was done until 1970, when a joint uranium exploration programme was initiated by the Chilean Nuclear Energy Commission (CCHEN) and the Spanish Nuclear Energy Organisation (JEN). The objective of this project was a two-year investigation of the uranium potential of the Cu-Fe-Co-district of the Tambillos, IV Region.

Between 1976 and 1980 CCHEN with the support of the UNDP/IAEA carried out a regional exploration programme covering an area of 150 000 km^2. Applying geochemical drainage surveys, as well as aerial and ground radiometric methods, this project resulted in the discovery of 1 800 airborne anomalies, 2 000 geochemical and ground radiometric anomalies and the definition of 120 areas of interest. Follow-up work was done covering 84 areas of interest resulting in the discovery of 12 uranium occurrences of which 2 were selected for further detailed study. In addition to this regional programme, the joint CCHEN-UNDP/IAEA Project evaluated unconventional uranium resources associated with copper ores and phosphates.

Between 1980-1984, CCHEN, in cooperation with the Pudahuel Mining Company carried out a drilling programme at the Sagasca Cu-U deposit, III Region. In addition, a technical and economical investigation of the U potential of the Cu-deposit Huinquintipa, northern Chile was completed.

The 1983 postponement of the planned Chilean nuclear power programme until after the year 2000 and the weak international uranium market resulted in severe CCHEN budget and staff reductions, which limited further activities.

In 1986-1987, CCHEN and the Production Development Organisation (CORFO) investigated the phosphate deposit, Bahia Inglesa.

Further work done by CCHEN during 1990–1996 included the geological and uranium metallogenic investigation of areas mainly in the northern part of the country.

In 1990, CCHEN, in cooperation with the National Mining Corporation (ENAMI), initiated a programme to investigate the U-Th potential of Rare Earth Elements (REE) occurrences. This project covered tens of occurrences of which the Anomaly 2, also referred to as Diego de Almagro was selected as a high priority target for further work. This area covers 180 km^2 and hosts stratiform and vein-type mineralisation consisting of an association of davidite, ilmenite, magnetite, sphene, rutile and anatase, with 3.5-4 kg/tonne rare earths, 20-40 kg/tFe and 0.3-0.4 kg/tU.

Recent and ongoing activities

This REE-project continued in 1999-2000, during which time the Diego de Almagro Anomaly-2 (Cerro Carmen site) was assigned 1 400 tU as “prognosticated and speculative resources” (or “undiscovered resources”). Known resources attributed to Anomaly 2 total 1 392 tU. Outside of the Cerro Carmen site, the regional lineament that controls the mineralisation extends 60 km in a northwesterly direction. This structure, observed in satellite images, takes in other mining districts and for that reason it has been assigned 1 500 tU of speculative resources. The preliminary geological study of resources at the “Cerro Carmen” site was conducted under the Specific Co-operation Agreement between the CCHEN and the National Mining Company (ENAMI).

In 1998, CCHEN established the National Uranium Potential Evaluation project. This project combines metallogenic research with establishment of a geological data base with the objective of establishing a portfolio of research projects whose implementation would improve the assessment of the national uranium potential. In 1999-2000, CCHEN’s existing information was reviewed as part of the National Uranium Potential Evaluation project. It was concluded that the acid and intermediate volcanism, which is very extensive in the main mountain range from Regions I to III, formed a surface dipping to the west and ending in a lagoonal environment located in the central depression. The same conditions occur to the east. This volcanism covered the pre-volcanic landscape, preserving the surface drainage courses (now paleochannels). The leaching of these volcanic rocks carried large quantities of uranium into the lagoon system, paleochannels and other structures where solutions circulate. This process is shown by extensive layers of calcilutites, diatomaceous earth (Pampa Camarones), layers of salt (Salar Grande), argillites, limestones, limonite, volcanic ash (Quillagua, Prosperidad, Quebrada Amarga, Chiu-Chiu), with a uranium content of between 100 and 1 000 ppm. In addition, mineralised paleochannels containing copper and uranium (Sagasca, Cascada, Huinquintipa, Quebrada Ichuno, Chuqui Sur, El Tesoro, etc.) indicate the circulation of mineralising solutions. In the volcanic area, uranium mineralisation (torbernite and autunite) has been found in volcanic systems containing iron (El Laco and El Perro). These environments are considered to have great potential and further research is planned.

Uranium exploration expenditures

	1998	1999	2000
Government expenditures (USD million)	0.196	0.178	0.154

The above expenditures include wages and salaries, operational costs incurred by both ENAMI and CCHEN as well as CCHEN´s costs for administration.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Chile reports known conventional resources totalling 1 831 tU including 748 tU RAR and 1 083 EAR-I; no costs are assigned to either category. The combined RAR plus EAR-I total compares with 954 tU reported in the 1999 Red Book in which the two categories were not differentiated. The 1 January 2001 estimate includes 68 tU mainly in the low grade (0.02%U) surficial type occurrences Salar Grande and Quillagua and 1 763 tU in Upper Cretaceous metasomatic occurrences including mainly the Estacion Romero and Prospecto Cerro Carmen (REE) occurrences whose grades range between 0.02 and 0.24%U.

Known uranium resources (tonnes U)*

Cost range unassigned	
RAR	EAR-I
748	1 083

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

Undiscovered conventional resources are estimated to total 4 184 tU with no assigned cost category. The bulk of this resource (4 060 t) is expected to occur in the Upper Cretaceous metasomatic type occurrences. Within this group the majority of the resource, totalling 2 900 tU, is assigned to the REE occurrence Prospecto Cerro Carmen (Anomaly 2).

Undiscovered resources (tonnes U)*

Cost range unassigned	
EAR-II	Speculative resources
1 824	2 360

* As *in situ* resources.

Unconventional or by-product resources

As shown in the following table, Chile reported unconventional or by-product resources totalling 7 256 tU. The majority of these resources are associated with the Chuquicamata copper deposit and with the Bahia Inglesa and Mejillones uraniferous phosphate deposits. Uranium could potentially be recovered as a by-product from both types of deposits. However, because of the very low uranium content (0.005 to 0.02%U), production costs are projected to exceed USD 80/kgU.

Unconventional or by-product resources			
RAR	EAR-I	EAR-II	Speculative resources
1 798	0	1 818	3 640

Employment in the uranium industry

The staff of the geology and mining unit of CCHEN during 2000 included two geologists, one surveyor and one field assistant.

URANIUM PRODUCTION

None reported.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

At present, no uranium is required for commercial energy generation. However, CCHEN´s fuel element fabrication plant started the fabrication of 50 MTR type fuel elements in March 1998. This project is expected to end in 2001 and the fuel elements will be loaded into the La Reina research reactor. The required uranium raw material, 60 kg U enriched to 19.75% ^{235}U, was supplied by the Russian Federation.

NATIONAL POLICIES RELATING TO URANIUM

As provided for in Law 16 319 the CCHEN has the mandate to advise the Supreme Government in all matters related to the peaceful use of nuclear energy. It is also responsible for developing, proposing and executing the national plans for research, development, utilisation and control of all aspects of nuclear energy.

The mining law (Law 18 248 of 1983) allows private parties to acquire uranium claims and subsequently produce uranium. However, in view of the strategic importance of uranium and other radioactive materials the law provides for CCHEN the right of first refusal in any uranium sale. As private parties have not shown any interest in uranium activities due to the depressed markets the assessment of the country's potential and its periodic update remains the mandate of CCHEN within the framework of the National Nuclear Development Plan, as confirmed by Supreme Decree No. 302 of 1994. The objectives of the latter are the performance of geological research into materials of nuclear interest and related elements, periodic updating of the national potential for such resources based on geological assessments, development of applied knowledge and technology transfer.

Chile reported no information on uranium stocks or uranium prices.

• China •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium prospecting and exploration began in China in 1955. The 40 years since then can be divided into four stages. The main work of the early stage (1955 until 1960s) included organising prospecting teams, keeping abreast of prospecting techniques and carrying out regional uranium prospecting in China. During the 1960s the prospecting achievements were expanded by studying and gaining a better understanding of uranium metallogenesis. During the 1970s, comprehensive geophysical and geochemical prospecting methods were widely used for locating unexposed uranium deposits. Since the 1980s, research on regional geological settings has been strengthened to search for new types of uranium deposits including large, high-grade and more economical deposits.

Exploration activities completed in the last 40 years include: 3 000 000 km^2 of surface radioactive surveys, 2 500 000 km^2 of airborne radiometric surveys, and 30 000 000 m of drilling and tunnelling. This work resulted in the recognition of 12 uranium metallogenic belts and 8 prospective uranium regions.

Following the development of the international uranium market, the Bureau of Geology, in 1990, shifted its exploration strategy from the granitic, carbonaceous-siliceous-pelitic and volcanic deposit targets located mainly in south China to sandstone deposits amenable to *in situ* leaching techniques in north and northwest China.

The main uranium prospecting and exploration methods used are: surface and airborne gamma spectrometric surveys, radon surveys, radioactive hydrochemical surveys, structure-geophysical exploration methods, isotope-geological methods, remote sensing, mathematical geology and undiscovered resource prediction and assessment.

Since 1999, organisation of uranium exploration in China has been significantly changed as the result of reforming and restructuring of government organisations. The following organisations remain within the Bureau of Geology (BOG) (China Nuclear Geological Survey): the China National Nuclear Corporation, 3 geological teams, 1 airborne survey and remote sensing centre, 1 geological research institute, 6 regional uranium geological research centres and 6 regional uranium geological offices. Other geological teams and affiliated organisations or entities were transferred to local governments. The BOG will continue to undertake uranium exploration in China; the transferred entities will no longer take part in uranium prospecting and exploration in China unless contracts are made between the BOG and these organisations. After the reorganisation, the total staff of the BOG is about 5 500 among which are 2 800 technicians. This compares with a total staff of 45 000 including 14 000 technicians reported in 1997.

Recent and ongoing uranium exploration and mine development activities

Since 1990, uranium exploration in China continues to emphasise the discovery of ISL-amenable sandstone deposits. The majority of exploration projects are still carried out in the Xinjiang and Inner Mongolian Autonomous Regions, as well as in northeast China.

No significant discoveries were made during uranium exploration for sandstone deposits in the past two years, but a few occurrences have been found in the Yili Basin and Junger Basin in the Xinjiang Region, and Erlian Basin and the Manzhouli Area, Inner Mongolia. Exploration activities have also expanded uranium reserves in the known deposits in the Yili Basin, Xinjiang.

In 1999 and 2000, 38 and 52 exploration projects were carried out respectively, by the BOG including regional geological surveys, geophysical surveys and monographic study projects. Most of these projects were implemented in northwest, north and northeast China and were carried out by the affiliated entities of the BOG; geological teams outside of BOG conducted part of the drilling on a contract basis. The concentration of China's exploration efforts on ISL-amenable sandstone deposits in north China has led to the stagnation of exploration activities for other deposit types in south China due to their high production cost.

In addition to the exploration projects that the BOG is undertaking on its own, three technical co-operation projects are being conducted in the Xinjiang and Inner Mongolian Autonomous Regions, and in Jilin Province between the BOG and organisations from Uzbekistan, Kazakhstan and Russia.

Due to the reorganisation within the BOG in 1999, uranium exploration expenditures and drilling activities showed a significant decline, but recovered to normal level in 2000.

Detailed information on uranium exploration expenditures and drilling activities is not provided.

URANIUM RESOURCES

The known uranium reserves are divided into the following types, according to the host rock lithology.

Host rock	**Share of total reserves** (%)
Granite type	36.67
Sandstone type	24.55
Volcanic type	18.76
Carbonecous-siliceous-pelitic rock type	15.67
Intrusive, pegmatitic type	2.88
Quartzite type	0.59
Alkaline rock type	0.58
Phosphate type	0.30

The known intrusive (granitic) uranium deposits are mainly located in the Guidong granite massif, Guangdong Province, Zhuguangshan granite massif in south China, Taoshan granite massif, Jiangxi Province and the Jiling Caledonian granite massif in northwest China. The known volcanic uranium deposits are primarily distributed in Xiangshan, Jiangxi Province; Xiaoqiuyuan, Zhejiang Province; Baiyanghe, Xinjiang Region, and at the northern margin of the North China Platform. The sandstone uranium deposits mainly occurred in the Yili Basin, Xinjiang Autonomous Region; Hengyang Basin, Hunan Province; Xunwu, Jiangxi Province; Jianchang, Liaoning Province, Erlian Basin, Inner Mongolian Autonomous Region and small basins in western Yunnan Province. The Carbonaceous-siliceous-pelitic uranium deposits are mainly situated in Huangcai, Laowolong, Central-South China; Ganziping, Guangxi Autonomous Region; and Ruoergai at the boundary between Sichuan and Gansu Provinces.

Known uranium resources in China total 73 000 tU, as listed in the following table. The increase of 3 000 tU compared to the 1999 Red Book is due to the increases in known ISL sandstone deposits in the Yili Basin, Xinjiang Autonomous Region. The resources are not classified into the categories recommended by the IAEA.

The main uranium deposits or ore fields and known uranium resources in China are listed in the following table:

1	Xiangshan uranium field in Jiangxi Province	26 000 tU
2	Xiazhuang uranium field in Guangdong Province	12 000 tU
3	Quinglong uranium field in Liaoning Province	8 000 tU
4	Ganziping uranium deposit in Guangxi Autonomous Region	5 000 tU
5	Cengxian uranium deposit in Hunan Province	5 000 tU
6	Tengchong uranium deposit in Yunnan Province	6 000 tU
7	Lantian uranium deposit in Shanxi Province	2 000 tU
8	Yili uranium deposit in Xinjiang Autonomous Region	9 000 tU
	Total	**73 000 tU**

URANIUM PRODUCTION

Historical review

China's uranium industry was established in 1958. From the early 1980s to 1996, China's uranium industry introduced a number of improvements designed to better meet both the conditions of a market economy and the uranium requirements of the country's nuclear power programme. These improvements cover reduced uranium production, including closure of uneconomic uranium mines and mills. The remaining producers are required to further improve both their technology and management, with the objective of increasing China's competitive position by reducing uranium production costs.

In the 1990s, new production centres including the Yining ISL facility in the Xinjian Autonomous Region, the Lantian heap leaching facility in the Shanxi province and the Benxi mine in the Liaoning province, came into production. While total Chinese uranium production declined, a minimum level is maintained.

The use of more efficient equipment and improved technology for cost-cutting purposes includes, for example, trackless mining methods, first introduced at the Quzhou mine and now also used in the Benxi mine. In addition to the introduction of single boom hydraulic drill jumbo H-104, and LHD-loaders (load-haul-dump) ST-1.5, a newly designed mine truck and service vehicle were introduced in 1997. This measure led to a production increase from 5.8 tonnes ore/man shift in 1996 to 8.4 tonnes in 1998.

Radiometric sorters, which have been used since the beginning of the Chinese uranium industry, have been further developed. The latest model (#5421-2), put in operation in the Fuzhou mine, treats 150 000 tonnes ore/year.

Heap leaching is widely used in China's uranium production centres. Currently, the entire production of the Lantian, Chongyi, Quzhou and Benxi mines, and partial production of the Fuzhou, Renhua and other mines, are being treated by heap leaching. Various types of heap leaching have been developed for the different local conditions. Surface heap leaching is easier to operate and is therefore more widely used. Underground heap leaching is also being successfully used in the Lantian and Chongyi mines. Concentrated acid curing and ferric sulphate leaching used at the Benxi mine simplifies the leaching process and reduces the amount of waste water.

Since 1970, special emphasis has been placed on ISL technology in China. Small-scale tests were conducted in Guangdong province until 1979, and in Deposit 381 in Tengchong, Yunnan Province between 1978 and 1981. A pilot mine with an annual production capacity of 3-5 tU was installed in 1991.

From 1989 to 1991, ISL production tests were carried out at Deposit 512 in Yili, Xinjiang Autonomous Region. The pilot plant used sulphuric acid leaching and had a 10 tU/year capacity. This was expanded to 40 tU in 1994. Annual production in 1998 reached 150 tU. Construction of the extension project with 100 tU/year capacity was completed and put into operation in 2000, bringing total capacity to 200 tU per year.

Status of production capability

In 1999 and 2000 the annual production increased slightly. The Yining, Lantian and Benxi production centres produced a total of 320 tU in 2000 as compared to 300 tU in 1998.

The technical details of the uranium production centres are provided in the following tables.

Uranium production centre technical details
(as of 1 January 2001)

	Centre #1	Centre #2	Centre #3
Name of production centre	Hengyang	Fuzhou	Chongyi
Production centre class	existing	existing	existing
Operational status	stand-by	operating	operating
Start-up date	1963	1966	1979
Source of ore: • Deposit names • Deposit type	 Chenxian and other mines siliceous schist and sandstone	 volcanic	 Chongyi Mine granite
Mining operation • Type (OP/UG/ISL) • Size (tonnes ore/year) • Average mining recovery (%)	 UG 3 000 85-90	 UG, OP 700 92	 UG, OP 350 90
Processing plant • Type (IX/SX/AL) • Size (tonnes ore/day) for ISL (kilolitre/day or litre/day) • Average processing recovery (%)	conventional IX, AL 3 000 85-88	conventional IX, AL 700 90	heap leach IX, AL 350 NA
Nominal production capacity (tU/year)	500-1 000	300	120
Plans for expansion	NA	NA	NA

Uranium production centre technical details (cont'd)
(as of 1 January 2001)

	Centre #4	Centre #5	Centre #6
Name of production centre	Yining	Lantian	Benxi
Production centre class	existing	existing	existing
Operational status	operating	operating	operating
Start-up date	1993	1993	1996
Source of ore • Deposit names • Deposit type	 Dep. 512 sandstone	 Lantian granite	 Benxi granite
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 ISL NA NA	 UG 200 80	 UG 100 85
Processing plant • Type (IX/SX/AL) • Size (tonnes ore/year) for ISL (kilolitre/day or litre/day) • Average processing recovery (%)	 IX, AL NA NA	heap leaching IX, AL NA 90	heap leaching SX, AL NA 90
Nominal production capacity (tU/year)	200	100	120
Plans for expansion	to 300 tU/year	NA	NA

Ownership structure of the uranium industry

No changes in ownership of China's state owned uranium industry have occurred since 1994. It is 100% government-owned.

Employment in the uranium industry

Following the decline of the level of employment between 1994 and 1996, employment numbers have stabilised since 1996 as shown in the following table. However, employment is expected to decrease in 2001.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
8 500	8 500	8 500	8 000

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Using the experience derived from many years of production, numerous measures have been introduced to control, monitor and reduce the harmful environmental impact of uranium production in compliance with current regulations.

These measures include the backfilling of waste rock and tailings into mined out areas, the treatment of mine and used process water, and the covering of waste and tailings piles with soil, concrete, etc., to reduce radon release.

In addition, a large amount of work has been done to decommission uranium mines and mills. Since the 1980s, a number of production facilities have been closed. Of these, five small mines have been completely decommissioned, while eight mine or mine-mill complexes are in various stages of decommissioning. The regulations and standards that govern decommissioning activities in China have been established by the State Environmental Protection Administration. Information on the costs related to environmental management in existing and closed operations is not available.

URANIUM REQUIREMENTS

In the mainland of China, two nuclear power plants (NPP) are in operation. They include the 300 MWe Quinshan plant in Zhejiang province and the Daya Bay plant in Guangdong province with an installed capacity of 1 800 MWe.

The construction of four new nuclear power plants with a capacity of 6 600 MWe is underway. The current status of this programme is as follows:

- Quinshan Phase II, two 600 MWe PWR, the first is scheduled to be connected to the grid in 2002 and the second in 2003.
- Quinshan Phase III, two 700 MWe PHWR (Candu-6), which started construction in 1998 are scheduled to be put into operation in 2003.
- Ling Ao NPP in Guangdong province, two 1 000 MWe, these two units will be put into operation in 2003.
- Tianwan (Lianyungang) NPP, two 1 000 MWe VVER type PWR in Jiansu province. The construction of the two units will be completed in 2004 and 2005, respectively.

These projects will increase the total nuclear generating capacity to about 8 700 MWe in 2005. Additional nuclear capacity is being planned between 2005 and 2020, as shown in the following tables.

Installed nuclear generating capacity to 2020
(MWe net)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 100	2 100	8 700	12 700	14 700	18 000	23 000	22 000	26 000

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
380	380	1 500	2 200	2 600	3 200	4 100	3 900	4 600

Supply and procurement strategy

The known uranium reserves and resources, together with the recently expanded uranium production capability, will be sufficient to fill the requirements for China's nuclear development programme for the short term. Further reactor-related uranium requirements will have to be met by still undiscovered resources. To convert this uranium potential into known resources and reserves, China is placing emphasis on its uranium exploration activities. Subsequent to the numerous technical, organisational and managerial improvements in the uranium industry, uranium is now being produced at a cost level that is competitive on the international market.

China reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Czech Republic •

URANIUM EXPLORATION

Historical review

Following its start in 1946, uranium exploration in Czechoslovakia (CSFR) 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 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 has traditionally been 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 northwestern 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 continued to decline, reaching USD 660 000 in 1992 and USD 201 000 in 1996. No field exploration has been carried out since the beginning of 1994.

Recent and ongoing activities

Exploration activities have been focused on the conservation and processing of previously collected exploration data. Processing the exploration data and building the exploration database will continue at a reduced level in 2001.

Uranium exploration and development expenditures and drilling effort – domestic (CZK-million)

	1998	**1999**	**2000**	**2001** (expected)
Industry expenditures	0.50	0.70	0.20	0.10
Government exploration expenditures	2.50	1.60	1.50	1.80
TOTAL expenditures	3.00	2.30	1.70	1.90
TOTAL EXPENDITURES (USD million)	0.09	0.06	0.04	0.05

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, one is being mined (Rozná), and two, including Osecná-Kotel and Brzkov have resources that are not recoverable in the near future because of high production costs. Undiscovered uranium resources are believed to occur in the Rozná and Brzkov vein deposits in the metamorphic complex of western Moravia, as well as in the sandstone deposits of Stráz block, Tlustec block and Hermánky region in the Northern Bohemian Cretaceous basin.

Known conventional resources (RAR & EAR-I)

Known conventional recoverable resources as of 1 January 2001 decreased by 26 970 tU in comparison with the previous estimate.

In detail, the RAR recoverable at costs below USD 80/kgU decreased by 1 740 tU and the RAR below USD 130/kgU decreased by 4 620 tU. The decrease in RAR was the result of the re-evaluation of the Brzkov and the Osecná-Kotel deposits and the depletion of resources at the Rozná and Stráz operating production centres.

EAR-I decreased by 22 350 tU to 310 tU as of January 2001. EAR-I below USD 80/kgU declined by 800 tU to 310 tU as a result of the re-evaluation of the Brzkov deposit and the depletion of resources at the Rozná production centre. EAR-I between USD 80-130/kgU decreased by 21 550 tU in connection with the re-evaluation of the Hamr and Osecná-Kotel deposits.

All the known uranium resources recoverable at costs below USD 80/kgU as well as resources between USD 80-130/kgU are tributary to the existing Rozná and Stráz production centres.

Undiscovered conventional resources (EAR-II & SR)

No new areas favourable for the discovery of resources have been identified in the last two years.

EAR-II decreased by 9 500 tU to 180 tU as of January 2001 as a result of the re-evaluation of the Brzkov and Hvezdov deposits at costs below USD 130/kgU. The resources below USD 80/kg U are tributary to the Rozná production centre and are the same as reported 1 January 1999.

In addition to the EAR-II, there are SR totalling 179 000 tU as *in situ* resources, unassigned to any cost category. The SR are believed to exist mostly in the Stráz block, Tlustec block and Hermánky region, all in the Cretaceous basin in the northern Bohemia.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	2 370	2 370

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	310	310

* Mining losses of ~5% have been accounted for in estimating the resources.

Estimated additional resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
180	180

Speculative resources
(tonnes U)

Cost ranges		
<USD 130/kgU	Unassigned	TOTAL
0	179 000	179 000

100% of known conventional resources recoverable at USD 80/kgU or less are at existing production centres.

URANIUM PRODUCTION

Historical review

The 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 in the period 1950-1991. The Hamr and Stráz production centres, supported by sandstone deposits, started operation in 1967. The peak production of about 3 000 tU was reached in about 1960 and production remained between 2 500 and 3 000 tU/year from 1960 until 1989/1990, when it began to decline. During the period 1946-2000, a cumulative total of 107 080 tU was produced in the Czech Republic. About 86% of the total was produced by underground and open pit mining methods while the remainder was recovered using *in situ* leaching (ISL).

Historical uranium production (tonnes U)

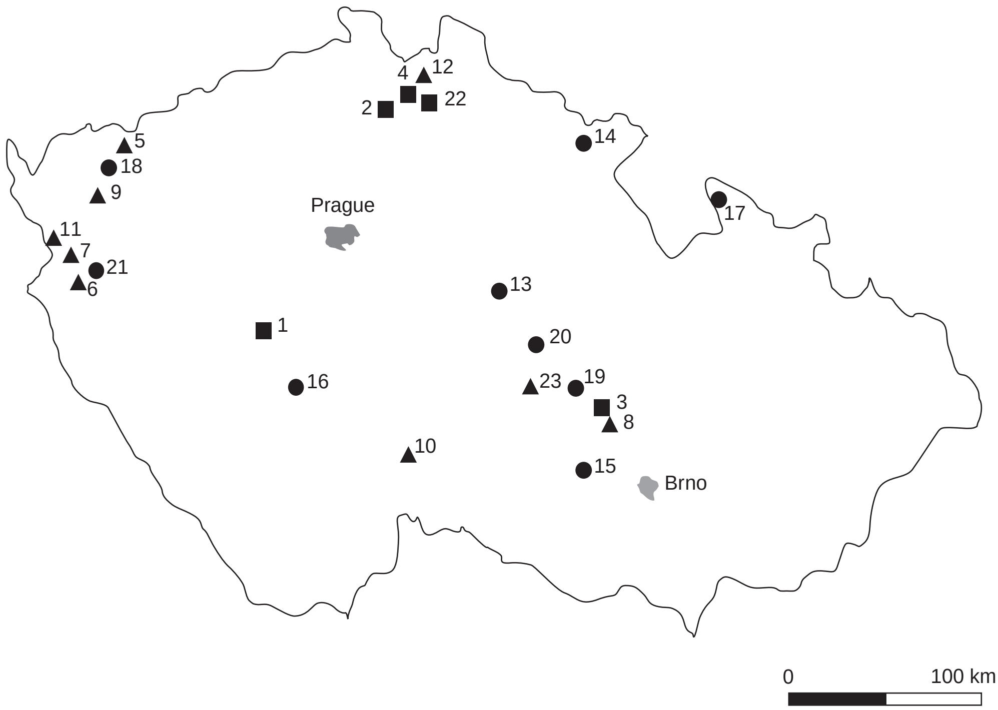
	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Processing plant	90 476	297	310	320	91 403	330
In situ leaching	14 723	290	270	170	15 453	140
In place leaching*	3	0	0	0	3	0
Heap leaching	125	0	32	0	125	0
Other methods e.g. mine water treatment, environmental restoration.	24	23	32	17	96	31
Total	105 351	610	612	507	107 080	501

* Also known as Stope Leaching or Block Leaching.

Status of production capability

Production capability has not changed in the last two years. The decommissioning and restoration of the Stráz ISL mine in the Northern Bohemian Cretaceous basin has continued. As deposit restoration continues, annual uranium output will decrease in the course of the next few years. In addition to the Stráz deposit, only one mine remains in operation at present, the Rozná underground mine in the metamorphic complex of western Moravia.

Major uranium deposits in the Czech Republic



No	Deposit	Size	Status	Type	No	Deposit	Size	Status	Type
1.	Príbam	B	V	H	13.	Licomerice-Brezinka	S	V	H
2.	Stráz	B	C	S	14.	Vnitrosudetská pánev	S	V	S
3.	Rozna*	B	T	Z	15.	Jasenice	S	V	Z
4.	Hamr	B	V	S	16.	Predborice	S	V	H
5.	Jáchymov	M	V	H	17.	Javorník-Zálesí	S	V	H
6.	Vítkov	M	V	M	18.	Hájek	S	V	S
7.	Zadní Chodov	M	V	Z	19.	Slavkovice-Petrovice	S	V	H
8.	Olsí	M	V	Z	20.	Chotebor	S	V	H
9.	Horní Slavkov	M	V	H	21.	Svatá Anna	S	V	H
10.	Okrouhlá Radoun	M	V	Z	22.	Osecná-Kotel	B	P	S
11.	Dylen	M	V	Z	23.	Brzkov	M	P	H
12.	Brevniste	M	V	S					

Size:
- ■ B >10 000 tU
- ▲ M >1 000 tU and <10 000 tU
- ● S >100 tU and <1 000 tU

Type:
- H = vein deposits (“classic” veins)
- Z = vein deposits (“zone” deposits)
- M = vein deposits (metasomatic deposits)
- S = stratiform, sandstone – type
- * milling plant

Status:
- V = mined out
- C = closed (extraction under remediation regime)
- T = being exploited
- P = planned, prospective

Ownership structure of the uranium industry

All uranium related activities, including exploration and production have been carried out by the government-owned enterprise, DIAMO, s.p., based in Stráz pod Ralskem. Consequently, the entire production in 2000, totalling 507 tU was owned by the national government.

Ownership of uranium production in 2000

DOMESTIC				FOREIGN				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
507	100	0	0	0	0	0	0	507	100

Employment in the uranium industry

With the continuing reduction of uranium related activities, direct employment in the Czech uranium industry has declined to some 3 180 workers, as of the end of 2000. This employment is engaged in uranium production, decommissioning and restoration activities.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
3 410	3 300	3 180	2 850

Future production centres

In compliance with the government's decision, uranium production will continue at a reduced level. Under the current scenario, Rozná underground mine will continue annual production of 330 tU until 2003. The Stráz ISL operation will produce a decreasing amount of uranium under the remediation regime; expected production in 2002 is 100 tU.

No other production centres are committed or planned in the near future.

Short-term production capability
(tonnes U/year)

2001				2002				2005			
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	660	660	0	0	550	550	0	0	110	110

2010				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	84	84	0	0	87	87	0	0	80	80

Uranium production centre technical details
(as of 1 January 2001)

Production centre name	Dolní Rozínka (Rozná)	Stráz
Production centre class	existing	existing
Operational status	operating	closed*
Start-up date	1957	1967
Source of ore: • Deposit name • Deposit types • Reserves (active resources) • Grade (% U)	 Rozná vein 1 180 tU 0.323	 Stráz sandstone 1 500 tU 0.030
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 UG 660 95	 ISL – 60 (estimated)
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day; for ISL kl/day or l/hr) • Average processing recovery (%)	 ALKAL/IX/CWG 580 95	 ISL/AL/IX 50 000 kl/day –
Nominal production capacity (tU/year)	400	250

* Extraction continues under remediation regime.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Mining and milling of uranium ores in the Czech Republic led to serious impacts on the environment, the removal of which will require a long-lasting remediation procedure. It will continue for many years and will require considerable financial resources.

Currently, in conjunction with the reduction of uranium production, DIAMO's main programme consists of decommissioning and restoration activities which are described below.

Environmental impact assessment (EIA)

All projects in the government-owned enterprise DIAMO, which relate to the act of CNR No. 244/1992 Coll., are subject to standard environmental impact assessment procedures. In the past two years, EIA procedures were followed for remediation projects of tailings impoundments in the uranium production facility Dolní Rozínka and in Mydlovary.

Monitoring

Environmental monitoring proceeds according to the monitoring programme for all uranium sites, which is approved by authorities of the state administration and by expert supervision. The monitoring programme defines the extent, frequency and methodology of sampling and its assessment. Sampling and analytical work is performed by DIAMO, s.p. and by external laboratories. Monitoring results are regularly evaluated and used for risk analyses, project planning, management of remediation work and EIAs. The environmental status of areas affected by DIAMOs operation is periodically published.

Tailings impoundment

Environmental remediation of tailings impoundments of uranium processing plants in the Czech Republic represent the top-priority environmental tasks of DIAMO, s.p. Tailings impoundments of former chemical processing plants in Mydlovary and Stráz pod Ralskem are of the most environmental concern. Also the tailings impoundment remediation project of the uranium chemical processing plant in Dolní Rozínka (currently in operation) will be technically and financially demanding. The pilot project on remediation performed under the terms of the Phare programme (Remediation Concepts for the Uranium Mining Operations in CEEC) was successful.

Waste rock management

DIAMO manages many waste rock dumps resulting from underground uranium mining throughout the Czech Republic. Waste rock dumps with negative environmental impact and no possibility of further utilisation were decommissioned and reclaimed prior to other dumps. Parts of waste rock dumps are successfully processed to crushed stone and are exploited in building industries (Vítkov, Zadní Chodov, Dylen, Príbram). Some waste rock dumps are reshaped or removed, reclaimed and incorporated into the surrounding landscape (Olsí, Licomerice, Hájek). Other waste rock dumps are technically and biologically reclaimed or *in situ* reforested (Okrouhlá Radoun, Pucov, Krizany, Príbram). The waste rock dumps represent meaningful landscape-creation elements.

Effluent management

DIAMO performs many different activities related to water management. It supplies drinking water for customers, carries out treatment of effluent, implements pumping, cleaning and drainage of mine waters and waters from tailings impoundments into public streams. A particular problem is water treatment related to the remediation of the Stráz uranium deposit after *in situ* leach mining. Several water treatment plants and decontamination stations had to be restored or built (Okrouhlá Radoun, Zadní Chodov, Pucov, Licomerice, Horní Slavkov, Stráz pod Ralskem and others) to ensure effective water management. This activity is conducted according to laws and regulations and it is strictly controlled by the state administration and by expert supervision.

Site rehabilitation

Site rehabilitation is carried out in accordance with the complex process of decommissioning and remediation of uranium mining and milling facilities. Site rehabilitation projects provide alternative uses for uranium production machinery, buildings, technology and mining areas. Removing production facilities including buildings with resulting decontamination and biological reclamation of soil is most often performed in the remote uranium sites (e.g. facilities in western Bohemia). If other activities are planned for former production facilities, a complete decontamination and decommissioning process is performed, e.g. chemical processing plant Mydlovary, Stráz pod Ralskem, Krizany mine and others.

Regulatory activities / environmental law and regulation

Complex laws and regulations related to the operation, decommissioning and restoration of the mining and milling facilities are in place and need to be followed in the Czech Republic. The State administration and expert supervision control the implementation of these laws. At the beginning of the 1990s, Czech Republic legislation was completed, which included other important acts concerning the environment. In preparation for the entry by the Czech Republic into the European Union, exact adoption and implementation of European environmental law is in progress. Current environmental and remediation activities are already being brought to common European standards.

Social issues

At the end of the 1980s, the government issued decrees related to the contraction of uranium production in the Czech Republic. Production was decreased step by step to about 20% of 1989 production or about 500 tU yearly. About 90% of uranium industry employees were discharged and the current employment level is about 3 000. The contraction programme consists of gradually decreasing the payroll and development of a compensatory plan for the staff at each production centre. DIAMO transformed itself into an engineering company with appropriate expertise in the environment. The social part of the contraction programme is financed by the state.

Expenditures on environmental activities and social issues (CZK million)

Item / Year	1998	1999	2000	2001*	Total 98-01
Decommissioning, remediation, water treatment, monitoring	1 037.7	891.0	873.0	1 099.2	3 900.9
Social programme and measures	422.9	442.2	476.5	490.0	1 831.6
Total	1 460.6	1 333.2	1 349.5	1 589.2	5 732.5

* Expected.

URANIUM REQUIREMENTS

Uranium requirements in 1999 and 2000 were influenced by starting up of the Temelín Unit 1 and 2 nuclear power plants, as the quantity of uranium needed for the first core is higher than for reloads. Also, different lead times for conversion and fabrication (according to terms of current contracts with different suppliers) have contributed to somewhat variable uranium needs in the period of 2000-2005.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 632	2 544	3 456	3 456	3 472	3 456	3 472	3 456	3 472

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
772	512	605	680	690	680	690	680	690

Supply and procurement strategy

CEZ, a.s., purchases uranium concentrates from the domestic producer DIAMO, s.p., based on long term contracts.

NATIONAL POLICIES RELATING TO URANIUM

DIAMO has exclusive rights for the exploration, mining and processing of uranium. Continued production is planned at both Stráz (under decommissioning and restoration programmes) and Rozná mines, which still have sufficient reserves for several years of production. CEZ, a.s., the only uranium consumer for energy purposes in the Czech Republic, purchases uranium concentrates from domestic sources. The government strategy is to balance uranium production with reactor-related uranium requirements.

URANIUM STOCKS

Stocks in the form of natural uranium are held by the government (>2 000 tU) as well as by DIAMO (500 tU). The utility company, CEZ, a.s., holds uranium inventory only in the form of fabricated fuel.

Total uranium stocks
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	>2 000	0	0	0	>2 000
Producer	500	0	0	0	500
Total	>2 500	0	0	0	>2 500

URANIUM PRICES

No information reported.

• Finland •

URANIUM EXPLORATION

Historical review

Uranium exploration was carried out in Finland from 1955 to 1989, first by several organisations but from the late 1970s mainly by the Geological Survey. Since their beginning in the early 1970s, the regional aerogeophysical 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%; 950 tU) and the Pahtavuoma-U vein deposit (0.19%; 500 tU) in Paleoproterozoic quartzite and greenstone-associated graphitic schists, respectively.
- The Kuusamo province in northeastern 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%; 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%; 1 000 tU) and the Askola area.

The geological settings further include:

a) Uraniferous phosphorites associated with sedimentary carbonates of the Paleoproterozoic sequences, e.g., the Vihanti-U (Lampinsaari) deposit (0.03%; 700 tU) and the Nuottijärvi deposits (0.04%; 1 000 tU).

b) Uranium mineralisation and uraniferous carbonate veins in Paleoproterozoic albitite and albite diabase dykes, mostly in northern Finland.

c) Uranium- and thorium-bearing dykes and veins of Paleoproterozoic pegmatite granites.

d) Surficial concentrations of young uranium in recent peat.

Possible by-product uranium occurs in the low-grade Ni-Cu-Zn deposit of Talvivaara (0.001-0.004% U), hosted by Paleoproterozoic black schists, in central Finland, and in pyrochlore of the Paleozoic Sokli carbonatite (0.01% U) in eastern Lapland.

Recent and ongoing uranium exploration activities

There are no exploration activities in Finland for uranium.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Finland reports 1 500 tU of Reasonably Assured Resources in the cost range USD 80-130/kgU, included in the deposits of Palmottu and Pahtavuoma-U.

An additional 2 900 tU in the cost range RAR USD 130-260/kgU are contained in the deposits Nuottijärvi, Vihanti-U (Lampinsaari) and Kesänkitunturi, and in those of the Koli area (Ipatti, Martinmonttu and Ruunaniemi). No EAR-I resources are reported.

Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	1 500

Undiscovered conventional resources (EAR-II & SR)

None reported.

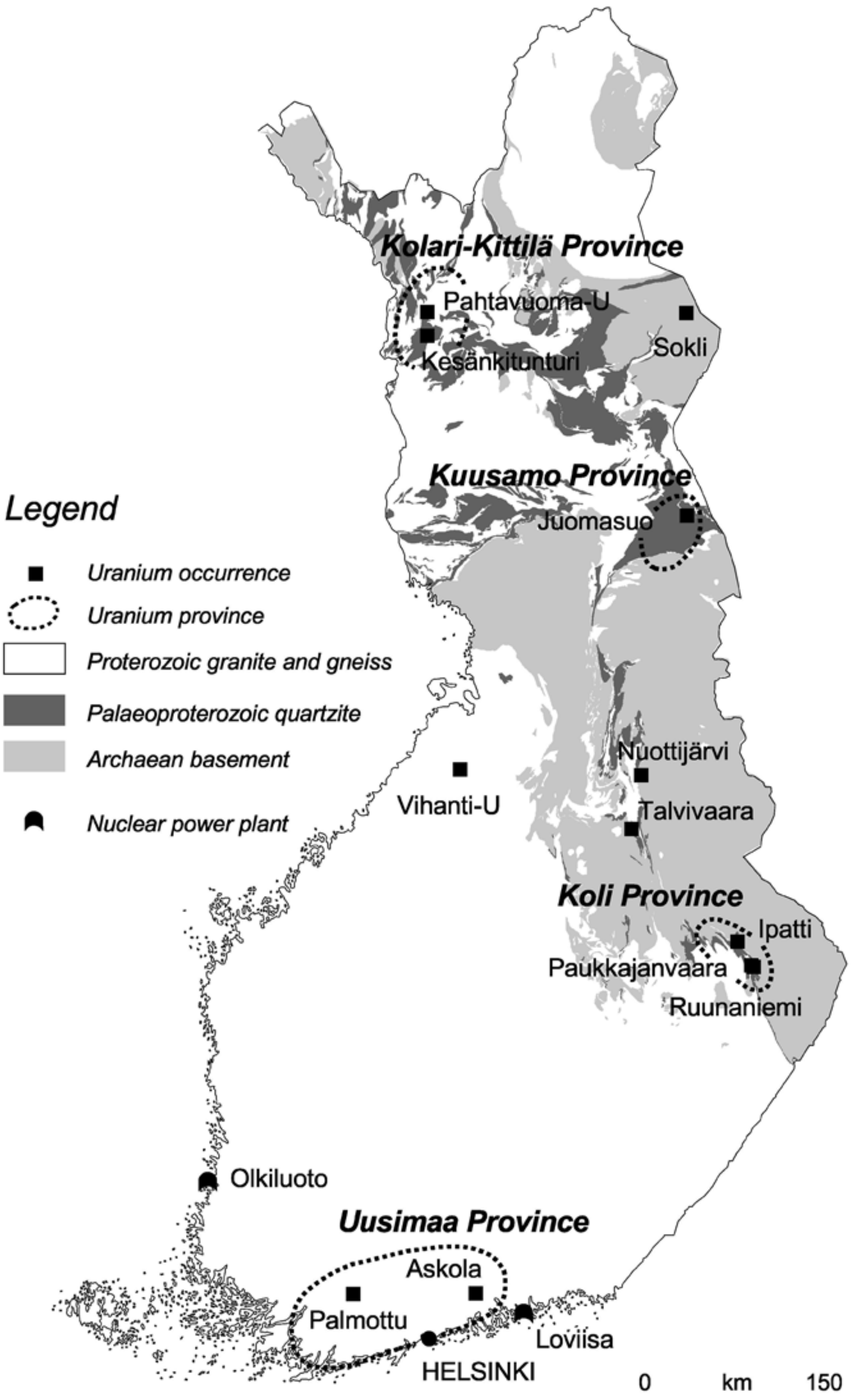
Unconventional resources and other materials

As by-product resources, from 3 000 to 9 000 tU could by recovered from the Talvivaara black schists, and another 2 500 tU from the Sokli carbonatite.

Unconventional resources
(tonnes U)

Cost range	Cost range	Total
<USD 130/kg U	Unassigned	
0	5 500-11 500	5 500-11 500

Uranium deposits and occurrences in Finland



URANIUM PRODUCTION

Historical review

Uranium production in Finland has been confined only to the now restored Paukkajanvaara mine, operated as a pilot plant between 1958 and 1961. A total of 40 000 tonnes of ore was hoisted, and the concentrates produced equalled about 30 tU. Currently, Finland has no production capability and has reported no plans to develop any.

Historical uranium production (tonnes U)

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Processing plant	30	0	0	0	30	0
Total	30	0	0	0	30	0

Environmental activities and socio-cultural issues

A research programme on radionuclide transport analogy surrounding Palmottu deposit has been completed. The results were presented as several publications and reports. Five European countries participated in the programme.

According to legislation in Finland, export of spent nuclear fuel is not permitted after 1996. From the beginning of the 1980s, investigations were made to solve the problem of final disposal. Posiva Ltd was established in 1996 for investigating the final disposal of spent nuclear fuel into Finnish bedrock, and a proposal for the site was made in 2000.

On 21 December 2000, the Finnish Government made a Decision-in-Principle on a project concerning final disposal of spent nuclear fuel. According to the Decision, the project for constructing a final disposal plant is in line with the overall good of society, and the project can proceed towards more in-depth investigations.

The Paukkajanvaara uranium mine was operated during 1958-1961. After the mining operations, the opening of the shaft was blocked, but the barren rock and tailings pond were left in open air. In October 1993, the pit and tailings were covered with uncontaminated soil. The old concentration plant has been torn down and the site covered. The Finnish Centre for Radiation and Nuclear Safety has been monitoring the mine area and its surroundings since 1984.

URANIUM REQUIREMENTS

At the beginning of 2001 four reactors were in operation: Olkiluoto 1 and Olkiluoto 2 owned by TVO (Teollisuuden Voima Oy) and Loviisa 1 and Loviisa 2 owned by Fortum Power and Heat Oy (the former IVO). The installed capacity was 2.6 GWe. No new reactors are under construction. Uranium requirements are approximately 500 tU/year for the four reactors.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 600	2 600	2 600	2 600	2 600	2 600	2 600	2 600	2 600

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
500	500	500	500	500	500	500	500	500

Supply and procurement strategy

TVO procures natural uranium, enrichment services and fuel fabrication from several countries. Fortum Power and Heat Oy purchases fuel assemblies from Russia, but lead test assemblies have been ordered from an alternative source.

NATIONAL POLICIES RELATING TO URANIUM

Licences for mining, enrichment, possession, fabrication production, transfer, handling, use and transport of nuclear materials and nuclear wastes may be granted only to Finnish citizens, Finnish corporations or foundations, or to governmental authorities. However, under special circumstances, foreign corporations or authorities may be granted a license to transport nuclear material or nuclear waste within Finland. No significant changes to Finnish uranium policies are reported.

URANIUM STOCKS

The nuclear power utilities maintain reserves of fuel assemblies for about one year’s use.

URANIUM PRICES

Due to confidentiality aspects price data are not available.

• France •

URANIUM EXPLORATION

Historical Review

Uranium prospecting in France began in 1946, focusing on already known uranium ore deposits and the few mineralisation occurrences discovered during radium exploration.

In 1948, exploration work based on foot, carborne and airborne radiometric surveys, and very early geological mapping, led to the discovery of the La Crouzille deposit, formerly of major importance. By 1955, deposits had been identified in the granite areas of Limousin, Forez, Vendée and Morvan.

Based on geological mapping and radiometric, geophysical and geochemical techniques, prospecting activities first concentrated on the areas surrounding known deposits. They were subsequently extended to sedimentary formations in small intragranitic basins and terrigeneous formations, arising from eroded granite mountains and mainly located north and south of the Massif Central.

Between 1977 and 1981, prospecting was subsidised by the government (Plan for Uranium Exploration Aid) for a total of approximately USD 38 million. The purpose of this aid was to encourage exploration activities in France and abroad, at sites considered to be promising but with a significantly high risk. In theory, there was a subsidy ceiling of 35% of the total cost of the project, and the subsidy was to be reimbursed if a commercially viable discovery were made within the specified sites.

Recent and ongoing activities

Since 1987, uranium exploration activities have been declining in France. After focusing on areas around production centres in the hope of finding, in their vicinities, deposits more likely to be mineable, exploration activities are now restricted to only those connected with exploitation.

The work was confined to the northwestern part of the Massif Central (where the Société des Mines de Jouac, a subsidiary of Cogéma, was continuing to mine the Bernardan deposit). The exploration activities confirmed in 1998 that the deposit's reserves were insufficient to envisage extending commercial exploitation beyond the year 2001, leading to the end of exploration expenses in France.

Abroad, Cogéma has been focusing on targets aimed at the discovery of exploitable resources, even in a difficult market economy.

In Australia, Canada, Niger and Central Asia, Cogéma is directly or indirectly involved in uranium exploration or development activities through subsidiaries. In Canada, Niger and Kazakhstan, it is also 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. French uranium exploration companies are all private companies in which the French Government holds shares through the parent companies.

Uranium exploration expenditures abroad*

	1998	1999	2000	2001 (expected)
French francs (× 1 000)	52 400	44 600	NA	NA
USD (million)	8.777	7.120	NA	NA

* The companies involved in uranium exploration in France are private companies in which the French Government has a majority shareholding and in which shares are also held by private investors. If, for statistical reasons, expenditures were to be split into two parts corresponding to public and private participation in the capital of companies, the values indicated should be multiplied by a factor of 0.815 and 0.185, respectively.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

The depletion of resources through mining in 1997 and 1998 has not been offset by new discoveries. As uranium exploration activities have totally ceased, this process is unlikely to be reversed.

RAR resources as of 1 January 2001 are down 27% from 1 January 1999. EAR-I remain unchanged.

The known resources belonging to the cost category below USD 80/kgU are reassessed each year. Most of the RAR and EAR-I resources in the cost category USD 80/kgU-130/kgU (those not located in orebodies actually mined) were assessed more than 5 years ago.

Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
194	194	194

Estimated additional resources – Category I
(tonnes U)

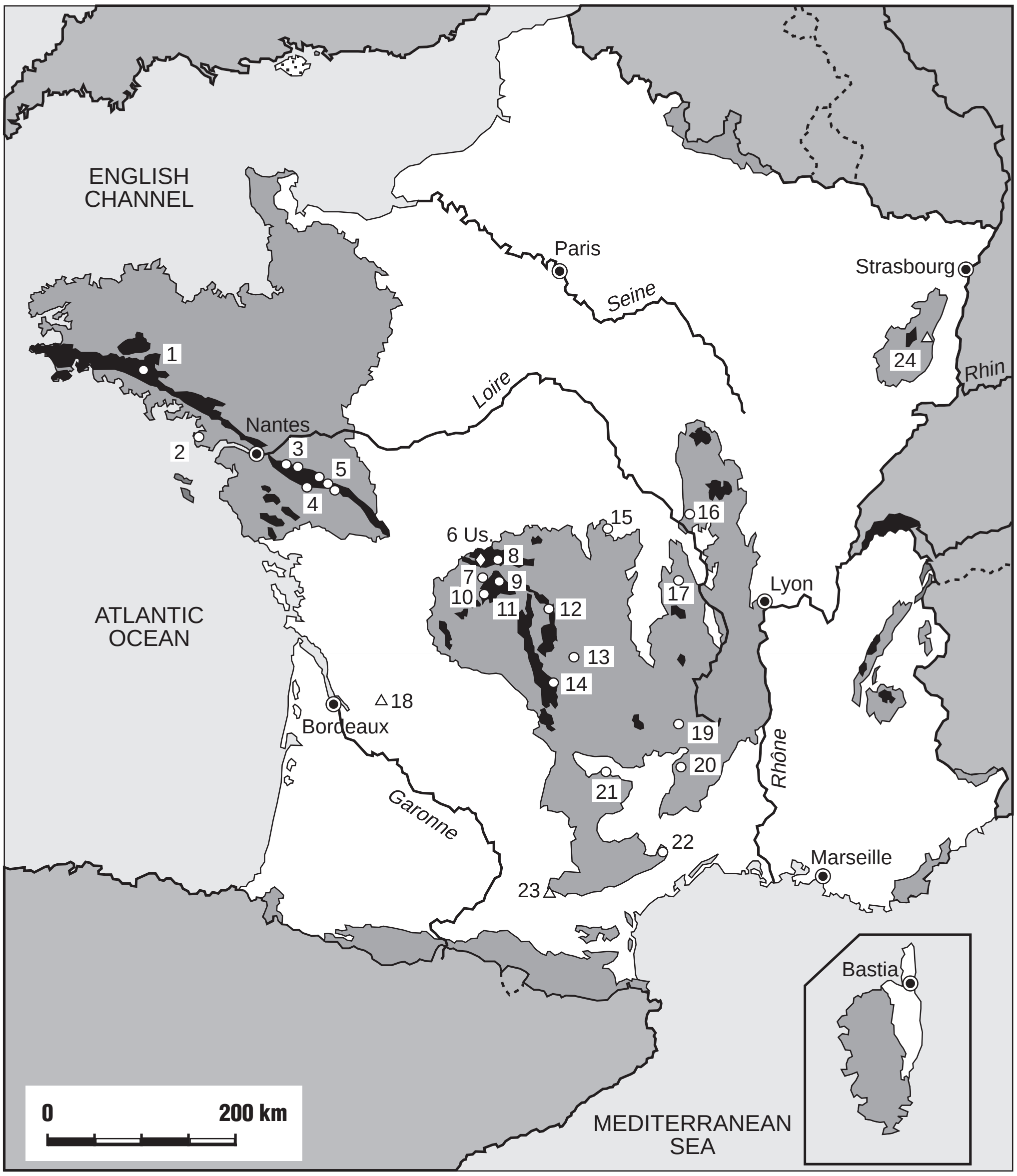
Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	11 739

Deductions for anticipated mining and ore processing losses are determined for each deposit with an estimated 10% loss for each deducted.

Undiscovered conventional resources (EAR-II & SR)

No systematic appraisal is made of undiscovered resources in France.

Main uranium deposits in France



Uranium deposits:

◊	Being mined
△	To be mined
○	Mined out
Us.	Operating uranium mill
■	Leucogranite
▒	Variscan Massif

1. Pontivy
2. Pennaran
3. Le Chardon
   L'Écarpière
4. Beaurepaire
5. La Chapelle Largeau
   La Commanderie
   La Dorgissière
6. Le Bernardan (Maihac)
7. Le Brugeaud
8. Bellezane
9. Fanay
   Le Fraisse
10. Magnac
    Vénachat
11. Henriette
12. Hyverneresse
13. St-Pierre-du-Cantal
14. La Besse
15. Cerilly
16. Grury
17. Les Bois Noirs
18. Coutras
19. Le Cellier
    Les Pierres Plantées
20. Les Bondons
21. Bertholène
22. Mas Laveyre
23. Tréville
24. St-Hyppolyte

Source: CEA-DCC/MNC, June 97.

URANIUM PRODUCTION

Historical review

As a result of the mine closures French uranium production has declined since 1990. With the closure of the Lodève mining site in 1997 and of Le Bernardan in 2001, there are no active uranium operations in France.

Historical uranium production (tonnes U)

	Pre-1998	1998	1999	2000	Total through 2000	2001 (expected)
Processing plant	72 500	452	416	296	73 664	120
Total	72 500	452	416	296	73 664	120

Status of production capability

All ore-processing plants in France are decommissioned or being decommissioned. No other production centre is under construction, planned or envisaged. The Le Bernardan production centre ceased operation in 2001.

Uranium production centre technical details
(as of 1 January 2001)

Name of production centre	Le Bernardan SMJ (Cogéma)
Production centre class	existing
Operational status	closed
Start-up date	1979
Source of ore • Deposit name • Deposit type	 Bernardan veins & orebodies in granites
Mining operation • Type (OP/UG/*in situ*) • Size (tonnes ore/year) • Average mining recovery (%)	 OP/UG 183 000
Processing plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	 AL/IX 500 97.1
Nominal production capacity (tU/year)	600
Plans for expansion	NIL
Other remarks	closed in 2001

Ownership structure of the uranium industry

Cogéma is the only French group operating in the uranium mining field. In France, its subsidiary, the "Société des Mines de Jouac", has been operating the Bernardan deposit whereas the Lodève deposit, now under restoration, was operated by Cogéma directly.

Ownership of uranium production in 2000

DOMESTIC				FOREIGN				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
296	100	0	0	0	0	0	0	296	100

Employment in the uranium industry

The number of working personnel is limited to the necessary minimum to certify remediation and safety of the old uranium sites. Reemployment of all working personnel at the Bernadan site is assured, with only a few people staying at Bernadan until 2004 in order to complete the remediation.

Future production centres

Given the current status of the uranium market, there are no plans to develop new production centres in the near future.

Short-term production capability
(tonnes U/year)

2001				2002				2005			
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	120	0	0	0	0	0	0	0	0	0	0

2010				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	0

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

There are three main phases in the working of an area containing commercial deposits of uranium. The environmental aspects which must be taken into account to avoid adverse impacts on the environment are as follows:

Mining and milling phase

The problems identified during the mining and milling phase relate to:

- The large volumes of products generated and handled:

  Solid products such as mine wastes, mill tailings and residual sludges arising from effluent treatment. Because of their chemical composition, some of these products are source terms that can potentially generate pollutants; the main problem is the possible air-borne or water-borne dispersal of pollutants such as radionuclides and associated heavy metals which they contain.

  Liquid products consisting primarily of mine water, process discharges and effluents from the dewatering of managed solids; because the quality of such effluents can vary substantially, they may require monitoring and treatment, where necessary, prior to discharge to the environment.

- Underground mining work which can temporarily alter the local hydrogeological environment and create a risk of instability. A network of piezoelectric sensors and stability checks are required.
- Open-pit mining activities whose impact on the landscape must be minimised. These activities require the stabilisation of mine workings and the monitoring of air quality in facilities and the surrounding environment in order to limit the dispersion of polluting dusts.

Post-mining and milling phase: remediation

Environmental problems are the direct consequence of past activities; the remediation of sites therefore corresponds to the period during which work is carried out to reduce, and preferably eliminate, the residual impact on the environment of the various source terms as well as mining and industrial facilities.

The measures to be taken primarily consist of:

- Installation of a selective discharge drainage system.
- Geotechnical work to make the wells safe and levels closest to the surface stabilised in order to prevent rocks from caving in at a later date.
- Contouring of mine waste dumps in order to stabilise them and blend them into the surrounding landscape.
- Covering tailings impoundments with sterile, protective rock material and, if necessary, contouring embankments.
- Decommissioning of plants and disposal of non re-usable products.
- Revegetation to complete stabilisation of the surface layer and landscaping.

Post-remediation phase: continued monitoring

This phase is primarily one of active surveillance following the completion of reclamation work and is aimed at ensuring the perennial limitation of the residual impact of the site on its surrounding environment.

This objective is achieved through continued monitoring of:

- Air quality (gamma radiation, radon, dust) in the surrounding environment.
- The chemical composition of different types of water discharge, in particular that of acid mine drainage, prior to release into the natural environment.
- The stability of mine workings that have been secured.
- The residual impact of the site through analyses of plants, wildlife and the food chain in the natural environment of the site.

Those data can be used together with forecasting models to predict the medium and long-term behaviour of the site and to adjust preventive and remedial measures to be taken during a period long enough to allow a satisfactory environmental equilibrium to be restored.

Experience has shown that problems related to water quality and soil stability, particularly for mines that have been closed for a very long time, are the most important ones.

The status of the site will gradually move towards that of passive surveillance. At this point monitoring activities and analyses can be reduced, subject to a detailed review of the results achieved. At present, the monitoring of mill impoundments must still be maintained in view of the decay period of the radionuclides they contain. However, reliable simulation models of their anticipated behaviour are currently being designed.

Cost of environmental management

Forez	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	1 274	1 648	2 200	2 000	7 122
Closing out tailings impoundments	0	0	0	0	0
Decommissioning/decontamination	0	0	0	0	0
Effluent management (gas, liquid)	0	0	1 000	1 000	2 000
Site rehabilitation	0	0	200	0	200
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (× 1 000)	**1 274**	**1 648**	**3 400**	**3 000**	**9 322**

Hérault	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	4	0	0	1 758	1 762
Closing out tailings impoundments	0	0	0	0	0
Decommissioning/decontamination	5 176	1 307	23 118	5 105	34 706
Effluent management (gas, liquid)	0	0	10 613	183	10 430
Site rehabilitation	59 448	40 154	19 088	3 918	122 608
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (× 1 000)	**64 628**	**41 461**	**52 819**	**10 964**	**169 506**

Cost of environmental management (cont'd)

La Crouzille	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	11 502	3 672	3 833	4 956	23 963
Closing out tailings impoundments	0	0	0	0	0
Decommissioning/decontamination	22 088	263	200	125	22 676
Effluent management (gas, liquid)	13 468	5 771	6 050	6 231	31 520
Site rehabilitation	242 457	18 083	15 415	172	276 127
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (× 1 000)	**289 515**	**27 789**	**25 498**	**11 484**	**354 286**

Vendée	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	9 409	2 815	2 820	2 050	17 094
Closing out tailings impoundments	0	0	0	0	0
Decommissioning/decontamination	14 889	0	0	0	14 889
Effluent management (gas, liquid)	5 630	1 559	2 193	1 458	10 840
Site rehabilitation	176 576	576	2 118	270	179 540
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (× 1 000)	**206 504**	**4 950**	**7 131**	**3 778**	**222 363**

Others	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	6 324	1 069	1 474	884	9 751
Closing out tailings impoundments	0	0	0	0	0
Decommissioning/decontamination	16	0	0	0	16
Effluent management (gas, liquid)	0	23	0	0	23
Site rehabilitation	27 547	76	0	0	27 623
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (× 1 000)	**33 887**	**1 168**	**1 474**	**884**	**37 413**

URANIUM REQUIREMENTS

Uranium requirements and supply strategy

The total number of nuclear power plants should not change now that the four N4 reactors have been put into service. The total capacity of nuclear power plants and the uranium requirements should also remain the same as no reactor are expected to be shut down in the next 15-20 years.

Since France is a net importer of uranium, its policy towards procurement is one of supply diversification. French mining operators participate in uranium exploration and exploitation outside France within the regulatory framework of the host countries. They also purchase uranium, under short or long-term contracts, either from mines in which they have shareholdings or from mines operated by third parties.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
63 200	63 200	63 200	63 200	63 200	63 200	63 200	63 200	63 200

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
8 879	8 568	8 568	8 168	8 168	8 168	8 168	8 168	8 168

NATIONAL POLICIES RELATING TO URANIUM

There have been no significant changes to national policy since the last report. Uranium exploration and production in France are unrestricted within the framework of existing regulations. On the whole, France is mainly a uranium importing country and there are no tariff barriers for imports.

URANIUM STOCKS

Électricité de France (EDF) possesses strategic uranium inventories, the minimum level of which has been fixed at the equivalent of three years forward consumption to offset possible supply interruptions.

URANIUM PRICES

Information on uranium prices is not available.

• Gabon •

URANIUM EXPLORATION

Historical review

Prompted by the sudden demand for uranium following World War II, the French Commissariat à l'Énergie Atomique (CEA) initiated uranium exploration in Central Africa. Though based in the then Congo, CEA geologists extended their activities into Gabon. In 1956, surface scintillometry surveys led to a uranium discovery in Precambrian sandstones of the Franceville Basin in the vicinity of the village Mounana.

Recent and ongoing activities

No exploration is reported.

URANIUM RESOURCES

With the closure of uranium production facilities in Gabon, uranium resource estimates are no longer updated.

URANIUM PRODUCTION

Historical review

The uranium production of COMUF experienced significant fluctuations since the company started producing in 1961. Impacting parameters were the ore processing capacity as well as the international uranium market. The main changes were:

- 1961–1969: attainment of a production level of approximately 400 tU/year.
- 1970–1973: gradual production increase to 500 tU/year.
- 1974–1979: rapid production increase to 1 250 tU/year.
- 1980–1989: production decrease to 900 tU/year.
- 1990–1993: further reduction to 550 tU/year.
- 1994–1996: maintenance of a production level of 600 tU/year with the possibility of an adjustment to 550 tU/year.
- 1999: termination of uranium production operations and initiation of mill decommissioning.

Historical uranium production
(tonnes U)

Production method	Pre-1998	1998	1999	2000	Total to 2000	2001 (expected)
Open pit mining	11 422	725	0	0	12 147	0
Underground mining	15 725	0	0	0	15 725	0
Total	27 147	725	0	0	27 872*	0

* Of the total production, 94 tU were found to be depleted in ^{235}U. The uranium was produced from the natural reactor sites of the Oklo deposits.

Status of production capability

The last ore from the Okelobondo underground mine was produced in November 1997. Ore production from the Mikouloungou open pit mine continued from June 1997 until March 1999, when all mine production was stopped at the COMUF production centre.

Ownership structure of the uranium industry

COMUF operated under a mutual agreement (“Convention d’Établissement”) between the Government of Gabon and the company.

Short-term production capability

Gabon terminated uranium production in 1999 and is decommissioning its production facilities.

Uranium production centre technical details
(as of 1 January 2001)

Name of production centre	Mounana
Production centre class	existing
Operational status	closed; being reclaimed
Start-up date	1988
Sources of ore: • Deposit name • Deposit type	 Mikouloungou / Okelobondo sandstone
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	 UG 800 80
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	 SX 1 300 95
Nominal production capacity (tU/year)	0
Plans for expansion	no

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

The most important environmental concerns are related to the impacts caused by the mining and milling activities. This includes the long-term management of the tailings and other waste produced at the mill site.

With the termination of all uranium production in Gabon, the Government started a programme for rehabilitation of the complete Mounana mining and milling operation. There are seven sites covering a total surface of about 60 ha to be rehabilitated. The work to be done consists of:

- The closure of all impoundments for tailings and other residues.
- The development of a lateritic cover over the tailings.
- Revegetation of the sites.

The objective of this remediation work is to assure a residual radiological impact that is as low as is reasonably achievable (i.e. following the ALARA principal). The work is intended also to ensure the physical stability of the impoundments of the residues, and if possible, provide for the future utilization of the affected area.

The Mounana mill is completely dismantled and restoration of the site is expected to be completed by late 2001. A programme for long term monitoring and surveillance of the tailings will then be implemented.

Gabon has no uranium requirements and reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Germany •

URANIUM EXPLORATION

Historical review

Exploration for uranium in Germany is a story that occurred in two countries, prior to reunification that occurred on 3 October 1990. A summary of the activities within the two countries is provided.

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. The mining of uranium first began at the 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 actitvities. The richer 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 uranium produced either hand-picked concentrate, gravity concentrate, or chemical concentrate was shipped to the USSR for further treatment. The price for the final product was simply agreed to between 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. Uranium exploration had started in 1950 in the vicinity of the radium spa at Ronneburg. 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.

Uranium exploration using a variety of ground-based and aerial techniques occurred in the southern part of the former GDR that covered an extensive area of about 55 000 km^2. About 36 000 holes 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 5.6 billion GDR Marks.

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 volcanic and continental sediments of the Saar-Nahe region and other areas with favourable sedimentary formations.

The initial phase included hydrogeochemical surveys, car-borne surveys, surveys on foot, 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 northeastern Bavaria. Uranium exploration ceased in western Germany in 1988. Through 1988, about 24 800 holes were drilled, totalling about 354 500 m. Total expenditures were on the order of USD 111 million.

There have been no exploration activities in Germany since the end of 1990. Several German mining companies did perform exploration abroad mainly in Canada up through 1997.

Recent and ongoing uranium exploration and mine development activities

There are no exploration activities and no plans for future activities.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Known conventional resources were last assessed in 1993. The known conventional resources occur mainly in the closed mines which are in the process of being decommissioned. Their future availability remains uncertain.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	3 000

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	4 000

* Mining losses have been accounted in the estimation at 10-15% and ore processing losses have been estimated at 5%.

Undiscovered conventional resources (EAR-II & SR)

All undiscovered conventional resources are reported as speculative resources in the cost category above USD 130/kgU.

Speculative resources
(tonnes U)

Cost range	Cost range	Total
<USD 130/kg U	Unassigned	
0	74 000	74 000

URANIUM PRODUCTION

Historical review

Federal Republic of Germany before 1990

An uranium processing centre at Ellweiler, in the state of Baden-Württemberg was operated by Gewerkschaft Brunhilde beginning in 1960. Serving as a test mill for several types of ore its capacity was only 125 tU per year. It was closed on 31 May 1989 after producing around 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.

Since 1992, all uranium production in Germany has been derived from the clean-up operations at the Königstein mine.

Status of production capability

There is no commercial production of uranium in Germany. Since 1992 only minor amounts of uranium, about 30 tU per year, are recovered from clean-up activities in previous mines.

Historical uranium production (tonnes U)

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Processing plant	209 326	0	0	0	209 326	0
In place leaching*[1]	5 407	0	0	0	5 407	0
Heap leaching	3 955	0	0	0	3 955	0
Other methods, *e.g.* mine water treatment, environmental restoration.	67	30	29	28	154	20
Total	218 755	30	29	28	218 842	20

* Also known as Stope Leaching or Block Leaching.

1. Since 1992 from decommissioning.

Ownership structure of the uranium industry

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, no commercial uranium industry remains. The German federal government though Wismut GMBH retains ownership of all uranium recovered in clean up operations.

Ownership of uranium production in 2000

DOMESTIC				FOREIGN				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
28	100	0	0	0	0	0	0	28	100

Employment in the uranium industry

All employment is engaged in decommissioning and rehabilitation of former production facilities.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
3 615	3 149	3 115	3 100

Future production centres

No production centres are planned.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

With the reunification of Germany in 1990, commercial uranium production was terminated. The German government took responsibility for the decommissioning and rehabilitation of former production sites and has allocated a total of 13 billion DEM in its Federal budget. Up to the end of 2000 about 6.7 billion DEM have been spent. Thanks to the efforts jointly invested in the Wismut project by all participants, significant progress has been achieved leading to a significant abatement of adverse environmental impacts. Expenditures related to environmental activities are tabulated below.

Expenditures for environmental activities
(in million DEM)

	1998	**1999**	**2000**	**2001**	**Total**
Monitoring	25.7	29.8	28.6	26.7	**110.8**
Rehabilitation of tailings	38.5	43.5	40.7	46.7	**169.4**
Site rehabilitation [1]	53.8	48.3	37.3	40.7	**180.1**
Water treatment	60.7	58.6	60.8	70.0	**250.1**
Waste rock management [2]	104.4	113.6	122.1	140.3	**480.4**
Total	**283.1**	**293.8**	**289.5**	**324.4**	**1 190.8**

1. Including demolition.
2. Including planning, licensing, administration.

URANIUM REQUIREMENTS

Historical review

According to the agreement between the Federal Government of Germany and the utility companies dated 14 June 2000, the future utilisation of nuclear power plants shall be restricted. For each plant the residual operating life remaining after 1 January 2000 shall be calculated on the basis of a standard operating life of 32 calendar years from the commencement of commercial power operation. Accordingly the future uranium requirements will decrease, however, details of the annual requirements for the period to 2020 cannot be given.

Installed nuclear generating capacity to 2020[2]
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
21 300	21 300	21 300	NA	NA	NA	NA	NA	NA

NA = Not available.

Annual reactor-related uranium requirements to 2020[2]
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
3 350	3 200	3 100	NA	NA	NA	NA	NA	NA

NA = Not available.

Germany reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• 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 its 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 in Permian sandstones was made in 1954.

2. Germany has announced plans to phase out the use of nuclear energy. However, specific schedules have not yet been finalised so specific forecasts are impractical.

Further work was concentrated on the evaluation of the deposit and its development. The first shafts were sunk in 1955 and 1956 for the mining plants 1 and 2. In 1956, the Soviet-Hungarian uranium joint venture was dissolved and the project became the sole responsibility of the Hungarian State. In the same year, uranium production from the Mecsek deposit started.

Exploration conducted by the geological staff of the Mecsek uranium mine continued until 1989 when it was terminated because of changes in market conditions.

URANIUM RESOURCES

Hungary's reported uranium resources are limited to those of the Mecsek uranium deposit.

The ore deposit 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 occurs in the upper 200 m of the unit. It is underlain by a very thick Permian siltstone and covered by a Lower Triassic sandstone. The thickness of the green ore-bearing sandstone, locally referred to as the productive complex, varies from 15 m to 90 m. The ore minerals include uranium oxides and silicates associated with pyrite and marcasite.

Known conventional resources (RAR & EAR-I)

Hungary reports no RAR or EAR-I resources.

Undiscovered conventional resources (EAR-II & SR)

Speculative resources are not estimated. Continuing remediation work has caused a re-evaluation of Hungary's resources. Known uranium resources classified as EAR-I as of 1 January 1999, are now classified as EAR-II recoverable at costs below USD 130/kgU. These resources are tributary to the Mecsek production centre.

Estimated additional resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	18 399

URANIUM PRODUCTION

Historical review

The Mecsek mine, an underground facility, was the only uranium producer in Hungary. Prior to 1 April 1992, it was operated as the state-owned Mecsek Ore Mining Company (MÉV). The complex began operation in 1956 and was producing ore from a depth of 600-800 m in 1997 when it was permanently shutdown. It had been producing 500 000 to 600 000 tonnes ore/year at 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, agitated acid leach (and heap leaching) with ion exchange recovery. The nominal production capacity of the plant was about 700 tU/yearThe Mecsek mine consisted of 5 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. Until that time, raw ore was exported to the USSR. A total of 1.2 million tonnes ore was shipped to the Sillimäe metallurgy plant in Estonia. After 1963, uranium concentrates were shipped to the Soviet Union.

Uranium mining and milling operations in sections IV and V were closed down at the end of 1997. Total production from the Mecsek site including heap leaching was about 21 000 tU.

Heap and *in situ* leaching activities

Mecsek Ore Mining Enterprise actively prepared heap leaching of low grade uranium ores from 1965 until 1989 when the building of heaps was stopped. During this period about 7.2 million tonnes of low-grade ore with a uranium content of 100-300 grammes U/tonne were crushed to under 30 mm and placed in 2 piles for leaching.

The process was conducted on two separate sites: site Number 1 with 2.2 million tonnes of low-grade ore and site Number 2 with 5 million tonnes.

The leaching was carried out with sodium carbonate solution and uranium was recovered using anion exchange resin. Annual uranium production ranged from 5.5 tU in the first years, to 24 tU in 1980. Total production for the heap-leaching project is estimated at about 525 tU, the average recovery was about 60%. Production continued until 1997. The former heap-leaching piles have been relocated and the sites are under reclamation.

During the early 1980s, Hungary conducted exploration for sandstone hosted uranium deposits amenable to *in situ* leaching. A potentially favourable deposit was identified at the Dinnyeberki site about 20 km west of Pecs in southwestern Hungary. The uranium deposit occurs in an organic rich non-consolidated tuff layer in a sedimentary sequence of Tertiary age. The associated sediments occupy troughs of structural and erosional origin developed in the pre-Cenozoic basement. During 1988 test leaching was carried out using acid solutions injected through wells. The tests were discontinued and no further *in situ* leaching was conducted.

Status of production capability

The Hungarian government decided in December 1994 to stop uranium mining as of 31 December 1997. Uranium production was about 10 tU in 2000 and was the by-product of water treatment activities.

Historical uranium production (tonnes U)

	Pre-1998	1998	1999	2000	Total through 2000	2001 (expected)
Processing plant	20 475	0	0	0	20 475	0
Heap leaching	525	0	0	0	525	0
Other methods e.g. mine water treatment, environmental restoration.	0	10	10	10	30	10
Total	21 000	10	10	10	21 030	10

Ownership structure of the uranium industry

The Mecsek operation had been an affiliate of the state-owned property agency through 1992. Following an evaluation of all the assets, Mecsekuran Ltd. was incorporated. The assets were divided between the state and the company in such a way that the resources remained state property, while the mining concession was transferred to Mecsekuran.

Employment in the uranium industry

None reported.

Future production centres

None reported.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

In 1996, Mecsekuran Ltd. and the former Mecsek Ore Mining Company (MÉV), more recently the Mecsekérc Environmental Corporation, prepared the conceptual plan for the decommissioning of the uranium industry in the Mecsek region. This plan sets out the methodology and schedules for the shutdown of mines and processing plants. It also contains details on dismantling and demolition together with land restoration and environmental rehabilitation.

The Hungarian authorities (mining, environmental and water agencies) have accepted this plan and the financing requirements. In 1998 after the closure of the mines, the feasibility study for the stabilisation and remediation of the tailings ponds was finalised.

The most important activities in 2000 were the experimental covering of the tailings ponds and the vertical drainage as well as the conditioning and placing of the precipitation-waste for water treatment. The programme for total remediation will continue until the end of 2004.

Cost of environmental management

	Pre-1998	1998	1999	2000
Closing of underground spaces	NA	1 266 730	841 167	281 911
Reclamation of surficial establishments and areas	NA	156 347	303 100	589 728
Reclamation of waste rock piles and their environment	NA	62 657	160 286	141 523
Reclamation of heap-leaching piles and their environment	NA	195 375	705 566	608 162
Reclamation of tailings ponds and their environment	NA	167 893	370 310	740 644
Water treatment	NA	156 740	469 909	383 300
Reconstruction of electric network	NA	0	0	98 361
Reconstruction of water and sewage system	NA	0	1 000	0
Other infrastructural service	NA	172 000	170 000	93 193
Other activities including monitoring, staff, etc.	NA	241 398	339 808	431 561
SUBTOTAL	5 406 468	2 419 140	3 361 146	3 368 383
Reserves for the amount of 1998-2000	0	52 435	86 685	0
TOTAL in HUF (× 1 000)	**5 406 468**	**2 471 575**	**3 447 831**	**3 368 383**

URANIUM REQUIREMENTS

Hungary operates the Paks nuclear plant which consists of four VVER-440-213 type reactor plants with a total net nuclear electricity generating capacity of about 1 800 MWe. At present, there are no firm plans for the construction of additional plants. Recently the Paks plant was granted an extension of its operating lifetime.

The annual uranium requirements for these plants are about 370 tU. Until 1994, the requirements could be met by uranium mined domestically. As production ceased in 1997, uranium requirements are solely satisfied by imports.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
368	311	370	370	370	370	370	370	370

NATIONAL POLICIES RELATING TO URANIUM

In 1994, Hungary made the decision to end domestic uranium production by 1997. This policy remains in force. No information on uranium stocks or uranium prices was reported.

• 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 known uranium provinces in the Singhbhum, Jharkhand and Umra-Udaisagar belt in Rajasthan where vein-type mineralisation was already known. One deposit at 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. This resulted in the discovery of two main types of deposits:

- A relatively high-grade, medium-tonnage deposit in the Cretaceous sandstones of Meghalaya in northeastern India.
- 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 Chhottanagpur 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 with overlying Proterozoic Srisailam Quartzite at Lamabapur in Nalgonda district, Andhra Pradesh. These and other showings were further followed up, and by 1996 the following areas had been identified on the basis of favourable geological criteria and promising exploration results. They 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.

Exploratory drilling in the Lambapur Peddagattu area has confirmed the potential of the northwest 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 anomalies.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration activities in India have been concentrated in the following areas:

- Proterozoic basins such as in Cuddapah, Bhima, Chhattisgarh and Vindhyan for hosting unconformity-related deposits.
- The Cretaceous Mahadek sandstone of Meghalaya for sandstone deposits.
- The Singhbhum Shear Zone of Jharkhand State and basement granitic rocks, in parts of Andhra Pradesh, Orissa, and Chhattisgarh for vein deposits.
- Albitites of Rajasthan and migmatites of Uttar Pradesh for igneous intrusive-related deposits.

Cuddapah Basin

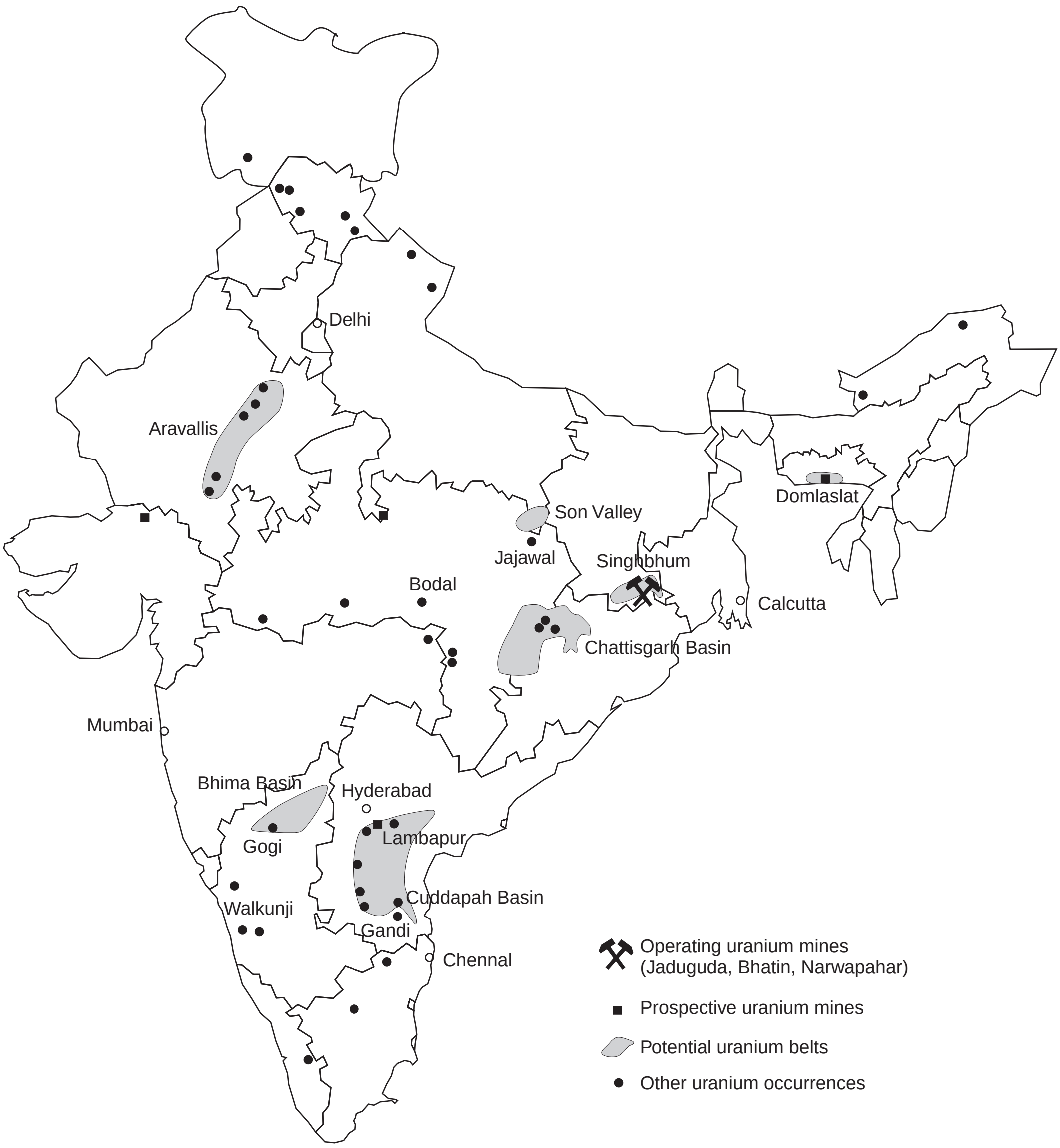
A medium-sized deposit of moderate grade has been identified at Lambapur – Peddagattu close to the northwestern margin of the Cuddapah basin, Andhra Pradesh. Evaluation and exploratory drilling of the mineralised unconformity between basement granite and overlying Srisailam Quartzite are being continued.

Extensive surface shows in a similar geological environment (unconformity surface) have been located within a 60 km^2 outlier at Chitrial. Exploratory drilling in this area is planned for the near future.

Banganapalli Quartzite (Kurnool Group) and its contact with the basement granite near Koppunuru hosts scattered uranium mineralisation over 50 km². Exploration drilling has confirmed the continuity of this mineralisation along the unconformity. Hydrogeochemical and geophysical surveys, ground surveys and drilling are being carried out to discover concealed deposits.

Extensive surface anomalies have been located in the Gulcheru Quartzite (lowermost member of the Cuddapah Supergroup) in the area around Gandi, along the southwestern margin of the Cuddapah basin. Exploratory drilling to evaluate these anomalies has begun.

Uranium occurrences in India



Bhima basin

Brecciated limestone along a major fault proximal to the unconformity contact of sediments of the Neoproterozoic Bhima Basin with the underlying basement granites is mineralised near Gogi, Gulbarga district, Karnataka. Drill holes have intersected grades up to 0.85% U in a mineralised zone with significant thickness. During 2000, drilling continued throughout the Bhima Basin.

Other Proterozoic basins

On the basis of discoveries of uranium occurrences related to unconformities, exploration efforts in other Proterozoic basins have been given first priority. The most promising among these basins are Kaladgi in Karnataka, Vindhyan in Uttar Pradesh, and Indravati in Chhattisgarh and Orissa. Exploration drilling to test the continuity of unconformity-contact mineralisation has begun.

Cretaceous sandstones of Meghalaya

Fluviatile sandstones of the Mahadek Formation (Cretaceous), covering an area of over 1 100 km², have been recognized as a potential host for sandstone uranium deposits. They are under detailed evaluation despite difficult logistics and heavy rainfall. Apart from the proven deposits at Domiasiat and Tyrnai, exploration drilling continues at Wahkyn, where new reserves have been established. New uranium occurrences have also been located at Phlangsynnei in the same geological setting.

Vein occurrences

Basement fractures in granitoids near the margins of the Cuddapah Basin of Andhra Pradesh and the Basin in Chhattisgarh and Orissa have been found to be extensively mineralised on the surface. Geological indications suggest they continue beneath the cover rocks, and like the Singhbhum Shear Zone in Jharkhand, have the potential to host vein deposits. Exploration has been intensified in these areas.

Intrusive occurrences

Albititic intrusives within rocks of the Aravalli Supergroup (Lower Proterozoic) and the Delhi Supergroup (Middle Proterozoic) are widespread within the northern and central parts of Rajasthan. They are exposed for a length of 270 km along a north-northeast/south-southwest trend. They are extensively mineralised on the surface and geological features suggest their continuity under the cover rocks. Exploration in these areas has been given a high priority.

Uranium exploration expenditures and drilling statistics

	1998	**1999**	**2000**	**2001** (expected)
Government expenditures				
(INR million)	505 300	513 600	627 900	608 000
(USD million)	12 812	12 090	14 368	13 098
Government surface drilling (m)	30 070	28 235	32 500	42 750

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

India's uranium resources are classified as RAR and EAR-I without assigning any cost category. These resources are located mainly in the following deposits:

- Vein and disseminated deposits associated with the Singhbhum Shear Zone, Jharkhand.
- Sandstone deposits in the Cretaceous sediments of Meghalaya.
- Unconformity-related deposits at the base of the Proterozoic sediments in the northwestern part of the Cuddapah Basin in Andra Pradesh.
- Dolostone-hosted stratabound-type of the Cuddapah Basin in Andra Pradesh.

The known resources as of 1 January 2001 include 54 470 tU RAR and 23 560 tU EAR-I as *in situ* resources. Since the publication of the last resource estimates in 1999, RAR have increased by 1 725 tU at the expense of EAR-I which have been reduced by 1 642 as a result of further exploration work carried out (1) along the Proterozoic unconformity of the Srisailam Quartzite of the Cuddapah Basin with the basement granite at Peddagattu, Nalgonda district, Andhra Pradesh, and (2) in the Cretaceous sandstones at Wahkyn, in the West Khasi Hills district of Meghalaya. Further additions to the resource base are expected in these areas.

Known uranium resources (tonnes U)*

Cost range unassigned	
RAR	EAR-I
54 470	23 560

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

As a result of continuing exploration in Meghalaya, Andhra Pradesh, Karnataka, Rajasthan and Jharkhand, additional areas with resource potential have been identified and the degree of confidence has increased in areas of ongoing activity. As a result, EAR-II have increased by 960 tU relative to the 1999 report.

While some Speculative Resources have been reassigned to the EAR-II category, total SR remain at the same level due to the addition of new promising uranium finds in the following areas: Bhima Basin in the Gulbarga district, Karnataka; in the Chhattisgarh Basin; and in basement fractures located in Chhattisgarh and in the Bargarh district, Orissa.

Undiscovered resources (tonnes U)*

Cost range unassigned	
EAR-II	Speculative resources
13 990	17 000

* As *in situ* resources.

Unconventional or by-product resources

Deposit	Location	Production centre name	**Tonnes U** (recoverable)
Copper deposits of the Singhbhum Thrust Belt	Singhbhum district, Jharkhand	Jaduguda	6 615

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. UCIL is now operating three underground mines at Jaduguda, Narwapahar and Bhatin in the eastern part of the Singhbhum (East) district, Jharkhand State (formerly undivided Bihar State). The ore is treated in the processing plant located at Jaduguda, about 150 km west of Kolkata (formerly Calcutta).

In addition, uranium is recovered as a by-product from the tailings available from the copper concentrator plants of M/S Hindustan Copper Ltd., at the Rakha and Mosaboni mines. The uranium is then further processed in the Jaduguda mill.

Status of production capability

The total installed capacity of the Jaduguda mill is about 2 100 t ore/day. Additional information for the Jaduguda, Narwapahar and Bhatin Mines and the Jaduguda mill is given in the following summary as is information on uranium recovery from tails of copper production.

Jaduguda Mine

The Jaduguda deposit consists of two ore bodies. The Foot Wall Lode (FWL) and the Hanging Wall Lode (HWL) are separated by a distance of between 60 and 100 m. The FWL extends over a length of about 600 m in a southeast-northwest direction. The HWL is 200 to 300 m long and is confined to the eastern part of the deposit. The average width is 3 to 4 m, with a maximum of 20 to 25 m. The FWL is more heavily mineralised and in addition to uranium, contains copper, nickel and molybdenum sulphide minerals. Both lodes have an average dip of 40 to 45 degrees to the northeast. The deposit has been explored to a depth of 800 m and is open below this level. The ore occurs in veins hosted in chlorite-biotite schist of the Singhbhum Shear Belt. The host rocks are of Proterozoic age.

The Jaduguda Mine was commissioned in October 1967. It uses a 5 m diameter, 640 m deep shaft to access the steeply dipping orebody. An auxiliary blind shaft is under development to access ore at depths between 555 and 900 m below the surface. The new shaft is located 580 m north of the main shaft. Mine levels are to be developed at depths of 620, 685, 750, 815 and 880 m. The crushing and loading stations are, respectively, at the 835 and 865 m levels.

In the main shaft, ore is hoisted in a 5 t skip from the 605 m level. The main working levels are developed at 65 m intervals. Development and mining is by conventional drill and blast operation using a drilling jumbo. A cut-and-fill stoping method is used to give about 80% ore recovery. Load-Haul-Dump (LHD) equipment is used to transfer ore to loading pockets where it is transferred to diesel powered track haulage for transport to the shaft for hoisting to the surface. De-slimed tailings are used as backfill material.

Narwapahar Mine

The Narwapahar Mine, located about 10 km west of Jaduguda, has been in operation since 1995. The Narwapahar Deposit consists of uraninite in chlorite-quartz schist with associated magnetite. The underlying schist is similar in composition but contains a greater amount of magnetite. The maximum strike length of the orebodies is 2 100 m and they extend to a depth of 600 m. There are six uranium bearing units or lodes. The orebodies are lenticular, with an average northeasterly dip of 30 to 40°. The thickness of individual orebodies varies from 2.5 to 20 m.

The deposit is accessed by a 355 m deep vertical shaft and a 7° decline from the surface. The decline provides access for trackless mining equipment. Room and pillar development is being used where the orebody is narrow (<3 m), while cut and fill is used in areas of increased width. Deslimed mill tailings are used as backfill material.

Bhatin Mine

The Bhatin deposit is located 4 km northwest of the Jaduguda deposit. A major fault occurs between the two deposits. The Bhatin Mine came into production in 1986. The orebody has a thickness of 2 to 10 m and an average dip of 30 to 40°. The geology is similar to the Jaduguda Deposit. The host rock is chlorite-biotite schist. The small deposit is developed using adits and inclines and is mined using the cut and fill method. Trucks are used to transport the ore to the Jaduguda Mill.

Uranium recovery from copper tails

Three uranium recovery plants at Rakha, Surda and Mosaboni also recover uranium from mill tails from copper concentrators, which were placed in production in the 1970s and 1980s. Following extraction of the copper, the tailings, with an average content of about 0.01% U_3O_8, are sent to the UCIL plants for uranium mineral recovery. A uranium bearing heavy mineral concentrate is produced by tabling the tails. The concentrates are transported by truck to the Jaduguda Mill for further processing. The combined output of the three plants is about 150 t/day concentrates.

Jaduguda Mill

Uranium ore produced from the Jaduguda, Bhatin and Narwapahar Mines, together with uranium mineral concentrates derived from copper processing Recovery Plants, are processed in the mill located at Jaduguda in eastern India. The mill has an installed capacity of 2 100 t ore/day. The mill was commissioned in October 1967.

Following crushing and grinding to 60% passing 200 mesh, ore is leached in pachuca tanks at a temperature of about 37°C using sulphuric acid. Following drum filtration of the pulp, ion exchange resin is used to recover uranium. Following elution, the product is precipitated using magnesia to produce magnesium di-uranate containing 70% U_3O_8. Mill recovery is about 80%.

A system of water treatment and reclaiming of tailings water implemented in March 1990 resulted in reduction of fresh water requirements, as well as increasing purity of the final effluent.

UCIL also operates a Magnetite Plant at Jaduguda to recover magnetite as a by-product.

Uranium production centre technical details
(as of 1 January 2001)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Jaduguda	Bhatin	Narwapahar	Turamdih (East)	Domiasiat
Production centre class	existing	existing	existing	planned	planned
Operational status	operating	operating	operating	development	planned
Start-up date	1968	1986	1995	2002-03	2008
Source of ore • Deposit name • Deposit type	Jaduguda vein	Bhatin vein	Narwapahar vein	Turamdih vein	Domiasiat sandstone
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	UG 850 80	UG 250 75	UG 1 000 80	UG 550 75	OP 1 500 90
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	Jaduguda IX/AL 2 100 87	Jaduguda	Jaduguda	Jaduguda	Domiasiat SX/AL 1 370
Nominal production capacity (tU/year)	175			40	160-200
Plans for expansion	NA	NA	NA	NA	NA
Other remarks	all ore processed at Jaduguda	ore processed at Jaduguda	ore processed at Jaduguda	ore processed at Jaduguda	

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 under the Department of Atomic Energy is responsible for uranium exploration programmes. Following discovery and deposit delineation, analysis is conducted to confirm the existence of a viable ore body. The evaluation stage may include exploratory mining.

Once a deposit of sufficient tonnage and grade is proved, it is turned over to UCIL for commercial mining and production of uranium concentrates. The registered office of UCIL, which was established on 16 October 1967 as a public sector undertaking, is located at Jaduguda, Singhbhum (East) district, Jharkhand State.

Employment in the uranium industry

About 4 000 people are engaged in uranium mining and milling activities.

Future production centres

The uranium deposit located at Turamdih in Singhbhum (East) district Jharkhand is being proposed for underground mining.

Another uranium deposit at Domiasiat in West Khasi Hills district, Meghalaya State, northeastern India, is being planned for open pit mining. Additional mines at two other locations are being planned.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

There are no environmental issues related to existing uranium mines and processing plants operated by UCIL. However, provisions are made for the management of environmental impacts. The Health Physics Division of the Bhabha Atomic Research Centre, located at Mumbai carries out environmental health monitoring of radiation, radon and dust at uranium production facilities through its Environmental Survey Laboratory at Jaduguda.

URANIUM REQUIREMENTS

Supply and procurement strategy

In India, exploration for uranium is carried out by the Atomic Minerals Directorate for Exploration and Research, a wholly owned government organisation. Neither private nor any foreign companies are involved in exploration, production and/or marketing of uranium. The UCIL, a public sector undertaking under the Department of Atomic Energy, is responsible for the production of yellow cake. The rest of the fuel cycle, up to the manufacture of fuel assemblies, is the responsibility of the Nuclear Fuel Complex, a wholly-owned government organisation.

Investment in uranium production in India is directly related to the country's nuclear power programme.

Installed nuclear generating capacity to 2020
(MWe net)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 503	2 503	2 503	7 209	7 209	NA	NA	NA	NA

NA Not available.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
397	397	397	1 000	1 000	NA	NA	NA	NA

NA Not available.

India reported no information on national policies relating to uranium, stocks of uranium, or uranium prices.

• Indonesia •

URANIUM EXPLORATION

Historical review

Uranium exploration by the Nuclear Minerals Development Centre of the Indonesian National Nuclear Energy Agency (BATAN) started in the 1960s. The first stage regional reconnaissance covered approximately 78% of a total of 533 000 km^2 estimated to be favourable for uranium mineralisation. Methods employed during the reconnaissance phase included integrated geochemical stream sediment, heavy mineral and radiometric surveys. Several geochemical and radiometric anomalies were found in granitic, metamorphic and sedimentary environments. Subsequently, uranium occurrences were identified in Sumatra, the Bangka Tin Belt and Sulawesi. A more detailed evaluation of these occurrences has not been made.

All exploration activities conducted since 1988 were concentrated in the Kalan area, West Kalimantan. During 1991-1992, exploration continued both within and surrounding the uranium occurrence at Kalan. A significant drilling programme was completed in 1992. The results of the exploration were evaluated and incorporated in a pre-feasibility study for a possible uranium mining operation at Kalan. In 1993-1996, BATAN continued its uranium exploration activities at the Kalan uranium occurrence and in the surrounding West Kalimantan region. During 1993-1994, exploration including drilling was concentrated at several sectors of Kalan referred to as Jeronang, Kelawai Inau and Bubu. In addition, work was done in the Seruyan and Mentawa areas and in areas surrounding Kalan, where similar geological conditions were found.

The follow-up work carried out in favourable areas since 1993 included systematic geological and radiometric mapping, radon surveys, deep trenching and several hundred m of drilling. These programmes covered relatively small areas in Tanah Merah-Dendang Arai (0.06 km^2), the Mentawa sector (0.3 km^2), and the Upper Rirang Valley (0.008 km^2).

Surface mapping in these areas discovered several uranium mineralisation occurrences in veinlets. The thickness of the mineralised veins ranges from a few mm (Dendang Arai), to 1-15 cm (Tanah Merah) and 1-100 cm (Jumbang I). The veins are filled with uraninite associated with molybdenite, pyrite, pyrrhotite, magnetite, hematite and ilmenite. Several drilled holes in Tanah Merah intersected 5 m of mineralisation at depths of about 33 m, 40 m and 50 m. In the Mentawa sector the mineralisation was identified as horizontal to vertical multiple lenticular zones.

In 1993-1995, BATAN also carried out reconnaissance over 3 000 km^2 on Irian Jaja Island. In 1995 and 1996 reconnaissance mapping was completed over a total area of 3 000 km^2 and 3 050 km^2, respectively.

Recent and ongoing activities

During 1998-1999, exploration activities were carried out in the Tanah Merah and Mentawa sectors of the Kalan area and in the surrounding Kalimantan area. These activities consisted of systematic geological and radiometric mapping and of radon surveys in order to delineate mineralised zones.

In 2000, exploration activity was limited to drilling in the Upper Rirang sector and in the Kalan area. This activity, which had been planned since 1998, will be continued in 2001.

Uranium exploration expenditures and drilling efforts

	1998	**1999**	**2000**	**2001** (expected)
Government expenditures: (IDR million) (USD million)	 1 334.43 0.114	 1 693.16 0.217	 498.84 0.061	 747.20 0.082
Government surface drilling (m)	0	0	453	300
Number of government holes drilled	0	0	10	6

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

As of January 2001, RAR total 6 797 tU recoverable at costs below USD 130/kgU. Of this total, 468 tU is recoverable at costs below USD 80/kgU. The 524 tU increase in RAR compared to the 1999 Red Book and the inclusion of resources recoverable at below USD 80/kgU resulted from data re-evaluation and computer modelling.

EAR-I at 1 699 tU remain virtually unchanged from the 1999 Red Book . Recovery costs for EAR-I are projected to be below USD 130/kgU.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	468	6 797

* As *in situ* resources.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	1 699

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

The undiscovered conventional resources, mainly from the Kalan prospect, are allocated to the SR category. The Mentawa sector, located some 50 km southeast of Kalan, has the same high geological favourability as Kalan and could host additional potential. To evaluate this resource potential a delineation drilling programme is needed. Speculative resources amount to 4 090 tU, nearly doubling the total of 2 057 tU reported in 1999. Recovery costs for the SR have not been assessed.

Speculative resources
(tonnes U)

Cost range	Total
Unassigned	
4 090	4 090

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

No significant environmental issues relating to uranium exploration and resource development have been identified.

Indonesia reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Islamic Republic of Iran •

URANIUM EXPLORATION

Historical review

Uranium exploration began in Iran in support of an ambitious nuclear power programme launched in the mid-1970s.

The programme continued over the last two decades despite sharp fluctuations in the level of activities and suspension of the nuclear power programme for a period of time.

The main activities started with airborne surveys conducted by foreign companies being accompanied by field reconnaissance by geologists and prospectors of the Atomic Energy Organisation of Iran (AEOI). These surveys covered the one-third of the area of Iran judged to be most favourable for uranium deposits.

This work was followed up by reconnaissance and detailed ground surveys. Regional and detailed exploration activities were started in the most prospective regions, depending on the available infrastructure and exploration manpower. Follow-up in about one-sixth of the area covered by the airborne surveys led to the definition of a few small prospects.

Recent and ongoing activities

New concepts and methodologies were generated during the 1998-1999 period including multi-discipline analyses, remote sensing, metallogenic prognosis and integration of multi-source exploration data in support of identification of sandstone and polymetallic uranium deposits. Development of infrastructure, new manpower and advanced technical facilities were implemented to modernise exploration approaches and provide the basis for more up-to-date prospection.

Processing and interpretation of remote sensing data and integration of this information with geophysical and geological data has led to discovery of an extensive uranium metallogenic zone in central Iran which hosts several geophysical anomalies and uranium shows. Evaluation of uranium and associated elements, rare earth elements (REE) and thorium, within this metallogenic zone, which has the potential to host metasomatic and hydrothermal deposits, will be the emphasis of future exploration programmes. Recent exploration efforts also led to definition of sedimentary basins in central and northwestern Iran with potential to host sandstone (infiltration-type) deposits:

- Evaluation of uranium resources in the Bafq-Posht-e-Badam metallogenic zone, which hosts the Saghand, Narigan, Zarigan and Sechahun discoveries. Exploration potential within this zone includes metasomatic and hydrothermal vein deposits associated with upper Precambrian magmatic and metasomatic complexes.
- Evaluation of the potential of intermountain basins in central Iran to host sandstone deposits (infiltration-type).
- Evaluation of uranium resources of polymetallic hydrothermal deposits discovered in the province of Azerbaijan, and of late alpine basins in the same region.

- Uranium exploration for coal-bearing basins in central and northwest Iran.
- Exploration in the Great Kavir basin and its drainage area.

Uranium exploration and development expenditures

	1998	**1999**	**2000**	**2001** (expected)
Government exploration expenditures (USD million)	0.875	1.0	1.7	4.5
Government surface drilling (m)	0	1 633	2 394	5 000
Number of government holes drilled	0	8	19	NA

URANIUM RESOURCES

On the basis of the geological setting and of host rock types, the most favourable area for uranium deposits is the central province. In this area, late Precambrian basement and Pan-African metallogenic series rocks are present.

The Saghand ore field and a few uranium and uranium/thorium prospects (Narigan, Sechahun, Zarigan, Khoshumi) are located in this area. Three types of radioactive mineralisation have been distinguished:

- Albite-amphibole metasomatic type with U-Th-REE mineralisation.
- Hydrothermal-metasomatic veins with U (Mo, Y) mineralisation.
- Hydrothermal polymetallic uranium mineralisation.

The first two types belong to the Pan-African metallogenic stage while the third is considered Alpine type.

Among the known resource bearing prospects the Saghand, Narigan, Sechahun and Zarigan occurrences have a Pan-African age, while the Talmessi, Khoshumi, Kale-Kafi and Arusan prospects were formed during the Alpine phase. These deposits plus the Bandarabass calcrete deposit host the known and undiscovered resources.

Known conventional resources (RAR & EAR-I)

Known resources totalling 1 367 tU have been attributed to the Saghand 1 and Saghand 2 deposits. Of this total 491 tU are classified as RAR and 876 tU as EAR-I; these totals remain unchanged from the 1999 Red Book. Both resource categories are recoverable at below USD 130/kgU.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	491

* As *in situ* resources.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	876

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

A total of 12 000 tU have been estimated for the EAR-II and SR categories as of 1 January 2001. Their distribution and cost category are specified in the table below. Undiscovered resources are attributed to the following deposits and prospects.

- Saghand Ore Field with 2 700 tU EAR-II and 4 800 tU SR associated with Th, REE, Ti and Mo.
- Narigan prospect with 800 tU EAR-II hydrothermal vein U-Mo-Co-mineralisation.
- Dechan prospect with 1 200 tU speculative resource, in which the uranium is associated with Cu ore formation in alkaline syenite.
- Zarigan prospect with 2 500 tU speculative resources in metasomatic-hydrothermal deposits associated with U, Th, Ti, and REE mineralisation.

Undiscovered resources
(tonnes U)

EAR-II		Speculative resources	
Cost ranges		Cost ranges	
<USD 80/kgU	<USD 1300/kgU	<USD 130/kgU	Unassigned
0	3 500	3 500	5 000

Iran reported no information on uranium requirements, national policies relating to uranium, uranium stocks, or uranium prices.

• Japan •

URANIUM EXPLORATION

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 reserves have been detected in Japan. Domestic uranium exploration activities in Japan were terminated in 1988.

Overseas uranium exploration began in 1966. Exploration activities were carried out mainly in Canada and Australia, and in other countries such as the United States, Niger, China and Zimbabwe.

In October 1998, PNC was reorganised into the Japan Nuclear Cycle Development Institute (JNC). Based on the decision by the Atomic Energy Commission in February 1998, uranium exploration activities which were carried out by PNC, were terminated in 2000, and mining interests and technologies which remain in JNC will be transferred to the private sector.

Recent and ongoing activities

Japan-Canada Uranium Co. Ltd., which took over JNC's mining interests in Canada, is carrying out exploration activities in Canada.

Uranium exploration and develoment expenditures – abroad
(in million JPY)

	1998	**1999**	**2000**	**2001** (expected)
Industry exploration expenditures	0	0	not reported	not reported
Government exploration expenditures	314	169	0	0
TOTAL EXPENDITURES	314	169	NA	NA
TOTAL EXPENDITURES (USD million)	2.28	1.39	NA	NA

URANIUM RESOURCES

Known conventional resources

About 6 600 tU of RAR have been identified. These reserves are classified as Reasonably Assured Resources recoverable at less than USD 130/kgU.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	6 600

* Mining losses (10%) and processing losses (5%) are accounted for.

URANIUM PRODUCTION

Historical review

A test pilot plant with a capacity of 50 tonnes ore per day was established at the Ningyo-toge mine in 1969 by PNC. The operation ceased in 1982 with a total production of 84 tU. In 1978, the vat leaching test of the Ningyo-toge ore began on a small scale with a maximum capacity of 12 000 tonnes ore per year, consisting of three 500-tonne ore vats. The vat leaching test was terminated at the end of 1987.

Historical uranium production (tonnes U)

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Processing plant	45	0	0	0	45	0
In place leaching*	39	0	0	0	39	0
Total	84	0	0	0	84	0

* Also known as Stope Leaching or Block Leaching.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

As of 1 January 2001, 52 nuclear power reactors were being operated in Japan. Total (gross) electric generating capacity was 45 082 MWe, providing approximately one-third of the electricity generated in Japan. Five additional reactors were under construction and four reactors were planned.

Installed nuclear generating capacity to 2020
(MWe gross)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
45 082	45 082	49 580	61 850	61 850	61 850*	61 850*	61 850*	61 850*

* Secretariat estimate.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
7 500	11 100	9 100	11 900	11 900	11 600	11 600	11 600*	11 600*

* Secretariat estimate.

Supply and procurement strategy

Japan has relatively scarce domestic uranium resources and, therefore, must depend to a great extent on overseas supply of uranium. 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 other ways of diversification of sources of supply.

NATIONAL POLICIES RELATING TO URANIUM

There is no special legislation for uranium exploration and exploitation under the Japanese Mining Laws and Regulations. Uranium exploration and exploitation is open to private companies incorporated in Japan. However, no private company has pursued uranium exploitation in Japan.

URANIUM PRICES

Uranium import prices are contracted by private companies. Government information is not available for these data.

• Jordan •

URANIUM EXPLORATION

Historical review

In 1980, an airborne spectrometric survey covering the entire country was completed. By 1988 ground based radiometric surveys of anomalies identified in the airborne survey were completed. During the 1988-1990 period, Precambrian basement and Ordovician sandstone target areas were evaluated using geological, geochemical and radiometric mapping and/or surveys.

During the period 1990-1992 a regional geochemical sampling programme, involving stream sediments and some rock samples, was completed over the basement complex area. Geological and radiometric follow-up was carried out at locations within the basement complex and Precambrian sandstone areas.

A systematic study and evaluation of the uranium concentration in Jordan's phosphate deposits was conducted to assess the environmental effects of the uranium. This study was completed in September 1997.

Recent and ongoing exploration and mine development activities

All uranium exploration activities in Jordan are conducted by the Natural Resources Authority (NRA), and projects have been funded by the government. The main findings from exploration activities are described below:

- Radiometric measurements (gamma and radon) and chemical analysis defined several surficial uranium occurrences in central, southern and southeastern Jordan. In central Jordan, the occurrences are closely related to varicoloured marble. They occupy an area of about 350 km^2.
- Uranium occurs 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 Maastrichtian-Palaeocene age. In the southern and southeastern area uranium occurs only as yellowish stains associated with chalk or marl.
- In the uranium-bearing rocks, dolomite is the major constituent, whereas the calcite and clay content are low.
- Preliminary leach tests using the alkaline method indicate leachability of more than 90%.
- Results of channel sampling in three areas in central Jordan indicate uranium contents ranging from 140 to 2 200 ppm over an average thickness of about 1.4 m. The average thickness of the overburden is about 0.5 m.

URANIUM RESOURCES

Unconventional or by-product resources

Jordan's uranium resources, which total approximately 70 000 tU, are associated with phosphate deposits and therefore, are best classified in the by-product category. The average uranium content of the Eshidia deposits, which constitute most of the phosphate resources, ranges between 25 and 50 ppm. The smaller Al-Hassa and Al-Abiad deposits have an average uranium content in the range of 60 to 80 ppm.

URANIUM PRODUCTION

Jordan does not currently produce uranium. In 1982, a feasibility study for uranium extraction from phosphoric acid was presented by the engineering company LURGI A.G., of Frankfurt, Germany, on behalf of the Jordan Fertiliser Industry Company. This company was later purchased by the Jordan Phosphate Mines Company (JPMC). One of the extraction processes evaluated was originally found to be economically feasible, but as uranium prices fell, the process became uneconomic and extraction plant construction was deferred.

Feasibility studies were resumed in 1989 through the use of a micro pilot plant. These tests, which were terminated in 1990, served as the basis for preparation of a project document for a uranium extraction pilot plant from phosphoric acid.

Jordan has no uranium requirements and has reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Kazakhstan •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration in Kazakhstan started in 1948, when the now independent Republic was a part of the USSR. Subsequent exploration activities can be divided into distinct stages, based on target areas and exploration concepts applied.

During the first stage which lasted through 1957, those portions of the Republic which were not overlain by young unconsolidated sediments, were covered by regional ground and airborne radiometric surveys. Investigations carried out in this period resulted in the discovery of several uranium deposits in what later became the uranium districts of Pribalkhash (vein-stockwork deposits in volcanics), Kokchetau (vein-stockwork deposits in folded sedimentary formations) and Pricaspain (phosphoritic fish bone detritus). These districts are respectively, near Lake Balkhash (in southeastern Kazakhstan), in northern Kazakhstan and near the Caspian Sea.

After 1957, conceptual models developed during regional assessment of Kazakhstan's sedimentary basins led to the discovery of sandstone deposits in which the uranium is associated with oxidation-reduction interfaces in the Chu-Sarysu basin, located in central Kazakhstan.

In addition, uranium mineralisation was discovered in the Koldjat deposit in the Ily basin in eastern Kazakhstan. The uranium which grades up to 0.1% U, is associated with coal and did not receive further attention due to economic reasons.

During 1970 and 1971, *in situ* leach (ISL) mining tests were successfully conducted at the Uvanas deposit in the Chu-Sarysu basin. Since that time, exploration has been concentrated on Mesozoic and Cenozoic sedimentary basins having the potential for ISL amenable deposits. The Stepnoye and Central Mining Companies are currently operating ISL mines in the Chu-Sarysu district. No. 6 Mining Company conducts ISL operations in the Syr-Darya district.

The main results of exploration for the last 30 years are discoveries of large uranium deposits associated with Cretaceous and Paleocene sediments of the Chu-Sarysu and Syr-Darya basins, which have significantly increased the resource base of Kazakhstan. Discovery and development of the ISL amenable resources have placed Kazakhstan in a position to compete with other low-cost uranium producers in the world. Because of the very large resource base, reconnaissance exploration has been suspended.

URANIUM RESOURCES

The uranium resources of Kazakhstan occur in several types of deposits. The two main uranium deposit types include vein-stockwork and sandstone deposits. Both types are further subdivided according to their geological settings.

The vein-stockwork deposits include two subtypes: vein-stockwork deposits in folded sedimentary complexes of Silurian-Devonian age, and those associated with continental effusive volcanics of Devonian age.

The sandstone hosted uranium deposits in Kazakhstan are of the roll-front type. These epigenetic sandstone deposits are named "bed oxidation type" by Kazakh geologists.

The epigenetic sandstone uranium subtype occurs in two approximately northsouth trending sedimentary basins: the Chu-Sarysu and the Syr-Darya, separated by the Karatau uplift. In both basins, the uranium mineralisation is associated with Cretaceous-Paleocene clastic sediments, consisting of several sandstone-clay sequences. In the case of the Chu-Sarysu basin, there are six sandstone-clay sequences with sandstone horizons between 50-70 m thick separated by impermeable clays. In both districts, the uranium mineralisation occurs along oxidation-reduction interfaces forming asymmetric rollfronts and lenses. High porosity and permeability of the host horizons, and their separation by impermeable clays, make this deposit subtype amenable to ISL methods. The deposits in the Chu-Sarysu district include Zhalpak, Uvanas, Mynkuduk, Inkay and Budyonovskoe in the northern part of the basin and Kandjugan and Moynkum in the southern part.

The Syr-Darya district includes roll-front deposits in Cretaceous sediments with the deposits Irkol, North-Karamurun (Severny Karamurun), South-Karamurun (Yuzhny Karamurun) and Zarechnoe.

There are 51 known uranium deposits in Kazakhstan (see map). These include 26 deposits which have been investigated and for which uranium resource estimates have been prepared. The deposits occur in 6 uranium districts: I. Kokchetav, II. Pribalkash, III. Ily, IV. Chu-Sarysu, V. Syr-Darya and VI. Pricaspian.

Known conventional uranium resources (RAR & EAR-I)

The known uranium resources of Kazakhstan recoverable at costs of below USD 130/kgU total 854 130 tU as of 1 January 2001. The resources are reported as *in situ*. When compared to the estimate of 1 January 1999, there is a decrease of 3 830 tU caused by depletion of the deposits as a result of uranium mining and extraction. The 3 830 tU reduction is greater than the total of 3 430 tonnes extracted for this period. The balance reflects mining and milling losses. Known resources which can be recovered at costs of below USD 40/kgU total 430 430 tU, or about 50% of the total. EAR-I remain unchanged from the 1999 estimates in all cost categories.

About 50% of Kazakhstan's known resources recoverable at costs below USD 40/kgU are tributary to existing and committed production centres. This percentage increases to 74% when the USD 80/kgU known resources are included.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
317 230	432 790	594 830

* As *in situ* resources adjusted for depleted resources.

Estimated additional resources – Category I
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
113 200	195 900	259 300

* As *in situ* resources.

Undiscovered conventional uranium resources (EAR-II & SR)

As no exploration was carried out in Kazakhstan during the 1999-2000 reporting period, both the EAR-II and SR recoverable at costs below USD 130kg/U, remained unchanged. Both estimates are reported as *in situ* resources.

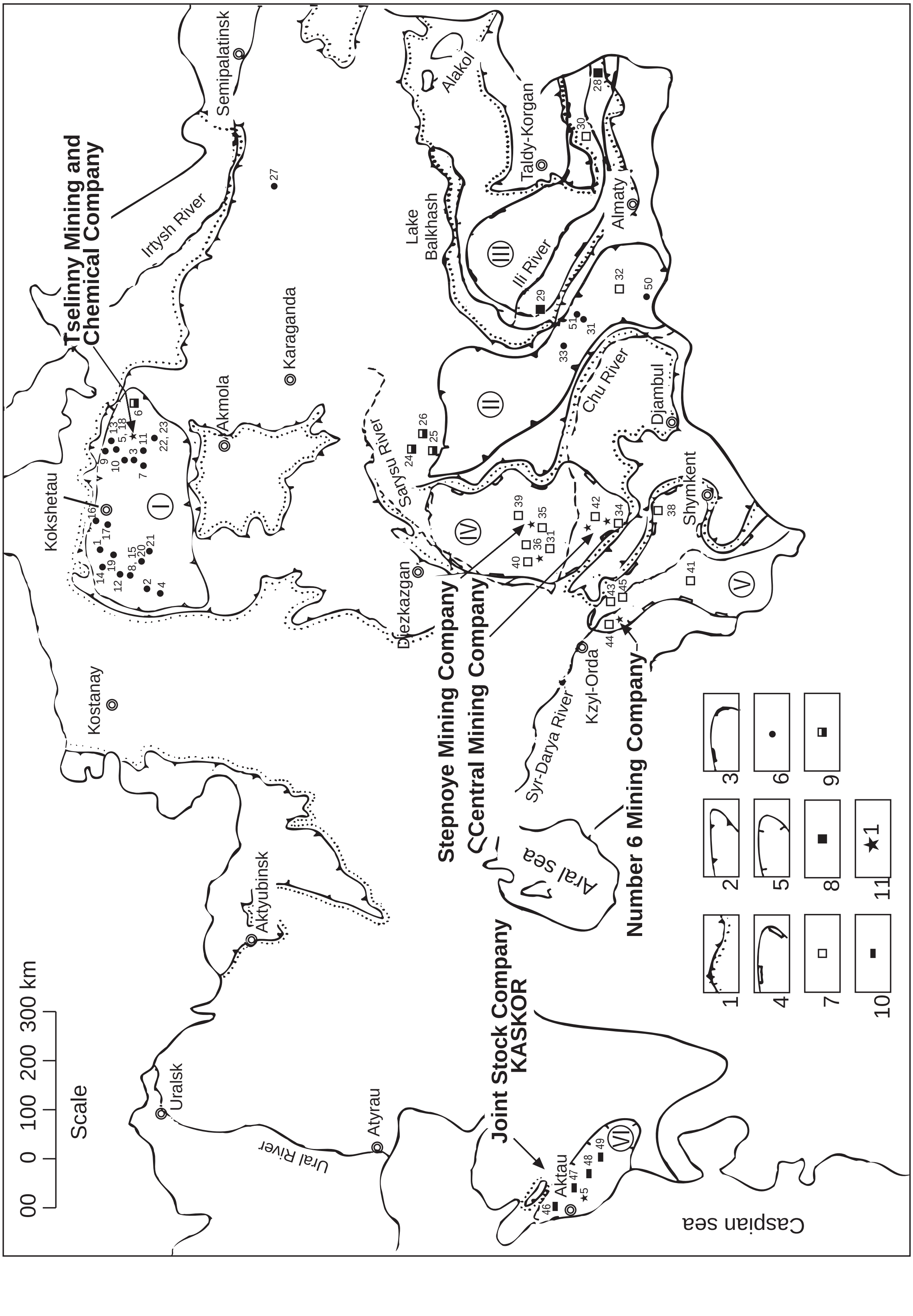
Estimated additional resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
NA	290 000	310 000

Speculative resources
(tonnes U)

Cost range		Total
<USD 130/kg U	Unassigned	
500 000	0	500 000

Uranium metallogenic provinces, deposits and production facilities of Kazakhstan



1. Borders of (a) Pre-Mesozoic and (b) Mesozoic-Cenozoic sediments

2. Uranium ore provinces with endogenic deposits in Pre-Mesozoic sediments
(I- Kokshetau, II- Pribalkhash)

3-5. Uranium ore provinces with exogenic deposits in Mesozoic to Cenozoic sedimentary formations:
3- with soil oxidation of coal beds (III- Ily)
4- with stratal oxidation (roll-front) in sandstone sequences (IV- Chu-Sarysu, and V- Syr-Darya)
5- with phosphatic fossil fish bone detritus (VI- Pricaspian)

6-10. Uranium deposits:
6- endogenic of different ore types
7- infiltration with stratal oxidation (i.e. roll-front)
8- infiltration with soil oxidation
9- infiltration with stratal oxidation (i.e. roll-front) in sediments of paleovalley
10- with phosphatic fossil fish bone detritus.

11. Production Centres/Mines:
1) Central Mining Company (Kandjugan)
2) Stepnoye Mining Company (Uvanas)
3) Number 6 Mining Company (Mynkuduk)
4) Tselinny Mining and Chemical Company (Grachev and Vostok)
5) Joint Stock Company “Kaskor” (Melovoye)

Deposits shown on map:
1. Grachev*
2. Shokhpak
3. Zaozyornoe
4. Kamyshevoe*
5. Shatskoe
6. Semizbay*
7. Tastykol
8. Akkan-Burluk
9. Glubinnoe
10. Koksorskoe
11. Vostochno-Tastykolskoe
12. Victorovskoe
13. Agashskoe
14. Fevralskoe
15. Burlukskoe
16. Slavyanskoe
17. Chaglinskoe
18. Shatskoe-I
19. Kosachinoe
20. Vostok*
21. Zvyozdnoe
22. Manybaysk*
23. Yuzhno-Manybayskoe
24. Shorly
25. Talas
26. Granitnoe
27. Ulken-Akzhal
28. Koldjat*
29. Nizhne-Iliyskayay*
30. Suluchokinskoe
31. Djusandalinskoe
32. Kopalysayskoe
33. Kyzyltas
34. Kandjougan*
35. Uvanas*
36. Mynkuduk*
37. Sholak-Espe
38. Kyzylkol
39. Zhalpak
40. Inkay* (planned)
41. Zarechnoe
42. Moynkum* (planned)
43. South Karamurun
44. Irkol*
45. North Karamurun*
46. Melovoe*
47. Tomak
48. Taybogar
49. Tasmurun
50. Kurdai
51. Botaburum

* Operating or closed mines.

URANIUM PRODUCTION

Historical review

Uranium production in 1999 and 2000 totalled 1 560 and 1 870 tU, respectively. Plans for 2001 indicate a significant increase to 2 250 tU.

Historical uranium production

	Pre-1998	1998	1999	2000	Total through 2000	2001 (expected)
Open pit mining	21 618	0	0	0	21 618	0
Underground mining	38 473	190	190	100	38 953	250
In situ leaching	23 581	1 080	1 370	1 770	27 801	2 000
Total	83 672	1 270	1 560	1 870	88 372	2 250

Status of production capability

In 1995, the Tselinny Mining and Processing Company stopped production at its Grachev and Vostok underground operations and suspended operation of the ore processing plant located at Stepnogorsk. All installations were mothballed. After a short re-activation of work in 1997 and 1998 Tselinny Mining and Processing Company again stopped uranium production. In 1999, the Tselinny Mining and Processing Company was sold and Closed Joint-Stock Company "KazSubton", which is a 100% foreign-owned company, was formed based on one mine and the Stepnogorsk processing plant. "KazSubton" plans to produce 250 tU in 2001 and 215 tU in 2002.

To replace the conventional uranium production, in 1996, two additional ISL operations, Katko and Inkay, initiated preparations for production, each with a production capability of 700 tU/year. The Katko project is being developed by a joint venture between the Kazak National Atomic Company (Kazatomprom) and Cogéma, and Inkay by Kazatomprom and Cameco Corporation.

In summary, current uranium production capability is associated with the five ISL production centres Tsentralnoe, Stepnoye, No 6, Katko and Inkay with an aggregated production capacity of 4 000 tU/year and the "KazSubton" production centre with production capacity of 2 500 tU. The technical details of the operating and planned ISL production centres are summarised in the first part of the relevant table, while the technical characteristics of the mothballed production centres are listed in the second part.

Ownership structure of the uranium industry

The mining companies Tsentralnoe, Stepnoye and No. 6 are controlled by the State Company Kazatomprom which was created at the end of 1996. The Inkay and Katko companies are joint operating companies with Cameco and Cogéma, respectively, as partners. "KazSubton", which now owns the Stepnogorsk mill and associated mines, is 100% foreign-owned.

Uranium production centre technical details (as of 1 January 2001)
Part 1: existing and operating centres

Name of production centre	**Tsentralnoe Mining Co**	**Stepnoye Mining Co**	**No.6 Mining Company**	**Katko**	**Inkay**	**Kazsubton Joint Stock Co.**
Production centre class	existing	existing	existing	committed	committed	existing
Operating status	operating	operating	operating	development	development	operating since 1998
Start-up date	1982	1978	1985	2001	2001	1958
Source of ore						
• Deposit names	Moynkum Kandjugan section 1	Uvanas, Mynkuduk East	North and South Karamurun	Moynkum section 2-3	Inkay section 1-2	Grachev, Vostok
• Deposit type	sandstone	sandstone	sandstone	sandstone	sandstone	stockwork-vein
• Reserves (active resources)	36 600	34 000	37 000	57 400	42 800	4 600
• Grade (%U)	0.063	0.042	0.086	0.064	0.063	0.133
Mining operation						
• Type	ISL	ISL	ISL	ISL	ISL	UG
• Size (tonnes ore/day)	NA	NA	NA	NA	NA	NA
• Average mining recovery (%)	NA	NA	NA	NA	NA	NA
Processing plant:						
• Type	IX	IX	IX	IX	IX	IX
• Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour)	NA	NA	NA	NA	NA	NA NA
• Average processing recovery (%)	NA	NA	NA	NA	NA	NA
Nominal production capacity (tU/year)	1 000	1 000	600	700	700	2 500
Plans for extension	none	none	none	none	none	

Uranium production centre technical details (as of 1 January 2001)
Part 2: mothballed centres

Name of production centre	Joint Stock Co Kaskor
Production centre class	existing
Operational status	mothballed since 1993
Start-up date	1959
Source of ore: • Deposit name • Deposit type • Reserves (active resources) • Grade (%U)	Tomak, Melovoye Fish bone detritus
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	OP NA NA
Processing plant • Type • Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour) • Average processing recovery (%)	IX NA NA NA
Nominal production capacity (tU/year)	2 000

Employment in the uranium industry

Employment at the existing production centres between 1998 and 2001 is compiled in the following table. Between 1992 and 2000, employment continuously decreased from 11 800 persons in 1992 to 4 100 in 2000, or by 65%. The decrease in employment can be largely attributed to the closure and sale of the Tselinny Company.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
4 800	4 600	4 100	4 000

Future production centres

For the near future, ISL will account for most of Kazakhstan's uranium production. In addition to the five existing and committed ISL production centres, two more production centres are planned at the Irkol and Zarechnoe deposits. Based on the existing, committed and planned production centres, production capability projections through the year 2005 are summarised in the following table. The production schedule for 2010 and beyond has not been established.

Short-term production capability
(tonnes U/year)

2001				2002				2005			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
2 250	2 250	2 250	2 250	2 500	2 500	2 500	2 500	3 200	3 300	3 200	3 300

In general, Kazakhstan's known uranium resources could support a relatively rapid increase in production in response to an increase in international demand.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Kazakhstan has significant environmental concerns about the wastes associated with its previous and presently operating uranium production facilities. It is also concerned about the environmental aspects of its large volume of sandstone hosted uranium resources that are amenable to *in situ* leach extraction.

The sandstone hosted uranium deposits occur in sedimentary basins that also host large groundwater resources. The contamination of groundwater related to the uranium deposits, both naturally occurring and resulting from leaching, led to the development of an exclusion zone equal in size to 150 km by 15 km. The extraction of drinking water is prohibited from this zone.

In addition, uranium mining and ore processing over 40 years have generated low-level radioactive waste rock dumps and mill tailings. The total volume of radioactive waste from mining and ore processing is estimated to be 235 million tonnes. A large portion of this waste was generated by operations which are now closed. The previous operators, in this case Soviet State Enterprises, do not accept responsibility for the clean-up. As no financial provisions were made to pay for the required remedial activities, the Republic of Kazakhstan must provide the necessary funding.

In 1997 and 1998, within the framework of the TACIS programme, special investigations were carried out to establish an inventory of all existing mine and mill radioactive waste storage sites in Kazakhstan and to measure the potential associated environmental hazard. It has been determined, that of 100 waste storage sites, only 5 or 6 sites have a significant environmental impact. The main danger and concern for all sites is the possibility of uncontrolled use of the waste for construction purposes.

Adoption of ISL methods of uranium production in Kazakhstan will limit additional radioactive mill tailings associated with uranium production. At the same time, the risk of ore-bearing aquifers being contaminated by ISL extraction solutions has increased. Currently, a study of the effect of ISL extraction on aquifers is underway. This is being done under an IAEA technical co-operation project to determine the optimal ISL processing parameters for conditions in Kazakhstan. In addition, an investigation is under way to better understand the process of natural attenuation, or self-remediation of the aquifer following leaching.

URANIUM REQUIREMENTS

The Government of Kazakhstan has ordered the fast-breeder reactor BN-350 with a net capacity of 70 MW(e), at Aktau on the Magyshlak Peninsula on the Caspian Sea to be shut down. The preliminary State Programme for development of atomic energy in Kazakhstan, which envisages co-operation with Russia, has not received full approval. Consequently all plans for the construction of nuclear power plants have been delayed indefinitely, which means that Kazakhstan will not have uranium requirements for the next several years. Future uranium requirements are not yet available.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
0	0	0	0	0	0*	600*	0*	600*

* Secretariat estimate.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
0	0	0	0	0	0*	102*	0*	102*

* Secretariat estimate.

Supply and procurement strategy

At the present time all uranium produced in Kazakhstan is exported for sale on the world market. The country does not maintain uranium stockpiles in any form.

NATIONAL POLICIES RELATING TO URANIUM

The main emphasis of the national policy of Kazakhstan relating to uranium is directed toward significantly increasing ISL uranium production for sale on the world market. The second objective supports the manufacture of enriched uranium pellets and other products at the Ulba plant in Kazakhstan. This is to be done in co-operation with the Russian Federation.

In accordance with the Government Decree, the National Atomic Company Kazatomprom is designated as the responsible authority for all uranium related export-import issues in Kazakhstan. No information on uranium stocks or uranium prices was reported.

• Republic of Korea •

URANIUM EXPLORATION

Recent and ongoing activities

The Korea Electric Power Corporation (KEPCO), as part of its exploration programme, had participated in a number of projects abroad, such as, the Crow Butte project in Nebraska, USA and the Cigar Lake and Dawn Lake projects in Saskatchewan, Canada. KEPCO, however, suspended the participation in these projects and sold its shares in 1999. The Dae Woo Corporation has participated in the Baker Lake project in Canada since 1983.

URANIUM RESOURCES

Korea has no known uranium resources.

URANIUM PRODUCTION

Korea has no domestic uranium production capability.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

KEPCO had 16 nuclear power plants in commercial operation as of 31 December 2000. The nuclear generating stock includes 12 PWR and four PHWR plants. The nuclear installed capacity of 13 716 MWe accounted for 28% of the country’s total generating capacity in 2000. According to the long-term power development plan in Korea, 12 additional nuclear power plants, including four PWR plants already under construction, will be on line by the year 2015, with a total nuclear capacity of 26 050 MWe.

Along with the steady increase in nuclear capacity, the requirements for uranium concentrates and fuel cycle services are increasing continuously.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
13 716	13 716	17 716	22 529		26 050		26 050	

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
3 400	2 900	3 000	4 200		4 300		4 300	

NATIONAL POLICIES RELATING TO URANIUM

In order to support the nuclear expansion programme effectively, KEPCO has pursued a stable, economic and secured programme of uranium procurement. Accordingly, the uranium requirements are mostly supplied through long-term contracts with suppliers in various countries including Canada, Australia, France, United States, etc.

URANIUM STOCKS

KEPCO maintains the stock level of around one-year forward reactor-consumption for the operating plants, as a strategic inventory. One-half of the stock is stored as natural uranium in overseas conversion facilities and the remainder is stored as enriched uranium at the local fabrication facilities.

Total uranium stocks
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Utilities	800	1 800	0	0	2 600

• Kyrgyzstan* •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical Review

Uranium mineralisation was first discovered in Kyrgyzstan in the Fergana Valley in the northwestern part of the country in the 19th century. This area was selected for intensive uranium exploration by the USSR after World War II.

The Maili-Su deposit was discovered in the Fergana Valley in 1943. Detailed exploration resulted in discoveries of the Maili-Say and Shakaptar deposits in 1946. All of these deposits occur in Paleogene bituminous limestones. Their total resources did not exceed 1 000 tU and ore grades were less than 0.01% U. Most of the known resources of the USSR at the end of the 1940s, which totalled about 700 tU, were located in the Fergana Valley in Uzbekistan, Tajikistan and Kyrgyzstan.

Three small uraniferous coal deposits were also discovered in the 1940s in the Min-Kush basin (Tien Shan area of central Kyrgyzstan): Tura-Kavak, Tuyuk-Su and Kashka-Su. A fourth uraniferous coal deposit, Dzhilskoe, was discovered near the southern shore of Lake Issyk-Kul.

Recent and Ongoing Uranium Exploration and Mine Development Activities

No uranium exploration or development activities were reported in Kyrgyzstan.

URANIUM RESOURCES

There are currently no known minable uranium resources in Kyrgyzstan.

URANIUM PRODUCTION

Uranium mining in Kyrgyzstan was located in three areas: Maili-Su, Tura-Kavak (also known as Min-Kush) and Dzhilskoe (also known as Kaju-Say). Ore was treated at local hydrometallurgical leaching facilities in each of these areas.

Mining at Maili-Su took place between 1946 and 1968. The ore was accessed through six underground shafts and was processed at two local plants. There are 23 tailings ponds associated with the Maili-Su mining and processing complex that cover a 10 km^2 area and contain 1.96 million m^3. In addition there are 13 waste rock piles resulting from the Maili-Su mining operation with a total volume of 1 million m^3.

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* Information in this report is based on Secretariat estimates and data.

A special production facility was constructed in 1948 to process the uranium-bearing coals of the Dzhilskoe deposit. The coals were first burned at a nearby power plant. A hydrometallurgical process was then used to recover uranium from the resulting ash. The mine and processing facility at Dzhilskoe were closed in 1956 because of high production costs. A similar process was used to treat the uraniferous coals at Tura-Kavak. The tailings ponds resulting from these two operations contain about 1.4 million m^3 of waste material – 1 million m^3 at Tura-Kavak and 0.4 million m^3 at Dzhilskoe.

Bulk ore, ore concentrates and leach products from Kyrgyzian uranium production operations were shipped for final processing to the Leninabad Mining Chemical Association (former Combine 6) mill in Tajikistan, which was built in 1946.

Uranium milling began in Kyrgyzstan in 1955, when the Kara Balta mill was built about 100 km west of the capital Bishkek. The Kara Balta mill, which had an annual capacity of 1.5 million tonnes of ore or about 2 500 tU, was initially operated by Yuzhpolymetal Mining and Metallurgical Combine; its successor, Kara Balta Ore Processing Combine, was subsequently replaced by Kyrgyzian Ore Refining Combine, the current mill operator.

The Kara Balta mill processed ore from Kyrgyzstan, Kazakhstan and Russia. Conventional milling operations were suspended in 1989 when mining was abandoned in southeastern Kazakhstan. Since 1994, the Kara Balta mill has processed yellowcake slurries from ISL operations in southern Kazakhstan. The slurries contain between 40 and 45% U and yield approximately 400 tU per year. Part of the Kara Balta milling circuit has been reconfigured to treat other commodities including gold ore, but processing of conventional uranium ore can be resumed.

• Lithuania •

URANIUM EXPLORATION, RESOURCES, AND PRODUCTION

Past exploration programmes have been unsuccessful in discovering uranium in Lithuania. Therefore, Lithuania has no uranium resources and is not currently undertaking any uranium exploration.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

On 5 October 1999 the Seimas (Parliament) of the Republic of Lithuania approved the National Energy Strategy submitted by the Government. According to this document, Unit 1 of Ignalina nuclear power plant (NPP) is to be shut down by 2005. In accordance with the Law on Decommissioning of

Unit 1 of the State Enterprise Ignalina Nuclear Power Plant, adopted by the Seimas on 2 May 2000, all preparatory activities on Ignalina Unit 1 decommissioning should have been performed by 1 January 2005. The final shut down date will be set by the Government. In 2004, the decision regarding the future of Unit 2 will be made. The projections of related uranium requirements are given in the following table.

Installed nuclear generating capacity to 2020
(MWe net)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 760	2 760	1 380	1 380	1 380	0	1 380	0*	1 380*

* Secretariat estimate.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
240	240	240	240	240	0	240	0*	240*

* Secretariat estimate.

Supply and procurement strategy and uranium prices

A bilateral agreement, under which the Russian Federation will supply fuel for the Ignalina nuclear plant over the long term, was signed in 1999 between the two countries. No information concerning uranium prices is reported.

NATIONAL POLICIES RELATING TO URANIUM

None reported.

URANIUM STOCKS

There is no stockpile of natural uranium material in Lithuania. A six-month stock of enriched fuel is generally maintained by the Ignalina NPP.

• Malaysia •

URANIUM EXPLORATION

Historical review

Uranium exploration in Malaysia dates back to the late 1950s, generally based on reconnaissance mapping as well as geochemical, airborne magnetometer and scintillation surveys. These early efforts were followed up with more detailed stream sediment geochemistry and helicopter-borne spectrometric surveys in the Sarawak and Sabak areas. No uranium exploration has been conducted in either Sabak or Sarawak since 1984, as these areas are judged to have a low potential to host uranium deposits. Limited exploration has continued, however, on the Malaysian Peninsula.

During 1991 and 1992, the Geological Survey of Malaysia (GSM) conducted an integrated ground exploration programme over 8 600 km^2 of granitic terrain in the Pahang, Perak, Selangor, Negeri Sembilan, Johore and Kelantan States. Five fertile granitic plutons were identified through this work. In addition to the field work, the digital data from the airborne radiometric survey completed in 1980 was reprocessed. The results were used to produce stacked profiles and new maps.

During 1995 and 1996, carborne radiometric surveys were carried out in parts of the states of Pahang and Kelantan utilising the GR650 Spectrometer System provided by the IAEA. A total of 1 000 km of traverse lines were covered with the collection of about 11 500 gamma ray readings. Fourteen areas totaling about 100 km of traverse line were found to have uranium potential.

Recent and ongoing activities

Exploration activities by the GSM continued during 1997 and 1998 on the Malaysian Peninsula. Carborne radiometric surveys were conducted in the states of Selangor, Pahang and Negri Sembilan in 1997 and 1998.

During 1999 and 2000, uranium exploration was conducted as part of a multi-element geochemistry regional survey which was implemented under the 7th Malaysia Development Programme (RMK7). The areas covered include South Pahang, North Johor and Negeri Sembilan/Melaka.

Uranium exploration expenditures

	1998	**1999**	**2000**	**2001** (expected)
Government expenditures				
MYR (× 1 000)	699	702	250	120
USD (million)	0.188	0.186	0.066	0.032

URANIUM RESOURCES

No uranium resources have been discovered in Malaysia.

Malaysia has no uranium production industry, no uranium requirements and reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Namibia •

URANIUM EXPLORATION

Historical review

In 1928, Captain G. Peter Louw discovered uranium mineralisation 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 by some underground exploration. Due to erratic uranium values and poor economic prospects for uranium the Anglo-American Corporation abandoned the search.

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 during this period and numerous uranium anomalies were identified. One of these developed into the Rössing deposit, where Rio Tinto Zinc had obtained exploration rights in 1966. This deposit was developed into a large scale open-pit mine which started production in 1976.

The development of Rössing, combined with a sharp upward trend in uranium prices, stimulated extensive exploration activity, mainly in the Namib Desert. Two major types of deposits were identified including the intrusive type, associated with alaskite at Rössing, and the surficial, calcrete type.

Of the intrusive deposits other than Rössing, the Trekkopje deposit has significant resources. The Langer Heinrich deposit is the most promising deposit of the surficial, calcrete type. Feasibility studies were carried out on several of these low-grade deposits but the fall in the market saw the cessation of any further work.

The combined effect of political uncertainty and the decline of uranium prices caused the rapid curtailment of exploration and development work in the early 1980s. This was indeed unfortunate as the refinement of exploration techniques which had proved so successful in the Namib Desert were poised to potentially locate a number of new deposits.

Since that time, the continued weakness of the uranium market discouraged further exploration activities, except in the immediate vicinity of the Rössing mine.

However, should a sustained upturn in demand for uranium occur, it remains possible that the development of one of the identified deposits may prove commercially viable, with Langer Heinrich generally regarded as having the best potential.

Recent and ongoing uranium exploration and mine development activities

Only limited exploration has taken place in Namibia since the exploration boom of the 1970s. Currently two Mineral Deposit Retention Licenses are valid covering the Valencia (intrusive alaskite) and Langer Heinrich (calcrete hosted surficial) deposits. In 1997 and 1998, Acclaim Uranium NL (an Australian company) carried out a major exploration drilling programme at the Langer Heinrich deposit. However, no further work was carried out in 1999-2000. An Exclusive Exploration License is valid over the Trekkopje deposit, but the exploration work completed in this area remains confidential as long as the license is active.

URANIUM RESOURCES

The uranium resources of Namibia, including both known and undiscovered categories, occur in a number of geological environments and consequently are hosted in several deposit types. The known resources are mainly associated with intrusive deposits. In addition, about 10% of total known resources are hosted in surficial deposits.

In addition to the known resources in the Rössing and Trekkopje intrusive deposits, located in the granite associated district of the Precambrian Damara Orogenic Belt, and those associated with surficial calcretes of the Langer Heinrich deposit, there is a large undiscovered uranium potential. Although it is not quantitatively assessed, the potential is in the following geological environments:

- The granitic terrain of the Damara Belt covers 5 000 km^2. This area is largely overlain by surficial deposits and/or wind-blown semi-consolidated sand. Past investigations concentrated on follow-up of airborne radiometric anomalies. Substantial additional resources, potentially the size of the Rössing deposit, are suspected under the post-mineral cover.
- Tertiary to recent surficial sedimentary terrains exist in semi-arid areas. This environment has further potential for calcrete deposits. Eleven of 38 identified regional airborne anomalies were successfully investigated by extensive drilling, which confirmed a portion of the known resources included in Namibia's resource totals. In most cases the drilling encountered low-grade mineralization associated with calcrete-filled palaeo-river channels. Although the presence of additional resources within Tertiary sediments is not discounted, the existence of large undiscovered resources is considered unlikely.
- Another potentially favourable geological environment is the sandstone basins that include the Permo-Triassic Karoo sediments which were extensively investigated in neighbouring countries in the early 1970s. These basins were explored to a limited extent in Namibia as well. The Karoo sediments are extensively dissected by river systems in the northwestern part of Namibia and consequently airborne radiometric expressions are very pronounced. Ground follow-up including substantial drilling delineated nearly 6 million tonnes of low-grade uranium mineralisation. However, this was excluded from the known resources due to high costs of recovery. It is believed that economically recoverable resources may be present within similar age sedimentary basins in other unexplored parts of Namibia.

Known conventional uranium resources (RAR & EAR-I)

Namibia's known conventional resources as of 1 January 2001 total 282 617 tU recoverable at costs below USD 130/kgU. While the RAR portion totaling to 175 104 tU is expressed as recoverable resources adjusted for mining (10-16%) and ore processing losses (14-30%), EAR-I are reported as *in situ* resources.

The last comprehensive resource assessment was completed before 1995; therefore, RAR are identical to those reported in the last edition of this report except for adjustments for depletion resulting from 1999 and 2000 cumulative production of 5 405 tU.

Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
61 834	143 869	175 104

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
70 546	90 815	107 513

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

Due to the availability of only limited data, EAR-II and SR have not been estimated. The discovery potential, however, is considered excellent, especially for intrusive deposits.

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 that lasted until March 1973. Surveying, mapping, drilling, bulk sampling and metallurgical testing in a 100 tonne/day pilot plant indicated the feasibility of establishing a production centre.

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).

Mine development commenced in 1974, and commissioning of the processing plant and initial production were in July 1976 with the objective of reaching full design capacity of 5 000 short tons of U_3O_8/year (3 845 tU/year) during 1977. Due to the highly abrasive nature of the ore, which was not identified during the pilot plant testing stage, the production target was not reached until 1979 after major plant design changes.

Historical uranium production
(tonnes U)

	Pre-1998	1998	1999	2000	Total through 2000	2001 (expected)
Open-pit mining	63 942	2 780	2 690	2 715	72 127	2 702
Total	63 942	2 780	2 690	2 715	72 127	2 702

Uranium production centre technical details
(as of 1 January 2001)

Production centre name	Rössing
Production centre class	existing
Operational status	operating
Start-up date	1976
Source of ore: Deposit name Deposit type Reserves (active resources) Grade (% U)	 Rössing intrusive NA 0.03
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 0P 41 902 82
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing recovery (%)	 AL/IX/SX 30 000 86
Nominal production capacity (tU/year)	4000

Status of production capability

Production during 1999 and 2000 was about 75% of capacity, with operations having been reduced in line with sales contracts.

During the past three years, substantial capital investment has been made to improve cost efficiency. In the processing area a pre-screening plant has been installed and tied into the fine crushing circuit to improve the throughput capacity of the circuit by removing under sized material from the bulk. In addition, construction of a pilot ore sorting plant was started in 2000 and was operating on a "start-stop" basis by year-end 2000. Radiometric ore sorting has the potential to remove about 25% of the total rock mass from the processing circuit by eliminating low-grade material prior to processing, thus improving performance by enhancing mine feed grade to the processing plant.

Short-term production capability
(tonnes U/year)

2001				**2002**				**2005**			
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	4 000	4 000	0	0	4 000	4 000	0	0	4 000	4 000

2010				**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	4 000	4 000	0	0	4 000	4 000	0	0	4 000	4 000

Ownership structure of the uranium industry

Rössing Uranium Limited is a mixed enterprise with private and governmental shareholders as detailed in the following list:

RTZ Corporation	56.3%
Namibian Government	3.5%
Rio Algom Limited	10.0%
IDC South Africa	10.0%
Others	20.2%

The uranium production is 100% owned by domestic private organisations.

Employment in the uranium industry

Rössing has continued to improve efficiency throughout its operation in an effort to offset historically low uranium prices. As part of implementing these improvements, employment has declined from 1 254 in 1997 to 902 in 2000.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
1 104	1 009	902	900

Future production centres

Under favourable market conditions Rössing, the only uranium producer in Namibia, could return to full production of close to 4 000 tU/year. Known resources could support this level of production at least through the year 2017.

Favourable market conditions would allow the development of one additional production centre with a production capacity of 1 000 tU/year. However, among the parameters which would impact a production decision is the availability of water.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Namibian environmental legislation is not specific to the uranium mining industry alone but covers all aspects of mining throughout the country.

Currently, environment activities are governed only by an environmental policy. However, an Environmental Act and an Integrated Pollution Control and Waste Management Bill are in a draft form. Furthermore, an Environmental Fund will be established to ensure that financial resources are available for mine rehabilitation.

Cost of environmental management
(ZAR × 1 000)

Existing operations	**Pre-1998**	**1998**	**1999**	**2000**	**Total**
Pre-operational environmental assessment	170	0	0	0	170
Monitoring	19 750	1 131	842	864	22 587
Stabilising waste dumps and/or impoundments	2 978	799	339	246	4 362
Decontamination of replaced equipment	0	0	0	0	0
Effluent management (gas, liquid)	11 670	309	448	474	12 901
Site rehabilitation	4 062	174	170	185	4 591
Radwaste disposal	0	0	0	0	0
Regulatory activities	190	10	10	10	220
Total	38 820	2 423	1 809	1 779	44 831

URANIUM REQUIREMENTS

Namibia has no plans to develop nuclear generating capacity and consequently has no reactor-related uranium requirements.

NATIONAL POLICIES RELATING TO URANIUM

The Namibian Government recognises that the country's uranium deposits represent a major economic resource both for Namibia and the uranium consumers of the world. It is thus committed to develop the deposits in a manner, which is safe for its workers and environmentally sustainable in the long-term. This policy has been expressed through legislation in the Minerals (Prospecting and Mining) Act of 1992.

Namibia achieved independence on 21 March 1990 and the Act was promulgated in 1 April 1994. With the introduction of the Act, a number of South African laws that previously regulated uranium production activities were repealed or amended. These laws include the Nuclear Installations (Licensing and Security) Act of 1963, the Atomic Energy Act of 1967 and their amendments.

While the repeal of the South African uranium-related legislation was justified, due to its complexity and reference to issues which were not relevant to Namibia, the provisions of the Namibian Minerals (Prospecting and Mining) Act of 1992 are not sufficiently detailed to control the safety or the environmental aspects of the uranium industry. The introduction of a new act, or amendments to existing legislation, is presently being considered.

Namibia reported no information on uranium stocks or uranium prices.

• Netherlands •

URANIUM EXPLORATION, RESOURCES AND PRODUCTION

The Netherlands has no uranium resources and is not undertaking any uranium exploration. No domestic uranium production capability exists. There are no plans to create any future production capability or conduct exploration.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

At present, the Netherlands has one nuclear reactor connected to the grid, the Borssele PWR reactor (449 MWe net).[1]

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
449	449	0	0	0	0	0	0	0

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
84*	10.3	0	0	0	0	0	0	0

* Secretariat estimate.

URANIUM STOCKS

The natural uranium stocks were disposed of by 31 December 1995. Since then, the Netherlands have held no further stocks.

1. The Dutch government is of the opinion that there is an agreement with the owners of the Borssele plant, EPZ, to shut down the plant by the end of 2003. EPZ has taken the standpoint that this is not the case. The Dutch government decided to bring the case to a civil court where it remains under review.

• Niger •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration in the Arlit area of Niger began in 1956 and was conducted by the *Commissariat à l'Énergie Atomique* (CEA), later followed by Cogéma. Discovery of mineralized areas eventually led to the mining of the Arlette, Artois and Ariège deposits by the *Société des Mines de l'Aïr* (Somaïr), and the Akouta and Akola deposits by the *Société des Mines d'Akouta* (Cominak). Exploration along the northwest extension of the Arlette flexure fault resulted in the discovery of the Taza deposit. The *Société Minière de Tassa N'Taghalgue* (SMTT) was organised to own the deposit, but assigned part of its mining rights to Somaïr in 1986.

In subsequent years, both Somaïr and Cominak were involved in exploration solely for the purpose of better evaluating known deposits. Somaïr delineated the Taza Nord deposit. Cominak evaluated a mineralized area located southeast of the Akola deposit.

Since 1993, both Somaïr and Cominak have carried out significant drilling programmes. Part of the drilling results led to a reassessment of the resource estimates of the Takriza and Tamou deposits by Somaïr and further evaluation of the South Akouta and Akola deposits by Cominak. The remainder of SMTT's mining rights were assigned to Somaïr in 1996, and SMTT was subsequently dissolved.

Recent and ongoing uranium exploration and mine development activities

In 1999 and 2000, Cominak drilled 82 boreholes totalling 17 854 m to complete the evaluation of the Akola deposit.

Uranium exploration and development expenditures and drilling efforts

	1998	**1999**	**2000**	**2001** (expected)
Industry expenditures				
XOF (million)	450	295	423	632
USD (million)	0.753	0.471	0.604	0.897
Development drilling (m)	16 575	18 553	19 301	23 000
Number of development holes	93	38	44	96

URANIUM RESOURCES

Known conventional uranium resources (RAR & EAR-I)

During 2000, the resources of the Takriza deposit were totally depleted as a result of Somaïr's production activities between 1996 and 2000.

The Tamou deposit has been re-evaluated and a new pit optimization has been completed, which takes into account production costs for 2000. As a result of this evaluation, resources decreased from 11 527 tonnes in 1999 to 8 909 tonnes in 2001.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
10 908	29 603	29 603

***** As *in situ* resources.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
11 168	25 529	25 529

***** As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

The Imouraren, Afasto East, Afasto West, Abkorum, Tamgak and Azelik deposits are estimated to contain more than 200 000 tonnes of uranium. These resources, for which estimates have existed for more than a decade, have not been placed in any cost range.

Estimated additional resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
16 194	16 194

Speculative resources
(tonnes U)

Cost range	Total
Unassigned	
200 000	200 000

URANIUM PRODUCTION

Historical review

Uranium is produced in Niger by two companies: Somaïr and Cominak, which have been operating mines in sandstone deposits since 1970 and 1978, respectively. A third company, the SMTT, assigned its mining rights to Somaïr in 1996. SMTT was subsequently dissolved. Details of Niger's historical uranium production and descriptions of its two operating production centres are summarized in the following tables.

Historical uranium production

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Processing plant	66 536	3 714	2 907	2 911	76 068	2 910
Heap leaching	5 785	7	4	0	5 785	0
Total	72 321	3 714	2 907	2 911	81 853	2 910

Uranium production centre technical details
(as of 1 January 2001)

Production centre name	Arlit	Akouta
Production centre class	existing	existing
Operational status	operating	operating
Start-up date	1970	1978
Source of ore: • Deposit name Deposit types • Reserves (active resources) • Grade (% U)	 Ariège, Taza, Arlette, Tamou sandstone	 Akouta, Akola sandstone
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 0P 2 000	 UG 1 800
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing recovery (%)	 AL/SX 2 000 95	 AL/SX 1 900 96.3
Nominal production capacity (tU/year)	1 500	2 300

Future production centres

A proposal is under consideration to enlarge the Cominak production centre in order to mine the Afasto West deposit, which has reserves estimated at 62 000 tU (estimate made in 1982).

Similarly, Somaïr mining activities are to be extended to the Imouraren deposit at which *in situ* leach (ISL) extraction is being evaluated. Imouraren reserves have been estimated at 22 200 tU (estimate made in 1977).

Status of production capability

Short-term production capability
(tonnes U/year)

2001				**2002**				**2005**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
2 910	0	0	0	2 960	0	0	0	2 960	0	0	0

2010				**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	0	0	0	NA	0	0	0	NA	0	0	0

Ownership structure of the uranium industry

Ownership of Niger’s two production companies is a follows:

Somaïr	Cominak
36.6% Niger (Onarem)	31% Niger (Onarem)
37.5% Cogéma (France)	34% Cogéma (France)
19.4% CFMM (France)	25% OURD (Japan)
6.5% Urangesellschaft	10% Enusa (Spain)

Employment in the uranium industry

The gradual reorganization of the uranium industry, which has been under way since 1990, has resulted in continuous staff reduction – from 3 173 in 1990 to 1 723 at the end of 2000. This figure is expected to fall to 1691 in 2001.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
2 012	1 830	1 723	1 691

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Both Cominak and Somaïr committed themselves in 2000 to an environmental management system complying with ISO 14001. Their goal is to receive certification in 2002.

Cominak's environment-related spending (impact assessment, monitoring, waste management, regulatory activities) totals approximately CFA 120 million per year (USD 171 290). Expenditures related to social and cultural programmes supported by Cominak totaled CFA 2 800 million per year (USD 4 million).

URANIUM REQUIREMENTS

Niger has no plans to develop nuclear generating capacity and consequently has no reactor-related uranium requirements.

NATIONAL POLICIES RELATING TO URANIUM

One of the main objectives of Niger's national uranium policy is to achieve a higher degree of international competitiveness in its uranium industry.

URANIUM STOCKS

None reported.

URANIUM PRICES

	1997	1998	1999	2000	2001
FRF/kgU	230	225	220	217	213
USD/kgU	40.07	37.69	35.12	30.98	30.22

• Philippines •

URANIUM EXPLORATION

Historical review

The search for uranium in the Philippines started in the early 1950s in areas containing radioactive anomalies. Since then, several prospecting and exploration programmes have been conducted throughout the archipelago both by the government and private sector. To date, more than 50% of the country has been covered at the reconnaissance level. Some areas were then followed up by semi-detailed and/or detailed geochemical surveys. Most of the exploration activities involving integrated application of geological, radiometric and geochemical techniques were carried out by the then Philippine Atomic Energy Commission (PAEC) now the Philippine Nuclear Research Institute (PNRI).

During 1997 and 1998, reconnaissance and semi-detailed uranium geochemical exploration were continued by the Philippine Nuclear Research Institute on Palawan Island. At least two prospective geochemical anomalies were identified in the San Vicente area. Uranium occurrences in this area are related to granitic and metamorphic rocks (phyllite and schist).

Recent uranium geochemical exploration is mainly confined to Palawan province, particularly in the northern part of the island.

Uranium exploration expenditures

	1998	**1999**	**2000**	**2001** (expected)
Government exploration expenditures				
PHP (× 1 000)	500	400	200	200
USD (million)	0.013	0.011	0.005	0.004

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

There are no significant known uranium resources in the Philippines. Minor occurrences have been identified in association with pyrometasomatic replacement and hydrothermal metalliferous deposits related to middle Miocene intrusives of acid to intermediate composition.

Undiscovered conventional resources (EAR-II & SR)

No formal estimate of undiscovered resources has been made so far.

The northern part of Palawan, located southwest of Luzon, was identified in the 1991-1992 period as a geologically favourable area for discovery of uranium resources. Northern Palawan is considered to be a rifted portion of a continental terrain where the oldest basement formations consist of folded sedimentary and metamorphic rocks. The age of the basement rock is thought to be Lower Proterozoic or older.

The basement rocks were intruded by Tertiary granitic bodies and ultramafics. They are partly covered by Tertiary sedimentary formations. Major thrust faults separate these formations. The granitic intrusive bodies are thought to be prospective and the metamorphic formations near these intrusives are also considered to be geologically favourable for uranium mineralisation.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Since the Philippines has no identified uranium resources, there are no significant environmental issues related to the country’s uranium development and exploitation.

URANIUM REQUIREMENTS

The Philippines began construction of a 620 MWe PWR nuclear reactor, designated PNPP-1, which was never completed. There are plans to convert this facility to a fossil fuel fired power plant. There are, therefore, no uranium requirements for the foreseeable future.

NATIONAL POLICIES RELATING TO URANIUM

By law, uranium exploration and mining is open to private enterprise. These activities are subject to nuclear safety regulations and existing production sharing arrangements including financial or technical assistance agreements as provided for in the mining law. All exploration and mining activities are monitored by the Mines and Geosciences Bureau (formerly Bureau of Mines).

The Philippines reported no information on uranium stocks or uranium prices.

• Poland •

URANIUM EXPLORATION

Historical review

Prospecting for uranium in Poland was initiated in 1947 when a bilateral agreement between Poland and the USSR government was signed. Extensive exploration and mining activities were carried out in the Lower Silesia region under the direction of Soviet Union experts. A systematic exploration programme, including geological, geophysical and geochemical surveys and related research, was carried out until 1966. According to the bilateral agreement, all uranium produced in Poland was transported to the Soviet Union. Extensive uranium exploration was undertaken in a number of localities in Lower Silesia. Uranium mining took place in Kowary Podgórze, Radoniow and Kletno.

URANIUM RESOURCES

None reported.

URANIUM PRODUCTION

Historical review

Uranium production in Poland was confined to the Lower Silesia mines operated between 1948 and 1963. In total, 660 tU were extracted. The town of Kowary was both a centre of uranium mining activities and the headquarters of the uranium mining company “Zaklady Przemyslowe R-1 (ZPR-1)”. Uranium ores from underground mines were transported directly to the Soviet Union.

Mining of uranium in Poland was terminated in 1963. Chemical treatment of low-grade ores started in Kowary in 1969 at the only uranium processing plant in Poland. The processing of low-grade ore continued until 1972. It produced a significant volume of waste, which was disposed of in a tailings pond constructed in Kowary. Data related to uranium mining activities are listed in the table below.

	Number	**Area** (km^2)	**Volume** (m^3)
Shafts and adits	156		
Waste rock and ore dumps	102	0.32	1 412 500
Tailings ponds	1	0.01	130 000

Status of production capability

Poland has no uranium production capability.

Ownership structure, employment and future production centres

Poland has neither a uranium industry nor any plans to create one.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

All mining and processing activities in Poland ceased more than 25 years ago, and the companies responsible for the associated environmental problems no longer exist. However, there is still a real need to remediate the environment in the areas around these sites. The Geological and Mining Law stipulates that the State Treasury is accountable for liabilities from all ceased uranium production activities in Poland. Therefore, the government is responsible for the funding of remediation, either from the national or the district Environmental Protection Fund.

The regional authority of the Voivodship and its special inspectorates or offices are responsible for the different aspects of remediation. Finally, the local authority has to approve the remediation plans and supervise their execution and effects. The inspectorates of Environmental Protection of Voivodship are responsible for environmental monitoring. The President of the National Atomic Energy Agency is responsible for radiological monitoring which is considered part of the environmental monitoring.

According to the Polish regulations, there are no specific maximum admissible concentrations defined for natural radioisotopes, with few exceptions. Limits for chemotoxic contaminants are partially available from several regulations. The admissible exposure for members of the critical group is derived by calculation from the general limit for the additional effective dose equivalent: 1.0 mSv/year. Since 1996, Poland has taken part in the PHARE multi-country Environmental Sector Programme on “Remediation Concepts for the Uranium Mining Operations in CEEC”. In the framework of the Programme, the inventory and a common database for the CEEC have been executed. According to this inventory, the situation in Poland is characterised by a large number of small-scale liabilities from uranium exploration, distributed over several locations in the country, and generally causing minor impacts on the environment.

There are only a limited number of issues related to mining and milling causing serious impacts. The most important is the tailings pond in Kowary. The tailings pond covers an area of 1.3 ha. It is a hydrotechnical construction closed on three sides by a dam that has been modified a number of times over the years. The dam is now 300 m long (the sum of the three sides), with a maximum height of 12 m. The overall facility is considered to be at the limits of geotechnical stability. As a result of the uranium processing activities, the tailings pond has been filled with about 2.5×10^5 tonnes of fine-grained gneisses and schists with average uranium content of 30 ppm. In the early 1970s, the Wroclaw University of Technology (WUT) received, by governmental decision, the ownership of both the area and facilities of the former uranium mining company ZPR-1. Subsequently, the ZPR-1 company (owned by WUT) has continued to use the existing chemical plant for various experimental processes on rare metals, chemical production and galvanic processes. As a result, about 300 tonnes of remnants of rare metals processing and 5×10^3 m^3 of post-galvanic fluids, with up to 30 tonnes of solids with a high content of Al, Ni, Zn and Na sulphates, have also been disposed of in the pond. The specific objectives of the remediation programme are related to the construction of the drainage systems, the design and construction of the tailings pond cover and the final site reclamation. The remediation programme of the tailings pond prepared in 1997 by the WUT is still being carried out. The remediation programme for the historic uranium liabilities in the Lower Silesia region is being prepared by the local authorities.

Poland has no uranium requirements and reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Portugal •

URANIUM EXPLORATION

Historical review

Uranium exploration first began in Portugal with the discovery in 1912 of the Urgeiriça deposit which contained radium and uranium. Radium was mined until 1944 and uranium has been mined since 1951. Between 1945 and 1962, a foreign privately-owned enterprise, Companhia Portuguesa de Radium Limitada (CPR) carried out radiometric surveys, detailed geological mapping, trenching and core drilling with gamma-ray logging in the granitic formations of the Beiras districts. In 1955 the Government started uranium exploration on a systematic basis using geological mapping, carborne and ground radiometric surveys, geophysics (resistivity surveys), trenching and diamond and percussion drilling. By 1961, the Junta de Energia Nuclear (JEN) had discovered about 100 deposits in the Hercynian granitic or perigranitic zones in the districts of Beiras and Alto Alentejo. The Beiras areas with its numerous small deposits together with the Urgeiriça mill constitute an integrated uranium production district. The Alto Alentejo area was found to be able to support another production centre. Since 1976, prospecting has been continued in the crystalline regions with known uranium resources. Exploration in sedimentary regions started in 1971, employing geological, radiometric, geochemical, emanometric and drilling surveys in the western Meso-Cenozoic fringe of the Portuguese basin.

Responsibility for uranium mining and exploration activities were transferred respectively from JEN to the publicly-owned enterprise “Empresa Nacional de Urânio, S.A.” (ENU), in 1977, and to the “Direcção-Geral de Geologia e Minas (DGGM)”, in 1978. ENU carried out prospecting activities in areas adjacent to uranium deposits and their extensions.

Recent and ongoing uranium exploration and mine development activities

A radiometric background map of Portugal (scale 1/200 000) is being completed under contract with the General Directorate of the Environment. A rare earth element exploration project is also being completed.

Uranium exploration activities were reduced to a minimum level in 1999, with the end of the drilling programme at the Tarabau deposit (South Portugal).

Uranium exploration expenditures and drilling effort – domestic

	1998	**1999**	**2000**	**2001** (expected)
Industry exploration expenditures PTE (million)	18.6	3.5	4.2	0
USD (million)	0.10	0.02	0.02	0
Industry exploration drilling (m)	2 634	183	116	0
Number of industry exploration holes drilled	79	5	14	0
SUBTOTAL exploration drilling	2 634	183	116	0
SUBTOTAL exploration holes	79	5	14	0
TOTAL DRILLING (m)	2 634	183	116	0
TOTAL NUMBER OF HOLES	79	5	14	0

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

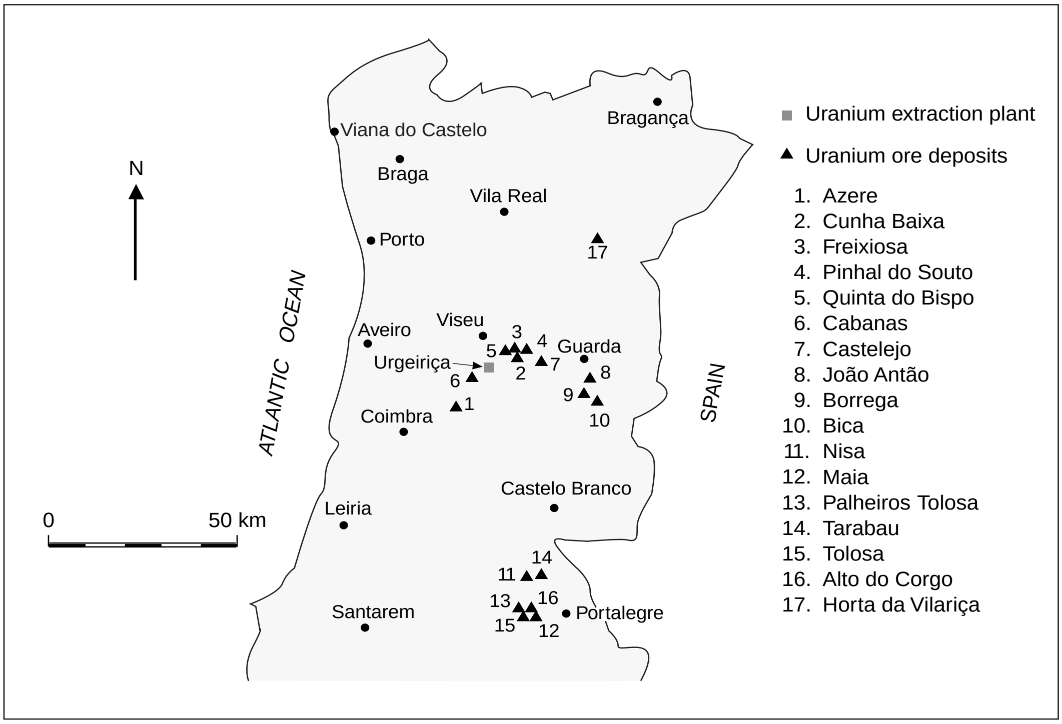
Portugal reports total RAR of 7 450 tU recoverable at costs of USD 80/kgU or less. Additionally, 1 450 tU are reported as EAR-I recoverable at costs equal to or below USD 130/kgU.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
NA	7 450	7 450

* Processing losses of ~10% have been accounted for in estimate.

Uranium deposits and occurrences in Portugal



Estimated additional resources – Category I
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	1 450

84% of known conventional resources recoverable at <USD 80/kgU are in existing production centres.

Undiscovered conventional resources (EAR-II & SR)

Undiscovered conventional resources include 1 500 tU of EAR-II and 5 000 tU of Speculative Resources recoverable at costs equal to or below USD 130/kgU.

Estimated additional resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	1 500

Speculative resources
(tonnes U)

Cost range <USD 130/kg U	Cost range Unassigned	Total
5 000	0	5 000

URANIUM PRODUCTION

Historical review

Between 1951 and 1962, the 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 mines by heap leaching. The uranium at that time was precipitated using magnesium oxide. During the period 1962 to 1977 the JEN took over the mining and milling activities from CPR, introducing organic solvent extraction. A total of 825 tU were produced from the Urgeiriça plant and the pilot plant at Senhora das Fontes. Between 1977 and 1994, ENU produced 1 651 tU.

Historical uranium production (tonnes U)

	Pre-1998	1998	1999	2000	Total through 2000	2001 (expected)
Processing plant	3 127	0	0	0	3 127	0
In place leaching*	249	1	0	0	250	0
Heap leaching	298	12	7	4	321	0
Other methods e.g. mine water treatment, environmental restoration.	0	6	3	10	19	3
Total	3 674	19	10	14	3 717	3

* Also known as Stope Leaching or Block Leaching.

Status of production capabilities

At present the Urgeiriça production mill, whose nominal production capacity is 170 tU/year, is operating at reduced capacity. The produced concentrate (14 tU/year) comes as a result of environmental activities and from low grade ore treatment by heap leaching.

Short-term production capability
(tonnes U/year)

2001				2002				2005			
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	0	NA	0	NA	0	NA	0	100	NA	170	NA

2010				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
100	NA	170	NA	NA	NA	150	NA	NA	NA	NA	NA

Uranium production centre technical details
(as of 1 January 2001)

Name of production centre	Urgeiriça
Production centre class	existing
Operational status	operating
Start-up date	1951
Source of ore • Deposit names • Deposit type(s)	 Sevilha Quinta do Bispo
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 OP
Processing plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average process recovery (%)	 IX/ SX
Nominal production capacity (tU/year)	170
Plans for expansion	no

Ownership structure of the uranium industry

All mining and milling activities are entrusted to ENU, a fully state-owned company, which also carried out uranium exploration activities in areas surrounding present and future mining sites through the end of 1992. Meanwhile, the exploration permit has expired and all the exploration activities have ceased. ENU was integrated in 1992 into the Portuguese state mining holding, Empresa de Desenvolvimento Mineiro (EDM). A new development programme is expected after extensive manpower reduction and financing restructuring activities are completed. DGGM/IGM ceased all exploration activities for uranium by the end of 1994 and its operating capacity has been allocated to other projects.

Ownership of uranium production in 2000

DOMESTIC				FOREIGN				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	14	100	0	0	0	0	14	100

Employment in the uranium industry

Employment has been reduced from 61 in 1998 to 50 in 2000.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
61	54	50	0

Future production centres

Feasibility and environmental studies have been completed for the Nisa project. Environmental impact studies were approved in 1999, but the project has been suspended.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

ENU is the owner of all exploitation rights of radioactive minerals and is, therefore, responsible for the environmental problems connected with this activity.

As currently planned, the production of uranium concentrates will cease at the end of the first quarter of 2001, but the responsibility for all safety and environmental problems will remain. Environmental activities consist of monitoring, effluent management and site rehabilitation. These represented the main activities of ENU during the year 2000.

The development of mining activities in a large area and the considerable number of mines exploited make the determination and control of the associated risks difficult and complex. Nevertheless, ENU has developed a campaign for the determination of the main impacts that will permit establishment of the projects and future actions necessary to eliminate the environmental problems.

Studies are underway to identify the problems affecting air, soil and surface water and groundwater. The problems include groundwater contamination associated with *in situ* leaching and percolation from the underground works.

At the underground mines, ENU treats the water in a closed circuit by pumping, neutralising and returning it to the mine with a pH of 8 to 9.

ENU has identified 58 old mines and is developing the necessary studies and procedures that will allow improvement of the actions designed to stabilise the environmental problems. Currently, six open-pit mines are rehabilitated and have installed control systems.

The budget for the studies and preliminary projects is estimated at about USD 35 to 40 million.

URANIUM REQUIREMENTS

Portugal has no uranium requirements.

NATIONAL POLICIES RELATING TO URANIUM

The national authorities responsible for national policies concerning uranium are the State Secretariat of Energy and the General Directorate of Energy. All mining and milling activities are entrusted to the Empresa Nacional de Urânio, a fully state-owned company and now a subsidiary of Empresa de Desenvolvimento Mineiro, SA, a state holding company for mining. Exploration is free and is granted by the Instituto Geológico e Mineiro, in accordance with Portuguese mining law. ENU has the exclusive right for mining and milling under Decree 120/80, as of 15 May 1980.

Total uranium stocks
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Utilities	300	0	0	0	300
Producer	14	0	0	0	14
Total	314	0	0	0	314

URANIUM PRICES

None reported.

• Romania •

URANIUM EXPLORATION

Historical review

Prospecting for uranium in Romania was initiated in about 1950 when a bilateral agreement between the Romanian and USSR governments (the Romanian-Soviet Joint Venture SOVROM-CUARTIT) was concluded. A series of radiometric surveys were then completed to identify uranium occurrences of industrial value.

Mine production started in 1952 at the Bihor and Ciudanovita deposits, in 1962, at the Avram Iancu deposit and in 1983, at the Crucea and Botusana deposits. Experimental mining was carried out at the Tulghes deposit in 1998. Other deposits including Ranusa, Padis, Arieseni, and Milova have been explored in detail to establish their full potential. Underground mining technology has been used in all of the deposits mined, with the exception of the Banat Mountains deposits, where open-pit mining was used. Since 1978, all of the produced ores have been processed at the Feldioara mill.

Recent and ongoing uranium exploration activities

Exploration expenditures declined by 90% between 1999 and 2000. No exploration expenditures are projected for 2001.

Uranium government exploration and development expenditures, and drilling statistics

	1998	1999	2000	2001 (expected)
Exploration expenditures (ROL × 1 000) (USD million)	 4 620 148 0.54	 3 270 472 0.21	 307 557 0.015	 0 0
Development expenditures (ROL × 1 000) (USD million)	 3 317 430 0.39	 5 226 373 0.34	 2 918 767 0.14	 8 916 543 0.35
Total (ROL × 1 000) Total (USD million)	7 937 578 0.934	8 496 845 0.549	3 226 342 0.157	8 916 543 0.348
Government exploration drilling (m)	3 521	1 390	70	0
Development drilling (m)	5 126	4 522	3 179	8 000
Total drilling (m)	8 647	5 912	3 249	8 000

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

A total of 9 233 tU of Known Conventional Resources are reported from ores with an average uranium content of 0.11% U. This includes 4 547 tU RAR and 4 686 tU EAR-I with a production cost of less than USD 130/kgU. No resources with lower production costs are reported. Known Resources decreased by 6 324 tU compared to the 1999 Red Book. The closing of some of Romania's mines between 1998 and 2000 accounts for the reduction in reported resources, though the mines were closed because of economic reasons and not because of depletion of reserves.

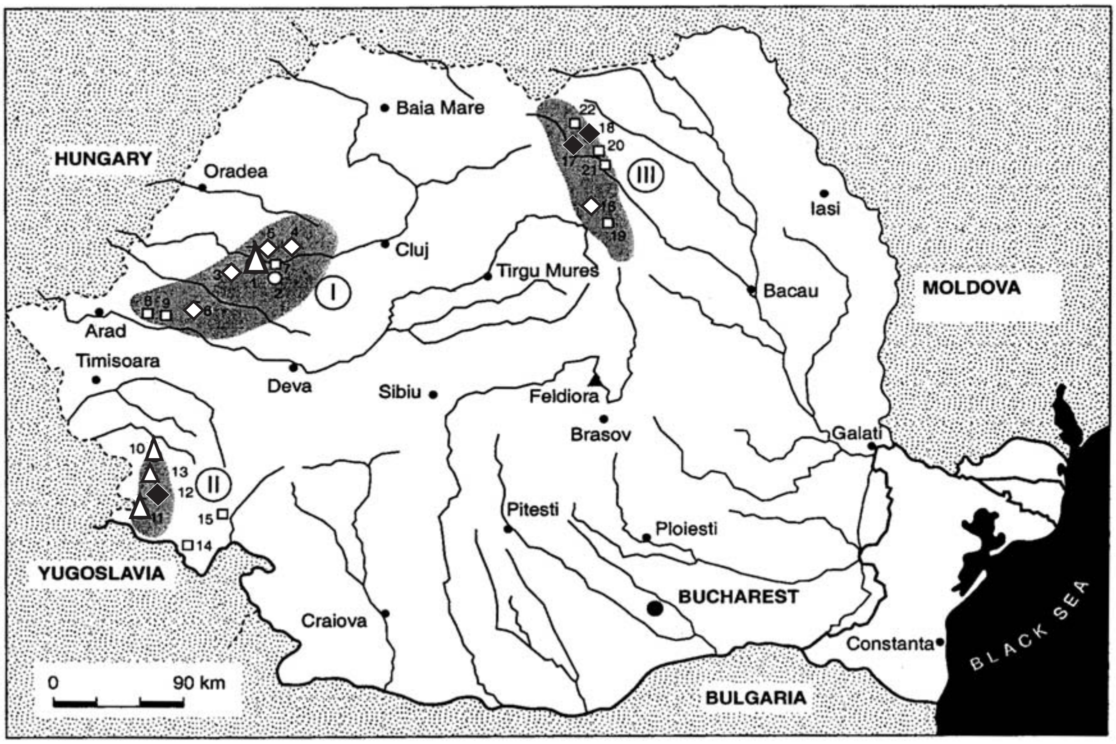
Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	4 547

Estimated additional resources – Category I
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	4 686

Romania



I. APUSENI MOUNTAINS

Deposits
1. Baita Bihor
2. Avram Iancu
3. Ranusa
4. Rachitele
5. Budureasa
6. Paiuseni

Occurrences
7. Arieseni
8. Milova
9. Conop

II. BANAT MOUNTAINS

Deposits
10. Ciudanovita
11. Natra
12. Dobrei South
13. Dobrei North

Occurrences
14. Illisova
15. Mehadia

III. EASTERN CARPATHIANS

Deposits
16. Tulghes
17. Crucea
18. Botusana

Occurrences
19. Bicazul Ardelean
20. Piriul Lesu
21. Holdita
22. Hojda

▲ Uranium processing plant – Feldiora

● Uranium provinces

Ⓘ Western Carpathians

Ⓘ Banat Mountains

Ⓘ Eastern Carpathians

◯ Large deposits: >20 000 t metal

◯ Medium deposits: 5 000-20 000 t metal

○ Small deposits: <5 000 t metal

Δ Ore deposits depleted

◆ Ore deposits in exploitation

◇ Ore deposits in exploitation

□ Mineralisation in exploitation

Undiscovered conventional resources (EAR–II & SR)

A total of 6 344 tU of undiscovered resources are reported. This includes 3 344 tU of EAR-II and 3 000 tU of Speculative Resources in the less than USD 130/kgU production cost category.

Estimated additional resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	3 344

Speculative resources
(tonnes U)

Cost range		Total
<USD 130/kg U	Unassigned	
3 000	0	3 000

URANIUM PRODUCTION

Historical review

Mining operations began in Romania in 1952 at the Bihor open pit mine and the Ciudanovita underground mine. Between 1952 and 1962, uranium ore was directly exported to the Soviet Union. Ore from the high-grade Bihor deposit (1.13-1.26% U) was sorted and shipped to the Sillamäe ore processing plant in Estonia. In 1962, shipment of ore to the Soviet Union was stopped, and between 1962 and 1978 ore was stockpiled at the mine sites.

In 1978, the Feldioara mill was commissioned, and since 1978 previously stockpiled ore and newly mined ore has been processed at Feldioara. In 1985, the Feldioara mill was modified to include a refining section capable of producing uranium oxide, which is used in fabrication of fuel for Romania's Candu-type reactors.

Status of production capability

Three mines are currently in operation: E.M. Banat, E.M. Bihor and E.M. Crucea. Ore from these mines is processed at the Feldioara hydrometallurgical plant, which uses a pressure alkaline leach circuit with recovery by ion exchange to produce sodium diuranate. This product is then further processed at the plant to produce uranium dioxide powder that may be sintered to produce fuel pellets. This process is conducted in the "R" mill at Feldioara.

A second production unit was planned at the Feldioara plant. Construction was about 50% complete when it was suspended because of the lack of funds. Completion of this facility would increase capacity to 600 tU of UO_2 concentrate.

Consideration is being given to the development of a mine in the Tulghes area.[2]

Historical uranium production
(tonnes U)

	Pre-1998	1998	1999	2000	Total through 2000	2001 (expected)
Processing plant production	17 422	132	89	86	17 729	85
Total	17 422	132	89	86	17 729	85

Uranium production centres technical details
(as of 1 January 2001)

Name of production centre	Feldioara mill, fed from 3 mines
Production centre class	existing
Operational status	operating
Start-up date	1978
Source of ore: • Deposit names • Deposit type	 Banat, Bihor and Crucea hydrothermal
Mining operation: • Type • Size (tonnes ore/year) • Average mining recovery (%)	(three mines) underground NA 90
Processing Plant: • Type • Size (tonnes ore/year) • Average processing recovery (%)	Feldioara ALKPL/IX 100 000 80
Nominal production capacity (tU/year)	300
Plans for expansion	suspended

Ownership structure of the uranium industry

In Romania all uranium exploration, research, exploitation and processing activities are conducted by the state.

Employment in the uranium industry

The number of people employed in the production centres has decreased from 5 000 in 1996, to 4 550 in 1997; 3 300 in 1998; 2 800 in 1999 and 2 150 in 2000. A further decrease to 2 070 is projected for 2001.

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2. Romania and the IAEA have initiated a co-operation project entitled "Restructuring of the Uranium Industry", the main goal of which is to introduce up-to-date technology and economic analysis techniques to Romania's uranium mining and milling industry

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
3 300	2 800	2 150	2 070

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

The Romanian uranium industry has a systematic programme for protection of the environment. Potential sources of environmental impacts during uranium exploration, exploitation and milling activities include:

- Mine and mill effluents containing natural radioactive elements above the maximum admissible concentration.
- Waste rock from mining operations.
- Low-grade ore with a uranium content of 0.01-0.05%, which at present is not processed, but stored at the mine site.
- Tailings from processing activities, stored in the dewatering ponds at the Feldiora mill.
- Metal and wooden wastes contaminated with radioactivity during exploitation and processing of radioactive minerals.
- Controlled flooding of the Banat county underground mines.
- Small mining works in areas where exploration for uranium was done, leaving adits and sterile dumps, and sometimes low-grade ore dumps.

The closure of the Ciudanovita mine in the Banat area is being done under a PHARE pilot project. This PHARE programme is sponsored by the European Commission and is called "Remediation Concepts for the Uranium Mining Operations in CEEC". With cessation of mining at the Banat county underground mines, controlled flooding of the mines will effectively start the mine closure process. Feasibility studies have been undertaken to assess the optimal techniques for flooding the mines, groundwater protection, mine water decontamination, dismantling facilities, stabilizing sterile rock dumps, site covering and rehabilitation, and environmental monitoring.

It is estimated that USD 6 million will be required to complete the Banat mine rehabilitation programmes. An additional USD 2 million will be required for building the mine and seepage water decontamination plant and for the projected 20-year environmental monitoring programme. Lack of funding has slowed implementation of the Banat rehabilitation effort, and it is anticipated that contributions from other countries will be required to ensure that the programmes can be initiated as planned by 2002.

Environmental assessment studies have also been undertaken for most of Romania's other mining and exploration locations, but no major rehabilitation projects are currently being planned except for the one in the Banat area.

URANIUM REQUIREMENTS

The goal of the Romanian uranium production industry is to cover the requirements of natural UO_2 powder necessary for the Cernavodã nuclear power plant (NPP). Annual production levels will take into account the uranium requirements for the commissioning and operation of a second NPP at Cernavodã of the same CANDU plant-type as the current plant. For this second plant the Romanian government has already approved long-term funding and co-operation with the Canadian AECL, with commissioning of the second plant scheduled for 2005-2006. Annual output from the Feldioara mill will have to total 200 tU beginning in 2010, in the form of natural UO_2 powder, having the nuclear purity required for CANDU reactor use. Consideration is being given to the building and commissioning of the NPP-3 and NPP-4 units at the Cernavodã plant. Foreign investors will play an important role in funding and exploiting these 2 PHWR-Candu type nuclear plants.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
650	650	650	1 300	1 950	1 300	1 950	1 950	2 600

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
100	100	100	200	300	200	300	300	400

Supply and procurement strategy

The goal of the present uranium supply strategy is to supply domestic requirements for Romanian CANDU power plants from local production. Present plans are to increase the annual production of natural UO_2 (nuclear grade) in order to supply the nuclear fuel plant known as FCN-PITESTI (which is the supplier of pellets/nuclear fuel rods for the CERNAVODÃ PHWR plant). There are no plans for exporting Romanian natural UO_2 as powder or chemical concentrates. However, the Uranium National Company S.A. has at present excess processing capacity for refining natural uranium from chemical concentrates, so the company may offer its services as a uranium refiner for foreign clients. At present, however, there is no contract for such services with any foreign company.

NATIONAL POLICIES RELATING TO URANIUM

Uranium activities in Romania are governed by the “Law of Mines” which is overseen by a government agency for mineral resources. There is no participation of private or foreign companies in exploration, production and marketing of uranium in Romania. There are no uranium exploration and production activities of government or private companies abroad. Currently no uranium is imported or exported from Romania.

URANIUM STOCKPILES

Romania does not maintain a stockpile of uranium.

URANIUM PRICES

None reported.

• Russian Federation* •

URANIUM EXPLORATION

Historical review

Since 1944, when uranium exploration began in the Russian Federation, 15 uranium bearing districts including more than 100 uranium deposits have been discovered. These districts are subdivided into four groups:

- The Streltsovsk district includes 19 uranium-molybdenum structure-bound volcanic deposits located within and marginal to a volcanic caldera. This site is operated by the Priargunsky uranium production centre.
- The Vitim, Transural, and West Siberian districts contain medium to small sized basal-channel sandstone deposits (paleo-valley type in Russian classification) with resources recoverable at below USD 80/kgU. Some of the deposits are amenable to *in situ* leach (ISL) mining and these districts have good potential for hosting new ISL production centres.
- The Stavropol district hosted two small vein deposits that have been mined out. Current activities in this district are connected with restoration and rehabilitation.
- Ten uraniferous districts with mainly small vein, volcanic and metasomatite deposits with high cost resources (>USD 80/kgU) and low uranium grades. They are unfavourable for production at current market prices.

Recent and ongoing uranium exploration activities

Exploration activities in the Russian Federation in the last 5 years were primarily focused on basal channel sandstone deposits and unconformity-related deposits.

Uranium exploration for sandstone deposits continued within the Transural, Vitim and West Siberian uranium districts. In the Transural district, which is situated within the Kurgan region, pilot ISL production has been started at the Dalmatovskoe deposit. In addition, exploration continued at the Khokhlovskoe deposit, which is being evaluated for ISL mining. Preliminary EAR-II for the Khokhlovskoe deposit are estimated at 10 000 tU.

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* This report is based on the Red Book 1999 and secretariat estimates.

The Vitim district is situated within the Autonomous Republic of Buryatia east of Lake Baikal. The Sheglovskoe basal channel (valley-type) sandstone deposit, which was discovered in 1998, has estimated EAR-II of 8 000 tU. Evaluation of the resource potential and ISL amenability of the Sheglovskoe deposit is in progress. In addition, evaluation of the ISL potential of the Khiagda deposit has been started.

The West Siberian uranium district is situated within the Kemerov and Novosibirsk Regions. Detailed drilling on a 100-25x400-200m grid has been conducted in the central section of the Malinovskoe deposit, which has estimated resources totalling 15 000 tU.

Exploration for unconformity-related deposits was concentrated in the Ladoga area within the Baltic Shield in northwest Russia, where drilling in the area of the Karkhu occurrence has encountered thin zones of high-grade uranium mineralisation in a geologic setting similar to the Athabasca Basin in Canada. Exploration in the area of the Karkhu occurrence is ongoing. Unconformity-related mineralization has also been discovered within the Aldan and Anabara Shields.

Annual uranium exploration expenditures in the Russian Federation were about USD 8 million during the last 3 years. All uranium exploration activities were conducted by the governmental organisation "Geologorazvedka", currently reorganised in the "Central Geological Expedition". Industry exploration capital was provided by the Ministry of Atomic Energy of Russia; exploration and development focused on deposits within the known uranium districts. Government exploration expenditures provided by the Ministry of Natural Resources were focused on discovery of new deposits. No exploration expenditures were made outside the Russian Federation during the 1999-2000 period.

Uranium exploration expenditures

	1998	**1999**	**2000***	**2001*** (expected)
Industry expenditures (RUB × 1 000)	26 700	130 000	NA	NA
Government expenditures (RUB × 1 000)	26 600	36 000	NA	NA
Total expenditures(RUB × 1 000)	53 300	166 000	226 000	223 000
Total expenditures (USD million)	8.65	6.87	7.99	8.01

* Secretariat estimate.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

An assessment of RAR or EAR-I has not been made in the Russian Federation within the last 5 years. There were no major changes in this category in the last two years. However, minor changes have been made to previous reports that include adjustments to account for production. Most of the Known Resources are related to the deposits of the Streltsovsk uranium ore district, which form the resource base for the Priargunsky production centre. Depletion to account for Priargunsky's production is factored into the estimates.

In addition to the Known Resources of the Streltsovsk district, approximately 10 200 tU of RAR in the <USD 80/kgU cost category are related to the Dalmatovskoe deposit in the Transural district. RAR and EAR-I resources in addition to those reported have been estimated in the < USD 80/kgU category, but they are not included in the resource totals since they have not been examined by the State Reserves Committee. For example, about 2 600 tU of RAR and 50 000 tU of EAR-I related to the Khiagda ore field in the Vitim district are not included in these totals. Similarly, in the Transural district 7 700 tU in the EAR-I category (Dobrovolnoe deposit) and 7 500 tU in the EAR-II category (Khokhlovskoe deposit) are not included in the reported resource totals.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
63 000	138 000	NA

* As *in situ* resources.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
17 200	36 500	NA

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

An assessment of Undiscovered Conventional Resources in the <USD 80/kgU category was completed in 1998. Most of these resources (92%) are hosted in two types of deposits:

- Basal channel sandstone deposits (paleo-valley type) within the Transural (40 000tU), West Siberian (180 000 tU) and Vitim (100 000 tU) uranium districts.
- Unconformity-related deposits and occurrences within the Baltic shield (Republic of Karelia) and in the southeast part of the Aldan shield (Yakutia).

Estimated additional resources – Category II*
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
56 300	104 500

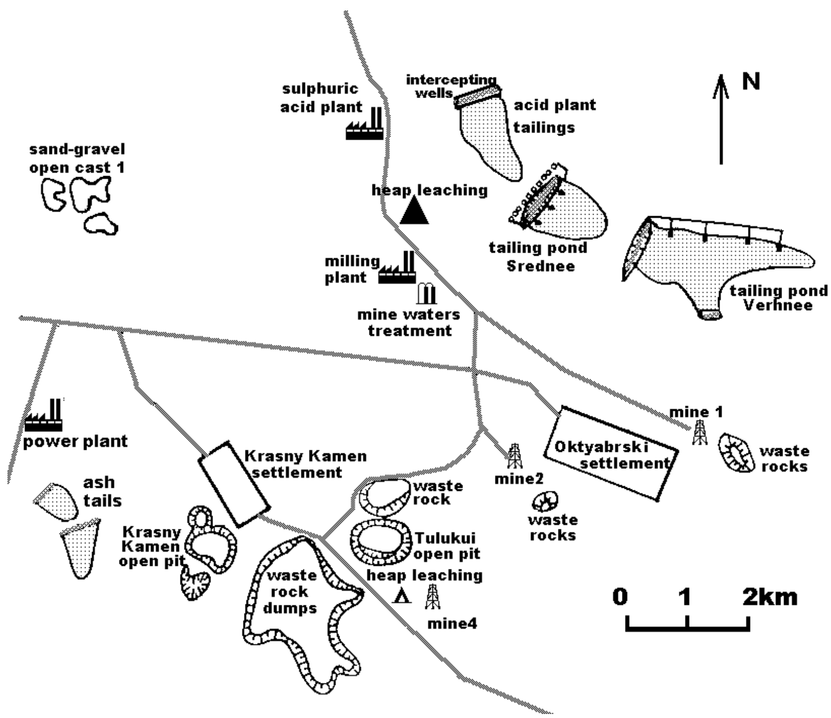
* As *in situ* resources.

Speculative resources*
(tonnes U)

Cost ranges		
<USD 80/kgU	Cost range unassigned	Total
550 000	450 000	1 000 000

* As *in situ* resources.

Priargunsky's operational units



URANIUM PRODUCTION

Historical review

Cumulative production through 2000 in the Russian Federation totalled 114 023 tU, which makes it the fifth largest uranium producer in the world based on historical production.

The first organization responsible for uranium production was the Lermontov Complex, presently – Lermontov State Enterprise "Almaz". Almaz is located 1.5 km from the town of Lermontov, in the Stavropol region or district. This district included the Beshtau and Byk vein deposits, which have been mined out. Their original resources totalled 5 300 tU, at an average grade of 0.1% U. These resources 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 starting in 1954. From 1965 to 1989 stope or block leaching 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 different leaching technologies.

Between 1968 and 1980, 440 tU were produced by ISL from the Sanarskoye deposit in the Transural district. The Malyshevsk Mining Enterprise operated the project.

The Joint Stock Company "Priargunsky Mining-Chemical Production Association" (PPGHO) has been the only active uranium production centre in Russia in last decade. The Priargunsky production centre is located in the Chita region 10-20 km from the town of Krasnokamensk, which has a population of about 60 000 persons. The production is based on 19 volcanic deposits of the Streltsovsk uranium district, which have an overall average uranium grade of about 0.2%U. This district has an area of 150 km^2. Mining has been conducted since 1968 by two open pits (both are depleted) and three underground mines (mines 1 and 2 are active and mine 4 is closed). Milling and processing has been carried out since 1974 at the local hydro-metallurgical plant using sulphuric acid leaching with subsequent recovery by a combination of ion exchange and solvent-extraction. Since the 1990s low-grade ore has been processed by heap and stope/block leaching.

More than 100 000 tU have been produced from the Streltsovsk deposits at Priargunsky, making it one of the most productive uranium districts in the world.

Status of production capability

Annual production at "Priargunsky Mining-Chemical Production Association" remains at between 2 500 and 3 000 tU, and plans are to maintain this level of production for the next 10 years. Currently two underground mines are in operation. Nearly all of Priargunsky's production comes from conventional underground mining, though a small amount is produced from low grade ores by heap leaching and stope/block leaching methods. Open pit mining was been stopped in 1997.

Historical uranium production (tonnes U)*

Production method	Pre-1998	1998	1999	2000	Total to 2000	2001 (expected)
Open pit mining	38 655	0	0	0	38 655	0
Underground mining	63 682	2 470	2 500	2 600	71 252	2 700
In situ leaching	3 186**	0	0	50	3 236	100
Stope/Block leaching	170	20	10	10	210	10
Heap leaching	430	40	100	100	670	100
Total	106 123	2 530	2 610	2 760	114 023	2 910

* Secretariat estimate.

** Including production by in place and heap leaching in the Stavropol district through 1990.

The RAR of the Streltsovsk district deposits can satisfy Priargunsky's planned production requirements for more than 20 years at the current production rates. New mines are planned to come into operation after 2010. Underground stope/block leaching will be developed for low grade ore zones during the next 5 years.

Ownership structure of the uranium industry

The Ministry of Atomic Energy of Russia owns all uranium production from the Russian Federation.

Employment in the uranium industry

The staff of Priargunsky Mining-Chemical Production Association included about 12 500 employees in 2000. This represents a reduction of 300 people since 1998. Less than half of the staff is involved in uranium production and the rest are working at associated non-uranium facilities: power plant, coal mining and processing, manganese and sand open pits, sulphuric acid plant, etc.

Employment in existing production centre
(persons-years)

1998	**1999**	**2000**	**2001** (expected)
12 800	12 700	12 500	12 300

Future production centres

In order to increase uranium production in Russia, two new ISL production centres are planned to come into operation in the next five to 10 years:

- In the Transural district, one production centre is committed. Pilot ISL development of the first commercial wellfield was started at the Dalmatovskoe deposit in 2000 by JSC (Joint Stock Company) "Dalur". Planned initial annual production is expected to be about 100 tU and may be increased to 700 tU in five to seven years. A two-well ISL pilot test was completed at the Khokhlovskoye deposit in mid-2000, and evaluation of the deposit is ongoing. ISL tests are also planned for the Dobrovolnoe deposit.
- In the Vitim district, experimental ISL testing has been started at the Khiagda deposit by the JSC Khiagda, and a few tonnes U were recovered at the local pilot processing plant. Feasibility studies will continue for the next two years on the Khiagda deposit.

Short-term production capability
(tonnes U/year)

2001				**2002**				**2005**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
3 000	3 100	3 000	3 100	3 000	3 200	3 000	3 200	3 000	4 000	3 000	4 000

2010				**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
3 000	5 000	3 000	5 000	3 000	5 000	3 000	5 000	3 000	5 000	3 000	5 000

Uranium production centre technical details
(as of 1 January, 2001)

	Centre #1	Centre #2	Centre #3
Name of production centre	JSC "Priargun Mining-Chemical Production Association"	JSC "Dalur"	JSC "Khiagda"
Production centre class	existing	planned	planned
Start-up date	1968	2002	2005
Source of ore • Deposit names • Deposit type(s)	Antei, Streltsovskoe, Oktyabrskoe, etc. volcanic, vein-stockwork	Dalmatovskoe (Transural U district) sandstone, basal channel	Khiagda (Vitim U district) sandstone, basal channel
Mining operation: • Type (OP/UG/ISL) • Size (t/ore/day) • Average mining recovery (%)	UG, IPL, HL 6 700 97	ISL NA NA	ISL NA NA
Processing plant: • Type (IX/SX/AL) • Size (t/ore/day) • Average process recovery (%)	AL, IX, SX 4 700 95	AL, IX NA NA	AL, IX NA NA
Nominal production capacity (tU/year)	3 500	700	under consideration
Plans for expansion	IPL, HL processing for low grade ores	Khokhlovskoe, Dobrovolnoe deposits	Sheglovskoe deposit

URANIUM DEMAND

The Russian Federation has 29 industrial power units located at nine nuclear power plants with a total gross installed capacity of 21 242 MWe of the following types:

- 13 water-cooled, water-moderated, energy reactors (six VVER-440 units and seven VVER-1 000 units).
- 15 uranium-graphite channel-type reactors (11 RBMK-1 000 units and four EGP-6 units).
- One BN-600 fast breeder reactor unit.

Russian Federation nuclear power plants produced 130.6 TWh in 2000. This total comprised 14.9% of the total electric energy production in the Russian Federation, up slightly from 14.41% in 1999. Nuclear electricity production is planned to grow to 220 TWh by 2010 and to 350 TWh by 2020.

The current annual requirements of domestic nuclear power plants total about 4 000 tU.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
21 242	21 242	26 000	21 242	36 000	17 500	46 000	17 500	57 000

Annual reactor-related uranium requirements
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
4 000	4 000	5 000	4 000	6 500	3 000	8 000	3 000	10 000

The Russian Federation reported no information on national policies relating to uranium, uranium stockpiles, or uranium prices.

• Slovak Republic •

URANIUM EXPLORATION/RESOURCES

Uranium exploration was performed within the Slovak Republic since 1950s in different regions. Based on the results of the evaluation it was concluded that the Slovak Republic has no known uranium resources. No uranium exploration has occurred since 1990.

URANIUM PRODUCTION

Historical review

In 1960s and 1970s some small quantities of uranium ore were mined in Eastern Slovakia. Production was stopped due to inefficiency and the low-grade of the ore.

Status of production capability

The Slovak Republic has no uranium mining industry or production capability and has no plans to create one in the future.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

The Slovak Republic has two nuclear power plants located at Bohunice and Mochovce. The Bohunice plant has four units of the VVER-440 type in operation, each with a capacity of 408 MWe net. The Mochovce plant has two VVER-440 type units in operation, each with a capacity of 388 MWe net.

Two additional VVER-440 type units, each with a capacity of 388 MWe net, are under construction at Mochovce. The plans are for the first two Bohunice units to continue operation through 2001 or 2002. Decommissioning will then begin.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 430	2 430	2 430	1 620	3 240	1 620	2 430	810	1 620

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
63	63	63	42	84	42	63	21	42

NATIONAL POLICIES RELATING TO URANIUM

The Slovak Republic utility purchases complete fuel assemblies for all operating units from Russian manufacturers. Presently, there are two contracts for fuel fabrication; one is valid to year 2001 and second one to year 2004.

URANIUM STOCKS

The Slovak Republic does not maintain an inventory of uranium.

URANIUM PRICES

None reported.

• Slovenia •

URANIUM EXPLORATION

Historical review

Exploration of the Zirovski Vrh area began in 1961. In 1968, the P-10 tunnel was developed giving access to the orebody. Mining began at Zirovski Vrh in 1982. Uranium concentrate production (as yellow cake) began in 1985.

Recent and ongoing activities

Expenditures for exploration ended in 1990. There are no recent or ongoing uranium exploration activities in Slovenia.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

The staff of the uranium mine Zirovski Vrh carried out the most recent resource assessment of the deposit in 1994. RAR are estimated to be 2 200 tU in ore with an average grade of 0.14% U. These resources are in the below USD 80/kgU category. EAR-I of 5 000 tU in the under USD 80/kgU category and 10 000 tU in the below USD 130/kgU category are reported. The average grade of these resources is 0.13% U. The resources are recoverable adjusted for 35% mining and 10% processing losses.

The deposit occurs in the grey sandstone of the Permian Groeden formation. The orebodies occur as linear arrays of elongated lenses within folded sandstone.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	2 200	2 200

* As recoverable resources in the Zirovski Vrh deposit.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	5 000	10 000

* As recoverable resources.

Undiscovered conventional resources (EAR-II & SR)

The 1994 estimate of resources includes EAR-II of 1 060 tU in the under USD 130/kgU class. They are reported as recoverable resources adjusted for estimated mining and processing losses of 35% and 10%, respectively.

Estimated additional resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	1 060

URANIUM PRODUCTION

Historical review

The Zirovski Vrh uranium mine was the only uranium producer in Slovenia. It is located 20 km southwest of Škofja Loka.

Ore production at the Zirovski Vrh mine started in 1982. The ore processing plant located at the mine began operation in 1984 to treat the previously stockpiled ore. The annual production capability of the mill was 102 tU. The ore was mined using a conventional underground operation with a haulage tunnel and ventilation shaft. The ore occurs in numerous small bodies in the mineralised coarse-grained sandstone. It was mined selectively using room and pillar, and cut and fill methods. In 1990, the operation was terminated and placed on temporary standby. Cumulative production from the Zirovski Vrh mine-mill complex totaled 382 tU.

Status of production capability

In 1992, the decision for final closure and subsequent decommissioning of the Zirovski Vrh mine and mill was made. Since 1992, there has been no production from the Zirovski facility. In 1994, the plan for the decommissioning of the centre was accepted by the Slovenian Government Authorities.

Ownership structure of the uranium industry

No changes in ownership have occurred since 1988. The Zirovski Vrh production centre is owned by the Republic of Slovenia.

Environmental activities and socio-cultural issues

The decommissioning plan for the Zirovski Vrh production centre provides for the following steps:

- Permanent protection of the biosphere against the consequences of the mining operation. This includes permanent protection of the surface against displacement and subsidence, sealing of the shaft and tunnels against surface waters, airtight sealing of the shaft and tunnels, as well as the provision for an unobstructed run-off for mine waters.

- Permanent remediation of the ore processing plant site in such a way that the remaining facilities can be used for other industrial purposes.
- Permanent rehabilitation of the mine waste and mill tailing areas. This includes the stabilisation of the disposal sites including prevention of the infiltration of precipitation, as well as erosion. Additional measures are being taken to prevent the solution and transport of harmful chemicals into ground and surface waters, and to control contamination by radon.

Remediation of the Zirovski Vrh mine site is expected to be completed by 2005. The Zirovski ore processing plant has been dismantled. The material that was generated was checked for radioactivity and was either disposed of at the Jazbec mining waste disposal site, or reused or recycled.

URANIUM REQUIREMENTS

The short-term nuclear generating capacity of Slovenia is based on the PWR at Krsko which started commercial operation in January 1983. The Krsko reactor was modernized in 2000, increasing its capacity from 632 to 672 MWe. The power plant is owned 50% each by Slovenia and Croatia. The Secretariat estimates that the installed nuclear generating capacity will remain at 672 MWe, through 2020. Annual reactor-related uranium requirements are estimated at 120 tU.

There is a moratorium against the construction of additional nuclear power plants in Slovenia.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
672	672	672*	672*	672*	672*	672*	672*	672*

* Secretariat estimate.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
120	120	120*	120*	120*	120*	120*	120*	120*

* Secretariat estimate.

NATIONAL POLICIES RELATING TO URANIUM

The company that owns and operates the Krsko plant will import uranium to cover future reactor-related uranium requirements.

Slovenia reported no information on uranium stocks or uranium prices.

• South Africa •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Witwatersrand Basin

Uranium exploration in South Africa commenced in the late 1940s when a world-wide investigation of uranium resources focused attention on the uranium content of the Witwatersrand quartz-pebble conglomerates. Uranium exploration in the Witwatersrand Basin was always conducted as an adjunct to gold exploration, until the oil crisis in the early 1970s. At that time the price of uranium increased dramatically. This resulted in an intensification of uranium exploration activities and in 1982 South Africa's first primary uranium producer, the Beisa Mine, commenced production.

The crash in the uranium market in the early 1980s substantially reduced interest in uranium exploration, and by the mid-1980s all exploration in the Witwatersrand Basin was directed exclusively at gold. An indirect result of these activities was the incidental discovery of new uranium resources because of the ubiquitous presence of uranium in the quartz-pebble conglomerates. In the early 1990s, the static gold price resulted in a substantial curtailment of gold exploration activities.

Karoo Basin

Discovery of uranium in the Karoo sediments during oil exploration resulted in diversification of uranium exploration activities. Work in the Karoo was at a low level until the advent of the oil crisis in the early-1970s when exploration activities increased. This activity, however, was relatively short-lived. Uranium exploration in the Karoo declined rapidly and finally ceased in the mid-1980s due to adverse uranium market conditions. Since then low key re-evaluations of identified deposits are virtually the only activities which have taken place.

Outside of the Witwatersrand and Karoo Basins, exploration activities have been directed at the discovery of other types of uranium deposits including unconformity-related, calcrete, alaskitic, breccia complex (Olympic Dam-type), and marine phosphate deposits. These activities were always on a lower key than in the two main uranium-bearing basins, and they were met with only very limited success.

Recent and ongoing uranium exploration activities

No exploration for uranium as a primary product has been carried out in South Africa for more than a decade. Exploration activities in the Witwatersrand Basin targeted gold, but the depressed gold market severely limited these activities. Information regarding the distribution of uranium exploration inside and outside South Africa by South African companies is not available, because of company confidentiality.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

A large portion of the country’s uranium resources occur as low-grade concentrations in the gold-bearing Witwatersrand quartz-pebble conglomerates. Uranium is recovered as a by-product of the gold operations and accounts for only about 10% of the total revenue from a tonne of Witwatersrand ore. Therefore, uranium is only discovered during gold exploration. Depressed gold prices have curtailed gold exploration, so this source has added little to South Africa’s uranium resource base.

South Africa reported no changes in uranium resources compared to 1999. Because uranium is only produced as a by-product, currency exchange rates, gold and uranium market prices and variations in mining and milling costs can all influence uranium resource totals and cost category allocation, both negatively and positively. However, without details of the effects of these adjustments, the Secretariat has assumed that reductions in RAR to account for 1999 and 2000 production constitute the only change in Known Resources compared to 1999.

A large portion of South Africa's known resources, recoverable at USD 80/kg or less, is tributary to existing gold production centres where gold is the primary product and uranium is recovered as a by-product. However, since many production centres have no uranium recovery circuit, only a small portion of the uranium is extracted; the rest ends up in the gold mine tailings dams. The availability of the resources in the tailings dams depends on the degree of dilution by non-uraniferous tailings and the possible usage of the tailings to backfill mined areas.

About 46% of the known resources recoverable at USD 40/kg U are tributary to existing production centres. About 28% of the incremental known resources recoverable at USD 80/kg U are also tributary to existing production centres.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
119 195	231 095	290 995

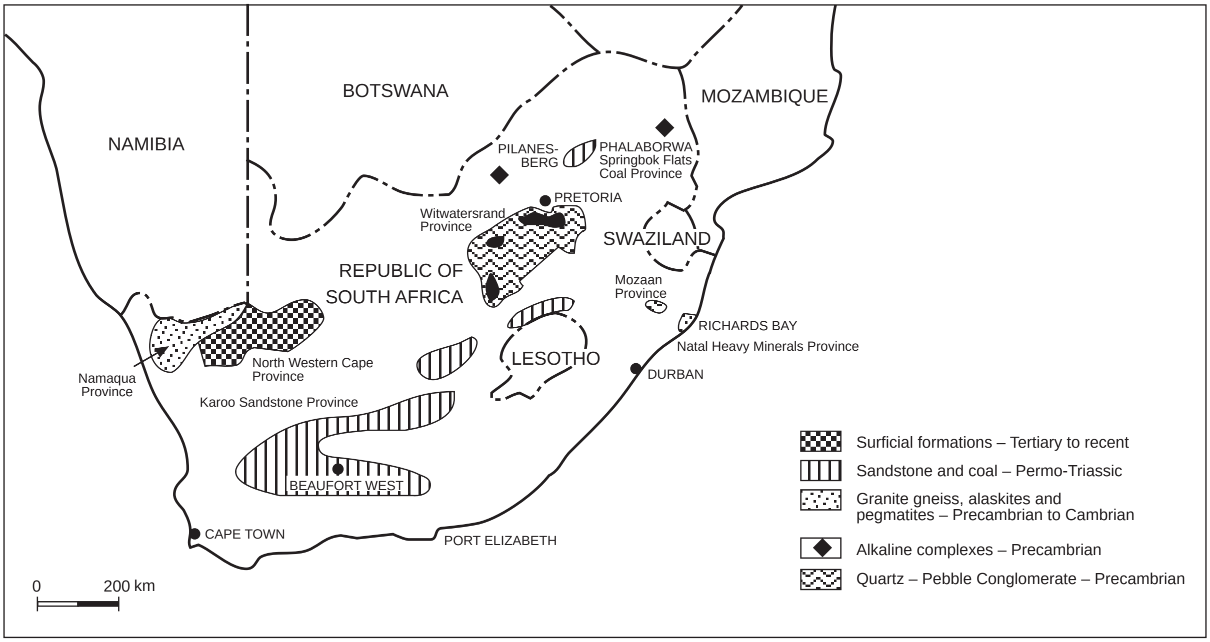
* Mining and ore processing losses deducted – variable percentage.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
48 100	66 800	76 400

* Mining and ore processing losses deducted – variable percentage.

Localities of uranium provinces in South Africa



Undiscovered conventional resources (EAR–II & SR)

Limited efforts have been made to identify subsidiary Witwatersrand-type basins outside of the currently known limits of the main basin. The lack of exploration funding for this speculative type of work has, however, hindered the achievement of any meaningful results.

The EAR-II at a production cost of less than USD 80/kgU are 34 900 tU as of 1 January 2001, which is the same as the 1 January 1997 and 1999 estimates. There is also no change in the Speculative Resources which total 1 113 000 tU with no cost range assigned.

Estimated additional resources – Category II*

(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
27 900	34 900	147 900

* Mining and ore processing losses deducted – variable percentage.

Speculative resources

(tonnes U)

Cost range	Total
Unassigned	
1 113 000	1 113 000

URANIUM PRODUCTION

Historical review

South African uranium production commenced in 1952 when a uranium plant was commissioned at the West Rand Consolidated Mine which exploited quartz-pebble conglomerates of the Witwatersrand Supergroup. This was closely followed by the commissioning of four more uranium plants at various centres in 1953. Production accelerated until 1959 when 26 mines around the Witwatersrand Basin were feeding 17 uranium plants for a total production of 4 954 tU. Production subsequently declined to 2 262 tU in 1965.

In 1971, Palabora Mining Company became the first non-Witwatersrand uranium producer in South Africa. This company produces uranium as a by-product of its open-pit copper mining operation in the Northern Province.

The world oil crisis in the 1970s again stimulated interest in uranium as an energy source. South African uranium producers responded by almost trebling production to 6 143 tU in 1980.

Many decades of gold mining and milling generated vast amounts of tailings around the Witwatersrand Basin which contain substantial reserves of gold and uranium. The boom in the uranium market lead to the establishment of tailings reprocessing plants at Welkom (Joint Metallurgical Scheme – 1977), in the East Rand (ERGO – 1978), and at Klerksdorp (Chemwes – 1979).

The collapse of the uranium market in the early 1980s has had serious repercussions in the South African uranium industry which has resulted in the closure of 17 uranium plants since 1980. This total includes the Western Areas, and the Hartebeestfontein plants which closed in 1997 and 1999, respectively. At year end 2000, only two plants were producing uranium from two mines.

Historical uranium production
(tonnes U)

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
By-product-production	150 607	965	927	838*	153 337	1 160
Total	150 607	965	927	838*	153 337	1 160

* Secretariat estimate.

Status of production capability

The two mines producing uranium at the end of 2000 were Vaal River Operations at Klerksdorp (previously Vaal Reefs), and Palabora in the Northern Province (previously Northern Transvaal). Both plants produce uranium as a by-product, gold being the primary product at Vaal River, and copper at Palabora.

Anglogold’s Vaal River operation has only one remaining uranium plant operating. The plant has a capacity of 10 000 tonnes of ore per day, with an expected output of approximately 1 000 tU per year.

Palabora is a large combined open-pit and underground copper producer which produces uranium as a by-product. The uranium ore mineral uranothorianite is first concentrated in a gravity separation plant, along with other heavy minerals. The uranium is then recovered at the NUFCOR uranium plant. The Palabora uranium plant is scheduled to be closed in 2002.

Major reductions in production capacity in the Witwatersrand took place in the late 1980s and early 1990s, but the situation stabilised and in the 1995/1996 period no plant closures took place. However, the negative trend resumed in 1997 with the closure of two further plants. In 1998, for the first time in over 45 years, South African uranium production fell below 1 000 tU.

The status of plants where uranium production has stopped may be summarised as follows. The nine uranium production plants which have been shut down and are being dismantled include: Beisa, Blyvooruitzicht, Buffelsfontein, Dreifontein, Ergo, Freegold, Harmony (Merriespruit), Stilfontein and West Rand Consolidated. Uranium production could not be restarted at these plants without completely rebuilding them. The Randfontein (Cooke) uranium plant was converted for the extraction of gold.

The status of the two uranium plants currently in operation is summarized in the following table.

Uranium production centre technical details
(as of 1 January 2001)

	Centre # 1	Centre # 2
Name of production centre	Vaal River Operations	Palabora
Production centre class	existing	existing
Operational status	operating	operating
Startup date	1977	1979
Source of ore:		
• Deposit names	Vaal Reef,	Palabora,
• Deposit type	quartz-pebble conglomerate	intrusive deposit
Mining operation:		
• Type	underground	open pit
• Size (tonnes ore/day)	10 000	80 000
• Average mining recovery (%)		27
• Grade	0.025	0.006
• Reserves	NA	150 tU
Processing Plant:		
• Type	AL/SX	AL/SX
• Size (tonnes ore/day)	10 000	0.3*
• Average processing recovery (%)	variable	variable
Nominal Production Capacity (tU/year)	1 000	90
Plans for expansion	none	none
Other remarks		to be shut down in 2002

* Tonnes of gravity concentrate per day.

Ownership structure of the uranium industry

Rio Tinto is the majority owner of Palabora; Vaal River Operations is owned by Anglogold. Both are private sector companies. The State does not participate in any uranium production activities.

Employment in the uranium industry

Employment at the uranium recovery plants totals 160, including 100 at Vaal River Operations and 60 at Palabora. These employment figures relate only to the uranium plants themselves and not to the mines.

Future production centres

When Palabora shuts down its uranium plant in 2002, South Africa will have only one remaining uranium producer, and there are no planned uranium production centres. The by-product character of the majority of uranium resources in South Africa makes it impossible to predict whether prospective production centres could be supported by the existing known resources in the RAR and EAR-I categories recoverable at costs of USD 80/kg U. The cost classification of a large part of South African uranium resources is based on the associated gold values, working costs and the dollar/rand exchange rate, all of which have little to do with the uranium market. Given favorable conditions in all these variables, South Africa would be able to return to the production levels achieved during the late 1970s and early 1980s, that is to say, in excess of 6 000 tU per annum. If the gold price and, more importantly, the uranium price do not improve substantially, however, this level of uranium production will not be attainable.

It takes a substantial period of time to reconstruct uranium plants at production centres where production was stopped in the past, or to construct new production centres. In addition to the conditional conventional producers, the Karoo sandstone and coal-hosted deposits may be able to support production levels of about 2 000 tU per year.

Short-term production capability

South Africa's projected capability to the year 2020 is shown in the following table:

Short-term production capability
(tonnes U/year)

2001				2002				2005			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 157	0	0	0	1 319	0	0	0	1 439	0	0	0

2010				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
1 225	0	0	0	537	0	0	0	429	0	0	0

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

South Africa has areas of mine related land which have been contaminated by radioactivity, particularly where existing or previously existing uranium plants are, or were located. If development takes place on former mine land, the area is radiometrically surveyed and, where necessary, cleanup is conducted. The South African Council for Nuclear Safety is the regulatory body responsible for the implementation of nuclear legislation related to these activities, and the standards conform to international norms. Vast areas around the gold/uranium mines are covered with slimes dams and rock dumps. South Africa has, however, strict environmental legislation which ensures that these areas are suitably rehabilitated. Environmental issues relating to gold/uranium mining on the Witwatersrand are dust pollution, surface and groundwater contamination and residual radioactivity. Old gold/uranium plants are being decommissioned. Scrap materials from these operations are decontaminated to internationally acceptable levels and then sold.

Cost of environmental management

The by-product status of all uranium production in South Africa makes it impossible to allocate environmental costs specifically to uranium mining activities. The South African mining industry expends considerable resources on environmental considerations at all stages of mining activity, from exploration to mine and mill closure.

URANIUM REQUIREMENTS

South Africa has one nuclear power plant designated Koeberg. This plant includes two reactors: Koeberg I, commissioned in 1984, and Koeberg II which came on-line in 1985. Together they consume about 200 tU/year.

Supply and procurement strategy

South Africa's internal uranium requirements are met from South African mines.

Installed nuclear generating capacity to 2020

Koeberg has an installed capacity of 1 842 MWe. Sites for further nuclear stations have been identified but no plans for future construction have been made because of current over-capacity in conventional coal-fired power stations.

ESKOM is actively pursuing the Modular Pebble Bed Reactor concept. These are small, modular nuclear reactors that produce 100 MWe. A number of these units can operated in tandem to produce the power requirements demanded by specific situations. There is a plan to have a demonstration plant in operation in 2005.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 842	1 842	1 842	1 800*	1 900*	1 800*	2 300*	1 800*	2 700*

* Secretariat estimate.

Annual reactor-related requirements to 2020

Koeberg reactor uranium requirements are expected to remain constant at 200 tU/year. No additional large nuclear plants similar to Koeberg are planned. The expansion of the use of nuclear power depends on the success of the Pebble Bed Reactor Project.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
200	200	200	210*	220*	210*	270*	210*	315*

* Secretariat estimate.

NATIONAL POLICIES RELATING TO URANIUM

South Africa's national policies affecting the production and export of uranium are defined in the Nuclear Energy Act, 1993, as amended. This Act covers the activities of the Atomic Energy Corporation of South Africa Ltd (AEC) and the national nuclear regulatory body, the Council for Nuclear Safety (CNS). This lead to the perception that the AEC and CNS were one and the same body. It is clearly unsatisfactory for a regulatory body and a participatory body to be controlled by a single Act. Two new Acts are, therefore, before Parliament aimed at separating the functions of the CNS and AEC, and establishing more transparent and accountable governance in both organisations. These new Acts will supersede the current Act. The relevant conditions mandated by the current Act are discussed below.

No person may prospect or mine for uranium without the permission of the Minister of Mineral and Energy Affairs. Such permission may be withheld only if the Minister is satisfied that the security of the State could be endangered if the applicant were given permission to proceed.

There are no restrictions on foreign participation in uranium prospecting and mining, and foreign-owned operations are subject to the same legal requirements as domestic companies. In a practical sense, uranium prospecting and mining are subject to the same laws and regulations applied to other material.

The State does not actively undertake prospecting operations. It limits its activities to general research, national resource assessment, geological mapping, airborne surveys and regional hydrogeological, geochemical and geophysical investigations.

The Nuclear Energy Act also provides that no person may dispose of uranium, or export it from South Africa, except under the authority of the Minister. In exercising this control, the Minister is required to consult the Atomic Corporation of South Africa Limited (AEC), the members of which represent various national interests, including the uranium mining industry. In practice, the Minister's functions are exercised by the chairman of the AEC.

No information on uranium stocks or uranium prices was reported.

• Spain •

URANIUM EXPLORATION

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 in sedimentary rocks started and the Mazarete deposit in Guadalajara province was discovered. Exploration activities by the Empresa Nacional del Uranio, S.A. (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 had been surveyed using a variety of exploration methods, adapted to different stages. An ample coverage of airborne and ground radiometrics of the most interesting areas has been achieved.

Recent and ongoing uranium exploration activities

No exploration and mine development activities were carried out in 1999 and 2000. The last expenditures were in 1998, ESP 2 million for development, which resulted in 18 development holes drilled totalling 641 m.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

During the period 1993-1996 the Empresa Nacional del Uranio, presently ENUSA INDUSTRIAS AVANZADAS, S. A., improved the knowledge of the uranium deposits in the Ciudad Rodrigo area (Salamanca Province), carrying out close-spaced drilling (more than 100 000 m each year) and updating mining projects and feasibility studies.

For this purpose, a new data acquisition system and mining software were successfully implemented between 1997-1999.

These studies were concentrated in the nearest orebodies to the Fe mining site. By these means estimates of RAR and EAR-1 resources were obtained. Where no detailed mining project was available, the EAR-1 category recoverable resources have been estimated as ratios, for each cost category, from *in situ* resources.

Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	2 460	4 925

Estimated additional resources – Category I
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	6 380

100% of known conventional resources recoverable at <USD 80/kgU are in existing production centres.

Undiscovered conventional resources (EAR-II & SR)

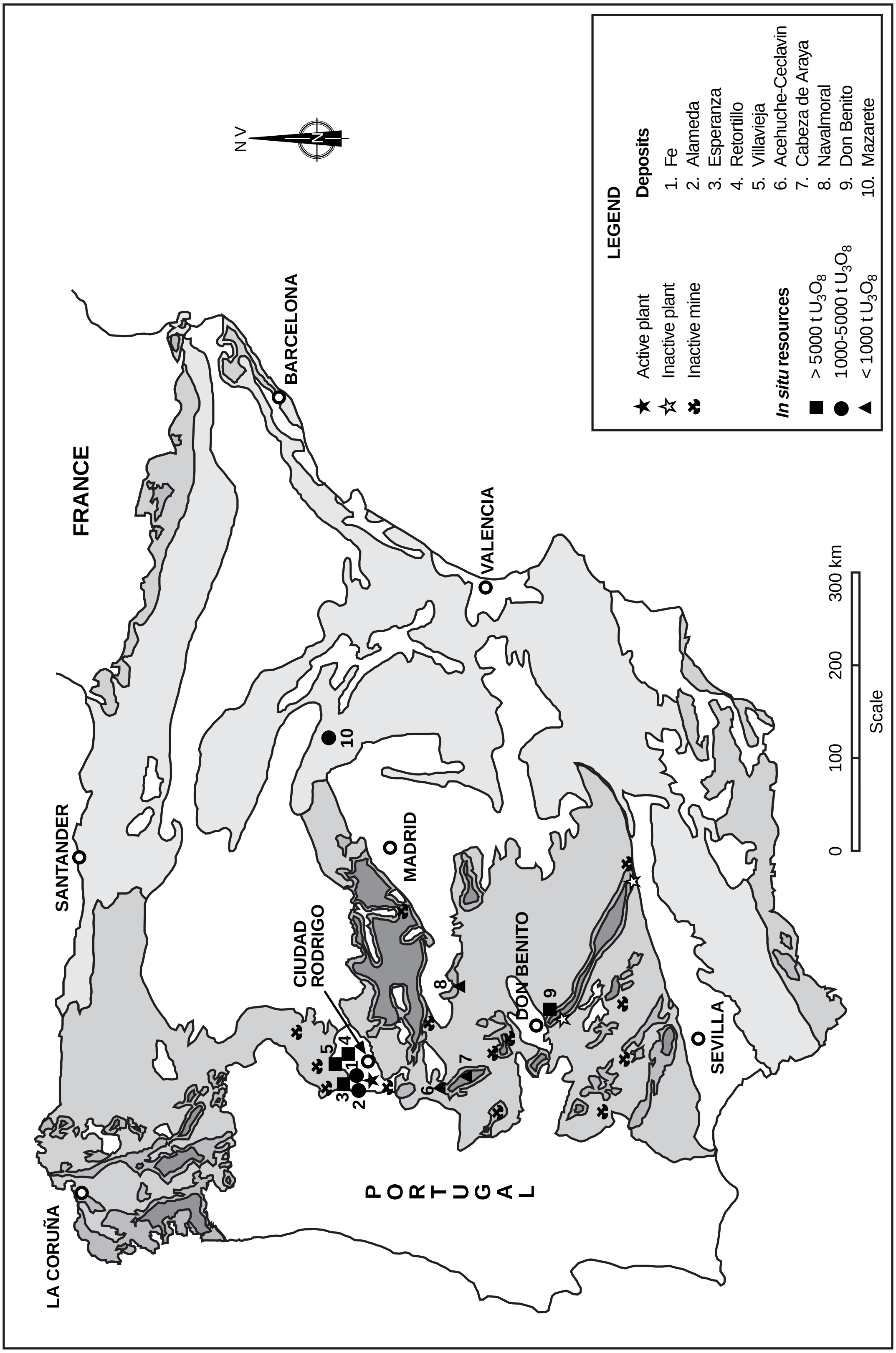
No resources for this category were reported.

URANIUM PRODUCTION

Historical review

Production started in 1959 at the Andujar 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.

Uranium deposits in Spain



Historical uranium production (tonnes U)

	Pre-1998	**1998**	**1999**	**2000**	**Total through 2000**	**2001** (expected)
Processing plant	4 196	255	255	255	4 961	13
Other methods e.g. mine water treatment, environmental restoration	0	0	0	0	0	17
Total	4 196	255	255	255	4 961	30

Uranium production centre technical details
(as of 1 January 2001)

Name of production centre	SAELICES EL CHICO
Production centre class	existing
Operational status	closed
Start-up date	1975
Source of ore • Deposit names • Deposit type(s)	Fe, D vein (Iberian) type
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	OP
Processing plant (Acid/ Alkaline): • Type (IX/SX/AL) • Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour) • Average process recovery (%)	AL/SX
Nominal production capacity (tU/year)	800
Plans for expansion	none
Other remarks	restoration activities plant is phase-out of production

Status of production capability

Production capability at the Fe Mine (Quercus Plant) is 800 tU/year.

Mining activities were terminated in December 2000. The processing plant will continue residual production at a very reduced level.

Future production centres

No new production centres are being considered.

Ownership structure of the uranium industry

The only active production facility in Spain belongs to the company Enusa Industrias Avanzadas, S.A., owned (60%) by Sociedad Estatal de Participaciones Industriales (SEPI) and Centro de Iniciativas Energeticas Medioambientales y Tecnologicas (CIEMAT), with 40%.

Ownership of uranium production in 2000

DOMESTIC				FOREIGN				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	255	100	0	0	0	0	25	100

Employment in the uranium industry

Employment at the Fe Mine was 106 at the end of the year 2000. As mining and other production activities are finished, this number was reduced to 64 people in January 2001, in accordance with plans for decommissioning and restoration.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
148	135	106	64

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

The present conditions of uranium production facilities in Spain are as follows:

- Fabrica de Uranio de Andujar (Jaén Province): Mill and tailings pile are closed and remediated, with a ten-year supervision programme (groundwater quality, erosion control, infiltration and radon control).
- Mine and Plant “LOBO-G” (Badajoz Province): Open pit and mill tailings dump are closed and remediated, with a five-year supervision programme (groundwater quality, erosion control, infiltration and radon control).
- Old Mines (Andalucía and Extremadura Regions): Underground and open pit mines are restored, with work being completed during the year 2000.
- Elefante Plant (Salamanca Province): Decommissioning Plan has been approved by Regulatory Authorities (heap leaching plant) during January 2001.
- Quercus Plant (Salamanca Province): Mining activities ended in December 2000. The processing plant will continue only residual production at a very reduced level.

URANIUM REQUIREMENTS

The net capacity of Spain's nuclear plants is 7.5 GWe. There are nine operating reactors. No new reactors are expected to be built in the near future.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
7 500	7 500	7 500	7 500	7 730	7 500	7 730	7 500	7 730

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 400	1 700	1 100	1 500	1 500	1 500	1 500	1 500	1 500

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

During 2000, the legislation that regulated enriched uranium strategic inventories was changed in a way that the minimum strategic inventories, which until 2000 were financed by the Spanish Government, have been reduced from 1.5 years requirements to less than a year and are now being financed by the Spanish utilities. No information on uranium prices was reported.

• Sweden •

URANIUM EXPLORATION

Historical review

Uranium exploration was carried out during the period 1950-1985. However, at the end of 1985, exploration activities were stopped due to availability of uranium at low prices in the world market.

There are 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) shale. Billingen (Västergötland), where the Ranstad deposit is 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 soda-metasomatism.

A third province is located north of Östersund 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 Åsele in northern Sweden.

Recent and ongoing exploration and mine development activities

There are no ongoing uranium exploration or mining activities in Sweden.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

There are small resources in granitic rocks (vein deposits) in Sweden.

Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	4 000

Estimated additional resources – Category I
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	6 000

Undiscovered conventional resources (EAR-II & SR)

There are no EAR-II or SR resources reported in Sweden.

Unconventional resources

There are potentially large resources of uranium in alum shale; however, these deposits are very low grade and the cost of recovery is above USD 130/kgU.

URANIUM PRODUCTION

Historical review

In the 1960s, a total of 200 tU were produced from the alum shale deposit in Ranstad and represents all of Sweden's historical production. This mine is now being restored to protect the environment.

Status of production capability

There is no uranium production in Sweden and there are no plans for production.

Uranium ownership, employment and future production centres

Sweden has no uranium industry. There are no plans for future production.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

The Ranstad mine was rehabilitated in the 1990s. The open pit was transformed into a lake and the tailings area was covered with a multilayer top to prevent the formation of acid from sulphur in the shale tailings. An environmental monitoring programme is now being carried out.

The total cost of restoration of the Ranstad mine was 150 million SEK. The current monitoring programme represents only minor costs.

URANIUM REQUIREMENTS

In 1999, one of Sweden's 12 nuclear power reactors, Barsebäck 1, was retired as a result of a political decision. Barsebäck 2 is also subject to closure but a definite date is not yet decided.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
9 400	9 400	9 400	8 800	9 400	8 800	9 400	8 800	9 400

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 500	1 500	1 500	1 400	1 600	1 400	1 600	1 400	1 600

Supply and procurement strategy

The utilities are free to negotiate their own purchases.

NATIONAL POLICIES RELATING TO URANIUM

Sweden has joined the Euratom Treaty and adjusted its policy accordingly.

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.

URANIUM PRICES

As Sweden is now part of the deregulated Nordic electricity market, costs of nuclear fuel are no longer reported.

• Switzerland •

URANIUM EXPLORATION

Historical review

In June 1979, the Federal Government decided to encourage uranium exploration by awarding a grant of CHF 1.5 million during the 1980-1984 period. During 1980 and 1981 about 1 000 m of galleries were excavated for prospecting by a private company in the Hercynian Massif of Aiguilles Rouges and the surrounding gneisses. The limited work so far has not allowed a clear picture of the factors controlling the mineralisation which is of low grade and disseminated in an area which is geologically very complex.

In 1982, the Federal Government supported surface prospecting to the south of Iserables and drilling at Naters (Valais). Between 1982 and 1984, in the framework of the five-year programme financed by the Federal Government, uranium exploration was carried out in the rugged region of the Penninic Bernhard nappe, in the western Valais. The radiometric and geochemical investigations concentrated mainly on the detrital deposits of the Permo-Carboniferous and schists of older age (series of Nendaz and the underlying series of Siviez). Owing to strong alpine tectonism, the uranium is generally irregularly disseminated in the rock. Radioactive anomalies seem to be bound to the carbonatic and chloritic facies of the Nendaz series, but their practical value could not be confirmed.

Recent and ongoing activities

Since 1985 all domestic exploration activities have been stopped. Private industry, however, had engaged in uranium exploration, mining and milling in the western USA from 1983 to 1995.

URANIUM RESOURCES

No uranium resources have been reported for Switzerland.

URANIUM PRODUCTION

Status of production capability, ownership structure and employment

Switzerland does not produce uranium.

Future production centres

No future production centres in Switzerland are envisaged in the short term.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

Switzerland has five operating nuclear power stations located at Beznau (Units 1 & 2), Muehleberg, Goesgen and Leibstadt. In 2000, total installed net nuclear capacity was about 3 200 MWe.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
3 200	3 200	3 200	3 200	3 200	2 115	3 200	2 115	3 200

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
360	375	265	585	585	390	585	390	585

Supply and procurement strategy

Switzerland reported that uranium is currently procured from a combination of long-term and spot market contracts.

NATIONAL POLICIES RELATING TO URANIUM

Switzerland does not produce uranium and does not export uranium. There is no official import policy as private companies handle their own procurement.

URANIUM STOCKS

It is the policy of nuclear plant operating companies to maintain a stockpile of fresh fuel assemblies at the reactor site equivalent to the fuel requirements for one to two years. In Switzerland, uranium stocks, if they exist, are held only by the utilities. No detailed information is available on utility uranium stocks.

URANIUM PRICES

None reported.

• Tajikistan* •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

The first reports of uranium occurrences in Tajikistan date back to the 1920s, when uranium was discovered in the Kuramin range west of the Tien Shan range. The Taboshary deposit, which is located about 40 km north of Khodzent (formerly Leninabad), was discovered in 1925. It was first exploited for radium, which was extracted at a special plant in Taboshary settlement starting in 1934.

Underground mining for uranium began at Taboshary in 1943, and Taboshary was the first uranium deposit mined in the former USSR after World War II. The uranium at Taboshary occurs as veins in a granitic host rock. The average ore grade was 0.06% U; secondary uranium minerals accounted for most of the mineralisation. Production from the Taboshary deposit, which is now depleted, totalled 500 tU.

The Adrasman deposit, which is located about 70 km northeast of Khodzent was discovered in 1934. It was first mined in 1945 for copper and bismuth; uranium was discovered at Adrasman in 1940. Underground mining for uranium began in 1946 and extended into the 1950s. The geology of the Adrasman deposit is similar to that at Taboshary. Resources at Adrasman, which have been mined out, totalled 103 tU at an average grade of 0.053% U.

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* This report is based on Secretariat estimates and is the first report from this country.

Uranium mineralisation has also been reported in the Gissar and Karetegin ranges of the southern Tien Shan. These occurrence are associated with Paleozoic complexes and include:

- Pitchblende mineralisation in Permian volcanics at Khanaka, Paridan, Rafikon and Mumin.
- Pitchblende in granite at Yakhob and Moscovskoye.
- Pitchblende-brannerite-fluorapatite in granite at Lugur and Farkak.
- Pitchblende-fluorapatite in middle Paleozoic carbonates at Vaidara.
- Bitumen-pitchblende and fluorapatite-bitumen-pitchblende in metasediments at Karategin and Kamaroy.

URANIUM RESOURCES

Tajikistan has no reported minable uranium resources.

URANIUM PRODUCTION

The first uranium production centre in the former USSR was built near Khodzent (formerly Leninabad), Tajikistan in 1945. This production centre, which processed uranium ore until the early 1990s was originally known as Combine No. 6 and later as Leninabad Mining-Chemical Combine. Most recently it was operated by Vostochny Rare Metal Industrial Complex ("Vostokredmet"). It is also known within the industry as the Leninabad mill.

Production during the early operating years of the Leninabad mill was based on ore mined in Tajikistan (Taboshary and Adrasman deposits) as well as the Maili-Su deposit in Kyrgyzstan and the Uigur and Tuya-Muyun deposits in Uzbekistan. Between 1945 and 1950, uranium concentrate from the GDR, Czechoslovakia, Poland and Bulgaria was also shipped to the Leninabad mill for processing. The production schedule between 1945 and 1950 is summarised in the following table:

Historical uranium production in Tajikistan at Leninabad Mill (Combine 6)

	1945	**1946**	**1947**	**1948**	**1949**	**1950**
Concentrate shipped from Europe, tU	0	60	209	452	989	1 640
Ore from USSR deposits						
Mined ore, 1 000 tonnes	18	57	191	299	476	732
Uranium contained in ore, tU	15	50	129	183	279	417
Mill recovery, %	46	56	57	69	72	75
Uranium production, tU	7	20	66	103	170	237

The annual capacity of the Leninabad mill was eventually expanded to 2 000 tU when it began processing ore from the Karamazar region and ISL slurry from the Kyzylkum region, both of which are in Uzbekistan.

In 1993, the Leninabad mill circuit was reconfigured to treat Pb-Zn-Ag ore.

• Thailand •

URANIUM EXPLORATION

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 Jurassic sandstone and granite host rocks. Sandstone mineralisation occurs in the Phu Wiang district of the Khon Kaen province, northeastern Thailand. This area had been independently investigated by DMR. The Cupertino area was investigated in co-operation with foreign organisations such as the IAEA, USGS and FBU. Granite hosted uranium occurrences associated with fluorite were discovered in the Doi Tao district, Om Koi district of Chiang Mai province and the Muang district of Tak province, northern Thailand. These occurrences have received the most attention.

The most important uranium exploration activity carried out in Thailand is the nation-wide airborne geophysical survey completed between 1985 and 1987. The survey was conducted by Kenting Sciences International Limited Canada, as contractor to the Canadian International Development Agency (CIDA). The original purpose of the survey was to support mineral exploration and geological mapping. Subsequently, the data quality has been proved to be suitable for natural radiation information. In 1993, DMR with the assistance of the IAEA, published a Background Radiation Map of Thailand at the scale of 1:1 000 000 from the existing airborne radiometric digital data.

Recent and ongoing activities

No government agencies or companies have been involved in uranium exploration activities from 1998 to 2000.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

A small uranium occurrence found in Jurassic sandstones in the Phu Wiang district is estimated to contain about 4.5 tU based on a cut-off grade of 0.01% U. This estimate is classified as RAR recoverable at a cost of less than USD 130/kgU.

Granitic areas in the Doi Toa and Om Koi districts (Chiang Mai province) in northern Thailand are considered to have some uranium potential. Uranium minerals have been identified in fluorite veins. Uranium assays yielded values between 0.02 and 0.25% U. The estimate of EAR-I is about 7 tU in the cost category below USD 130/kgU with a cut-off grade of 0.05% U.

Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	4.5

Estimated additional resources – Category I
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	7

Undiscovered conventional resources (EAR-II & SR)

No undiscovered conventional resources are reported.

Thailand has no uranium production industry nor any uranium requirements and reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Turkey •

URANIUM EXPLORATION

Historical review

Uranium exploration in Turkey began in 1956-1957 and was directed towards the discovery of vein deposits in crystalline terrain, such as acidic igneous rocks and metamorphics. As a result of these activities, some pitchblende mineralisation was found, but it did not form economic deposits. Since 1960, studies have been conducted in sedimentary rocks that surround the crystalline rocks 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 Köprübasi area. As a result of recent exploration activities, uranium mineralisation has been found in Neogene sediments in the Yozgat-Sorgun region of Central Anatolia. Exploration in Turkey ended in 1998 with the expenditure of about USD 1.2 million that year.

Ground radiometric and geochemical prospecting (taking stream sediment samples) was carried out in the southwestern Anatolia (Thrace Basin) in 1995, 1996 and 1997. The results were negative.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

A total RAR of 9 129 tU occurring in the ≤USD 80/kgU category (as *in situ* resources) are reported from the following deposits:

- Salihli-Köprübasi: 2 852 tU in 10 orebodies and at grades of 0.04-0.05% U_3O_8 (0.03-0.04%U) in fluviatile Neogene sediments.
- Fakili: 490 tU at 0.05% U_3O_8 (0.04%U) in Neogene lacustrine sediments.
- Koçarli (Küçükçavdar): 208 tU at 0.05% U_3O_8 (0.04%U) in Neogene sediments.
- Demirtepe: 1 729 tU at 0.08% U_3O_8 (0.07%U) in fracture zones in gneiss.
- Yozgat-Sorgun: 3 850 tU at 0.1% U_3O_8 (0.08%U) in Eocene deltaic lagoonal sediments.

No EAR-I are reported.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	9 129	9 129

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

None reported.

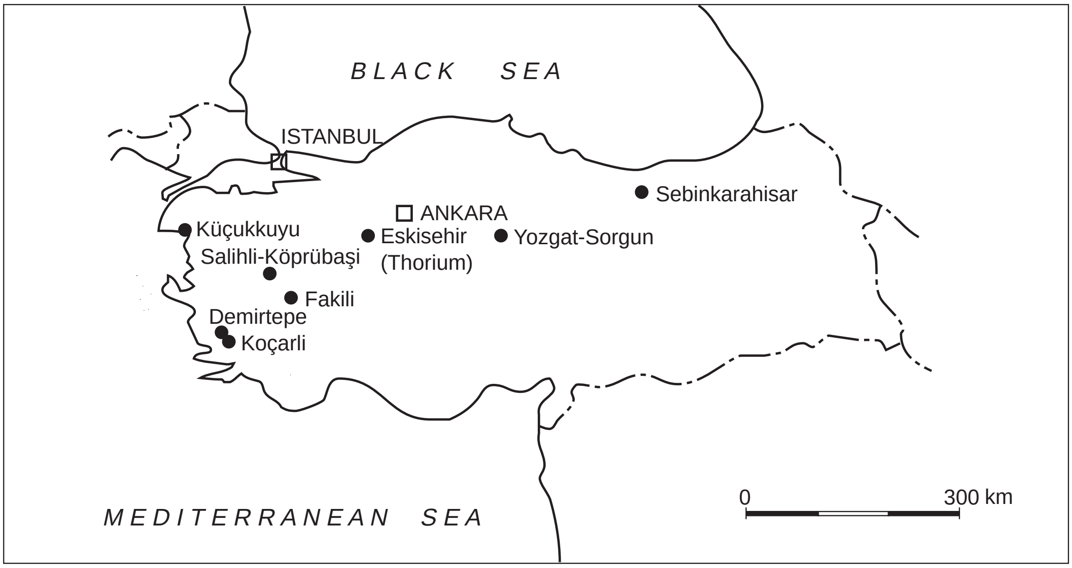
URANIUM PRODUCTION

Turkey has no uranium production industry.

ENVIRONMENTAL AND SOCIO-CULTURAL ISSUES ACTIVITIES

None reported.

Uranium deposits and occurrences in Turkey



URANIUM REQUIREMENTS

Turkey has no operating nuclear power plants.

URANIUM STOCKS

The Government holds a stock of 1.8 tU in the form of natural uranium.

No information was reported on Turkey’s national policies relating to uranium or uranium prices.

• Ukraine •

URANIUM EXPLORATION

Historical review

Exploration for commercial uranium deposits began in Ukraine in 1944, with radiometric surveys of museum samples, drill core, and accessible mine workings. Under a special government resolution, drillholes throughout the country were logged using gamma survey equipment. These activities lead to the discovery of the Pervomayskoye deposit in 1945 and the Zheltorechenskoye deposit in 1946. These deposits are associated with alkaline metasomatism of the ferruginous rocks of the Krivoi Rog basin. Deposits of other types were also identified, including small sandstone deposits in the sedimentary cover of the Ukrainian shield and deposits in bitumens and pegmatites. The sandstone deposits were amenable to *in situ* leach mining.

The first commercial uranium deposit (Michurinskoye) was discovered in 1964. It is associated with alkaline metasomatism and fault zones in a granite-gneiss complex of the Ukrainian shield. Further exploration for this new type of deposit led to the discovery of the Kirovograd uranium district which hosts Ukraine's two active uranium mines.

In 1995 a strategic decision was made to emphasize exploration for complex uranium-rare metal mineralisation, unconformity-related deposits and vein and vein stockwork hosted deposits. This activity, which is primarily conducted in crystalline and metamorphic rocks of the Ukrainian Shield, continued in 1999 and 2000.

In 1996, exploration for iron ore in the northern part of the Krivoy Rog basin coincidentally delineated uranium mineralisation containing up to 1.2% U over a thickness of 6.7 m. The mineralisation occurs in veins in a metasomatized schistose-quartzite. The State Geological Enterprise Kirovgeology carried out an evaluation of this area, but no further work is planned because of lack of encouraging results.

Specialised maps at a scale 1:50 000 are being prepared for areas thought to have good potential for new discoveries, including areas of the Ukrainian Shield covered by younger sediments with a thickness of 20-100 m or more. This initial evaluation of the more prospective areas includes geophysical surveys (gravity, magnetic and electrical prospecting, as well as isotope surveys) and extensive drilling. Kirovgeology began direct exploratory drilling after the compilation of a geological-structural map in each prospective area.

Recent and ongoing uranium exploration and mine development activities

In 1999 and 2000, exploration was ongoing in the most prospective areas of the Ukrainian shield and its slopes. The following is a summary of the most important exploration activities during this time period.

Initial geological mapping at a scale of 1:50 000 was conducted in a zone of structural and stratigraphic unconformity between the basement and Polesskay sediments on the western slope of the Ukrainian shield. Three prospective areas were defined for more detailed exploration in this area. In the central part of the shield, exploration was ongoing within the Zapadno-Inguletskay structural zone and in the southern part of the Bratsko-Zvenigorodskay zone. Anomalous uranium occurrences were also identified in these areas for additional evaluation.

In 1999-2000, laboratory tests were conducted to compare carbonate and acid leaching of uranium from sandstone deposits in the sedimentary cover of the Ukrainian shield. The samples were selected from ore intervals in the Safonovskoye and Novogurievskoye deposits. Uranium leaching using sulphuric acid with a concentration of 15 g/l was compared with that using a solution of soda (30 g of Na_2CO_3 per litre) with an oxidizer.

Uranium recovery using the acid solution averaged about 90%, compared to 85% recovery from the carbonate leach solution. Therefore, the effectiveness of carbonate leaching, which is more environmentally acceptable than acid leach systems, was demonstrated in the laboratory. The next step will be to perform field tests to obtain information on which to design full-scale carbonate leach projects.

Uranium exploration and development expenditures and drilling effort

	1998	1999	2000	2001 (expected)
Government expenditures UAH (× 1 000) USD (million)	3 900 1.94	6 300 1.6	11 400 2.1	13 500 2.48
Government exploration drilling (m)	21 020	40 130	38 700	19 180
Number of government holes drilled	298	496	326	151

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

The assessment of the known resources of Ukraine has not changed from the 1999 Red Book, and remains at 131 000 tU at a cost of less than USD 130/kgU. This total includes resources with production costs of less than USD 80/kgU in the Vatutinskoye (25 500 tU) and Michurinskoye (27 000 tU) metasomatite (albitite) deposits, both of which are being mined by underground methods. Resources totalling 10 100 tU associated with small deposits in sedimentary cover of the Ukrainian shield are also assigned to the less than USD 80/kgU cost category. These sedimentary deposits are potentially amenable to ISL extraction. Exploration of higher-grade areas within the Vatutinskoye and Michurinskoye deposits identified known resources totalling 19 250 tU recoverable at a cost of less than USD 40/kgU.

The remaining 68 400 tU RAR & EAR-I with expected mining cost greater than USD 80/kgU are concentrated in Severinskoye metasomatite deposit (50 000 tU), in the Yuzhnoye, Kalinovskoye and Lozovatskoye pegmatite deposits (15 000 tU) and in the Adamovskoye, Krasnooskolskoye and Berekskoye bitumen deposits (3 400 tU).

Approximately 30% of known resources recoverable at USD 40/kgU or less are tributary to existing or committed production centres. Of the known resources recoverable at USD 80/kgU or less, approximately 53% are tributary to existing or committed production centres.

By-product uranium resources that could be mined with other mineral resources have not been discovered in Ukraine.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
19 250	42 600	81 000

* As *in situ* resources.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	20 000	50 000

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

Undiscovered resources (EAR-II and SR) total 235 000 tU as of 1 January 2001, and remain unchanged compared to the 1999 Red Book.

The largest portion of the undiscovered resources are postulated to occur in the following types of deposits: metasomite (albitite) (133 500 tU), pegmatite (15 000 tU), bitumen (16 500 tU), sandstone deposits within the sedimentary cover of the Ukrainian Shield (20 000 tU), unconformity-related deposits (20 000 tU) and vein-stockwork deposits (30 000 tU).

Areas of albitite development between the Vatutinskoye deposit on the west and Michurinskoye deposit on the east are the most promising for discovery of new metasomatite deposits. The northwest slope of the Ukrainian shield (unconformity-related deposits) and Zapadno-Inguletskaya tectonic zone (vein deposits) located east of the Krivoy Rog iron-ore basin have potential for the discovery of high-grade uranium deposits.

Estimated additional resources – Category II*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	3 900

* As *in situ* resources.

Speculative resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
0	231 100	231 000

* As *in situ* resources.

URANIUM PRODUCTION

Historical review

The uranium mining and milling industry of the Ukraine was established in 1946 by a special decree of the Soviet Council of People's Deputies.

Short-term production capability
(tonnes U/year)

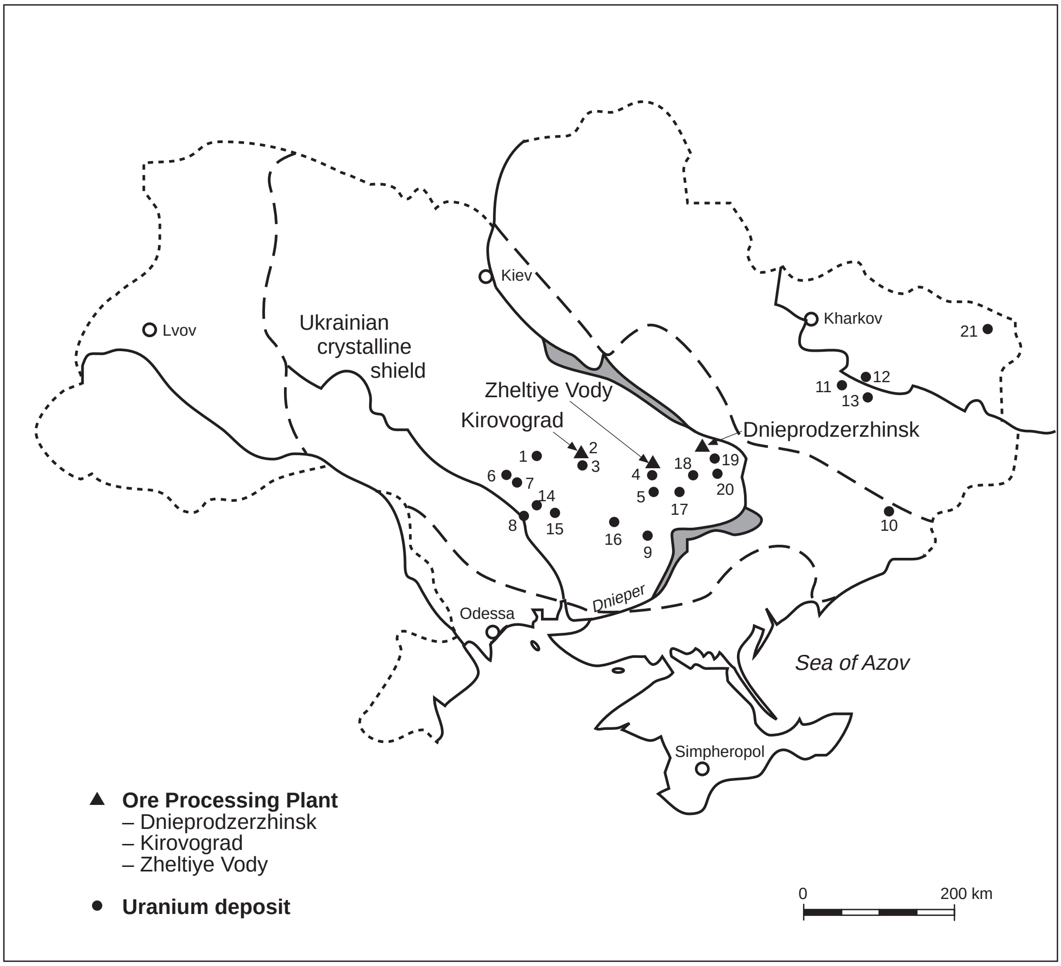
2001				2002				2005			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	1 000	0	0	0	1 000	0	0	0	1 000	0	NA

2010				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	1 500	0	0	0	2 000	0	0	0	2 000	0	0

Uranium production centre technical details
(as of 1 January 2001)

Name of production centre	Zheltiye Vody
Production centre class	existing
Operational status	operating
Start-up date	1959
Source of ore: • Deposit names • Deposit type • Grade	 Ingul'skii mine/Michurinskoye deposit Vatutinskii mine/Vatutinskoye deposit Metasomite (Albitite) 0.1
Mining operation • Type (OP/UG/*in situ*) • Size (tonnes ore/d) • Average mining recovery (%)	 UG NA NA
Processing plant • Type (IX/SX/AL) • Size (tonnes ore/d) • Average processing recovery (%)	Zheltiye Vody AL/IX and SX NA 95
Nominal production capacity (tU/y)	1 000
Plans for expansion	doubling the capacity to 2 000 tU/year

Uranium deposits of Ukraine



1. Vatutinskoye
2. Severinskoye
3. Michurinskoye
4. Zheltorechenskoye
5. Pervomaysskoye
6. Lozovatskoye
7. Kalinovskoye
8. Yuzhnoye
9. Nikolokozelskoye
10. Nikolayevskoye
11. Berekskoye
12. Krasnooskoiskoye
13. Adamovskoye
14. Sadovokonstantinovskoye
15. Bratskoye
16. Safonovskoye
17. Devladovskoye
18. Novoguryevskoye
19. Surskoye
20. Chervonoyarskoye
21. Markovskoye

Uranium mining

At present two mines are producing uranium ore (i.e. Ingul'skii and Vatutinskii). A third mine is planned to be developed on the Severinskoye deposit. The majority of current uranium production is coming from the Ingul'skii mine developed on the Michurinskoye deposit. The remaining production is from the Vatutinskii mine located near Smolina. ISL mining was also previously conducted at three sites (i.e. Devladove, Bratske and Safonovskoye).

Michurinskoye deposit

The Michurinskoye deposit was discovered in 1964 during water well drilling. Kirovgeology conducted exploration in 1965 and began development of the Ingul'skii mine in 1967.

The uranium deposits in this part of the Ukrainian shield occur in a major northwest-southeast trending tectonic zone that extends for hundreds of km and is about 10 km wide. The ore-bearing zone is about 10 m thick by 1 km long and extends to a depth of 1.5 km. The ore grade decreases with depth and the best grades occur between 90 and 150 m below the surface. Sixty percent of the uranium occurs in brannerite, with the oxides nasturan (pitchblende) and uraninite contributing most of the rest.

Ingul'skii mine

The Michurinskoye deposit is mined by the Ingul'skii mine. The main shaft is located 2 km from Kirovograd. Current production is less than 1 million t ore/year. The initial plan was for 1 million t ore/year with a 25-year life based on resources of 19.1 million tonnes ore. Mine production started in 1971. It reached the target level of 1 million t/year in 1976 and continued at that level until 1989.

The ore occurs in about 30 zones. Original estimated reserves of 19.1 million tonnes ore, were increased after 1967 by delineation of an additional 7 million tonnes. On 1 January 1995 reserves totalled about 13 million tonnes ore, using a cutoff grade of 0.03% U. The in-place grade is about 0.1% U. Dilution during mining is about 29%. The grade is increased to between 0.1 and 0.2% U using radiometric ore sorting of mine-car sized lots conducted within the mine.

Access to the mine is through two 7-m diameter shafts, designated the North and South shaft. Ore is hoisted at the North shaft using two 11-tonne capacity skips. The South shaft is used for hoisting workers, supplies and for technical access. A ventilation shaft provides 480 m^3 of fresh air/second. The principal mine levels are developed on 60 to 70 m intervals, designated 90, 150, 210, 280, and 350.

Ore is mined using conventional drill and blast operations with backfill. The mine is operated by 3 shifts with a total staff of about 850. Large ore blocks are sub-divided into 10-12 m high blocks for mining. A ring of blast holes is drilled every 4 to 5 m. Following blasting the ore is moved to loading pockets for transfer to the sub-level tracked haulage. The ore is transported by electric powered trams to the main shaft where it is crushed prior to hoisting to the surface.

Severinskoye deposit

The Severinskoye deposit, located about 20 km from the Michurinskoye deposit, has been evaluated for future mining. It is in the largest deposit class with RAR and EAR-I of 68 400 tU and an average grade of about 0.1% U. These resources are in the USD 80 to USD 130/kgU cost category.

Zheltiye Vody hydrometallurgical plant

The Zheltiye Vody Hydrometallurgical Plant is operated by VostGOK. Construction was started in 1958 and the mill came into production in January 1959. The design capacity of the mill is 1 million tonnes ore/year. In recent years the mill has been operating at about half capacity. A total of 30 to 35 persons/shift operate the mill.

Ore is hauled to the mill by dedicated trains from the 2 mines Ingul'skii and Vatutinskii, one at Kirovograd (100 km west) and the other at Smolina, near Beriozovka (150 km west). Ninety percent of the ore is produced at Kirovograd. Following grinding and spiral classification, ore is leached in autoclaves using sulphuric acid. Leaching conditions are at 150 to 200°C under 20 atmospheres pressure with a 4-hour residence time. Acid consumption is 80 kg/tonne ore.

In-pulp ion exchange resin is used to recover uranium. Following elution with a mixture of sulphuric and nitric acid, the uranium-bearing solution is further concentrated and purified using solvent extraction technology. Ammonia gas is used for precipitation. The dewatered precipitate is calcined at 800°C to give a dark coloured product. By 1994 the large Zheltiye Vody plant had produced 41.1 million t tailings from its uranium processing operations.

In situ leach mining

ISL uranium mining was conducted from 1966 to 1983 at the Devladove, Bratske, and Safonovskoye sites using acid leach technology. Uranium was recovered from sandstone-hosted deposits occurring at depths of about 100 m.

Ownership of the uranium industry

All activities related to the nuclear fuel cycle in Ukraine are organised and owned by the State. Prior to 1997 all related activities were conducted under the State Committee for Utilization of Nuclear Energy (GASCOMATOM). In 1997, a new Ministry of Energy of Ukraine was given the responsibility for uranium mining and production. The geological department of the uranium industry has also been reorganized.

The State Geological Enterprise "Kirovgeology", which is headquartered in Kiev, is responsible for all uranium exploration and development activities leading up to full scale production. The organisation is a subsidiary of the State Committee of Geology and Utilization of Natural Resources. The organisation has six district offices, or "expeditions", for conducting uranium exploration throughout prospective areas in Ukraine.

VostGOK, a subsidiary of the Ministry of Energy, is the organisation responsible for uranium mining and milling in Ukraine. In support of its mining and milling activities, VostGOK operates a large sulphuric acid plant, manages the energy and electrical supply and produces mining equipment and related spare parts. VostGOK also controls 100% of the Ukrainian uranium production.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

The accumulations of waste associated with uranium production in Ukraine have a negative impact upon the environment. The impact is primarily related to the tailings disposal areas where wastes from hydrometallurgical processing are located. Additional impacts may also be associated with waste rock, low grade ores and tails from radiometric ore concentration within the areas of uranium mining. At present, no mines are being decommissioned in Ukraine.

In 1996, Ukraine enacted a new constitution which provides a legislative base to conduct rehabilitation activities related to nuclear activities. The new laws provide for regulation of radiation safety; radioactive waste management; and environmental reclamation. The environmental reclamation activities relate to industrial activity modifications and to liquidation and permanent closure of facilities for mining, processing and handling radioactive ores (SP-LKP-91).

A programme is being conducted by VostGOK to clean up and rehabilitate sites in Zheltiye Vody contaminated by uranium mill tailings. The programme was established by the Council of Ministers of Ukraine on 8 July 1995. It is the basis for reclaiming contaminated land, decreasing the concentration of radon in houses, and conducting environmental monitoring in the city.

A State programme for improvement of radiation protection at facilities of the atomic industry of Ukraine was also established. The programme, which covers all sites and environmental issues of uranium mining and milling in Ukraine, has a budget of USD 360 million. It provides for: decontamination of contaminated lands, environmental monitoring, installing personnel monitoring systems where required; and for improving technology for treatment of effluents, uranium bearing waste rock and contaminated equipment and land. It also provides for improving national regulations, scientific and design support for the programme, and liaison with international organisations regarding the programme.

URANIUM REQUIREMENTS

Reactor-related uranium requirements for Ukraine are based upon an installed nuclear generating capacity of 12 880 MWe in 2000, increasing to 14 800 MWe in 2010 in the low case, and further increasing to between 15 800 and 17 800 MWe in the years between 2010 and 2020 in the high case. Annual uranium requirements are expected to increase correspondingly.

Installed nuclear generating capacity to 2020
(MWe net)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
12 880	11 880	13 800	14 800	15 800	14 800	15 800	15 800	17 800

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 200	2 050	2 350	2 500	2 650	2 500	2 650	2 650	2 950

Supply and procurement strategy

Ukraine’s operating uranium production facilities provide approximately 50% of its reactor-requirements. All uranium concentrate produced in the Ukraine is shipped to the Russian Federation for conversion, enrichment and fuel fabrication. The shortfall between the national production and reactor-related requirements is met through purchases from the Russian Federation. No uranium stockpiles are kept in Ukraine.

Ukraine plans to increase its uranium supply capability to meet 80% of its requirements. This programme requires substantial increases in activities ranging from uranium exploration to production. In addition, the Ukraine Government announced a programme for establishing the technical capabilities for a complete fuel cycle in Ukraine by 2010.

No information was reported on national policies relating to uranium, uranium stocks, or uranium prices.

• United Kingdom •

URANIUM EXPLORATION

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 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., members of the Rio Tinto group of companies).

There were no industry expenditures reported for domestic exploration from 1988 to the end of 2000, nor were any government expenditures reported for exploration either domestic or abroad. Since 1983, all domestic exploration activities have been halted.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

The Reasonably Assured Resources (RAR) and Estimated Additional Resources – Category I (EAR-I) are essentially zero.

Undiscovered conventional resources (EAR-II & SR)

There are small quantities of *in situ* Estimated Additional Resources – Category II (EAR-II) and Speculative Resources. Two districts are believed to contain uranium resources:

Metalliferous mining region of southwest England (Cornwall and Devon)

Uranium occurs in veins and stockworks, often in association with tin and other metals, emplaced in Devonian metasediments and volcanics and related to the margins of uraniferous Hercynian granites. Mineralisation is locally of moderate grade (0.2-1% U) but of sporadic distribution. Resource tonnages of individual prospects may be up to several hundred tonnes U.

North Scotland including Orkneys

The Precambrian metamorphic rocks of north Scotland, with intruded Caledonian granites, are overlain by a post-orogenic series of fluviatile and lacustrine Devonian sediments. Uranium occurs in phosphatic and carbonaceous sediments disseminated in arkosic sandstone (Ousdale) and in faults both within the sediments (Stromness) and in underlaying granite (Helmsdale). Resources of a few thousand tonnes of uranium are indicated with an average grade less than 0.1% U.

There has been no geological reappraisal of the UK uranium resources since 1980 and all subsequent submissions have been based on this original estimate.

URANIUM PRODUCTION

Status of production capability

The United Kingdom is not a uranium producer. Re-enrichment of depleted uranium was reported to have occurred in 1999 and 2000 though the details are commercially confidential.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

The UK's nuclear power stations supplied over 78.3 TWh in 2000, compared with 87.7 TWh in 1999. This represented 22% of total electricity supplied in 2000 (compared with 25.5% in 1999).

In April 1994, British Nuclear Fuels plc (BNFL) began construction of the Sellafield MOX Fuel Plant (SMP) which will fabricate, on behalf of customers, mixed oxide (MOX) fuel from a blend of plutonium and uranium. In the summer of 2000, SMP underwent uranium commissioning and as of mid-2001 is awaiting final government approval to operate.

In May 2000, BNFL announced a lifetime strategy for its fleet of magnox stations. The strategy provides a phased programme for the cessation of electricity generation and has been announced ahead of time in order to bring clarity to BNFL's business plan and certainty about the future for those concerned. This will also mean that the magnox reprocessing plant (B205) at Sellafield will close once all the fuel has been processed, thought to be around 2012.

Urenco, the British-Dutch-German organisation, operates uranium enrichment plants using centrifuge technology in all three countries and supplies a uranium enrichment service to nuclear station operators world-wide. The UK's share is held by BNFL. Early in 2000, the Dutch and German governments announced their intention to sell their share of the company and a number of companies have expressed an interest. Urenco has continued to expand its enrichment capacity in line with increased business commitments reaching a total capacity across its three sites of 4 800 tonnes of separative work (tSW) at the end of 2000.

Installed nuclear generating capacity to 2020
(MWe net)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
12 490	12 490*	12 000	10 000		7 000		4 000	

* Secretariat estimate.

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 250	2 250*	2 400	1 850		1 139		750*	

* Secretariat estimate.

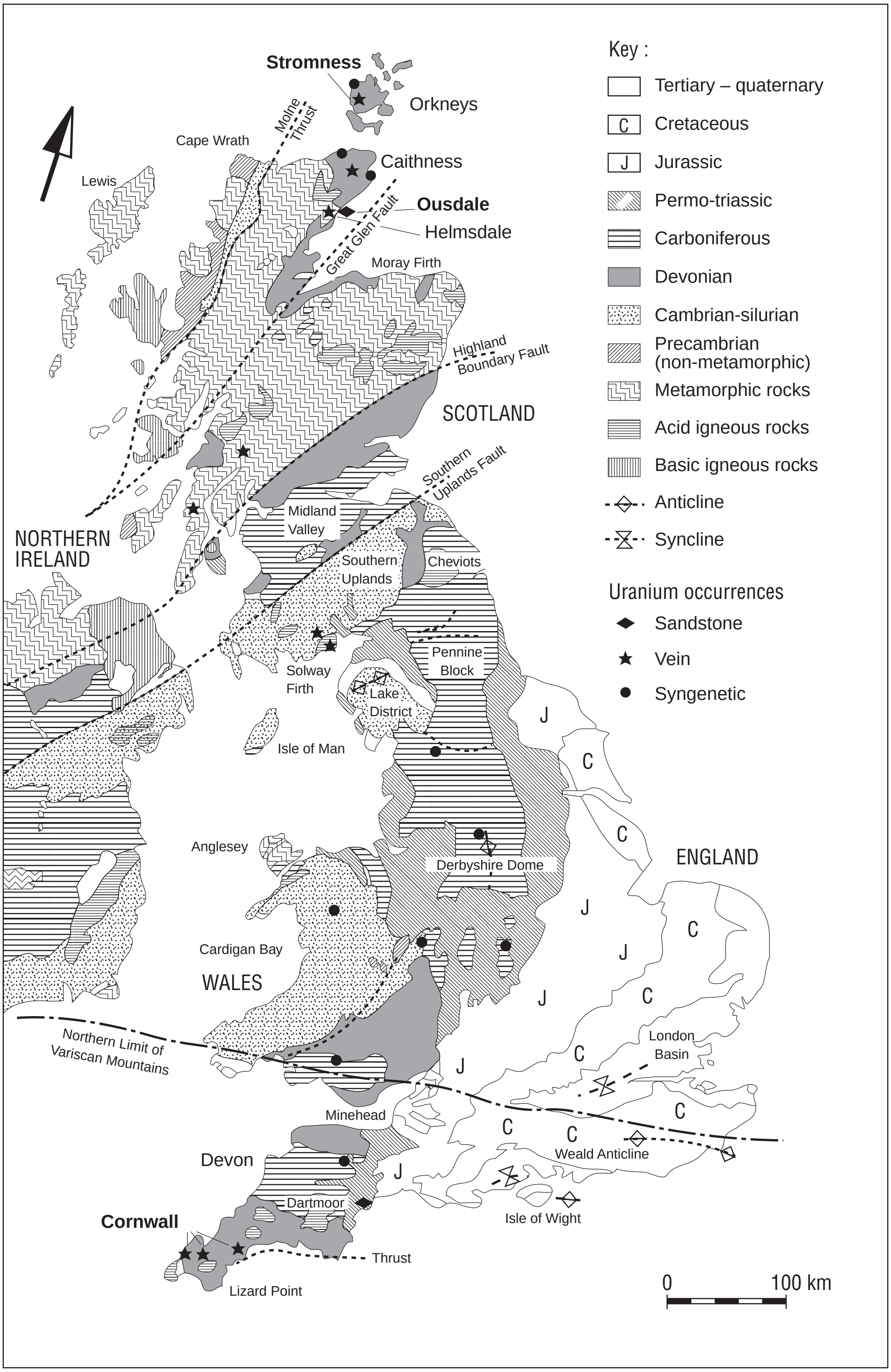
Supply and procurement strategy

The Government's central policy objective is to ensure secure, diverse and sustainable supplies of energy at competitive prices. The energy sources White Paper, published on 8 October 1998, observed that existing nuclear power plants make a valuable contribution to diversity of supply and emissions reduction. The Government believes that existing nuclear stations should only continue to contribute both to electricity supply and to reduction of emissions as long as they can do so to the high safety and environmental standards, which are currently observed. The White Paper also noted that nuclear power's share of generation is expected to decrease in the first decades of the 21st century as existing capacity is retired.

As with other forms of generation in the UK, it is for the market to take the initiative for proposals for new generating capacity. There are no plans to build new nuclear plants at this point in time.

British Nuclear Fuels plc (BNFL) is a public limited company wholly-owned by the UK Government. In line with the Government's commitment to give greater commercial freedom to commercial organisations within the public sector, consideration is being given to the introduction of a public private partnership (PPP) into BNFL. This is subject to the company's overall progress towards achieving a range of targets on safety, health, environment and business performance. In March 2000, the Government announced that the introduction of a PPP into BNFL would not be before the latter part of 2002.

Uranium occurrences in the United Kingdom



In April 2000, the Department of Trade and Industry launched an entirely voluntary consultation on the options being proposed for the future management of the Dounreay Prototype Fast Reactor (PFR) fuels. These options are:

- Replace the dissolver and upgrade the associated facilities so that the fuels can be reprocessed as originally intended.
- Reprocess the majority of the fuels at Sellafield Thermal Oxide Reprocessing Plant (THORP) and the remainder at Dounreay (or elsewhere) storing the recovered material at Sellafield.
- Convert the fuels to a form suitable for long-term storage at Dounreay.

All of these options are consistent with the Government's decision, in June 1998, to accept no new commercial reprocessing contracts at Dounreay.

NATIONAL POLICIES RELATING TO URANIUM

No changes to uranium policy were reported in the United Kingdom. As regards the current policy on participation of private and foreign companies, the UK Atomic Energy Act 1946 gives the Secretary of State for Trade and Industry wide-ranging powers in relation to uranium resources in the United Kingdom, in particular to obtain information (section 4), to acquire rights to work minerals without compensation (section 7), to acquire uranium mined in the United Kingdom on payment of compensation (section 8), and to introduce a licensing procedure to control or condition the working of uranium (section 12A).

There are no specific policies relating to restrictions on foreign and private participation in uranium exploration, production, marketing and procurement in the United Kingdom nor exploration activities in foreign countries. There is no national stockpile policy in the UK. Utilities are free to develop their own policy. Exports of uranium are subject to the Export of Goods (Control) Order 1970 (SI No. 1 288), as amended, made under the Import, Export and Customs Powers (Defence) Act 1939.

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 of America •

URANIUM EXPLORATION

Historical review

From 1947 through 1970, the US Government fostered a domestic, private-sector uranium exploration and production industry to procure uranium for military uses and to promote research and development into 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, and Federal exploration programmes were ended. The Government has continued to monitor private-industry exploration and development activities to meet Federal informational 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 nuclear reactors being built or planned for civilian electric power stations. The peak total in annual surface drilling (exploration and development) was reached in 1978, when 14 700 km of borehole drilling were completed. From 1966 through 1982, US surface drilling totalled some 116 400 km in the search for new uranium deposits. The US industry completed an additional 12 050 km of surface drilling from 1983 through 1999. Surface drilling is the primary method of delineating uranium deposits in the United States, and the annual total for drilling has proved to be a reliable indicator of overall US exploration activity.

In the United States, 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 region and in the Wyoming Basins and Texas Gulf Coastal Plain regions. Vein and other structure-controlled deposits were developed in the Front Range of Colorado, near Marysvale in Utah, and in northeastern Washington State. Since 1990, large sandstone-hosted deposits have been mined in northwestern Nebraska. Several relatively high-grade deposits associated with breccia-pipe structures were mined in northern Arizona, but those mines have not been active since the mid-1990s. A large uranium deposit discovered in Virginia in the early 1980s has been pre-empted from exploitation by a State-imposed moratorium on uranium mining in that State.

Recent and ongoing uranium exploration activities

Total US surface drilling (exploration and development) completed during 2000 was 312 km, a decrease of 59% from the 1999 total. Not included in the 1999 total is drilling completed for uranium production control at mining projects. Exploration and development drilling in 1999 was 763 km.

In 2000, US industry firms reported total exploration expenditures of USD 6.7 million, a decrease of 25% from the level reported for 1999. The expenditures total was apportioned as follows: “surface drilling” accounted for USD 5.6 million, land acquisition and “other exploration” accounted for USD 1.1 million. In 2000, there were no exploration expenditures for uranium by the US Government. Foreign contributions to domestic exploration expenditures for 2000, less than USD 1 million, were increased over the total for 1999.

At year end 2000, the total land area held for uranium exploration in the United States by domestic and foreign firms was about 2 770 km^2, a decrease of 15% below the 1999 total. US firms reported they acquired only a small amount of exploration land during 2000.

The US Government no longer reserves land for uranium production. Under the Atomic Energy Act of 1954, about 100 km^2 of public land were set aside for exploration and production. Currently, private firms hold leases to about 15 remaining active tracts (those having ongoing exploration and/or mining), and these are administered under the Federal "Uranium Lease Management Programme." Inactive lease tracts, those not eligible for further leasing or mining, will be reclaimed and submitted for restoration to the public domain.

Uranium exploration and development expenditures and drilling effort – domestic
(in million USD)

	1998	**1999**	**2000**	**2001** (expected)
Industry exploration expenditures	2.261	0.276	NA	NA
Government exploration expenditures	0	0	0	NA
SUBTOTAL exploration expenditures	2.261	0.276	NA	NA
SUBTOTAL development expenditures	15.814	7.616	NA	NA
TOTAL EXPENDITURES	**21.724**	**8.968**	**6.694**	**NA**
Industry exploration drilling (km)	271	54	NA	NA
Number of industry exploration holes drilled	1 370	265	NA	NA
SUBTOTAL exploration drilling (km)	271	54	NA	NA
SUBTOTAL exploration holes	1 370	265	NA	NA
SUBTOTAL development drilling (km)	1 144	709	NA	NA
SUBTOTAL development holes	5 231	2 911	NA	NA
TOTAL DRILLING (km)	1 415	763	312	NA
TOTAL NUMBER OF HOLES	6 601	3 176	1 550	NA

Uranium exploration and development expenditures – abroad
(in million USD)

	1998	**1999**	**2000**	**2001** (expected)
Industry exploration expenditures	3.616	NA	NA	NA
Government exploration expenditures	0	0	0	NA
SUBTOTAL exploration expenditures	3.616	NA	NA	NA
SUBTOTAL development expenditures	NA	NA	NA	NA
TOTAL EXPENDITURES	3.616	NA	NA	NA

NA = not available.

URANIUM RESOURCES

Known conventional resources (RAR)

For the United States, the estimate of RAR for the USD 80/kgU category at year end 2000 was 104 000 tU, a decrease of 1 000 tU below the level reported for the same category as of year end 1999 and 2 000 tU below the level reported for 1998. The estimate for RAR for the USD 130/kg U category at the end of 2000 was 348 000 tU, a decrease of about 1 000 tU below the level reported for 1999 and about 7 000 tU below the level reported for 1998.

For 2000, active mine properties and other selected properties were re-evaluated to account for annual production and to include adjustments for updated costs and mining technology information. The result was a reduction in the estimated resources for each reserve category. The 2000 resource estimates have been adjusted to account for mining dilution (10-40%), and processing losses, (10-15%).

Reasonably assured resources
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
NA	104 000	348 000

Undiscovered conventional resources (EAR-II & SR)

The United States 2001 resource estimates for the EAR and SR categories are listed in the following tables. It should be noted that the United States does not separate EAR into EAR-I and EAR-II.

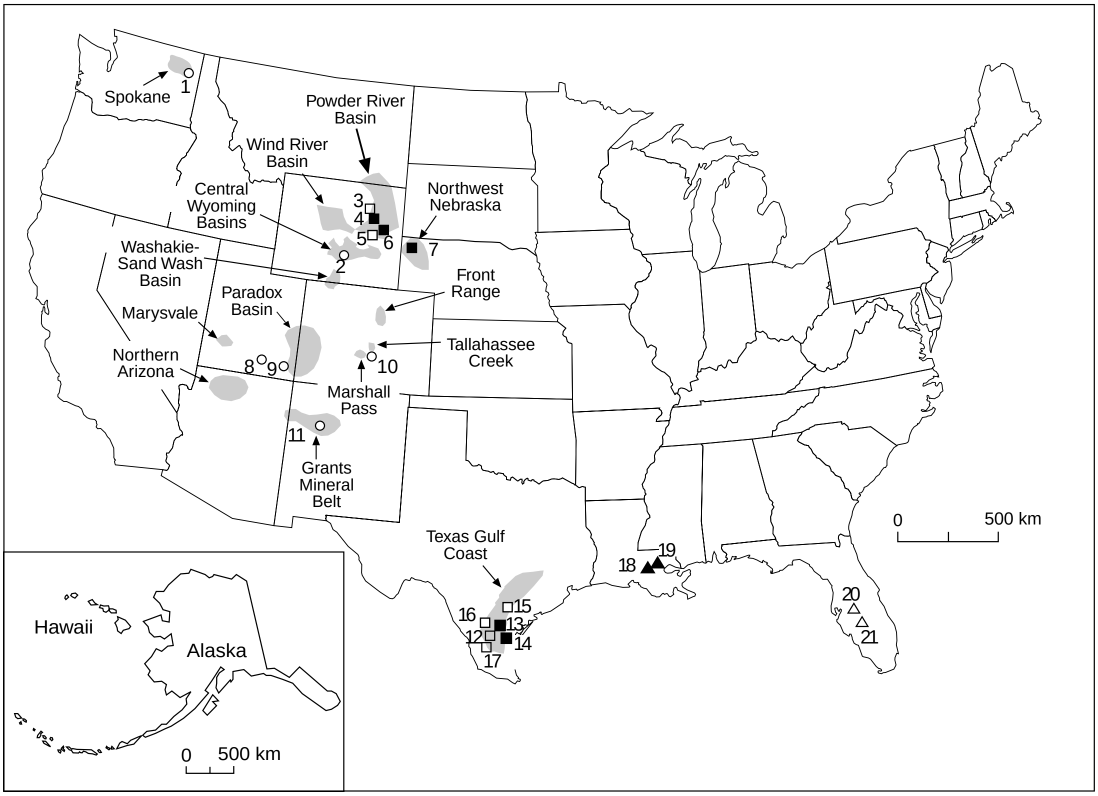
Estimated additional resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
NA	839 000	1 273 000

Speculative resources
(tonnes U)

Cost ranges		**Total**
<USD 130/kg U	Unassigned	
858 000	482 000	1 340 000

Major US uranium reserve areas and status of mills and plants, 2000



Active at the end of 2000

5. Smith Ranch
6. Highland
7. Crow Butte
10. Canon City

Inactive at the end of 2000

1. Dawn/Ford [a]
2. Sweetwater
3. Irigaray [b]
4. Christensen Ranch [c]
8. Shootaring
9. White Mesa
11. Ambrosia Lake [d]
12. Holiday-El Mesquite [b]
13. Rosita
14. Kingsville Dome
15. Hobson
16. West Cole
17. O'Hern
18. Sunshine Bridge
19. Uncle Sam
20. Plant City
21. New Wales

Uranium Production Centres

Active	Inactive	
●	○	Conventional mill
■	□	*In situ* leach plant
▲	Δ	Byproduct from phosphate processing
(grey area)		**Major uranium reserve area[e]**

[a] Recovered uranium by processing the waste stream at a mine water treatment plant during 2000.
[b] Recoverd uranium by processing water from *in situ* leach mine restoration during 2000.
[c] Recovered uranium by active *in situ* leaching and processing water from *in situ* leach mine restoration during 2000.
[d] Recovered uranium by processing mine water solution during 2000.
[e] Major areas containing reasonably assured resources at USD 130/kgU or less.

Sources: Based on US Department of Energy, Grand Junction Project Office (GJPO), National Uranium Resource Evaluation, Interim Report (June 1979) Figure 3.2, GJPO data files; and Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (2000).

URANIUM PRODUCTION

Historical review

Under the Atomic Energy Act of 1946, designed to meet the US Government's uranium procurement needs, the Atomic Energy Commission (AEC) from 1947 to 1970 fostered a domestic uranium industry, chiefly in the western 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, implemented a domestic uranium ore procurement programme designed to stimulate a civilian-based domestic mining industry. The AEC also negotiated uranium concentrate procurement contracts, pursuant to the Atomic Energy Act of 1946 and 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 periods. By 1961, a total of 27 privately-owned mills were in operation. Eventually, 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 their uranium contracts, although several mills continued to produce concentrate for the commercial market after fulfilling their AEC commitments. The Atomic Energy Act of 1954 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's projected requirements. 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 that its procurement programme would enter a "stretch-out" phase," wherein the Government would be committed to take only set annual quantities of uranium for 1967-1970. This change also assisted in sustaining a viable domestic uranium industry while it converted to a private marketplace. The Government's uranium procurement programme was ended at year end 1970, and the industry became a private sector, commercial enterprise with no additional Government purchases.

Since 1970, domestic uranium production has supported the commercial market. After achieving peak annual production of 16 810 tU in 1980, the US industry experienced generally declining annual production from 1981 to 1993. US uranium concentrate production increased each year from 1994 to 1996, but it has declined each year since. Production from all sources in 2000 totalled about 1 520 tU. *In situ* leach (ISL) mining and non-conventional uranium recovery technologies have dominated US production since 1991. Production in 2000 was 1 130 tU and came largely from ISL plants in Wyoming and Nebraska. Conventional mill production in 2000 was about 390 tU from mills in Colorado, New Mexico and Washington.

Status of production capability

At year-end 2000, one conventional uranium mill (360 tonnes of ore per day [TPD]) was operating in the United States, and five mills (combined capacity of 11 970 TPD) were on standby. At year end, the status of the 14 ISL and nonconventional plants (combined capacity, 4 860 tU/year) in the United States was as follows: of 10 *in situ* leach plants, three (1 920 tU) were operating; two (885 tU) were closed indefinitely; one (385 tU) was closed permanently; and four (690 tU) were in restoration. Four phosphate by-product plants (970 tU) were closed permanently.

Ownership structure of the uranium industry

Foreign privately held firms accounted for just over half of US uranium concentrate production in 2000. Firms controlled by foreign governments increased slightly their overall share of US production from 26% in 1999 to 28% in 2000. The share of domestic production controlled by US privately held firms rose to 21% in 2000 from 19% in 1999.

US uranium concentrate production for 2000 attributed according to the percentages of ownership for firms that owned and operated domestic production facilities is shown below.

- Foreign private ownership: 51%
- Foreign government ownership: 28%
- US private ownership: 21%

Historical uranium production
(tonnes U)

	Pre-1998	**1998**	**1999**	**2000 (P)**	**Total through 2000 (P)**	**2001** (expected)
Processing plant	309 858	124	349	391	310 723	NA
In situ leaching and others[1]	38 832	1 685	1 425	1 131	43 073	NA
Total	348 691	1 810	1 773	1 522	353 796	1 077

P Provisional data.

NA Not available.

1. Others includes production from mine water processing, lignite ashing, and heap leaching, and by-product production from wet-process phosphoric acid, copper-waste dump leaching, beryllium and REE recovery projects, and minor sources. Totals may not equal sum of components because of independent rounding.

Ownership of uranium production in 2000

Domestic				**Foreign**				**Totals**	
Government		**Private**		**Government**		**Private**			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	325	21	421	28	776	51	1 552	100

Employment in the uranium industry

In the US uranium raw materials industry, employment (as person years expended) declined to 627 in 2000, a downturn of 26% from the 1999 level of 848 person years. This represents the largest downturn in overall sector employment since 1992. The combined activities "exploration-mining-milling-processing" decreased to 401 person years in 2000, a decline of 38% below the 1999 level. For 2000, exploration declined by 84%, mining by 49%, and milling by 47%. Processing registered a small increase of 4%. Reclamation employment in 2000 fell by 13%, which represents the lowest level reported for that sector since 1992.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
911	649	401	NA

Future production centres

No plans regarding construction of new uranium concentrate production facilities were announced by the domestic uranium raw materials industry in the United States during 1999 and 2000.

Short-term production capability
(tonnes U/year)

2001				**2002**				**2005**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
2 300	2 500	3 000	3 700	2 300	2 500	3 000	3 700	2 100	3 700	2 700	6 100

2010				**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
1 100	1 900	1 700	6 900	800	1 300	1 000	5 000	700	1 300	1 000	5 000

Uranium production centre technical details
(as of 1 January 2001)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4
Name of production centre	Ambrosia Lake	Canon City	Christensen Ranch	Crow Butte
Production centre class	existing	existing	existing	existing
Operational status	standby	standby	standby	in operation
Start-up date	1958	1979	1989	1991
Source of ore • Deposit names • Deposit type(s) • Reserves (active resources) • Grade (% U)	 various sandstone NA NA	 Schwartzwalder vein NA NA	 Christensen Ranch, Irigaray sandstone NA NA	 Crow Butte sandstone NA NA
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 UG NA NA	 UG NA NA	 ISL NA NA	 ISL NA NA
Processing plant (Acid/ Alkaline): • Type (IX/SX/AL) • Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour) • Average process recovery (%)	 AL/SX 6 350 NA	 AL/SX 360 NA	 ISL NA NA	 ISL NA NA
Nominal production capacity (tU/year)	3 300	210	250	380
Plans for expansion	unknown	unknown	unknown	unknown
Other remarks	none	none	in reclamation	none

Uranium production centre technical details
(as of 1 January 2001)

	Centre # 5	Centre # 6	Centre # 7	Centre # 8
Name of production centre	Converse County Mining Venture	Ford	Hobson	Holiday-El Mesquite
Production centre class	existing	existing	existing	existing
Operational status	in operation	standby	standby	shut down
Start-up date	1988	1957	1979	1979
Source of ore • Deposit names • Deposit type(s) • Reserves (active resources) • Grade (% U)	 Highland sandstone NA NA	 Midnite vein disseminated NA NA	 various sandstone NA NA	El Mesquite, various sandstone NA NA
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 ISL NA NA	 OP NA NA	 ISL NA NA	 ISL NA NA
Processing plant (Acid/ Alkaline): • Type (IX/SX/AL) • Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour) • Average process recovery (%)	 ISL NA NA	 AL/SX 410 NA	 ISL NA NA	 ISL NA NA
Nominal production capacity (tU/year)	770	200	380	230
Plans for expansion	unknown	unknown	unknown	unknown
Other remarks	none	none	closed indefinitely	in restoration

Uranium production centre technical details
(as of 1 January 2001)

	Centre # 9	Centre # 10	Centre # 11	Centre # 12
Name of production centre	Irigaray	Kingsville Dome	New Wales	Plant City
Production centre class	existing	existing	existing	existing
Operational status	shut down	standby	shut down	shut down
Start-up date	1978	1988	1980	1981
Source of ore • Deposit names • Deposit type(s) • Reserves (active resources) • Grade (% U)	 Irigaray sandstone NA NA	 Kingsville Dome sandstone NA NA	 NA phosphorite NA NA	 NA phosphorite NA NA
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 ISL NA NA	 ISL NA NA	 OP NA NA	 OP NA NA
Processing plant (Acid/ Alkaline): • Type (IX/SX/AL) • Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour) • Average process recovery (%)	 ISL NA NA	 ISL NA NA	 DEPA/TOPO NA NA	 DEPA/TOPO NA NA
Nominal production capacity (tU/year)	130	500	290	230
Plans for expansion	unknown	unknown	unknown	unknown
Other remarks	in restoration	closed indefinitely	closed permanently	closed permanently

Uranium production centre technical details
(as of 1 January 2001)

	Centre # 13	Centre # 14	Centre # 15	Centre # 16
Name of production centre	Rosita	Shootaring	Smith Ranch	Sunshine Bridge
Production centre class	existing	existing	existing	existing
Operational status	shut down	standby	in operation	shut down
Start-up date	1990	NA	1986	1981
Source of ore • Deposit names • Deposit type(s) • Reserves (active resources) • Grade (% U)	 Rosita (Rogers) sandstone NA NA	 Various sandstone NA NA	 Smith Ranch sandstone NA NA	 NA phosphorite NA NA
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 ISL NA NA	 UG NA NA	 ISL NA NA	 OP NA NA
Processing plant (Acid/ Alkaline): • Type (IX/SX/AL) • Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour) • Average process recovery (%)	 ISL NA NA	 AL/SX 680 NA	 ISL NA NA	 DEPA/TOPO NA NA
Nominal production capacity (tU/year)	380	750	770	160
Plans for expansion	unknown	unknown	unknown	unknown
Other remarks	closed permanently	none	none	closed permanently

Uranium production centre technical details
(as of 1 January 2001)

	Centre # 17	Centre # 18	Centre # 19	Centre # 20
Name of production centre	Sweetwater	Uncle Sam	West Cole	White Mesa
Production centre class	existing	existing	existing	existing
Operational status	standby	shut down	shut down	standby
Start-up date	1981	1978	1981	1980
Source of ore • Deposit names • Deposit type(s) • Reserves (active res.) • Grade (% U)	Green Mountain, various sandstone NA NA	NA phosphorite NA NA	Various sandstone NA NA	Various breccia pipe; sandstone NA NA
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	UG NA NA	OP NA NA	ISL NA NA	UG NA NA
Processing plant (Acid/ Alkaline): • Type (IX/SX/AL) • Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour) • Average process recovery (%)	AL/SX 2 720 NA	DEPA/TOPO NA NA	ISL NA NA	AL/SX 1 810 NA
Nominal production capacity (tU/year)	350	290	80	1 650
Plans for expansion	unknown	unknown	unknown	unknown
Other remarks	none	closed permanently	in restoration	None

UG: Underground mine(s).

OP: Open pit mine(s).

AL/SX: Acid leach/solvent extraction (process).

ISL: *In situ* leach mine(s).

IX: Ion exchange technology.

DEPA/TOPO: After Di 2-Ethylhexyl Phosphoric Acid and Tri-n-Octyl Phosphine Oxide, two extractants used to strip uranium from the phosphoric acid product during the production process.

NA: Not available.

tU/year: Tonnes of U per year, rounded to nearest 10 tonnes.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Overview

Mill tailings, and particularly their contained radionuclides, are a major source of environmental impact to air, soil, surface water and groundwater. In the United States, a growing appreciation of the extent and severity of damages that had accumulated in the natural environment resulting from ineffective regulatory oversight in governing mine discharges, hazardous waste disposal, and unreclaimed mining sites, led to the passage, beginning in the 1970s, of several US Federal and State laws designed to protect air, water, and land resources. Environmental effects traceable to uranium extraction and beneficiation can include the direct disturbances in the natural surface environment, radionuclides present in the waste products from mines and mills, increased surface-water runoff from mined areas, erosion by wind and water, and contamination of nearby groundwater reservoirs.

In the United States, uranium ores were processed at mills during the 1940s to produce concentrate for Government requirements during World War II and also from 1947 through 1970 under the US Atomic Energy Commission's uranium procurement programme. The large amounts of mill tailings that accumulated at these mill sites contained hazardous chemicals from the milling operations as well as the ore-processing waste materials. The radioactivity remaining in the waste materials after recovery of the uranium values is about 85% of the radioactivity of the original ore mill feed.

In 1971, the Subcommittee on Raw Materials of the Joint Committee on Atomic Energy heard testimony on the dangers and inherent public health threat from the use of uranium mill tailings materials for construction at civilian sites, which later became known as vicinity properties. As a result of these hearings, the Congress authorised a Federal programme to co-operate with the State of Colorado for removal of tailings from sites and structures in the Grand Junction, Colorado, area. The Government paid 75% of the cost and the State paid the remainder.

In 1974, the Congress directed an assessment of problems associated with uranium mill tailings at 22 inactive sites. The Uranium Mill Tailings Radiation Control Act (UMTRCA) was passed in late 1978. The act assigned responsibilities to three Federal agencies: the Environmental Protection Agency (EPA), the US Department of Energy (DOE), and US Nuclear Regulatory Commission (NRC). The EPA was directed to establish standards for cleanup and disposal of contaminated material from both inactive and active uranium processing sites. After taking into account the economic cost of implementing new standards and considering public health, safety, and the environment, the EPA formulated standards to limit the release of radon gas into the environment and required that any disposal methods be designed to control radiological hazards "for up to 1 000 years, to the extent achievable, and in any case for at least 200 years".

The UMTRCA legislation authorised identification of additional mill tailings sites, and two such sites were later designated. Title I of the act covers sites that were already inactive at the time the legislation was enacted, and Title II covers cleanup of sites that were then still active.[1] Under the act,

1. Title I mills were operated to meet uranium requirements of the Federal Government from 1947-1970. The objective of the US Department of Energy (DOE) is to clean up "the current waste inventory within the DOE nuclear weapons complex by the year 2019".

the DOE was required to cleanup all Title I sites to EPA's standards: this involved the Title I sites[2] and the vicinity properties contaminated by the spread of hazardous radioactive materials by wind, water, and human intervention.[3] In some cases, where tailings piles were exposed to weather, groundwater became contaminated due to the effects of rain and snowmelt. The act created a plan of Federal and State co-operation under which the Government and the states, wherein Title 1 sites are located, would co-operate for cleaning up the sites. The cost for cleanup activities at Title I sites was borne mainly by the DOE, and affected states contributed up to 10 % of the actual cost for sites located within their borders. The DOE and State, with NRC concurrence, selected the cleanup method and oversaw the cleanup work. The Federal Government was responsible for the cost of cleanup for sites located on tribal lands.

NRC, working with EPA, was required to establish regulations governing the control and cleanup of the mill tailings and land at Title II sites. These sites are licensed by NRC or by the state in which they are located. NRC's regulations are to conform with and implement and enforce EPA's general standards. UMTRCA requires that the expense for cleaning up the Title II sites be borne primarily by the firms that own and operate those sites. Under UMTRCA, the Federal Government becomes the long-term custodian for all sites cleaned up under Title I. For sites reclaimed under Title II, the host State can elect to become the long-term custodian: otherwise the Federal Government is to assume that responsibility.[4] Before the Federal Government takes custody to Title II sites, NRC also is responsible for making financial arrangements with the site owners/operators so as to assure that sufficient funds will be available to cover the costs of any necessary long-term monitoring and ongoing routine maintenance for remediated sites. The DOE will ultimately be responsible for costs of long-term surveillance and maintenance of Title I low-level radioactive waste disposal sites, but it will not be financially responsible for those activities at Title II sites once custody is transferred. At year-end 1999, DOE, under the Long-Term Surveillance and Monitoring Programme (LTSM), had custody of 25 low-level radioactive waste disposal sites and was responsible for surveillance, monitoring, and maintenance. By 2006, about 50 such low-level radioactivity sites from various reclamation programmes are projected to be included in the LTSM programme.[5]

Cleanup of surface contamination involves four key steps: (1) identify, or characterise, the type and extent of contamination, (2) obtain a disposal site for contaminated materials, (3) develop a decommissioning plan that prescribes the cleanup method and specifies design requirements, and (4) carry out the cleanup according to specifications and regulations as appropriate.

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2. Under Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), the DOE in 1979 set up its Uranium Mill Tailings Remediation Action project (UMTRA) to manage cleanup and disposal of the tailings at 22 inactive sites throughout the United States. Two more mill tailings sites were added later. Through UMTRA, DOE co-ordinated the cleanup work with affected states, Indian tribes, and local governments. The State of North Dakota later requested that the DOE remove two Title I sites located in that State: the sites were thought to pose very small risk to the public and the environment, and State funding as well as public support for cleaning up the North Dakota sites were limited. The North Dakota sites were removed, without cleanup, from the list of Title I sites by the Secretary of Energy in 1997, after DOE prepared an Environmental Assessment and Finding of No Significant Impact in compliance with the National Environmental Policy Act.

3. Overall, 5 335 vicinity properties were cleaned up under the UMTRA programme.

4. "Long-Term Surveillance and Maintenance Program, 1998 Report", US Department of Energy, Grand Junction Office, Grand Junction, Colorado, March 1999, (p 5).

5. "Long-Term Surveillance and Maintenance Program, 1998 Report", US Department of Energy, Grand Junction Office, Grand Junction, Colorado, March 1999, (p 6).

Based on assessments undertaken to detail the potential risks to public health from tailings, the DOE in 1979 established a cleanup priority for Title I sites, ranking them as high, medium, or low. The rankings determined the order in which cleanup would be performed at the sites, but it did not prevent start up of work on lower priority sites before all higher priority sites were completed. All sites, regardless of risk ranking or cleanup priority, were required to be cleaned up to EPA-established standards.

In 1980, Congress established a different method of setting cleanup priorities. Under the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA), or "Superfund," potentially hazardous sites are screened to identify those with contamination and risk sufficient to warrant including them on the National Priorities List.[6] On the list are sites that present the most serious threats to public health and the environment. Under Superfund, the generators of hazardous wastes and waste transporters, in addition to site owners/operators, are potentially responsible for either cleaning up the site or reimbursing the Federal Government for the costs of the remedial activities. The DOE, however, was required to reimburse, up to a maximum limit for all Title II sites, the owners/operators for the costs of remediation attributable to mill tailings generated as a result of uranium sales to the United States.

CERCLA created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Over five years, USD 1.6 billion was collected and the tax went to a fund for cleaning up abandoned or uncontrolled hazardous waste sites. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites; provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for clean up when no responsible party could be identified. This law was and currently is being used for clean up of abandoned uranium mines.

Applicable EPA standards under UMTRCA are contained in "Health and Environmental Protection Standards for Uranium and Uranium Mill Tailings," Code of Federal Regulations, 40 CFR Part 192. The NRC is responsible for issuing operating licenses under "Domestic Licensing of Source Material," 10 CFR Part 40. It requires that each operating license contain provisions covering the decontamination, decommissioning, and reclamation of the licensed facility. The actions that the licensee must take pertaining to site decommissioning are described in the license document as issued to the facility operator. The operating-license applicant must submit to the NRC or the agreement State[7], a Generic Environmental Impact Statement (GEIS) that covers all aspects for construction and operation of the facility and describes provisions for reclamation of the site and its waste materials.

Surety for site remediation

On approval of the proposed decommissioning plan by the NRC or State, the licensee must also provide a surety to guarantee that funds required to reclaim the site will be available to complete site restoration work to standards established by Federal and State regulations, with the assumption that a third party might be required to do the work if the licensee is unable to complete the task. The NRC or State and the licensee must agree on the estimated cost for decommissioning work. The surety amount

6. Uranium mill tailings being cleaned up by DOE under Title I of UMTRCA are exempt from Superfund.

7. Three states, Colorado, Texas, and Washington, under agreement with the US Nuclear Regulatory Commission (NRC), elected to operate state-level programmes for regulating uranium production facilities within their borders. All regulations adopted and applied by a State must conform to those of the NRC, which is authorised to review all such regulations.

must cover a number of activities, such as plant decommissioning, tailings reclamation, groundwater restoration, well-field closure, surface decontamination, revegetation, and long-term monitoring. Contaminated equipment and structures must be crushed and disposed of along with contaminated soil residues in a licensed disposal area. The cost estimate and surety must include a fee set by the NRC or the agreement State for funds necessary for the long-term surveillance and monitoring of the site to protect public health and safety. As of 31 December 1999, the US uranium industry had committed over USD 235 million to surety. For each license, the surety is reassessed annually to accommodate inflation and to take into account decommissioning work completed up to that time.

In addition to the UMTRCA and CERCLA legislation, the statutes and associated regulations established to provide environmental controls over reclamation of uranium recovery facilities include the Clean Water Act (CWA), as amended (33 USC 1251 *et seq*); the Clean Air Act (CAA), as amended (42 USC 7401 *et seq*); The Safe Drinking Water Act (SDWA), as amended (42 USC 300 (f) *et seq*); and the Atomic Energy Act (AEA) (42 USC 2021 *et seq*), as amended by the Uranium Mill Tailings Radiation Control Act (UMTRCA) (72 USC 7901 *et seq*). For clean-up of facilities which meet certain ranking criteria due to their potential hazard to the public and the environment, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 USC. 9601 *et seq.*) is controlling.

The CWA gives EPA the authority to impose effluent limits, via permits, on point-source discharges, including those from active uranium extraction and beneficiation sites, to waters of the United States. It also gives EPA the authority to regulate storm water discharges from both inactive and active mine sites through permits.

The CAA gives EPA authority to regulate emissions of both "conventional" pollutants, like PM_{10} (particulate matter less than 10 microns) and hazardous pollutants such as radon. Both are air pollutants emitted by uranium extraction and beneficiation activities. The Underground Injection Control (UIC) programme was established under the authority of the Safe Drinking Water Act. This programme established a permit system to assure that underground sources of drinking water are protected and that the injection of process fluids and liquid wastes, including those from uranium extraction and beneficiation, into the subsurface via such wells will not contaminate potable water reservoirs.

Authority for State agency regulation of uranium extraction and beneficiation activities comes from federally delegated programmes and State statutory authority. Federal programmes that apply to uranium extraction and beneficiation activities and that can be delegated to States include the UIC programme, the National Pollutant Discharge Elimination System (NPDES) programme, and NRC licensing and radiation protection regulations. In order for a State to administer any or all of these Federal programmes, the State must have requirements that are equally as stringent as the respective Federal programmes.

Current regulations: uranium mines

The NRC, like the AEC from which it was created, does not interpret its regulatory authority as encompassing underground or open pit uranium mines. In similar fashion, The Office of Surface Mining (OSM) in the US Department of the Interior (DOI) excludes itself from the regulation of uranium mines and focuses rather on standards and regulations for cleanup of coal mines. The individual States carry out the enforcement of most regulations that pertain chiefly to mining activities. Under regulations and standards developed for cleanup of active and abandoned coal mines nationwide, a fee is assessed per ton of coal mined to establish a fund for use in reclamation of abandoned coal mines and for the closure of hazardous mine openings left from other mining operations. The funds are derived from coal mining operations, and most of the reclamation effort has been on coal mines and on metal mines other than uranium mines. States that have successfully restored their legacy of abandoned coal mines can use the remaining funds to cleanup other abandoned hard-rock mines, including uranium mines. This approach was used in Wyoming and, under an agreement with the OSM, is now being used by The Navajo Nation government in Arizona. Colorado and Wyoming have active state mining programmes that reflect their significant mineral and coal resources and mining industries. For example, State laws in Wyoming have been effective in encouraging phased open pit operations and associated reclamation activities. Colorado also has an abandoned mines law and a fund for reclamation work.

Mines on Federal land also may be subject to requirements established by the Bureau of Land Management (BLM), Department of Interior, or to requirements specified under terms of lease agreements, such as those applicable to mineral leases on Indian lands. The Federal Land Policy and Management Act of 1976 (Public Law 94-579) provides the basis for BLM control of mining lands. Regulations as promulgated in 43 CFR Part 3809, "Surface Management", are designed to protect Federal lands from degradation. These regulations primarily apply in cases where the surface disturbance covers an area over five acres (2.02 ha).

Larger operations require a pre-approved operating plan, but existing mines can continue to operate while plans are being developed and approved. The regulations are general in scope and do not pre-empt State laws regarding mining properties. Where the State and BLM regulations may overlap or result in contradictory implementation, the State and BLM must reach agreement by reconciling differing interpretations while still protecting the environment.

For open pit mines, the principal environmental concerns involve the excavations and associated waste piles. Such mine pits may require backfilling, or their pit walls may have to be reshaped to eliminate steep high slopes. Waste piles may have to be contoured to a more natural shape that will enhance successful revegetation. Other than a mandatory requirement to close shafts and mine openings, underground mines generally have few reclamation requirements. For open pit uranium mines, reclamation costs can be substantial. For example, one uranium mining company reported that it cost about USD 35 million to backfill and reshape its pits in the Powder River Basin area of Wyoming.

Reclamation of mined areas includes returning the landscape to its original condition. Overburden materials must be returned to mined-out pits and any remaining waste-rock piles contoured to blend with the local terrain. The disturbed site then must be covered with original topsoil (which has been stored separately) for reseeding as necessary to establish vegetation. To enhance its long-term survival, the vegetation selected should be indigenous to the area. After satisfactory completion of site remediation by the licensee, the surety is released, and title to the site (including tailings) passes to the DOE or the appropriate State agency that assumes responsibility for long-term monitoring and care of the site.

Costs of environmental management after closure

Costs of environmental management after closure consist primarily of reclamation and monitoring costs. For uranium mills, these costs include mill decontamination and demolition, long-term tailings stabilisation, and ground water remediation. For mines, the reclamation costs incurred cover partial backfilling of pits, stabilisation of waste rock piles, recontouring the disturbed land surfaces, and revegetation. Monitoring is a post-closure cost for both mills and mines.

In the United States, the total cost for surface cleanup of 22 former uranium ore processing sites designated as Title I sites under the Uranium Mill Tailings Remedial Action Project (UMTRA) was reported to be USD 1.476 billion [8, 9]. Not included in this amount is the cost for groundwater cleanup at the Title I sites, which DOE estimated in 1995 would cost an additional USD 147 million above the surface cleanup cost with completion of the groundwater cleanup work projected for 2014. Surface cleanup of the Title II sites is in progress, and at the end of 1999, the total cost estimated for work already completed at these sites was about USD 600 million. Also in 1999, it was estimated that the costs for surface cleanup completed at 22 major uranium mining sites in the United States was about USD 300 million. The costs incurred to date under the OSM Abandoned Mines programme for surface cleanup of abandoned uranium mine properties that is administered by several states have not been tabulated.

URANIUM REQUIREMENTS

Annual uranium requirements for the period 2001 through 2020 are projected to peak in 2010 at 19 740 tU (high case). Requirements are projected to decline to about 15 940 tU (high case) in 2015. For 2020, the projected requirements (high case) total 17 860 tU, in line with the anticipated closings of some nuclear power plants.

Supply and procurement strategy

The United States does not have a national policy on uranium supply or on procurement. Decisions about uranium production, supply, and sales and purchases are made solely in the private sector by firms involved in the uranium mining and nuclear power industries.

Installed nuclear generating capacity to 2020
(MWe net)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
97 480	97 480	97 480	90 620	96 860	65 570	94 250	55 300	88 530

Annual reactor-related uranium requirements to 2020
(tonnes U)

2000	2001	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
20 570	18 420	18 670	17 440	19 740	11 510	15 940	12 150	17 860

In the United States, no additional nuclear reactors were permanently shut down during 2000. The table below provides a history of reactor closings in the United States.

8. The cost stated in this section represents amounts for the years in which the costs were incurred and have not been adjusted to current dollars.

9. "UMTRA Project, Uranium Mill Tailings Remedial Action Surface Project, 1979-1999, End of Project Report", DOE/AL/62350-500, Prepared by Jacobs Engineering Group, Inc., Albuquerque, NM, for the US Department of Energy, Environmental Restoration Division, Albuquerque, NM, May 1999 (p. 109).

United States

US Formerly Licensed commercial nuclear power reactors

Reactor name	Type	Power Mega-watts thermal	State	Dates of operation
GE VBWR	BWR	50	CA	1957-1963
Hallam	SCGM	240	NE	1962-1964
Picqua	OCM	46	OH	1962-1966
CVTR	PTHW	64	SC	1962-1967
Pathfinder	BWR	190	SD	1964-1967
Bonus	BWR	50	PR	1964-1968
Elk River	BWR	58	MN	1962-1968
Fermi 1	SCF	200	MI	1963-1972
Indian Point 1	PWR	615	NY	1962-1974
Peach Bottom 1	HTG	115	PA	1966-1974
Humboldt Bay	BWR	200	CA	1962-1976
Dresden 1	BWR	700	IL	1959-1978
Three Mile Island 2	PWR	2 770	PA	1978-1979
Shippingport	PWR	236	PA	1957[a]-1982
La Crosse	BWR	165	WI	1967-1987
Fort St. Vrain	HTG	842	CO	1973-1989
Rancho Seco	PWR	2 772	CA	1974-1989
Shoreham	BWR	2 436	NY	1989-1989
San Onofre 1	PWR	1 347	CA	1967-1992
Yankee Rowe	PWR	600	MA	1963-1992
Trojan	PWR	3 411	OR	1975-1993
Connecticut Yankee	PWR	1 825	CT	1964-1997
Maine Yankee	PWR	2 440	ME	1963-1997
Millstone 1	BWR	2 311	CT	1986-1998
Zion 1	PWR	1 040	IL	1973-1998

a Reactor began power operation with first core

VBWR	Vallecitos boiling water reactor	BWR	Boiling water reactor
SCGM	Sodium cooled, gas moderated (reactor)	OCM	Organic cooled and moderated (reactor)
PTHW	Pressure tube, heavy water moderated (reactor)	SCF	Sodium cooled fast (reactor)
PWR	Pressurised water reactor	HTG	High temperature, gas cooled (reactor)

NATIONAL POLICIES RELATING TO URANIUM

Since 1991, the United States has restricted uranium imports from the former Soviet Union republics. At the end of 1998, agreements were in place with Kazakhstan, Kyrgyzstan, Russia, and Uzbekistan to limit imports from those republics in exchange for a suspension of the antidumping investigations by the US Department of Commerce (DOC).

The original suspension agreement with Russia had required that under a specific quota, an import of Russian-origin uranium or separative work units (SWU) in a US market transaction must be matched with a quantity of newly produced US-origin uranium or SWU. The previous ratio had been 1:1 for US- to Russian-origin natural uranium. In January 2000, the DOC and Minatom signed an amendment to the Russian suspension agreement whereby, under a matched sales contract, the annual share of Russian-origin natural uranium in matched sales was to be allowed up to 10 million pounds (annual maximum) U_3O_8 equivalent. The new amendment would allow up to 2.5 pounds (or kgU) of Russian-origin natural uranium to be matched with 1 pound (or kgU) of newly produced US-origin uranium. Furthermore, submission of matched-sales contracts to DOC for confirmation with suspension agreement provisions will no longer be required. The new amendment allows Minatom or its representative to notify DOC of a new contract and provide the new contract's key terms.

In early 1999, Kazakhstan requested termination of its uranium import suspension agreement. As a result of the required subsequent case review, a negative determination for Kazakhstan was issued in July 1999. In August 1999, a further review was undertaken by the US Government to determine whether termination of the suspension investigations on uranium from Russia and Uzbekistan and revocation of the antidumping duty order on uranium from Ukraine would likely lead to continuation or recurrence of material injury.

This review led in August 2000 to the determination that termination of the suspended investigation on uranium from Russia would be likely to lead to continuation or recurrence of material injury in the United States and that revocation of the antidumping duty orders on uranium from Ukraine and on uranium from Uzbekistan would not be likely to lead to continuation or recurrence of material injury to an industry in the United States within a reasonably foreseeable time.

In January 2001, the International Trade Commission determined there was reasonable indication that an industry in the United States was threatened with material injury due to imports of LEU that are alleged to be subsidised and to be sold in the US at less-than-fair-value. The subject LEU was from France, Germany, the Netherlands, and the United Kingdom. In 2001, the US Department of Commerce (DOC) released its preliminary determination for subsidies and antidumping margin rates for LEU imported from France and the United Kingdom. The DOC's Final Determination was issued on 14 December 2001, and the ITC Final Determination is expected on 18 January 2002. The DOC also determined that the subject LEU imported into the United States from Urenco of Germany and The Netherlands was not sold at below-fair-market value and is not subject to duty. The applicability of anti-dumping laws on such imports and the standing of the petition are being contested by the exporting countries and the European Commission.

URANIUM STOCKS

At the end of 2000, total commercial stocks of uranium (natural and enriched uranium equivalent) were about 43 210 tU, representing a decrease of 12% below the level at the end of 1999, 48 680 tU.

Utility stocks held at year end 2000, about 21 500 tU, were 4% less than at year-end 1999, 22 370 tU and supplier stocks at year end 2000, about 21 720 tU, were 18% below the 1999 level of 26 480 tU. Enriched uranium stocks reported by suppliers at year end 2000, about 16 860 tU, were 11% above year end 1999 level of about 15 150 tU, and enriched uranium held by utilities, 7 280 tU were about 40% above the 1999 level. Uranium stocks held by the US Government at the end of 2000, about 20 410 tU, were unchanged from the 1999 level. It held no stocks of enriched uranium at the end of 2000. Note that the totals for commercial stock inventories for 2000 include stocks held by the US Enrichment Corporation.

Total uranium stocks*
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	20 410	0	NA	NA	20 410
Producer	4 850	16 860	NA	NA	21 720
Utility	14 220	7 280	NA	NA	21 500
Total	39 480	24 140	NA	NA	63 620

* Totals are rounded to the nearest 10 tonnes U. Totals might not equal sum of components because of independent rounding.

URANIUM PRICES

Average US uranium prices, 1991-2000
(USD per kilogram U equivalent)

Year	Domestic utilities from domestic suppliers	Domestic utilities and suppliers from foreign suppliers
2000	29.77	25.88
1999	30.90	27.42
1998	31.99	29.08
1997	33.46	30.69
1996	35.91	34.19
1995	28.89	26.52
1994	26.79	23.27
1993	34.17	27.37
1992	34.96	29.48
1991	35.52	40.43

Note: Prices shown are quantity-weighted averages (nominal US dollars) for all primary transactions (domestic- and foreign-origin uranium) for which prices were reported. The transactions can include US-origin as well as foreign-origin uranium.

• Uzbekistan •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration in Uzbekistan pre-dates the 1945 start-up of uranium mining at the small vein deposits (Shakaptaz, Uiguz Sai, and others) in the Fergana valley of eastern Uzbekistan. Exploration, including airborne geophysical surveys, ground radiometry, underground workings, etc., conducted during the early 1950s, over the remote Kyzylkum desert in central Uzbekistan, led to the discovery of uranium in the Uchkuduk area. Drilling confirmed the initial discovery and development of the first open pit mine at Uchkuduk began in 1961.

Following development of a model for uranium deposits hosted by unconsolidated oxidised Meso-Cenozoic sediments, core drilling and a range of geophysical bore hole logging methods became the main exploration tools for exploring the sedimentary environment. Based on the knowledge of the deposit characteristics and using the improved drilling techniques, large areas in the Karakata depression located in the Bukinai area and the southern rim of the Zirabulak-Ziaetdin mountains were explored. This led to the discovery of major sandstone uranium deposits including Severny (Southern), Bukinai, Sabyrsai, Yuzhny (Northern) Bukinai, Sugraly, Lavlakan, and Ketmenchi. In addition, exploration for uranium deposits in metamorphic schists in the Auminzatau and Altyntau areas started in 1961. This resulted in the discovery of the Rudnoye and Koscheka U-V-Mo deposits.

Development of the *in situ* leach (ISL) mining technique for recovery of uranium from sandstone deposits in the early 1970s led to a re-evaluation of previously ignored deposits including Lavlakan and Ketmenchi, and to an increase in exploration efforts in the sedimentary environments of the Kyzylkum desert.

Exploration was concentrated in the northwestern Nuratau mountains and the southeastern part of the Zirabulak-Ziaetdin mountains. The discoveries made in these areas include the Alendy, Severnyi and Yuzhny (South) Kanimekh deposits (Nuratau mountains) and the Shark and Severny (North) Maizak deposits (Zirabulak-Ziaetdin mountains). Recognition of the polymetallic nature of the sandstone uranium deposits led to the recovery of selenium, molybdenum, rhenium and scandium as by-products during ISL processing.

Since 1994, the Navoi Mining and Metallurgical Complex (NMMC) has funded all uranium exploration activities in Uzbekistan. Uranium exploration is the responsibility of two organizations. Exploration within and around known deposits is the responsibility of the geological divisions of the producing companies. The search for new deposits is carried out by the State Geological Company Kyzyltepageologia. However, since the early 1990s, exploration drilling has been limited to the delineation of known deposits and the search for extensions of known deposits.

Recent and ongoing uranium exploration and mine development activities

Between 1997 and 2000, Kyzyltepageologia evaluated the known resources (RAR and EAR-I) of the Kendiktyube, Severniy Kanimeh, Tokhumbet and Ulus deposits. A portion of the resources of these deposits were turned over to NMMC. Kyzyltepageologia will, however, continue to explore on the flanks of these three deposits. In addition, evaluation of the Yangy site of the Tutly deposit has begun.

The following table provides statistical data on uranium exploration and development between 1998 and 2000. It includes the activities and expenditures of both the industrial organisation NMMC and the State Geological Company Kyzyltepageologia.

Uranium exploration and development expenditures and drilling statistics

	1998	1999	2000	2001 (expected)
Exploration expenditures (UZS × 1000)*	543 866	659 690	940 824	1 402 380
Development expenditures (UZS × 1000)	1 180 784	1 587 091	2 328 326	3 324 183
Total expenditures (UZS × 1000)	1 724 650	2 246 781	3 269 150	4 726 563
Total expenditures (USD million)	19.652	19.392	14.152	6.850
Exploration surface drilling (m)	183 525	207 633	217 804	249 920
Development surface drilling (m)	347 871	355 650	385 887	380 000
Number of exploration boreholes	929	991	1 165	1 369
Number of development boreholes	1 728	1 973	1 988	1 900
Total surface drilling (m)	**531 396**	**563 283**	**603 691**	**629 920**
Total number of boreholes	**2 657**	**2 964**	**3 153**	**3 269**

* The exploration statistics include expenditures incurred by NMMC and Kyzyltepageologia and activities undertaken by both organizations.

URANIUM RESOURCES

All of Uzbekistan's significant resources are located in the central Kyzylkum area, comprising a 125 km-wide belt extending over a distance of about 400 km from Uchkuduk in the northwest, to Nurabad in the southeast. The deposits are located in four districts: Bukantausky or Uchkuduk, Auminza-Beltausky or Zarafshan, West-Nuratinsky or Zafarabad, and Zirabulak-Ziaetdinsky or Nurabad.

Uzbekistan's uranium resources occur in sandstone and breccia complex deposits. The sandstone deposits are located in Mesozoic-Cenozoic depressions filled with up to 1 000 m of clastic sediments of Cretaceous, Paleogene and Neogene age. The uranium is concentrated as rollfronts (bed oxidation zones) in sandstone and gravel units. The mineralisation consists of pitchblende and sooty pitchblende with minor coffinite. Average ore grades vary between 0.026 and 0.18% U. Associated elements include selenium, vanadium, molybdenum, rhenium, scandium and lanthanoides in potentially commercial concentrations. The depth of the ore bodies is between 50 and 610 m. Twenty-five uranium deposits belonging to this type are reported (see map), many of which are amenable to ISL extraction techniques.

The breccia complex deposits are hosted by metamorphosed and tectonically deformed black carbonaceous and siliceous schists of Precambrian to Lower Paleozoic age. Mineralisation includes uranium-vanadium-phosphate ores. The average uranium grade is between 0.06 and 0.132%, associated with up to 0.024% Mo, 0.1-0.8% V, 68 g Y/tonne and 0.1-0.2 g Au/tonne. The ore bodies occur at depths ranging from 20 to 450 m. There are 5 deposits of this type, most of which could be mined by open pit and processed by heap leaching.

Known conventional resources (RAR & EAR-I)

As of 1 January 2001, known uranium resources (RAR & EAR-I) recoverable at costs below USD 130/kg U total 172 065 tU, an increase of 41 987 tU compared to the 1999 Red Book. Of the known resources, 125 000 tU occur in sandstone deposits and 47 000 tU in breccia complex deposits. Allocation of known resources by cost category and deposit type is as follows:

Deposit type	**<USD 40/kgU** (tonnes U)	**USD 40-USD 130/kg U** (tonnes U)
Sandstone	100 800	24 200
Breccia Complex	36 000	11 000
Total	136 800	35 200

Resources distribution by cost category and uranium district is summarised in the following tables. Uzbekistan reported its resources in all categories as *in situ* resources. It did, however, advise the Secretariat that it typically assumes mining and processing losses of 30% in converting from *in situ* to recoverable resources.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
90 076	90 076	115 351

* As *in situ* resources.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
46 804	46 804	56 714

* As *in situ* resources.

Known conventional resources and undiscovered conventional resources*
(tonnes U)

Uranium ore region	Deposit types	Category	
		RAR & EAR-I	EAR-II & SR
Bukantausky (Uchkuduk)	Sandstone	19 379	32 968
	Breccia complex	33 132	11 234
TOTAL Bukantausky		**52 511**	**44 202**
Auminza-Beltausky(Zarafshan)	Sandstone	41 504	47 744
	Breccia complex	13 892	42 660
TOTAL Auminza-Beltausky		**55 396**	**90 404**
West-Nuratinsky (Zafarabad)	Sandstone	51 762	46 773
	Breccia complex	0	0
TOTAL West-Nuratinsky		**51 762**	**46 773**
Zirabulak-Ziaetdinsky (Nurabad)	Sandstone	12 396	50 141
	Breccia complex	0	0
TOTAL Zirabulak-Ziaetdinsky		**12 396**	**50 141**
	Sandstone	125 041	177 626
	Breccia complex	47 024	53 894
Total		**172 065**	**231 520**

* As *in situ* resources.

Undiscovered conventional uranium resources (EAR-II & SR)

Undiscovered resources are estimated to total 229 567 tU, of which 84 959 tU are EAR-II recoverable at costs of less than USD 130/kg U, while the remaining 144 608 tU are SR unassigned to any cost category. Of the total undiscovered resources, nearly 80% are assigned to sandstone uranium deposits and are nearly equally divided among the four uranium districts: Bukantausky (Uchkuduk), Auminza-Beltausky (Zarafshan), West-Nuratinsky (Zafarabad) and Zirabulak-Ziaetdinsky (Nurabad). The best potential for breccia complex deposits is thought to be in the Auminza-Beltausky (Zarafshan) district. Ore depths and characteristics are expected to be similar to known resources.

Estimated additional resources – Category II*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
56 306	56 306	84 959

* As *in situ* resources.

Speculative resources*
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
0	144 608	144 608

* As *in situ* resources.

URANIUM PRODUCTION

Historical review

Uranium production in Uzbekistan began in 1946 at several small volcanic hosted vein deposits in the Fergana valley and Kazamazar uranium district. The mines are no longer in operation and the deposits are depleted. The ore was processed in the Leninabad uranium production centre in Tajikistan.

Commercial uranium mining began at Uchkuduk in 1958 with the development of both open pit and underground mines. The ore was stockpiled until the completion in 1964 of the hydrometallurgical uranium processing plant in Navoi, located some 300 km southeast of Uchkuduk. The mill and all mines have been operated by the NMMC. ISL experiments conducted at the Uchkuduk deposit started as early as 1963, leading to the commercial application of ISL in 1965.

Conventional underground mining operations started at the Sabyrsaj and Sugraly deposits in 1966 and 1977, respectively. In 1975, ISL extraction began to replace the underground mining of the Sabyrsaj mine, and conventional underground mining at Sabyrsaj was stopped in 1983. The Ketmenchi ISL plant began operation in 1978. In 1994, reduction of uranium demand led to the closure of the open pit Uchkuduk mine as well as both the underground and ISL Sugraly mines.

Status of production capability

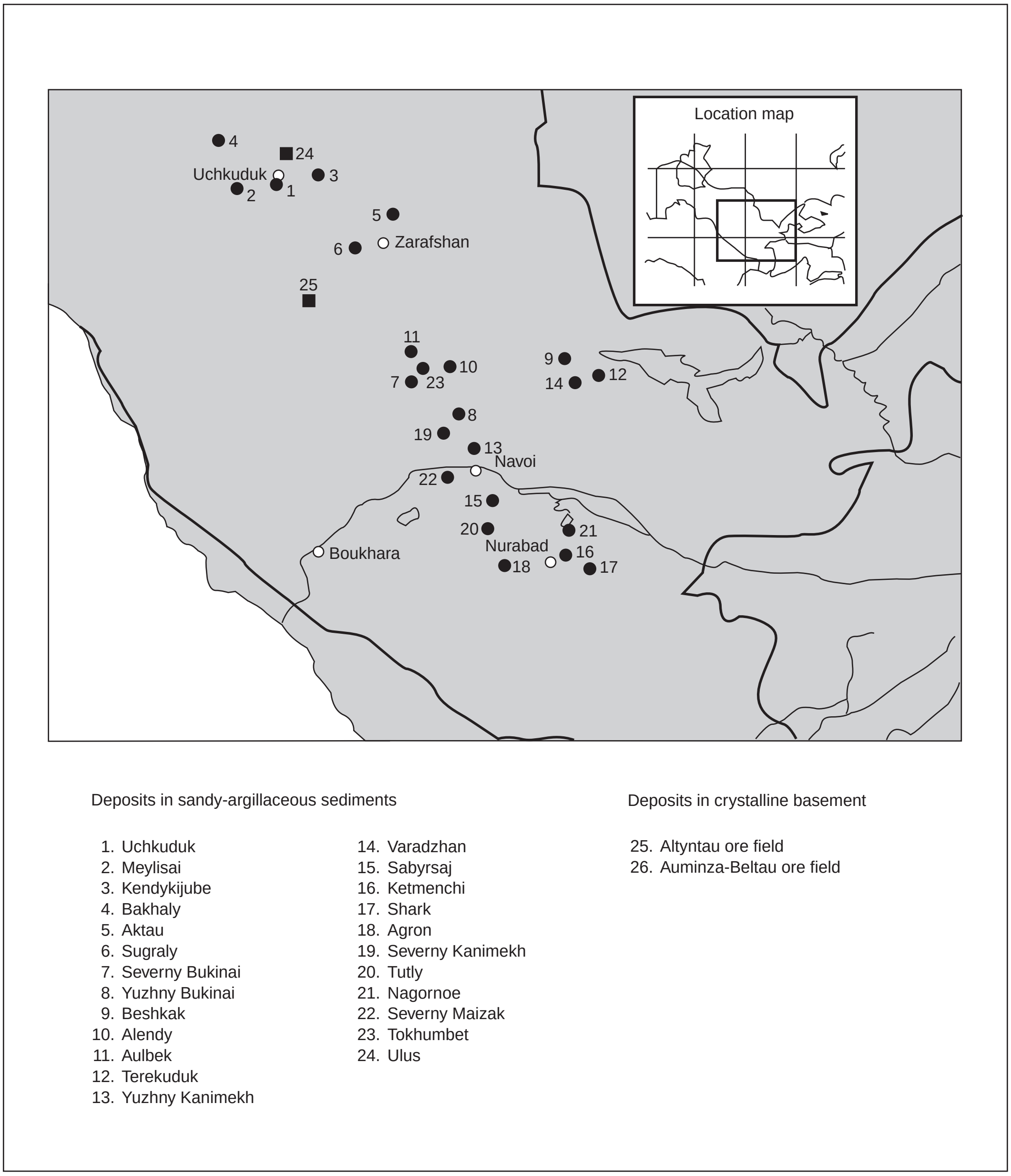
Since 1994, NMMC has been producing uranium using only ISL technology. Operating and planned facilities in 2001-2002 are located at ISL centres which are organised in three NMMC divisions. They are referred to as: “Northern Mining Division”, located in Uchkuduk, with the Uchkuduk and Kendyktube centres; as “Southern Mining Division” in Zafarabad with Sabyrsaj, Shark, Ulus and Ketmenchi, and as “Mining Division No. 5” in Nurabad with Severny (North) Bukinai, Yuzhnyi (South) Bukinai, Lyavlyakan and Beshkak. The available technical details of the production centres of the three active mining divisions, as well as those of the inactive “Eastern Mining Division”, are summarised in the following table.

Production from the three mining divisions is transported by rail to the central metallurgical plant located at Navoi, which has a nominal production capacity of 3 000 tU/year.

Uranium production in the Kyzylkum area peaked in the 1980s when 3 700 to 3 800 tU/year were being produced.

Uzbekistan

Uranium deposits of Uzbekistan



Historical uranium production
(tonnes U)

	Pre-1998	1998	1999	2000	Total to 2000	2001 (expected)
Open-pit mining	36 249	0	0	0	36 249	0
Underground mining	19 719	0	0	0	19 719	0
In situ leaching	33 677	1 926	2 159	2 028	39 790	2 350
Total	89 645	1 926	2 159	2 028	95 758	2 350

Uranium production centre technical information
(as of 1 January 2001)

Name of production centre	Northern mining division	Southern mining division	Mining division No. 5	Eastern mining division
Production centre class	existing	existing	existing	existing
Operational status	operating	operating	operating	mothballed
Start-up date	1964	1966	1968	1977
Source of ore: • Deposit names • Deposit type	Uchkuduk Kendyktube sandstone	Sabyrsaj Ketmenchi Shark Ulus sandstone	North Bukinai South Bukinai Beshkak, Lyavlyakan sandstone	Sugraly* sandstone
Mining operation: • Type • Size • Average mining recovery (%)	ISL NA 70	ISL NA 70	ISL NA 70	NA NA NA
Processing plant • Type • Size • Average process recovery (%)	Navoi AL NA 99.5			
Nominal production capacity (tU/year)	3 000			

* The Sugraly deposit has been placed under the management of the Northern Mining Division.

Ownership structure of the uranium industry

NMMC is part of the government holding company Kyzylkumredmetzeloto. Consequently, the entire uranium production of NMMC is owned by the Government of Uzbekistan.

Employment in the uranium industry

Five towns were constructed to support Uzbekistan’s uranium production activities: Uchkuduk, Zarafshan, Zafarabad, Nurabad and Navoi. Those towns provide the infrastructure, including roads, railway and electricity, required to support a combined population of 500 000 persons. This population is the source of NMMC’s stable and highly skilled work force.

Employment in existing production centres
(person-years)

1998	**1999**	**2000**	**2001** (expected)
8 165	7 734	7 331	7 300

Future production centres

Future uranium production in Uzbekistan will come entirely from ISL operations. There is no information as to the expected life time of the operating ISL plants. However, Uzbekistan has reported that the existing production centres will be capable of mining all known deposits. Uzbekistan plans to continue uranium production through 2040 at a rate of up to 3 000-3 100 tU/year.

Short-term production capability
(tonnes U/year)

2001				**2002**				**2005**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
2 350	2 350	2 350	2 350	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500

2010				**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
2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500

Environmental activities and socio-cultural issues

More than 30 years of uranium production related activities by NMMC have impacted Uzbekistan's natural environment. This includes the areas affected by conventional mining and processing of uranium ores, as well as the operation of *in situ* leach facilities. In addition to the areas directly affected by these activities, there are surface accumulations comprising an estimated 2.42 million m^3 of sub-economic uranium bearing material. The uranium content of this material is estimated to be 2-5 mg/kg (0.002 to 0.005%U). This is in addition to the 60 million tonnes of tailings located near the Navoi Hydrometallurgical Plant Number 1, and groundwater impacted by *in situ* leach mining. The total area impacted by ISL mining is 13 km^2. The related contaminated material recovered from the surface of these operations is about 3.5 km^3.

In order to fully evaluate the extent of any contamination and develop a programme for reclamation and restoration, NMMC is working with Uzbekistan's leading experts, specialists from the Commonwealth of Independent States, as well as with international organisations.

The results of radiation monitoring of NMMC's uranium mining and processing activities indicate that the average annual effective equivalent radiation dose of the critical population group living in these regions does not exceed 1 mSv/year relative to a sum of all radiation-hazard factors.

NMMC's overall environmental policy regarding its uranium production activities is:

- To provide for the ecological safety for all NMMC projects by using the most ecologically acceptable and cleanest *in situ* leach mining method.
- To close those mining and processing enterprises that are economically and environmentally less effective.
- To isolate and properly dispose of all accumulated radioactive wastes.
- To reclaim land disturbed by the enterprise's uranium activities.

To realize these objectives, NMMC has been developing and carrying out a step-by-step programme for evaluating and, where necessary, reclaiming the environmental impact of more than thirty years of uranium production operations. Following are examples of these activities.

1. Weak acid leaching

Since it began using ISL extraction in 1963, NMMC has carried out research, including pilot studies, directed toward decreasing its negative impact on groundwater. Following successful completion of pilot studies, NMMC implemented what it terms weak acid leaching, which has the advantage of causing less contamination of the leach aquifer. In addition, weak acid leaching is between 17% and 20% less expensive than strong acid leaching. Weak acid leaching does not achieve as high of a recovery ratio as strong acid leaching, but that disadvantage is more than offset by its environmental and cost advantages. Approximately 50% of Uzbekistan's uranium production now comes from weak acid leaching.

2. Tailings impoundment

Processing of uranium ore at the NMMC hydrometallurgical plant between 1964 and 1994 generated a mill tailings impoundment with the following characteristics: area – 600 ha; tailings mass – 60 million tonnes; total specific alpha activity – 90 kBq/kg; dosage of gamma-radiation on the surface of the tailings impoundment – varies from 3 to 12 μSv/h; density of radon flow – 1.0 to 2.0 $Bq/m^2/sec$; concentration of short-lived decay products in the near-surface atmospheric layer above tailings impoundment – varies from 6.0 to 33 Bq/m^2; average annual concentration of long-lived alpha-active radionuclides over tailings impoundment – $0.8x10^{-15}$ Ci/L.

A system of wells has been installed to monitor and control potential groundwater contamination from the tailings impoundment. Recovered waters are returned to the plant for use in processing. When it stopped processing conventional uranium ore in 1994, NMMC began covering the tailings impoundment with inert tailings generated from processing of gold ore. Approximately 100 ha or 17% of the uranium tailings impoundment surface had been covered with a 0.5 to 1.0 m layer of inert tailings by the end of 2000. Radon exhalation over the covered part of the tailings impoundment has decreased by 10 times and blowing of radioactive dust has been stopped in the covered area. NMMC expects to have the entire uranium tailings impoundment covered by 2012.

3. Low-grade stockpiles

During underground mining at Uchkuduk, low-grade stockpiles with a volume of 1.4 million m^3 covering an area of 237 000 m^2 were generated. The general characteristics of these stockpiles are as follows: average uranium grade – 0.017%U; exposure rate over the stockpile – 40 to 300 μR/h; short-lived radon decay products – 10 to 40 Bq/m^3; concentration of long-lived radionuclides of uranium series – $0.1\text{-}10^{-15}$ Ci/L. The concentration of radionuclides in the air within the living area of the town of Uchkuduk does not exceed permissible levels.

The stockpiles are located in fenced areas marked with "Radiation hazard" signs. Drains have been installed to control rainwater runoff from the stockpiles. Due to lack of financing, NMMC has no immediate plans to bury or process the stockpiles.

4. Waste water treatment

No waste water containing radionuclides is generated during NMMC's ISL operations. According to NMMC studies, residual solutions in aquifers where "hard" or concentrated acid leaching has been utilized undergo self-remediation to pre-mining conditions in 10 to 15 years. Weak acid leaching does not significantly change the composition of the production aquifer waters.

5. Restoration of mined out ISL sites

Reclamation of ISL mine sites is carried out according to national environmental laws. Particular emphasis is placed on cleaning up spills of production solutions containing radionuclides and sulfuric acid salts. Site restoration includes collecting and disposing of contaminated soil in specially prepared sites. After site restoration is complete, the land is returned to the land owner. Since 1994, NMMC has returned 25 087 ha of reclaimed lands to land owners, including more than 1000 ha of former ISL sites.

6. Environmental legislation

Uzbekistan has joined in 10 conventions and signed 12 international agreements in which it has agreed to work toward achieving specific environmental standards. It has established about 100 Federal statutory acts either directly of indirectly connected with environmental and natural resources protection to ensure compliance with these international standards.

URANIUM REQUIREMENTS

Uzbekistan has no national uranium requirements. Therefore, all of its production is committed for export.

NATIONAL POLICIES RELATED TO URANIUM

As a member of the IAEA, Uzbekistan complies with all international agreements related to the peaceful use of the uranium produced on its territory.

The uranium production is currently owned and controlled by the Republic of Uzbekistan. Private entities including domestic and foreign companies and individuals are not currently active in uranium exploration and production.

No information on uranium stocks or uranium prices was reported.

• Viet Nam •

URANIUM EXPLORATION

Historical review

Uranium exploration in selected areas of Viet Nam began in 1955. Since 1978, a systematic regional exploration programme has been underway throughout the entire country.

About 330 000 km^2, equivalent to almost 100% of the country, have been surveyed at the 1:200 000 scale using surface radiometric methods combined with geological observations. About 103 000 km^2 (31% of the country) have been explored at the 1:50 000 scale. Nearly 80 000 km^2, or 24% of the country, has been covered by an airborne radiometric/magnetic survey at the 1:25 000 and 1:50 000 scales. Selected occurrences and anomalies have been investigated in more detail by 75 800 m of drilling and by underground exploration workings.

Recent and ongoing activities

Uranium exploration is conducted by the Geological Division for Radioactive and Rare Elements and the Geophysical Division of the Department of Geology and Minerals of the Ministry of Industry. The total staff employed in uranium exploration activities ranges from 300 to 500 people who work from several regional offices. From 1997 through 2000, exploration has been concentrated on evaluation of the uranium potential of the Nong Son basin, Quang Nam province. Exploration activities are concentrated on two projects: (1) exploration of sandstone terrain in the Tabhing area, in the western part of the Nong Son basin; and (2) exploration of the Ben Giang area.

The following table lists exploration expenditures and drilling statistics for the 1998-2000 period.

Uranium exploration expenditures and drilling statistics

	1998	**1999**	**2000**	**2001** (expected)
Government expenditures (USD million)	0.12	0.12	0.11	0.11
Government surface drilling (m)	800	300	0	NA

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Viet Nam reports RAR recoverable at USD 130/kgU or less of 1 337 tU, as *in situ* resources. EAR-I of 6 744 tU are reported in the Khe Hoa-Khe Cao deposit, Nong Son basin. Both of these totals remain unchanged from the 1999 Red Book. However, EAR-I of 1 091 tU recoverable at a cost of USD 80/kgU or less is included in this report. No resources in this category had been previously reported.

Reasonably assured resources*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	1 337

* As *in situ* resources.

Estimated additional resources – Category I*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
NA	1 091	6 744

* As *in situ* resources.

Undiscovered conventional resources (EAR-II & SR)

EAR-II increased by 1 160 tU in the less than USD 130/kgU category compared to the 1999 Red Book. Speculative resources are the same as reported in the 1999 Red Book. The EAR-II recoverable at costs below USD 130/kgU are located mainly in the Tabhing occurrence of the Nong Son basin.

Estimated additional resources – Category II*
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	0	6 860

* As *in situ* resources.

Speculative resources are estimated at 230 000 tU, of which 130 000 tU are not assigned to any cost category (see table).

Speculative resources*
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
100 000	130 000	230 000

* As *in situ* resources.

Unconventional and by-product resources

Unconventional resources are reported to occur in: coal deposits of the Nong Son basin; rare earth deposits; the sedimentary Binh Duong phosphate deposit; and the Tien An graphite deposit.

URANIUM PRODUCTION

None reported.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

The Government is planning to construct a nuclear power plant before 2015.

Installed nuclear generating capacity to 2020
(MWe net)

2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
0	0	0	0	0	0	700*	0	1 400*

* Secretariat estimate.

Annual reactor-related uranium requirements to 2020
(tonnes U)

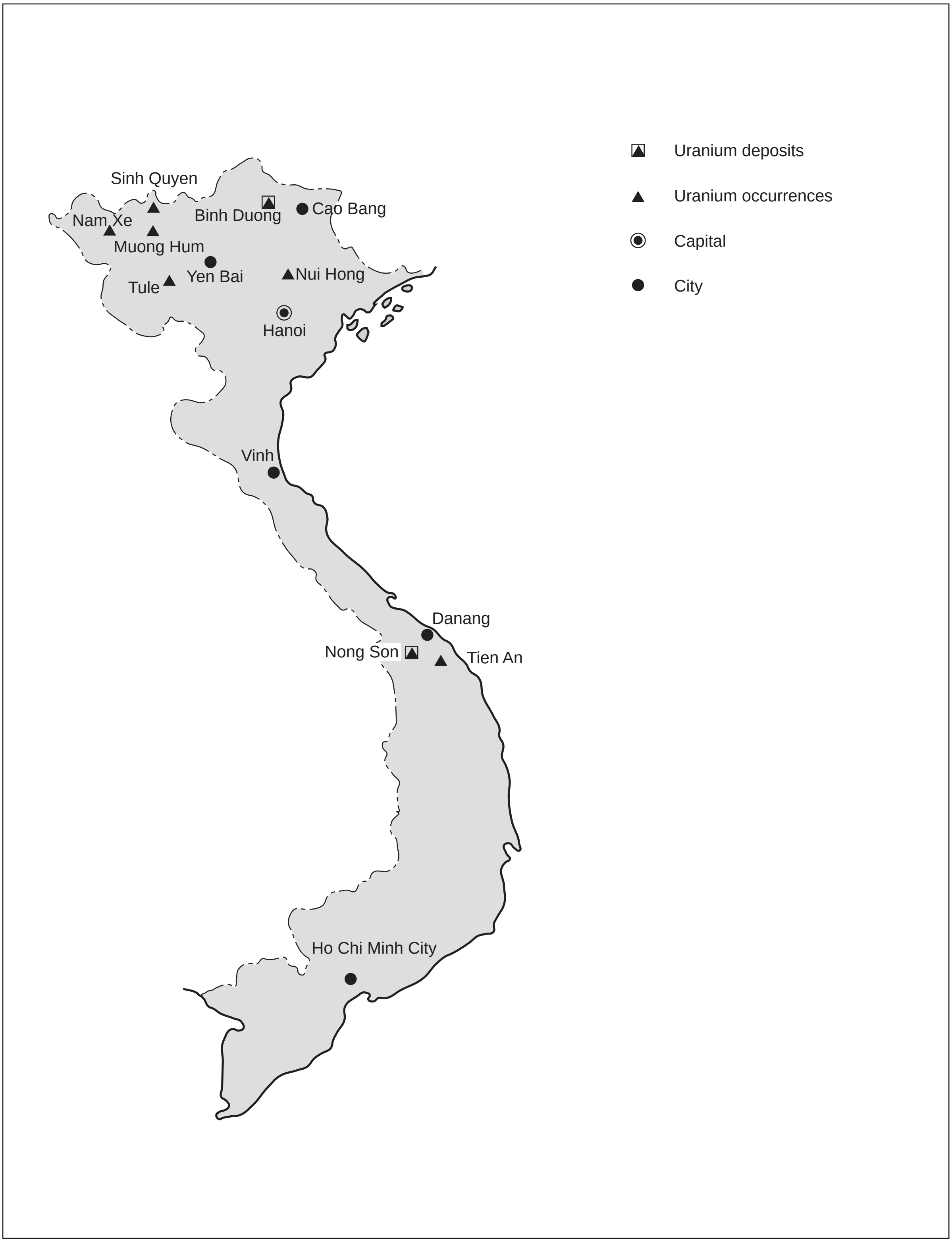
2000	**2001**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
0	0	0	0	0	0	120*	0	240*

* Secretariat estimate.

NATIONAL POLICIES RELATING TO URANIUM

Viet Nam is a country with few fossil fuels. Therefore, in its energy policy for the 21st century, the Government includes nuclear power as one of the alternatives. However, no long-term plans for developing a domestic uranium supply have been established. Viet Nam reported no information on uranium stocks or uranium prices.

Principal uranium deposits and occurrences in Viet Nam



Annex 1

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Viet Nam	Mr. N.L. DO	Viet Nam Atomic Energy Commission, Hanoi
	Dr. B. X. TRINH	Dept. of Geology and Minerals, Ministry of Industry, Hanoi
European Commission	Dr. A. BOUQUET	Euratom Supply Agency, Brussels
IAEA	Dr. D.H. UNDERHILL Mr. J. MCMURRAY **(Scientific Secretary)**	Division of Nuclear Fuel Cycle and Waste Technology, Vienna
OECD/NEA	Dr. I. VERA Mr. R. PRICE **(Scientific Secretary)**	Nuclear Development Division, Paris

Annex 2

LIST OF REPORTING ORGANISATIONS

Algeria	Commissariat à l'Énergie Atomique (COMENA), 02, Boulevard Franz Fanon, BP 399, Alger-Gare, 16000, Alger
Argentina	Comisión Nacional de Energía Atómica, Unidad de Proyectos Especiales de Suministros Nucleares, Avenida del Libertador 8250, 1429 Buenos Aires
Armenia	Ministry of Energy, Dept. of Atomic Energy, Government House, 2 Republic Square, 375010 Yerevan
Australia	Department of Industry, Tourism and Resources, Coal and Mineral Industries Division, Uranium Industry Section, GPO Box 9839, Canberra, ACT 2601
Belgium	Ministère des Affaires économiques, Administration de l'énergie, Service de l'énergie nucléaire, 154 Boulevard Émile Jacqmain, B-1210 Brussels
Brazil	Commissão Nacional de Energia Nuclear, Rua General Severiano, 90, 22294-900, Botafogo, Rio de Janeiro
Canada	Uranium and Radioactive Waste Division, Energy Resources Branch, Natural Resources Canada, 580 Booth Street, Ottawa, Ontario K1A OE8
Chile	Comisión Chilena de Energía Nuclear, Departamento de Materiales Nucleares, Amunategui No. 95, Santiago
China	Bureau of Mining and Metallurgy, China National Nuclear Corporation, P.O. Box 2102-9, Beijing 100822 Bureau of Geology, China National Nuclear Corporation, P.O. Box 762, Beijing 100013
Czech Republic	DIAMO s.p., Máchova 201, 471 27 Stráz pod Ralskem CEZ, a.s., Nuclear Fuel Cycle Section, Jungmannova 29, 111 48 Praha 1
Finland	Ministry of Trade and Industry, Energy Department, P.O. Box 37, FIN-00131 Helsinki Geological Survey of Finland, P.O. Box 96, FIN-02151 Espoo
France	Commissariat à l'Énergie Atomique, Centre d'études de Saclay, F-91191 Gif-sur-Yvette cedex
Gabon	Ministère des Mines, de l'Énergie, du Pétrole et des Ressources hydrauliques, Cabinet du Ministre, B.P. 874 & 576, Libreville
Germany	Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, D-30657 Hannover
Hungary	Mecsekuran Ltd., P.O. Box 65, H-7633 Pécs

India	Atomic Minerals Directorate for Exploration and Research, Department of Atomic Energy, 1-10-153-156, Begumpet, Hyderabad 500 016 Uranium Corporation of India Ltd., Jaduguda Mines P.O., Bihar, Singhbhum (East), India 832 102
Indonesia	Nuclear Minerals Development Centre (NMDC), National Nuclear Energy Agency (BATAN), Jln. Cinere Pasar Jumat, P.O. Box 6010, Jakarta 12060
Iran, Islamic Rep. of	Atomic Energy Organisation of Iran, P.O. Box 11365/8486, Tehran
Japan	Ministry of International Trade and Industry, 3-1 Kasumigaseki, 1-chome, Chiyoda-ku, Tokyo 100
Jordan	Natural Resources Authority, P.O. Box 7, Amman Jordan Phosphate Mines Co., P.O. Box 30, Amman
Kazakhstan	Atomic Energy Agency of the Republic of Kazakhstan (KAEA), Chaykina str. 4, Almaty, 480020
Korea, Rep. of	Atomic Energy International Co-operation Division, Ministry of Science and Technology, Government Complex Building II, Gwachun, 427-760
Lithuania	State Nuclear Power Safety Inspectorate, Sermuksniy 3, LT-2600 Vilnius
Malaysia	Geological Survey of Malaysia, 19th-21st Floor, Luth Building, Jalan Tun Razak, 50736 Kuala Lumpur
Namibia	Geological Survey of Namibia, Ministry of Mines and Energy, P.O. Box 2168, Windhoek
Netherlands	Ministry of Economic Affairs, Electricity Division, P.O. Box 20101, NL-2500 EC The Hague
Niger	Ministry of Mines and Energy, B.P. 11700, Niamey
Philippines	Philippine Nuclear Research Institute, Don Mariano Marcos Avenue, Diliman, Quezon City
Poland	National Atomic Energy Agency, Krucza str. 36, 00921-Warsaw
Portugal	Ministério da Economia, Instituto Geológico e Mineiro, 38 Rua Almirante Barroso, P-1000 Lisbon
Romania	Uranium National Company S.A., 68 Dionisie Lupu Street, Bucharest Research & Development Institute for Rare and Radioactive Metals, 78 Carol I Blvd., 70132 Bucharest
Russian Federation	Ministry for the Russian Federation of Atomic Energy, Bolshaya Ogdynka st. 24/26, Moscow, 109017 Geologorazvedka Concern, Marshala Rybalko 4, Moscow, 123436
Slovenia	Ministry of Environmental and Spatial Planning, Slovenian Nuclear Safety Administration, Vojkova 59, SI-1113 Ljubljana
Slovak Republic	Nuclear Regulatory Authority of the Slovak Republic, Bajkalská 27, P.O. Box 24, 820 07 Bratislava 27
South Africa	Atomic Energy Corporation of South Africa Limited, P.O. Box 582, Pretoria 0001
Spain	ENUSA, Aprovisionamiento de Uranio, Santiago Rusiñol, 12, 28040 Madrid

Sweden	KOM Nuclear Fuel and Environment Project (NFE), P.O. Box 5810, S-102 48 Stockholm
Switzerland	Nordostschweizerische Kraftwerke AG, Parkstrasse 23, CH-5401 Baden
Thailand	Department of Mineral Resources, Economic Geology Division, Rama VI Road, Bangkok 10400
Turkey	Turkish Atomic Energy Authority, Eskisher Yolu No. 9, 06530 Ankara
Ukraine	The State Geological Enterprise “Kirovgeology”, 8 Kikividze Street, 252103 Kiev
United Kingdom	Department of Trade and Industry, London SW1H OET British Energy plc, 10 Lochside Place, Edinburgh EH12 9DF British Nuclear Fuels plc (BNFL), Risley, Warrington, Cheshire WA3 6AS
United States	Energy Information Administration, Coal, Nuclear, Electric and Alternate Fuels (EI- 50), US. Department of Energy, Washington, D.C. 20585
Uzbekistan	The State Committee of the Republic of Uzbekistan on Geology and Mineral Resources, 11 Shevchenko st., 700060 GSP, Tashkent The Navoi Mining and Metallurgical Complex, 27 Navoi st., 706800 Navoi The State Geological Enterprise “Kyzyltepageologia”, Tashkent, 7a Navoi st., 700000 Tashkent
Viet Nam	Viet Nam Atomic Energy Commission, 59 Ly Thuong Kiet, Hanoi Geological Division for Radioactive and Rare Elements, Department of Geology and Minerals

Annex 3

GEOLOGIC TYPES OF URANIUM DEPOSITS[1]

The uranium resources of the world can be assigned on the basis of their geological setting to the following fifteen main categories of uranium ore deposit types:

1. Unconformity-related deposits.
2. Sandstone deposits.
3. Quartz-pebble conglomerate deposits.
4. Vein deposits.
5. Breccia complex deposits.
6. Intrusive deposits.
7. Phosphorite deposits.
8. Collapse breccia pipe deposits.
9. Volcanic deposits.
10. Surficial deposits.
11. Metasomatite deposits.
12. Metamorphic deposits.
13. Lignite.
14. Black shale deposits.
15. Other types of deposits.

The main features of these deposits are described below:

1. Unconformity-related deposits

Deposits of the unconformity-related type occur spatially close to major unconformities. Such deposits most commonly developed in intracratonic basins during the period about 1 800-800 million years ago, but also during Phanerozoic time. Type examples are the ore bodies at Cluff Lake, Key Lake, and Rabbit Lake and others in northern Saskatchewan, Canada, and those in the Alligator Rivers area in northern Australia.

2. Sandstone deposits

Most of the ore deposits of this type are contained in rocks that were deposited under fluvial or marginal marine conditions. Lacustrine and eolian sandstones are also mineralised, but uranium deposits are much less common in these rocks. The host rocks are almost always medium to coarse-grained poorly sorted sandstones containing pyrite and organic matter of plant origin. The sediments are commonly associated with tuffs. Unoxidised deposits of this type consist of pitchblende and coffinite in arkosic and quartzitic sandstones. Upon weathering, secondary minerals such as carnotite, tuyamunite and uranophane are formed.

The Tertiary, Jurassic and Triassic sandstones of the Western Cordillera of the United States account for most of the uranium production in that country. Cretaceous and Permian sandstones are important host rocks in Argentina, Europe (Germany, the Czech Republic, Hungary) and Central Asia (Kazakhstan, Uzbekistan). Other important uranium deposits have been found in Carboniferous deltaic sandstones in Niger; in Permian lacustrine siltstones in France; and in Permian sandstones of the Alpine region. The deposits in Precambrian marginal marine sandstones in Gabon have also been

1. This classification was developed by the IAEA in 1988-89 and replaces the classification defined and used in the Red Books 1986, 1988, 1990 and 1992.

classified as sandstone deposits. Resources in sandstone deposits form the basis for *in situ* leach (ISL) mining. Important examples of ISL amenable sandstone deposits include: Kazakhstan (Inkay, Moynkum and Mynkuduk); United States (Crow Butte and Smith Ranch); and Uzbekistan (Uchkuduk, Sugraly and Bukinay).

3. Quartz-pebble conglomerate deposits

Known quartz-pebble conglomerate ores are restricted to a specific period of geologic time. They occur in basal Lower Proterozoic beds unconformably situated above Archaean basement rocks composed of granitic and metamorphic strata. Commercial deposits are located in Canada and South Africa, and sub-economic occurrences are reported in Brazil and India.

4. Vein deposits

The vein deposits of uranium are those in which uranium minerals fill cavities such as cracks, fissures, pore spaces, breccias and stockworks. The dimensions of the openings have a wide range, from the massive veins of pitchblende at Jachymov (Czech Republic), Shinkolobwe (Democratic Republic of the Congo) and Port Radium (Canada) to the narrow pitchblende filled cracks, faults and fissures in some of the ore bodies in Europe, Canada and Australia.

5. Breccia complex deposits

Deposits of this group were developed in Proterozoic continental regimes during anorogenic periods. The host rocks include granitic and felsic volcanoclastics rocks. Uranium occurs in copper-gold mineralisation within hematite-rich breccias. The main representative of this type is the Olympic Dam deposit in South Australia. Deposits in Zambia, Democratic Republic of the Congo and the Aillik Group in Labrador, Canada, may also belong to this category.

6. Intrusive deposits

Deposits included in this type are those associated with intrusive or anatectic rocks of different chemical composition (alaskite, granite, monzonite, peralkaline syenite, carbonatite and pegmatite). Examples include the Rössing deposit in Namibia, the uranium occurrences in the porphyry copper deposits such as Bingham Canyon and Twin Butte in the USA, the Ilimaussaq deposit in Greenland, Palabora in South Africa as well as the deposits in the Bancroft area, Canada.

7. Phosphorite deposits

Sedimentary phosphorites contain low concentrations of uranium in fine-grained apatite. For the purpose of this report uranium of this type is considered an unconventional resource. Examples include the deposits in Florida, USA, where uranium is recovered as a by-product, and the large deposits in North African and Middle-Eastern countries.

8. Collapse breccia pipe deposits

Deposits in this grouping occur in circular, vertical pipes filled with down-dropped fragments. Uranium is concentrated in the permeable breccia matrix and in the accurate fracture zones enclosing the pipe. Type examples are the deposits in the Arizona Strip in Arizona, USA.

9. Volcanic deposits

Uranium deposits of this type are stratabound and structurebound concentrations in acid volcanic rocks. Uranium is commonly associated with molybdenum, fluorine, etc. Type examples are the uranium deposits Michelin in Canada, Nopal I in Chihuahua, Mexico, Macusani in Peru and numerous deposits in China and the Commonwealth of Independent States, particularly the Streltsovsk district in the Russian Federation.

10. Surficial deposits

Uraniferous surficial deposits may be broadly defined as uraniferous sediments, usually of Tertiary to Recent age which have not been subjected to deep burial and may or may not have been calcified to some degree. The uranium deposits, associated with calcrete, which occur in Australia, Namibia and Somalia in semi-arid areas where water movement is chiefly subterranean are included in this type. Additional environments for uranium deposition include peat and bog, karst caverns as well as pedogenic and structural fills.

11. Metasomatite deposits

Included in this grouping are uranium deposits in alkali metasomatites (albitites, aegirinites, alkali-amphibole rocks) commonly intruded by microcline granite. Type examples are the deposits Espinharas in Brazil, Ross Adams in Alaska, USA, as weIl as the Zheltye Vody deposit in Krivoy Rog area, Ukraine.

12. Metamorphic deposits

Uranium deposits belonging to this class occur in metasediments and/or metavolcanics generally without direct evidence of post-metamorphic mineralisation. Examples include the deposits at Forstau, Austria, and Mary Kathleen in Australia.

13. Lignite

Deposits of this type, generally classified as unconventional uranium resources, occur in lignite and in clay and/or sandstone immediately adjacent to lignite. Examples are uraniferous deposits in the Serres Basin, Greece, North and South Dakota, USA and Melovoe, in Kazakhstan.

14. Black shale deposits

Low concentrations of uranium occur in carbonaceous marine shales. These resources are considered unconventional resources for the purpose of this report. Examples include the uraniferous alum shale in Sweden, the Chatanooga Shale in the USA, the Chanziping deposit of the "argillaceous-carbonaceous-siliceous-pelitic rocks" type in the Guangxi Autonomous Region in China and the deposit of Gera-Ronneburg, in the eastern portion of Germany.

15. Other deposits

Included in this grouping are those deposits which cannot be classified with the deposit types already mentioned. These include the uranium deposits in the Jurassic Todilto Limestone in the Grants district, New Mexico, USA.

Annex 4

INDEX OF NATIONAL REPORTS IN RED BOOKS 1965-2001

The following index lists all national reports and the year in which these reports were published in the Red Books. A detailed listing of all Red Book editions is shown at the end of this Index.

Algeria						1975	1977	1979	1982										2002
Argentina		1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Armenia																		2000	2002
Australia		1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Austria							1977												
Bangladesh											1986	1988							
Belgium									1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Benin													1990						
Bolivia							1977	1979	1982	1983	1986								
Botswana								1979		1983	1986	1988							
Brazil				1970	1973	1975	1977	1979	1982	1983	1986			1992	1994	1996	1998	2000	2002
Bulgaria													1990	1992	1994	1996	1998		
Cameroon							1977		1982	1983									
Canada	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Central African Republic				1970	1973		1977	1979			1986								
Chile							1977	1979	1982	1983	1986	1988		1992	1994	1996	1998	2000	2002
China													1990	1992	1994	1996	1998	2000	2002
Colombia							1977	1979	1982	1983	1986	1988	1990			1996	1998		
Costa Rica									1982	1983	1986	1988	1990						

Cuba												1988		1992		1996	1998		
Czech Republic															1994	1996	1998	2000	2002
Czech/Slovak Fed. Republic													1990						
Denmark (Greenland)	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986		1990	1992		1996	1998		
Dominican Republic									1982										
Ecuador							1977		1982	1983	1986	1988							
Egypt							1977	1979			1986	1988	1990	1992	1994	1996	1998	2000	
El Salvador										1983	1986								
Estonia																	1998		
Ethiopia								1979		1983	1986								
Finland					1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
France	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Gabon		1967		1970	1973				1982	1983	1986					1996	1998	2000	2002
Germany				1970		1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Ghana							1977			1983									
Greece							1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998		
Guatemala											1986	1988							
Guyana								1979	1982	1983	1986								
Hungary														1992	1994	1996	1998	2000	2002
India	1965	1967		1970	1973	1975	1977	1979	1982	1983	1986		1990	1992	1994	1996	1998	2000	2002
Indonesia							1977				1986	1988	1990	1992	1994	1996	1998	2000	2002
Iran, Islamic Republic of							1977										1998	2000	2002
Ireland								1979	1982	1983	1986			1992			1998		
Italy		1967		1970	1973	1975	1977	1979	1982	1983	1986	1988		1992	1994	1996	1998	2000	
Ivory Coast									1982										

Jamaica									1982	1983									
Japan	1965	1967		1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Jordan							1977				1986	1988	1990	1992	1994	1996	1998	2000	2002
Kazakhstan															1994	1996	1998	2000	2002
Korea, Republic of						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Kyrgyzstan																1996			2002
Lesotho												1988							
Liberia							1977			1983									
Libyan Arab Jamahirya										1983									
Lithuania															1994	1996	1998	2000	2002
Madagascar						1975	1977	1979	1982	1983	1986	1988							
Malawi																		2000	
Malaysia										1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Mali											1986	1988							
Mauritania													1990						
Mexico				1970	1973	1975	1977	1979	1982		1986		1990	1992	1994	1996	1998	2000	
Mongolia															1994	1996	1998		
Morocco	1965	1967				1975	1977	1979	1982	1983	1986	1988	1990				1998		
Namibia								1979	1982	1983	1986	1988	1990			1996	1998	2000	2002
Netherlands									1982	1983	1986		1990	1992	1994	1996	1998	2000	2002
New Zealand		1967					1977	1979											
Niger		1967		1970	1973		1977				1986	1988	1990	1992	1994	1996	1998	2000	2002
Nigeria								1979											
Norway								1979	1982	1983				1992		1996	1998		
Pakistan		1967															1998	2000	2002
Panama										1983		1988							
Paraguay										1983	1986								

Peru							1977	1979		1983	1986	1988	1990	1992	1994	1996	1998	2000	
Philippines							1977		1982	1983	1986		1990		1994	1996	1998	2000	2002
Poland																		2000	2002
Portugal	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Romania														1992	1994	1996	1998	2000	2002
Russian Federation															1994		1998	2000	2002
Rwanda											1986								
Senegal									1982										
Slovak Republic															1994	1996	1998	2000	2002
Slovenia															1994	1996	1998		2002
Somalia							1977	1979											
South Africa	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986			1992	1994	1996	1998	2000	2002
Spain	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Sri Lanka							1977		1982	1983	1986	1988							
Sudan							1977												
Surinam									1982	1983									
Sweden	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Switzerland						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Syrian Arab Republic									1982	1983	1986	1988	1990		1994				
Tajikistan																			2002
Tanzania													1990						
Thailand							1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Togo								1979											
Turkey					1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
Ukraine															1994	1996	1998	2000	2002
United Kingdom						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002
United States	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002

Uruguay							1977		1982	1983	1986	1988	1990						
USSR														1992					
Uzbekistan															1994	1996	1998	2000	2002
Venezuela											1986	1988							
Viet Nam														1992	1994	1996	1998	2000	2002
Yugoslavia														1992					
Zaire		1967			1973		1977					1988							
Zambia											1986	1988	1990	1992	1994	1996	1998		
Zimbabwe									1982			1988		1992	1994	1996	1998		

1. 1.OECD/ENEA: World Uranium and Thorium Resources, Paris, 1965;
2. OECD/ENEA: Uranium Resources, Revised Estimates, Paris, 1967;
3. OECD/ENEA-IAEA: Uranium Production and Short-Term Demand, Paris, 1969;
4. OECD/ENEA-IAEA: Uranium Resources, Production and Demand, Paris, 1970;
5. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1973;
6. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1975;
7. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1977;
8. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1979;
9. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1982;
10. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1983;
11. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1986;
12. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1988;
13. OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1990;
14. OECD/NEA-IAEA: Uranium 1991: Resources, Production and Demand, Paris, 1992;
15. OECD/NEA-IAEA: Uranium 1993: Resources, Production and Demand, Paris, 1994;
16. OECD/NEA-IAEA: Uranium 1995: Resources, Production and Demand, Paris, 1996;
17. OECD/NEA-IAEA: Uranium 1997: Resources, Production and Demand, Paris, 1998;
18. OECD/NEA-IAEA: Uranium 1999: Resources, Production and Demand, Paris, 2000;
19. OECD/NEA-IAEA: Uranium 2001: Resources, Production and Demand, Paris, 2002.

Annex 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.

The NEA and the IAEA have therefore asked organisations from its Member countries to provide such factors to be published in this report.

The contributions of these organisations are presented in the following table.

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	WWER -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	3.2	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	0.490	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 initail 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 Data non available.

Conversion factors and energy equivalences 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] = 1 TOE
1 tonne of coal equivalent (TCE)(standard, LHV)		=	29.3 GJ[1] = 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 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[2]
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

1. World Energy Council standard conversion factors (from WEC, *1998 Survey of Energy Resources*, 18th edition).

2. With 1 000 kWh (final consumption) = 860 Mcal as WEC conversion factor.

Annex 6

CURRENCY EXCHANGE RATES*
(in national currency units per USD)

COUNTRY (currency abbreviation)	June 1998	June 1999	June 2000	January 2001
Algeria (DZD)	57.600	65.980	73.120	75.770
Argentina (ARS)	0.998	0.998	0.998	0.998
Armenia (AMD)	495.000	545.000	537.000	556.000
Australia (AUD)	1.610	1.536	1.730	1.800
Austria (ATS)	12.400	13.141	14.696	14.788
Belgium (BEF)	36.700	38.524	43.083	43.353
Brazil (BRL)	1.153	1.700	1.850	1.950
Bulgaria (BGL)	1 745.000	1 830.000	2.140	2.165
Canada (CAD)	1.460	1.470	1.500	1.510
Chile (CLP)	450.000	480.000	518.000	570.000
China (CNY)	8.270	8.270	8.267	8.266
Colombia (COP)	1 300.000	1 660.000	2 085.000	2 187.020
Congo, Republic of (XAF)	597.000	626.439	700.562	704.957
Costa Rica (CRC)	253.550	282.900	305.650	317.500
Cuba (CUP)	1.000	1.000	1.000	1.000
Czech Republic (CZK)	33.260	35.700	38.730	37.700
Denmark (Greenland) (DKK)	6.770	7.100	7.970	8.030
Egypt (EGP)	3.385	3.397	3.429	3.740
Finland (FIM)	5.400	5.678	6.350	6.389
France (FRF)	5.970	6.264	7.005	7.049
Gabon (GBF)	597.000	626.439	700.562	704.957
Germany (DEM)	1.780	1.867	2.088	2.101
Greece (GRD)	305.000	311.000	364.000	366.204
Hungary (HUF)	206.000	239.000	277.000	285.000
India (INR)	39.440	42.480	43.700	46.420
Indonesia (IDR)	11 700.000	7 800.000	8 236.000	9 108.000
Italy (ITL)	1 740.000	1 849.140	2 067.940	2 080.910
Iran, Islamic Republic of (IRR)	3 000.000	7 700.000	8 200.000	7 915.000
Japan (JPY)	138.000	122.000	107.000	115.000
Jordan (JOD)	0.708	0.708	0.708	0.708
Kazakhstan (KZT)	76.000	119.000	142.000	144.400
Korea, Republic of (KRW)	1 352.000	1 172.000	1 121.000	1 217.000
Kyrgyzstan (KGS)	19.920	40.700	48.100	49.000

CURRENCY EXCHANGE RATES* (cont'd)
(in national currency units per USD)

COUNTRY (currency abbreviation)	June 1998	June 1999	June 2000	January 2001
Lithuania (LTL)	4.000	4.000	4.000	4.000
Malawi (MWK)	25.890	43.300	49.020	80.500
Malaysia (MYR)	3.728	3.767	3.774	3.785
Mauritania (MRO)	176.300	204.550	239.980	249.090
Mexico (MXN)	8.500	9.250	9.420	9.500
Mongolia (MNT)	822.000	995.000	1 010.000	1 102.000
Morocco (MAD)	9.610	9.802	10.668	10.805
Namibia (NAD)	5.170	6.260	7.070	7.600
Netherlands (NLG)	2.000	2.104	2.353	2.368
Niger (XOF)	597.000	626.439	700.562	704.957
Norway (NOK)	7.520	7.890	8.910	8.880
Peru (PEN)	2.840	3.320	3.510	3.500
Philippines (PHP)	38.600	37.750	42.800	49.750
Poland (PLN)	3.360	3.830	4.400	4.110
Portugal (PTE)	182.000	191.460	214.115	215.458
Romania (ROL)	8 501.000	15 463.000	20 553.000	25 632.000
Russian Federation (RUB)	6.162	24.180	28.270	27.850
Slovak Republic (SKK)	34.080	44.203	47.686	48.511
Slovenia (SIT)	160.000	177.430	221.000	231.000
Somalia (SOS)	7.486	7.950	9.700	10.460
South Africa (ZAR)	5.170	6.260	7.070	7.600
Spain (ESP)	151.000	158.899	177.700	178.815
Sweden (SEK)	7.700	8.600	8.950	9.550
Switzerland (CHF)	1.480	1.520	1.670	1.640
Syria (SYP)	45.000	46.000	46.000	46.000
Tajikistan (TJS)	754.000	—	—	2.400
Thailand (THB)	40.000	36.875	39.065	42.845
Turkey (TRL)	252 000.000	398 000.000	621 000.000	675 000.000
Ukraine (UAH)	2.010	3.923	5.410	5.440
United Kingdom (GBP)	0.600	0.630	0.666	0.680
United States (USD)	1.000	1.000	1.000	1.000
Uruguay (UYU)	10.300	11.080	11.880	12.390
Uzbekistan (UZS)	87.760	115.860	231.000	690.000
Viet Nam (VND)	12 975.000	13 863.000	14 028.000	14 460.000
Yugoslavia (YUM)	11.080	10.685	11.660	66.100
Zambia (ZMK)	1 670.000	2 370.000	2 870.000	4 100.000
Zimbabwe (ZWD)	17.920	37.223	37.182	55.000

* Source: The Department of Finance of the United Nations Development Programme, New York.

Annex 7

GROUPING OF COUNTRIES AND AREAS* WITH URANIUM-RELATED ACTIVITIES

The countries associated with the geographical areas used in this report are listed below.

1. North America

Canada**	Mexico**	United States of America**

2. Central and South America

Argentina	Bolivia	Brazil
Chile	Colombia	Costa Rica
Cuba	Dominican Republic	Ecuador
El Salvador	Guatemala	Guyana
Jamaica	Panama	Paraguay
Peru	Surinam	Uruguay
Venezuela		

3. Western Europe and Scandinavia

Austria**	Belgium**	Denmark**
Finland**	France**	Germany**
Ireland**	Italy**	Netherlands**
Norway**	Portugal**	Spain**
Sweden**	Switzerland**	United Kingdom**

4. Central, Eastern Europe and South East Europe

Armenia	Belarus	Bulgaria
Croatia	Czech Republic**	Estonia
Greece**	Hungary**	Lithuania
Poland**	Romania	Russian Federation
Slovak Republic**	Slovenia	Turkey**
Ukraine	Yugoslavia	

5. Africa

Algeria	Benin	Botswana
Cameroon	Central African Republic	Congo, Democratic Republic
Egypt	Ethiopia	Gabon
Ghana	Ivory Coast	Lesotho
Liberia	Libyan Arab Jamahiriya	Madagascar
Malawi	Mali	Mauritania
Morocco	Namibia	Niger
Nigeria	Rwanda	Senegal

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* This list has been compiled to describe countries on a geographical basis, 2001.

** OECD Countries.

Somalia	South Africa	Sudan
Tanzania	Togo	Zambia
Zimbabwe		

6. Middle East, Central and South Asia

Bangladesh	India	Iran, Islamic Republic of
Jordan	Kazakhstan	Kyrgyzstan
Pakistan	Sri Lanka	Syrian Arab Republic
Tajikistan	Uzbekistan	

7. South East Asia

Indonesia	Malaysia	Philippines
Thailand	Viet Nam	

8. Pacific

Australia**	New Zealand**

9. East Asia[1]

China	Korea, Democratic People's Republic of	Japan**
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	Kazakhstan	Tajikistan
Azerbajdzhan	Kyrgyzstan	Turkmenistan
Belarus	Moldava	Ukraine
Georgia	Russian Federation	Uzbekistan

European Union

Austria	France	Italy	Spain
Belgium	Germany	Luxemburg	Sweden
Denmark	Greece	Netherlands	United Kingdom
Finland	Ireland	Portugal	

1. Includes Chinese Taïpei.

Annex 8

TECHNICAL ACRONYMS

The following abbreviations for technical terms in mining and ore processing were used in some tables:

	Type	Acronym
Mining Operation	Open Pit Underground	OP UG
Processing	a) Feed Preparation Crush-Wet Grind Semi-Autogenous Grind	 CWG SAG
	b) Sorting and Preconcentration Radiometric Sorting Density Separation Magnetic Separation Flotation	 Rad-Sort Dens-Sep Mag-Sep Flot.
	c) Leaching Acid Leaching Two-stage Acid Leaching Alkaline Pressure Leaching *In Situ* Leaching In Place Leaching (Stope/Block) Heap Leaching Percolation Leaching Alkaline Atmospheric Leaching	 AL 2 AL ALKPL ISL IPL HL Perc L ALKAL
	d) Extraction Ion Exchange Solvent Extraction	 IX SX

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