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

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Uranium 2003: Resources, Production and Demand

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Uranium 2003: Resources, Production and Demand

NEA No. 5291

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, 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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Photos: Uranium processing plant at Ranger mine, Alligator Rivers region, Northern Territory, Australia. Kombolgie sandstone escarpment in the distance. Courtesy of Energy Resources of Australia Ltd.

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 20th edition of the Red Book replaces the 2001 edition and reflects information current as of 1 January 2003.

The Red Book offers a comprehensive assessment of the uranium supply and demand situation up to the year 2020. The basis for the assessment consists of estimates of uranium resources in several categories of existence and economic attractiveness, projections of production capability, installed nuclear capacity and related uranium requirements. Annual statistical data and projections of uranium resources, exploration, production, installed nuclear capacity, annual uranium requirements, uranium stocks and relevant uranium policies are presented. In addition, detailed national reports are provided that include information on environmental activities.

This publication analyses the uranium supply and demand situation throughout the world by evaluating data on uranium resources, past and present production, and plans for future production, comparing that data with projected future reactor-related uranium requirements. The impact of secondary sources of uranium is considered. Longer-term projections of uranium demand, based on expert opinion rather than on information submitted by national authorities, are qualitatively discussed in the report.

This publication has been prepared on the basis of data obtained through questionnaires sent by the NEA to its member countries (18 countries responded) and by the IAEA for those states that are not OECD member countries (25 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 2003 – Resources, Production and Demand, presents the results of the most recent review of world uranium market fundamentals and provides a statistical profile of the world uranium industry as of 1 January 2003. First published in 1965, this, the 20th edition of what has become known as the "Red Book", contains official data provided by 43 countries along with unofficial data for one additional country on uranium exploration, resources, production and reactor-related requirements. Projections of nuclear generating capacity and reactor-related uranium requirements through 2020 are provided as well as a discussion of long-term uranium supply and demand issues.

Exploration

Worldwide exploration expenditures in 2002 totalled about USD 95 million, an increase of about 7% over 2001 expenditures, but still less than expenditures of between USD 110 million and USD 155 million recorded from 1996 to 1998. Exploration activities remain concentrated in areas with potential for unconformity-related deposits and ISL-amenable sandstone deposits, primarily in close proximity to known resources. Limited expenditures were directed toward "grass roots" exploration. Over 80% of the exploration expenditures in 2002 were devoted to domestic activities. Non-domestic exploration expenditures, although reported by two countries only (Canada and France), rose to almost USD 17 million in 2002, reversing a declining trend in non-domestic exploration expenditures that began in 1997. Exploration spending is expected to rise slightly in 2003, with expenditures projected to total over USD 98 million.

Resources

Total Known Conventional Resources (RAR & EAR-I) in both the <USD 80/kgU (about 3 537 000 tonnes U) and <USD 130/kgU (about 4 589 000 tonnes U) categories increased significantly compared to their 2001 levels. Known Resources in the <USD 40/kgU increased by about 21% compared to 2001, mainly due to increases in this category reported by Australia, Canada, Niger and Kazakhstan. Total Undiscovered Conventional Resources (EAR-II & Speculative Resources) in 2003 amounted to about 9 794 000 tonnes U (tU), a decline of some 2 477 000 tU from the total reported in 2001, mainly due to reductions reported by China and the Russian Federation.

Resource totals, on balance, remained little changed between 2001 and 2003, showing that new discoveries or the transfer of resources to higher confidence categories have approximately kept pace with production.

Production

Uranium production in 2002 totalled 36 042 tU, essentially unchanged from the 36 011 tU produced in 2000, but down somewhat from the 37 020 tU produced in 2001. A total of 20 countries reported output in 2002, compared to 21 in 2000, as Portugal ceased production in 2001. Besides Brazil, where production increased significantly at a new facility that had just begun production in 2000, the most significant production increase between 2000 and 2002 occurred in Kazakhstan, which reported a 51% increase. More modest production increases (<10%) were also recorded in Canada, Niger and the Russian Federation. In contrast, production in the United States declined by 40% between 2000 and 2002 while Namibia (14%), Australia (10%) and Uzbekistan (8%) also recorded decreased output. Significant reductions also occurred in France and Spain as uranium mines ceased production in 2001 and 2002, respectively; the limited output from these two countries in 2002 was the result of mine restoration activities. Underground mining accounted for 43% of global production in 2002; open pit mining, 27%; *in situ* leach mining, 18%; with co-product and by-product recovery from copper and gold operations and other unconventional methods accounting for most of the remaining 12%. Uranium production in 2003 is expected to decline to 35 382 tU, as reductions in Canada and the United States are expected to offset anticipated increases in Kazakhstan, the Russian Federation, Australia and Namibia.

Environmental aspects of uranium production

Although the focus of this publication remains uranium resources, production and demand, the importance of environmental aspects of uranium production is clear given the number of countries reporting on activities and providing cost information on environmental programmes in their country reports. Although the majority of these activities are related to the decommissioning and reclamation of inactive sites, there is also information on reclamation activities at sites still in production, as well as notification of ISO 14001 certification of uranium facilities and information on environmental assessment processes. Additional information on the environmental aspects of uranium production may be found in the national reports section of this document and a joint NEA/IAEA Uranium Group titled *Environmental Remediation of World Uranium Production Facilities*, Paris, OECD, 2002.

Uranium demand

At the end of 2002, a total of 441 commercial nuclear reactors were operating with a net generating capacity of about 364 GWe requiring about 66 815 tU. By the year 2020, world nuclear capacity is projected to grow to between about 418 GWe net in the low demand case and 483 GWe net in the high demand case. Accordingly, world reactor-related uranium requirements are projected to rise to between about 73 495 tU and 86 070 tU by 2020. Significant regional variation exists within these broad projections.

Several factors, including projected base load electricity demand, public acceptance of nuclear energy and proposed waste management strategies, as well as the economic competitiveness of nuclear power plants and fuel compared to other energy sources, will impact these projections. Concerns about longer-term security of supply of fossil fuels and a heightened awareness that nuclear power plants emit no greenhouse gases nor acid rain could well contribute to even greater projected growth in uranium demand over the long-term.

Supply and demand relationship

At the end of 2002, world uranium production (36 042 tU) provided about 54% of world reactor requirements (66 815 tU), with the remainder being met by secondary sources including civilian and military stockpiles, uranium reprocessing and re-enrichment of depleted uranium.

The uranium market over the mid-term remains uncertain due to the limited information available on the nature and extent of secondary supplies. Information presented in this document suggests that although commercial inventories have declined, they remain substantial. Given that uranium derived from the conversion of warhead material will likely constitute a significant source of supply in the near term, a continuation of an oversupplied, low-priced market is implied. Hence, low production levels and the draw down of civilian and military inventories may continue for several years. Low uranium prices have impacted the production sector in a number of ways, such as stimulating consolidations and mine closures and deferring investment in project development and exploration. Production and exploration are likely to remain low until sufficient information 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, secondary sources, i.e., excess commercial inventories, the expected delivery of Low Enriched Uranium (LEU) derived from Highly Enriched Uranium (HEU) warheads, re-enrichment of tails and spent fuel reprocessing, are necessary to ensure adequate supplies in the near-term.

However, secondary sources are expected to decline in importance, particularly after 2020, and reactor requirements will have to be increasingly met by 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 the timely development of resources. Because of the long lead-times necessary to discover new resources and bring them into production (typically in the order of 10 to 20 years or more), there exists the potential for the development of uranium supply shortfalls and significant upward pressure on uranium prices as secondary sources are exhausted. The long lead times required to bring resources into production underscores the importance of making timely decisions to pursue production capability well in advance of any supply shortfall. Improved information on the nature and extent of world uranium inventories and other secondary sources would permit the accurate forecasting necessary to make such 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 economic growth. Nuclear electricity generation will continue to play an important role, although the magnitude of that role remains uncertain.

Regardless of the magnitude of the role that nuclear energy ultimately plays in the future, the uranium resource base described in this document (including known and undiscovered resources) is adequate to meet future projected requirements. However, questions remain as to whether these resources can be developed within the timeframe required to meet future uranium demand.

I. URANIUM SUPPLY

This chapter summarises the current status of worldwide uranium resources, exploration and production. In addition, production capabilities in reporting countries for the period ending in the year 2020 are presented and discussed.

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 less than USD 130/kgU (<USD 130/kgU).[1] Relative changes in different resource and cost categories of KCR between this edition and the 2001 edition of the Red Book are given in Table 1. As shown in Table 1, KCR in the <USD 130/kgU increased significantly between 2001 and 2003. This increase is mainly the result of increased resources reported by Australia, Canada, Kazakhstan, Niger and Russia, as well as the inclusion for the first time of resource estimates from China and India.[2] The overall KCR increase between 2001 and 2003 amounted to about 655 000 tU, which represents about 10 years of 2002 global uranium requirements. The most significant changes occurred in the RAR <USD 40/kgU and the EAR-I <USD 40/kgU categories. Current estimates of RAR and EAR-I, on a country-by-country basis, are presented in Tables 2 and 3, respectively.

Distribution of Known Conventional Resources by Categories and Cost Ranges

The most significant changes between 2001 and 2003 in Known Conventional Resources occurred in Australia, Kazakhstan, Niger, the Russian Federation and South Africa, which gained resources, and Ukraine, which experienced a net reduction in resources (Table 4). Canada reported both increased low-cost RAR (<USD 40/kgU) and decreased EAR-I (<USD 40/kgU). The distribution of RAR and EAR-I, among countries with major resources, is shown in Figures 1 and 2, respectively.

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1. All KCR are reported as recoverable uranium. In cases where resources were reported by countries as *in situ*, resource figures were adjusted to estimate recoverable resources either by using recovery factors provided by the country or applying Secretariat estimates according to expected production method (see ***Recoverable Resources*** in Annex 3).

2. In the previous editions of the Red Book, the KCR in India and China were not reported because a breakdown of resources by cost categories was not provided. In this report, KCR in China were provided by cost category for the first time. For India, since no cost classification was reported, all KCR have been assigned to the <USD 130/kgU category.

Table 1. **Changes in Known Conventional Resources 2001-2003**
(1 000 tU)

Resource category	2001	2003	Changes*
KCR (Total)			
<USD130/kgU	3 933	4 588	+655
<USD80/kgU	3 107	3 537	+430
<USD40/kgU**	> 2 086	> 2 523	> +437
RAR			
<USD130/kgU	2 853	3 169	+316
<USD80/kgU	2 242	2 458	+216
<USD40/kgU**	> 1 534	> 1 730	> +196
EAR-I			
<USD130/kgU	1 080	1 419	+339
<USD80/kgU	865	1 079	+214
<USD40/kgU**	> 552	> 793	> +241

* Changes might not equal differences between 2003 and 2001 because of independent rounding.

** 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.

RAR recoverable at costs <USD 130/kgU increased by about 316 000 tU, or 11%, compared to 2001. Similar changes occurred in RAR recoverable at costs <USD 80/kgU and <USD 40/kgU, where increases amounted to about 216 000 tU (10%) and 196 000 tU (13%), respectively. These changes are mainly the result of increases in Australia (Olympic Dam) and Niger, resulting from the discovery of additional resources and the transfer of higher cost resources into a lower cost category.

EAR-I recoverable at <USD 130/kgU increased by about 339 000 tU, or 31%, compared to 2001. EAR-I increases were greatest in Australia, Kazakhstan, Niger and the Russian Federation, while reductions were greatest in Canada and Ukraine. EAR-I recoverable at costs <USD 80/kgU and <USD 40/kgU experienced similar increases, about 214 000 tU (25%) and 241 000 tU (44%), respectively. These changes are mainly related to the discovery of additional resources, the transfer from one category into another, combined with the decision in Ukraine, after reviewing projected production costs, to not report resources with projected costs >USD 130/kgU.

Distribution of Resources by Production Method

In 2003, countries reported known conventional resources by cost categories and, for the first time, by the expected production method, i.e., open-pit or underground mining, ***in situ leaching***, ***heap leaching or in place leaching***, ***co-product/by-product*** or unspecified. It is important to note that the value for "unspecified mining method" is principally the result of countries with a relatively large resource base, such as India and Mongolia, not reporting resources by the expected mining method.

Table 2. **Reasonably Assured Resources (RAR)**
(recoverable resources as of 1 January 2003, tonnes U)

COUNTRY	Cost ranges				
	< USD 40/kgU	USD 40-80/kgU	< USD 80/kgU	USD 80-130/kgU	< USD 130/kgU
Algeria (a) (b) (c)	NA	NA	19 500	0	19 500
Argentina	4 780	100	4 880	2 200	7 080
Australia	689 000	13 000	702 000	33 000	735 000
Brazil (b) (c)	26 235	59 955	86 190	0	86 190
Bulgaria (a) (b) (c)	1 665	4 205	5 870	0	5 870
Canada	297 264	36 570	333 834	0	333 834
Central African Republic (a) (b) (c)	NA	NA	6 000	6 000	12 000
Chile (c) (d)	NA	NA	NA	NA	560
China (c)	26 235	8 825	35 060	0	35 060
Congo, Dem. Rep. of (a) (b) (c)	NA	NA	1 350	0	1 350
Czech Republic	0	830	830	0	830
Denmark (b) (c)	0	0	0	20 250	20 250
Finland (b) (c)	0	0	0	1 125	1 125
Gabon (b)	0	0	0	4 830	4 830
Germany (a) (b)	0	0	0	3 000	3 000
Greece (a) (b)	1 000	0	1 000	0	1 000
India (c) (d)	NA	NA	NA	NA	40 980
Indonesia (b) (c)	0	320	320	4 300	4 620
Iran, Islamic Republic of (c)	0	0	0	370	370
Italy (a) (b)	NA	NA	4 800	0	4 800
Japan (b)	NA	NA	NA	NA	6 600
Kazakhstan (b) (c)	280 620	104 005	384 625	145 835	530 460
Malawi (a) (b) (c)	NA	NA	8 775	0	8 775
Mexico (a) (b) (c)	0	0	0	1 275	1 275
Mongolia (a) (b) (c)	7 950	38 250	46 200	0	46 200
Namibia (b) (e)	57 262	82 035	139 297	31 235	170 532
Niger	89 800	12 427	102 227	0	102 227
Peru (c)	NA	NA	1 215	0	1 215
Portugal	NA	NA	7 470	0	7 470
Romania (b) (c) (e)	0	0	0	3 325	3 325
Russian Federation (c)	52 610	71 440	124 050	18 970	143 020
Slovenia (b)	0	2 200	2 200	0	2 200
Somalia (a) (b) (c)	0	0	0	4 950	4 950
South Africa (f)	119 184	112 480	231 664	83 666	315 330
Spain	0	2 460	2 460	2 465	4 925
Sweden (b)	0	0	0	4 000	4 000
Thailand (a) (c)	0	0	0	5	5
Turkey (b) (c)	0	6 845	6 845	0	6 845
Ukraine (c)	15 380	19 250	34 630	30 030	64 660
United States	NA	NA	102 000	243 000	345 000
Uzbekistan (c)	61 510	0	61 510	18 110	79 620
Vietnam (c)	NA	NA	NA	NA	1 005
Zimbabwe (a) (b) (c)	NA	NA	1 350	0	1 350
Total (g)	**1 730 495**	**575 197**	**2 458 152**	**661 941**	**3 169 238**

NA Not available.
(a) Not reported in 2003 response, data from previous Red Book.
(b) Assessment not made within the last 5 years.
(c) *In situ* resources were adjusted by the Secretariat to estimate recoverable resources using recovery factors provided by countries or estimated by the Secretariat according to the expected production method.
(d) Cost data not provided, therefore resources are reported in the <USD 130/kgU category.
(e) Data from previous Red Book, depleted by past production.
(f) Data depleted by 1999-2002 production.
(g) 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.

Table 3. **Estimated Additional Resources (EAR) – Category I**
(recoverable resources as of 1 January 2003, tonnes U)

COUNTRY	Cost ranges				
	< USD 40/kgU	USD 40-80/kgU	< USD 80/kgU	USD 80-130/kgU	< USD 130/kgU
Argentina	2 860	0	2 860	5 700	8 560
Australia	276 000	11 000	287 000	36 000	323 000
Brazil (b) (c)	0	57 140	57 140	0	57 140
Bulgaria (a) (b) (c)	1 650	4 650	6 300	0	6 300
Canada	86 560	18 150	104 710	0	104 710
Chile (c) (d)	NA	NA	NA	NA	885
China (c)	5 890	8 800	14 690	0	14 690
Congo, Dem. Rep. of (a) (b) (c)	NA	NA	1 275	0	1 275
Czech Republic	0	90	90	0	90
Denmark (b) (c)	0	0	0	12 000	12 000
France (b) (c)	0	0	0	9 510	9 510
Gabon (b)	0	0	0	1 000	1 000
Germany (a) (b)	0	0	0	4 000	4 000
Greece (a) (b)	NA	NA	6 000	0	6 000
Hungary (b) (c)	0	0	0	13 800	13 800
India (c) (d)	NA	NA	NA	NA	18 935
Indonesia (b) (c)	0	0	0	1 155	1 155
Iran, Islamic Republic of (c)	0	0	0	700	700
Italy (a) (b)	0	0	0	1 300	1 300
Kazakhstan (b) (c)	131 220	106 560	237 780	79 380	317 160
Mexico (a) (b) (c)	0	0	0	525	525
Mongolia (a) (b) (c)	8 250	7 500	15 750	0	15 750
Namibia (b) (c)	57 142	16 418	73 560	13 525	87 085
Niger	125 377	0	125 377	0	125 377
Peru (c)	NA	NA	1 265	0	1 265
Portugal	NA	NA	1 450	0	1 450
Romania (b) (c)	0	0	0	3 608	3 608
Russian Federation (c)	15 860	18 400	34 260	86 960	121 220
Slovenia (b)	0	5 000	5 000	5 000	10 000
Somalia (a) (b) (c)	0	0	0	2 550	2 550
South Africa	49 313	17 627	66 940	13 400	80 340
Spain	0	0	0	6 380	6 380
Sweden (b)	0	0	0	6 000	6 000
Thailand (a) (c)	0	0	0	5	5
Ukraine (c)	900	3 835	4 735	6 675	11 410
Uzbekistan (c)	31 760	0	31 760	7 080	38 840
Vietnam (c)	NA	NA	820	4 615	5 435
Total (e)	**792 782**	**275 170**	**1 078 762**	**320 868**	**1 419 450**

NA Not available.
(a) Not reported in 2003 responses, data from previous Red Book.
(b) Assessment not made within the last 5 years
(c) *In situ* resources were adjusted to estimate recoverable resources, using recovery factors provided by the countries or estimated by the Secretariat according to the expected production method.
(d) Cost data not provided, therefore resources are reported in the <USD 130/kgU category.
(e) 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.

Of the low-cost RAR (<USD 40/kgU) reported by mining method, recovery as a co-product/by-product is the most important (mainly in Australia and South Africa), followed closely by underground mining. Significant portions of these low-cost resources are expected to be recovered by *in situ* leaching, underlining the importance of this method in future production. With respect to RAR recoverable at costs <USD 130/kgU reported by mining method, most are expected to be produced by underground mining (over 1/3 of the reported resources), followed by co-product/by-product then by open-pit mining and *in situ* leaching (Table 5).

Similar observations may be made for the EAR-I resources (Table 6). In the <USD 40/kgU category, uranium recovered as co-product/by-product represents the most important production method. In the <USD 130/kgU category, underground mining is expected to be the most important production method (about 30% of the reported resources with a specified production method), followed by open-pit mining, *in situ* leaching, and recovery as co-product/by-product.

Table 4. **Major Conventional Resource Changes**
(recoverable resources in 1 000 tonnes U)

Country	**Resource category**	**2001**	**2003**	**Changes**	**Reasons**
Australia	RAR <USD 40/kgU	654	689	+35	Increase in Olympic Dam resources resulting from the discovery of additional resources and the transfer of resources from higher cost categories into the <USD 40/kgU category
	EAR-I <USD 40/kgU	185	276	+91	
Canada	RAR <USD 40/kgU	278	297.3	+19.3	Ongoing appraisal of deposits and a transfer of resources from the EAR-I category to the RAR category
	EAR-I <USD 40/kgU	102.8	86.6	-16.3	
Kazakhstan	EAR-I <USD 40/kgU	101.9	131.2	+29.3	Re-evaluation of resources following development and ISL mining tests
	EAR-I <USD 80/kgU	176.3	237.8	+61.5	
	EAR-I <USD 130/kgU	233.4	317.2	+83.8	
Niger	RAR <USD 40/kgU	10.9	89.8	+78.9	Re-evaluation of resources following feasibility study of the Ebba deposit and the transfer of resources previously classified as EAR-II into the EAR-I category
	RAR USD 40-80/kgU	18.7	12.4	-6.3	
	EAR-I <USD 40/kgU	11.2	125.4	+114.2	
	EAR-I USD 40-80/kgU	14.4	0	-14.4	
Russian Federation	RAR USD 80-130/kgU	0	19	+19	First reporting of resources in these cost categories
	EAR-I USD 80-130/kgU	0	87	+87	
South Africa	RAR <USD130/kgU	291	315.3	+24.3	Re-evaluation of resources
Ukraine	EAR-I <USD 80/kgU	15.4	3.3	-12.1	Deduction of high-cost resources associated with metasomatite and bitumen-type deposits
	EAR-I <USD 130/kgU	23.1	7.2	-15.9	

Figure 1. **Distribution of Reasonably Assured Resources (RAR) among Countries with Major Resources**

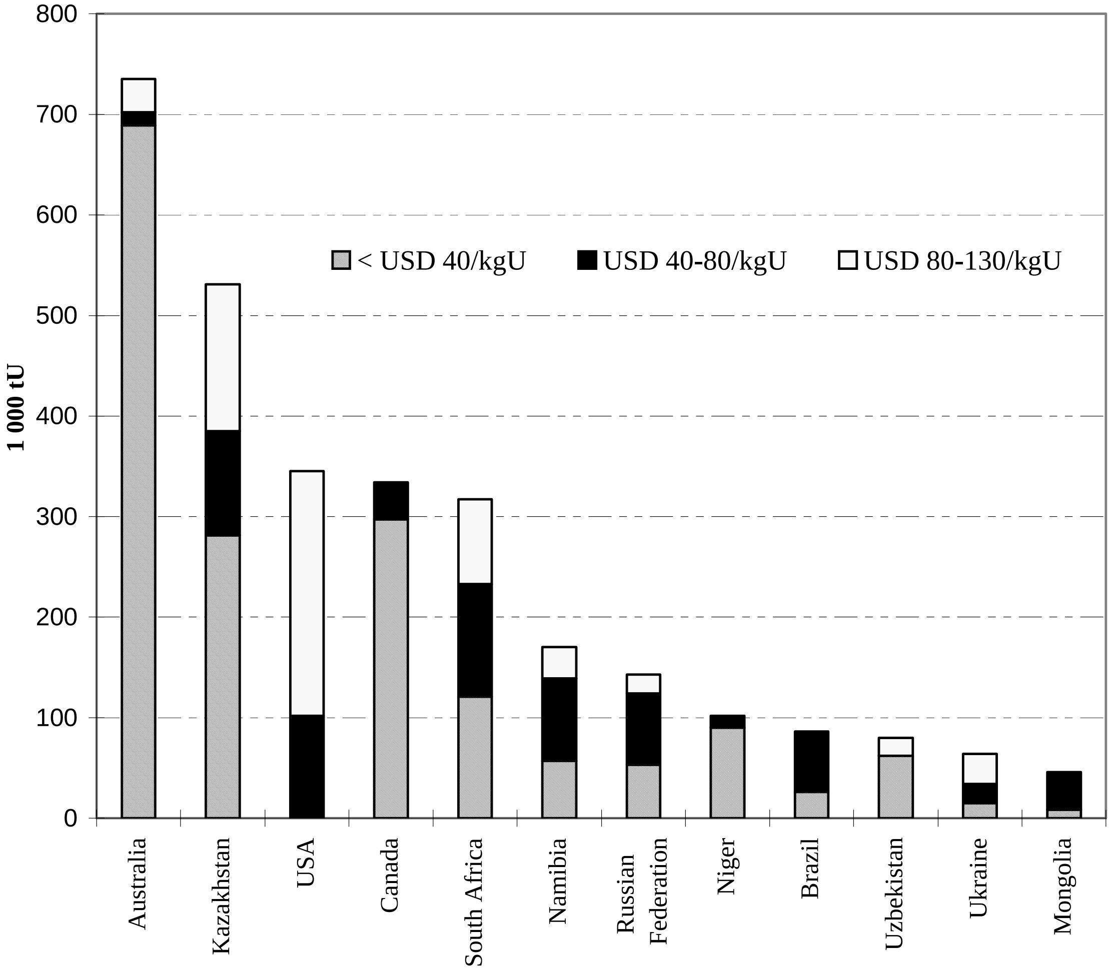


Table 5. **Reasonably Assured Resources (RAR) by Production Method**
(tonnes U)

	<USD 40/kg U	<USD 80/kg U	<USD 130/kg U
Open-pit mining	231 492	361 267	501 562
Underground mining	439 566	754 937	1 094 627
In situ leaching	358 435	399 435	450 200
Heap leaching	29 840	35 660	45 880
In-place leaching	300	300	300
Co-product/by-product	588 742	666 473	730 238
Unspecified mining method	82 120	240 080	346 431
TOTAL	**1 730 495**	**2 458 152**	**3 169 238**

Figure 2. **Distribution of Estimated Additional Resources – Category I (EAR-I) among Countries with Major Resources**

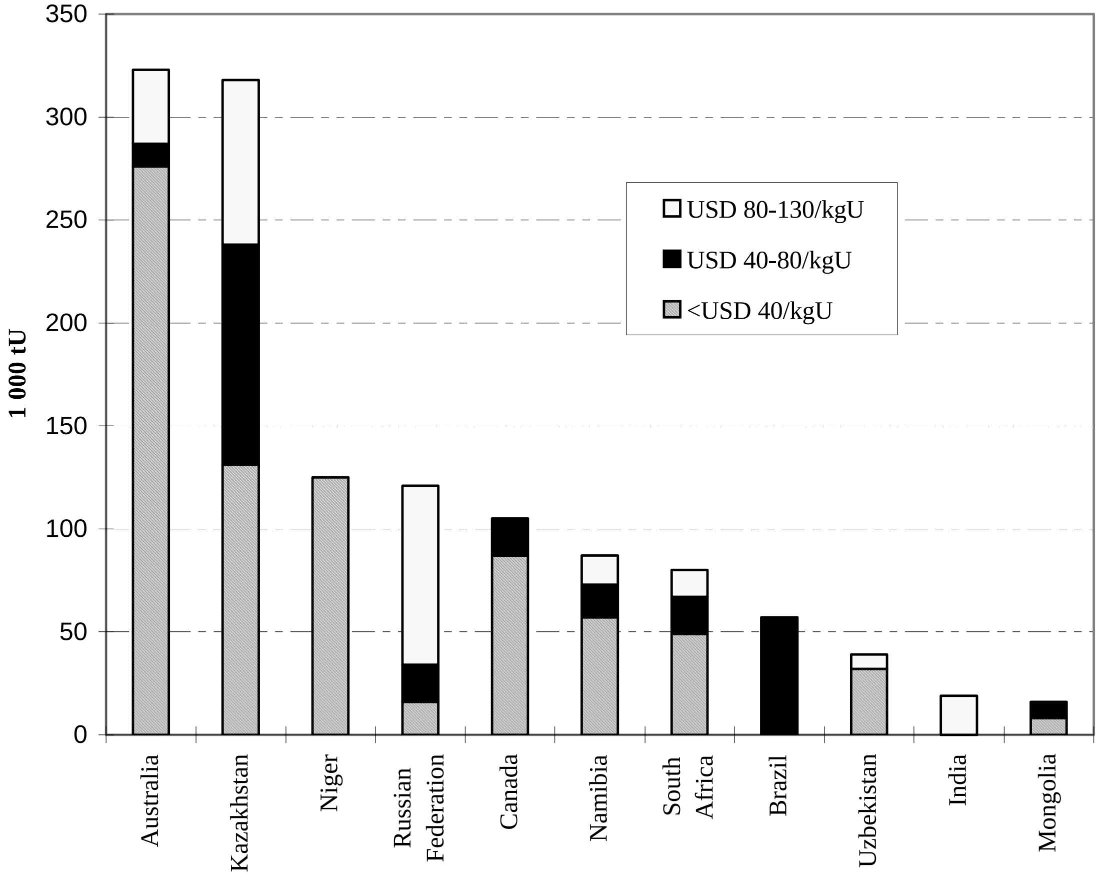


Table 6. **Estimated Additional Resources – Category I (EAR-I) by Production Method** (tonnes U)

	<USD 40/kg U	**<USD 80/kg U**	**<USD 130/kg U**
Open-pit mining	178 659	212 859	269 492
Underground mining	67 680	206 095	345 255
In situ leaching	167 760	170 010	238 616
Heap leaching	12 690	17 425	20 179
In-place leaching	1 500	1 500	7 030
Co-product/by-product	242 433	267 498	273 562
Unspecified mining method	122 060	203 375	265 316
TOTAL	**792 782**	**1 078 762**	**1 419 450**

Availability of Resources

A total of 12 countries provided estimates of the availability of resources for near-term production by reporting the percentage of KCR (RAR and EAR-I), recoverable at costs <USD 40/kgU and <USD 80/kgU, that are tributary to existing and committed production centres. Resources tributary to existing and committed production centres in these countries total 1 858 984 tU at <USD 40/kgU, a 22% increase compared to 2001, and 2 178 355 tU at <USD 80/kgU, a 13% increase compared to 2001 (Table 7). These resources are sufficient to meet projected uranium requirements through 2020. However, though sufficient resources exist, the associated production centres do not yet have nor are projected to have sufficient capacity to meet these requirements (see the Supply and Demand relationships section for further detail).

Table 7. **Availability of Known Resources in Producing Countries or Countries Ready to Produce in the Near Future**

Country	RAR + EAR-I recoverable at <USD 40/kgU in Existing or Committed Production Centres			RAR + EAR-I recoverable at <USD 80/kgU in Existing or Committed Production Centres		
	Total resources	%	Available resources	Total resources	%	Available resources
Argentina	7 640	100	7 640	7 740	100	7 740
Australia	965 000	90	868 500	989 000	88	870 320
Brazil	26 235	40	10 494	143 330	60	85 998
Canada	383 824	100	383 824	438 544	88	385 919
Czech Rep	NA	NA	NA	920	100	920
Kazakhstan	382 500	60	229 500	560 935	41	229 500
Namibia	114 404	90	102 964	212 857	90	191 571
Niger	215 177	24	52 677	227 604	28	62 813
Russian Federation	68 470	100	68 470	158 310	100	158 310
South Africa	168 497	43	72 454	298 604	35	104 981
Ukraine	16 280	25	4 086	39 365	56	21 887
Uzbekistan	90 505	65	58 376	90 505	65	58 376
Total	**2 438 532**		**1 858 984**	**3 167 714**		**2 178 335**

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 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 is assigned a higher degree of confidence than SR. Almost all EAR-II and SR are reported as *in situ* resources.

Worldwide, reporting of SR is incomplete, as only 28 countries reported, compared to 43 that reported RAR. A number of countries, e.g. Australia, did not report undiscovered conventional resources for the 2003 Red Book, while others indicated that they do not perform systematic evaluations of this type of resource. Nonetheless, some of these countries, such as Australia, are considered to have significant resource potential in sparsely explored areas. It should also be noted that the United States does not report EAR-I and EAR-II separately. Therefore, all EAR reported by the United States are classified as EAR-II. An unspecified portion, however, belongs to EAR-I.

EAR-II are estimated to total about 2.3 million tU recoverable at <USD 130/kgU, including about 1.5 million tU at <USD 80/kgU (Table 8).

Table 8. **Reported Undiscovered Conventional Resources***
(in 1 000 tonnes U, as of 1 January 2003)

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	1.4	NA	NA	NA
Brazil	120.0	120.0	0.0	500.0	500.0
Bulgaria (a)	2.2	2.2	16.0	0.0	16.0
Canada	50.0	150.0	700.0	0.0	700.0
Chile	NA	2.3	NA	2.4	2.4
China	3.6	3.6	4.1	0.0	4.1
Colombia (a)	NA	11.0	217.0	NA	217.0
Czech Republic	0.2	0.2	0.0	179.0	179.0
Denmark	0.0	0.0	50.0	10.0	60.0
Egypt	0.0	0.0	0.0	0.1	0.1
Germany (a)	0.0	0.0	0.0	74.0	74.0
Greece (a)	6.0	6.0	0.0	0.0	0.0
India	NA	15.5	NA	17.0	17.0
Indonesia	0.0	0.0	0.0	4.1	4.1
Iran, Islamic Republic of	0.0	3.4	4.5	6.0	10.5
Italy (a)	NA	NA	NA	10.0	10.0
Kazakhstan	290.0	310.0	500.0	0.0	500.0
Mexico (a)	NA	3.0	NA	10.0	10.0
Mongolia (a)	0.0	0.0	1 390.0	NA	1 390.0
Niger	9.5	9.5	0.0	0.0	0.0
Peru	6.6	6.6	19.7	0.0	19.7
Portugal	0.0	1.5	5.0	0.0	5.0
Romania (a)	NA	3.0	3.0	0.0	3.0
Russian Federation	56.3	104.5	545.0	0.0	545.0
Slovenia	0.0	1.1	0.0	0.0	0.0
South Africa	34.9	110.3	NA	1 112.9	1 112.9
Ukraine	0.0	1.6	0.0	255.0	255.0
United States (b)	839.0	1 273.0	858.0	482.0	1 340.0
Uzbekistan	56.3	85.0	0.0	146.6	146.6
Venezuela (a)	NA	NA	0.0	163.0	163.0
Vietnam	0.0	7.9	100.0	130.0	230.0
Zambia (a)	0.0	22.0	0.0	0.0	0.0
Zimbabwe (a)	0.0	0.0	25.0	0.0	25.0
Total (reported by countries)**	**1 474.6**	**2 254.5**	**4 437.3**	**3 102.0**	**7 539.3**

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

** Totals may not equal sum of components due to independent rounding.

NA Not available.

(a) Not reported in 2003 responses, data from previous Red Book.

(b) USA does not report EAR-I and EAR-II separately. Therefore, all EAR is classified as EAR-II.

The estimated total for countries reporting SR recoverable at <USD 130/kgU is about 4.44 million tU, essentially unchanged compared to the 2001 total. About 3.1 million tU of additional SR are reported without an estimate of production cost, compared with 5.5 million tU in 2001. The most significant declines occurred in China (1.77 million tU), and in the Russian Federation (0.46 million tU). Total reported SR are estimated to amount to about 7.54 million tU, down from 9.94 million tU in 2001.

Unconventional Resources and Other Materials

No specific compilation of unconventional uranium resources and other potential nuclear fuel materials, e.g., thorium is provided in this report, since few countries reported any relevant information. Most of the unconventional uranium resources reported are associated with ***uranium from phosphates***.

Uranium resources classified as unconventional, in which uranium exists at very low grades or can only be recovered as a minor by-product, include about 22 million tonnes that occur in phosphate deposits and up to 4 000 million tonnes contained in seawater. The technology to recover the uranium from phosphates is mature; it has been utilised in Belgium and in the United States, but high recovery costs limit the utilisation of these resources, with estimated production costs for a new 100 tU/year project, would be in the range of USD 60-100/kgU including capital investment. Research in Japan has hinted that it is possible to tap the vast resources of uranium contained in the world's oceans. At present, only laboratory-scale quantities have been extracted and the cost of extraction is estimated to be very high, on the order of USD 300/kgU. [1,2]

Thorium, abundant and widely dispersed, could also be used as a nuclear fuel resource. Existing estimates of thorium resources total more than 4.5 million tonnes (reserves and additional resources). [3] These estimates are considered conservative because data from China, Central and Eastern Europe and the Former Soviet Union are not included, and because the historically weak market demand has limited thorium exploration.

Other secondary sources of uranium, though small compared with the resources described above, play a significant role in supplying current nuclear fuel requirements and are expected to continue to do so through 2020. These resources are discussed in detail in the Uranium Demand section of this book.

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, mainly ***unconformity-related*** and ***sandstone-type*** deposits.

Canada and France were the only countries to report exploration expenditures abroad in 2002 (Table 9). In 2003, expenditures abroad are expected to increase to USD 18.5 million, about 9% above the 2002 total. The trends in domestic and abroad exploration expenditures for selected countries are depicted in Figure 3.

Domestic exploration expenditures decreased from 1997 to 1999, then slightly increased in 2000 where a total of 21 countries reported domestic exploration expenditures of about USD 115.2 million, 16% higher than in the previous year (Table 10). In 2001, the declining trend in exploration expenditures resumed, with only 18 countries reporting exploration activities amounting to about USD 89 million, or 23% less than in 2000. This included China, which reported exploration expenditures for the first time. In 2002, domestic exploration expenditures totalled about USD 95.1 million, an increase of about USD 6.1 million (about 7%) compared to the 2001 total. Seventeen countries reported exploration expenditures in 2002, though only nine countries, i.e., Australia, Canada, China, Egypt, India, Kazakhstan, Niger, Russia and Uzbekistan accounted for about 96% of total domestic exploration expenditures. All of these countries, except China and Niger, reported decreases in exploration expenditures compared to their 2000 totals. It is also important to note that 87% of Kazakhstan's expenditures, about USD 10.3 million, and 72% of Uzbekistan's expenditures, about USD 9.5 million, were spent on development-related activities. Vietnam is the only other country, besides China and Niger, to report an increase in domestic exploration expenditures between 2000 and 2002. Russia, however, plans to significantly increase exploration expenditures in 2003. Overall, domestic exploration expenditures are expected to slightly increase to about USD 98.4 million in 2003, about USD 3.3 million more than in 2002 (about 3.5%).

Table 9. **Uranium Exploration Expenditures – Abroad**
(USD thousands in year of expenditure)

COUNTRY	Pre-1996	1996	1997	1998	1999	2000	2001	2002	2003 (expected)
Belgium	4 500	0	0	0	0	0	0	0	0
Canada*	2 920	3 650	3 986	3 000	3 000	3 667	2 597	2 549	2 548
France*	675 926	6 808	8 972	8 777	7 120	7 330	7 690	14 370	15 970
Germany	396 021	3 137	4 000	NA	NA	0	0	0	0
Japan*	381 315	7 533	4 752	2 280	1 390	NA	NA	NA	NA
Korea, Rep. of*	22 490	511	603	445	NA	NA	NA	NA	NA
Spain	20 400	0	0	0	0	0	0	0	0
Switzerland*	29 657	0	0	0	0	0	0	0	0
United Kingdom*	61 263	0	0	0	0	0	0	0	0
United States*	228 770	422	3 050	3 616	NA	NA	NA	NA	NA
TOTAL	**1 823 262**	**22 061**	**25 363**	**18 118**	**11 510**	**10 997**	**10 287**	**16 919**	**18 518**

* Country selected to display trend in exploration expenditures (abroad).
NA Not available.

Current Activities and Recent Developments

North America. Canada continued to be the world's leader in domestic exploration spending with annual expenditures in 2001 and 2002 of about USD 16.2 million and 22.9 million, respectively. Uranium exploration and surface development drilling increased to 78 000 m in 2002, compared to 48 000 m in 2001. As in recent years, a significant portion of the overall exploration expenditures can be attributed to advanced underground exploration, deposit appraisal activities, and care and maintenance expenditures associated with projects awaiting production approvals. Basic "grass roots" uranium exploration reached USD 10.5 million in 2002, up from about USD 9.1 million in 2001. Well over 90% of the combined exploration and surface development drilling took place in Saskatchewan. Exploration was also carried out in Alberta, Labrador, Nunavut and Quebec. Canada's 2003 exploration expenditures are expected to total about USD 19.1 million, a decline of about 17% from the 2002 level. Non-domestic exploration expenditures in 2002 amounted to USD 2.5 million, with activities mainly carried out in Australia and Kazakhstan. Non-domestic expenditures are expected to remain constant in 2003.

Table 10. **Industry and Government Uranium Exploration Expenditures – Domestic**◊
(USD thousands in year of expenditure)

COUNTRY	Pre-1996	1996	1997	1998	1999	2000	2001	2002	2003 (expected)
Argentina*	49 454	0	0	0	NA	791	777	265	276
Australia*	450 367	11 841	18 038	12 030	6 260	4 390	2 470	3 020	2 810
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	NA	NA	371
Canada*	1 073 172	28 467	42 029	41 096	33 000	30 667	16 234	22 876	19 108
Central African Rep.	20 000	NA	NA	NA	NA	NA	NA	NA	NA
Chile*	8 534	143	154	196	178	214	126	154	115
China (a)	NA	NA	NA	NA	NA	4 200	6 000	7 200	7 200
Colombia	23 935	0	0	0	0	NA	NA	NA	NA
Costa Rica	361	NA	NA	NA	NA	NA	NA	NA	NA
Cuba	836	86	50	NA	NA	NA	NA	NA	NA
Czech Republic*	1 329	201	163	90	64	44	48	25	60
Denmark	4 350	0	0	0	0	0	0	0	0
Ecuador	2 055	NA	NA	NA	NA	NA	NA	NA	NA
Egypt*	46 189	6 528	7 418	7 976	7 976	10 499	9 404	7 186	7 143
Finland	14 777	0	0	0	0	0	0	0	0
France*	895 998	7 960	1 742	1 040	0	0	0	0	0
Gabon*	91 100	1 338	343	0	0	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*	16 962	273	290	NA	NA	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*	216 185	9 250	11 183	12 812	12 090	14 368	12 060	11 922	13 310
Indonesia*	14 073	695	632	114	217	61	23	30	32
Iran, Islamic Rep. of	NA	NA	NA	857	1 000	1 700	1 004	1 389	1 752
Ireland	6 800	0	0	0	0	NA	NA	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*	522	100	100	150	0	0	0	0	0
Kazakhstan*	6 428	242	160	0	0	11 035	13 175	11 836	8 770
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 10. **Industry and Government Uranium Exploration Expenditures – Domestic**◊ (contd)
(USD thousands in year of expenditure)

COUNTRY	Pre-1996	1996	1997	1998	1999	2000	2001	2002	2003 (expected)
Malaysia*	9 799	0	245	188	186	66	NA	NA	NA
Mali	51 637	NA	NA	NA	NA	NA	NA	NA	NA
Mexico	24 910	0	0	0	0	0	NA	NA	NA
Mongolia	2 458	2 560	3 135	NA	NA	NA	NA	NA	NA
Morocco	2 752	NA	NA	NA	NA	NA	NA	NA	NA
Namibia*	17 930	0	0	0	0	0	0	0	0
Niger*	203 820	427	1 653	754	471	633	1 088	3 126	4 476
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*	4 183	0	0	0	0	0	0	0	0
Philippines*	3 447	19	19	13	11	5	4	4	4
Portugal*	17 250	114	154	102	18	19	0	0	0
Romania	5 446	1 776	1 198	934	549	157	NA	NA	NA
Russian Federation*	22 316	4 281	10 052	8 650	6 870	13 300	11 470	10 420	17 050
Slovenia (b)	1 006	NA	NA	NA	NA	NA	NA	NA	NA
Somalia	1 000	NA	NA	NA	NA	NA	NA	NA	NA
South Africa	108 993	0	0	0	0	0	0	0	0
Spain*	139 705	1 388	0	10	0	0	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*	10 921	0	0	0	0	NA	NA	NA	NA
Turkey	20 581	0	200	1 200	0	0	NA	NA	NA
Ukraine*	NA	1 376	1 611	1 940	1 606	2 107	1 701	1 898	1 501
United Kingdom	2 600	0	0	0	0	0	0	0	0
United States*	2 668 138	10 054	30 426	21 724	8 968	6 694	4 827	352	NA
Uruguay	231	NA	NA	NA	NA	NA	NA	NA	NA
Uzbekistan*	6 669	22 067	21 954	19 652	19 392	14 152	8 516	13 255	14 233
Vietnam*	1 689	208	227	120	120	104	104	130	195
Zambia	174	NA	NA	NA	NA	NA	NA	NA	NA
Zimbabwe	6 902	0	0	0	NA	NA	NA	NA	NA
TOTAL	7 370 438 (c)	111 394	153 176	131 648	98 976	115 206	89 031	95 088	98 406

◊ Domestic exploration and development expenditures represent the total expenditure from domestic and foreign sources in each country for each year.

NA Not available.

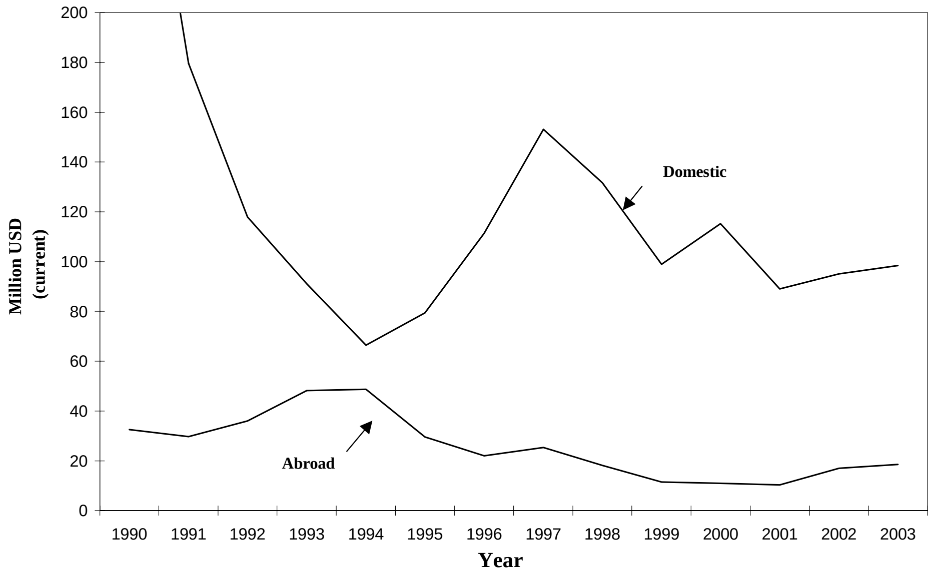
* Country selected to display trend in exploration and development expenditures.

(a) Development expenditures not included.

(b) Includes any expenditures spent in other parts of the former Yugoslavia (pre-1996).

(c) Includes USD 312 560 expended in Czechoslovakia and USD 247 520 from USSR.

Figure 3. **Trend in Exploration Expenditures for Selected Countries***



* See Tables 9 and 10 for the selected countries. Domestic exploration and development expenditures represent the total expenditure from domestic and foreign sources in each country for each year. Abroad expenditures are thus a subset of domestic expenditures.

In the **United States**, total uranium exploration expenditures declined through 2001 and 2002. US industry reported total exploration expenditures of USD 4.8 million in 2001, a decrease of 28% from 2000. Of the 2001 total, about USD 2.7 million were attributable to surface drilling and about USD 2.1 million was spent on other exploration activities, including land acquisition. Total expenditures in 2002 amounted to a total of about USD 0.35 million, a 93% decrease from 2001.

Central and South America. Argentina reported exploration expenditures totalling about USD 0.8 million and 0.3 million in 2001 and 2002, respectively. Activities included an evaluation drilling programme, laboratory tests for improving treatment methods, and a survey of environmental conditions in the Sierra Pintada area. **Brazil** did not report any exploration and development activities in 2001 and 2002 but plans are to fund 5 000 m of exploration drilling (about USD 0.4 million) in 2003. In 2001 and 2002, **Chile** reassessed regional geological information to improve knowledge of uranium potential. In addition, geophysical surveys at the Cerro Carmen site were conducted to define targets for additional exploration. However, no exploration expenditures were reported.

Western Europe and Scandinavia. Domestic exploration continued to decline to the point that no exploration expenditures were reported in 2002. **France** reported exploration and development expenditures in Australia, Canada, Kazakhstan, Niger, Mongolia and Russia amounting to a total of about USD 14.4 million in 2002.

Central, Eastern and South-eastern Europe. No fieldwork was conducted in the **Czech Republic** and exploration activities were focused on archiving and processing previously obtained data. In the **Russian Federation,** exploration activities were concentrated on sandstone deposits amenable to *in situ* leaching (ISL) and unconformity-related deposits. Major drilling programmes continued in the Transural, Vitim and Irkutsk districts, and in the north-western region of the country. Total expenditures in 2001 and 2002 amounted to USD 11.5 million and USD 10.4 million respectively, and are expected to increase to USD 17.1 million in 2003. **Turkey** is planning to explore granitic and acidic intrusive rocks in the Eskisehir region in 2003 and 2004. **Ukraine** continued exploration for ***vein-type*** and unconformity-related deposits in the Ukrainian shield area. Exploration expenditures totalled about USD 1.7 million and USD 1.9 million in 2001 and 2002 respectively, but are expected to decrease to USD 1.5 million in 2003.

Africa. In Egypt, exploration and evaluation activities concentrated on the black sand deposits of the northern Nile River delta that constitute a non-conventional resource for uranium and thorium, as well as on uranium deposits in the Sinai, eastern and south-western desert regions. Total expenditures in 2001 and 2002 were about USD 9.4 million and USD 7.2 million, respectively, and are expected to amount to USD 7.1 million in 2003. In **Niger**, activities focused on resource development in and around the existing mine sites in an effort to expand the resource base in the western Arlit area. Exploration and development expenditures of USD 1.1 million and USD 3.1 million were reported in 2001 and 2002, respectively. Annual drilling programmes of 26.2 km and 69.5 km were achieved in these two years. For 2003, total expenditures of USD 4.5 million are anticipated, funding 5 km of exploration and 80 km of development drilling.

Middle East, Central and Southern Asia. In **India**, active programmes are being conducted in several provinces, focusing on Proterozoic basins, Cretaceous sandstones, and other promising geological settings. Annual drilling increased from 32.5 km in 2000 to 44.4 km and 40 km in 2001 and 2002, respectively, and is expected to increase to 50.5 km in 2003. Exploration expenditures amounted to about USD 12.1 million and USD 11.9 million in 2001 and 2002, respectively, and are expected to increase to USD 13.3 million in 2003. In **Iran**, activities included exploration and evaluation of uranium resources associated to Precambrian magmatic and metasomatic complexes in the Bafq-Posht-e-Badam province, and exploration of sedimentary basins in central and north-western Iran. Total expenditures amounted about USD 1.0 million and USD 1.4 million in 2001 and 2002, respectively, and are expected to increase to about USD 1.8 million in 2003. In **Kazakhstan**, exploration was conducted in the Shu-Saryssu province in 2001 and 2002, where three ISL test sites were completed and mining tests were initiated. Total exploration and development expenditures were about USD 13.2 million and USD 11.8 million in 2001 and 2002, respectively, and are expected to amount USD 8.8 million in 2003. In **Uzbekistan**, exploration mainly focused on resource estimation in established ore fields. Total expenditures in 2001 and 2002 amounted about USD 8.5 million and USD 13.3 million, respectively, and are expected to increase to USD 14.2 million in 2003.

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

East Asia. For the first time **China** reported exploration expenditures, which amounted USD 6.0 million and USD 7.2 million in 2001 and 2002, respectively. China continues exploration for sandstone-type deposits amenable to *in situ* leaching in the Xinjiang and Inner Mongolian Autonomous Regions and in Northern China. In 2003, exploration expenditures are expected to amount to USD 7.2 million. Exploration continues in **Mongolia**, although details were not reported.

Pacific. Exploration continued in several regions of **Australia**, with annual expenditures of about USD 2.5 million in 2001 and about USD 3.0 million in 2002. Areas explored included the Arnhem Land (Northern Territory) for unconformity-related deposits, the Frome Embayment (South Australia) for sandstone deposits, and the Gawler Crato/Stuart Shelf region (South Australia) for ***hematite breccia complex type deposits***. In November 2001, the discovery at Prominent Hill of copper, gold, uranium, and rare-earth mineralisation in hematite breccia (a similar geological setting to the Olympic Dam deposit) was announced. In 2003, exploration expenditures are expected to amount to USD 2.8 million.

C. URANIUM PRODUCTION

In 2002, uranium was produced in 20 different countries, one less than in 2000, as Portugal ceased production in 2001. Two countries, Canada and Australia, accounted for over 51% of world production in 2002 and seven countries, i.e., Canada, Australia, Niger, Russian Federation, Kazakhstan, Namibia and Uzbekistan, accounted for 87% of world production in 2002. World uranium production increased by 2.8% from 36 011 tU in 2000 to 37 020 tU in 2001, then decreased to 36 042 tU in 2002 and in 2003 is expected to decline further to 35 382 tU.

Within OECD countries, production increased from 20 894 tU in 2000 to 21 968 tU in 2001 but then decreased to 20 114 tU in 2002. Production in 2003 is expected to decrease to 18 112 tU, down about 10% from the previous year. Table 11 shows production in selected countries and documents reasons for major changes between 2000 and 2002 listed. Historical uranium production on a country-by-country basis is provided in Table 12 and Figure 4.

Table 11. **Production in Selected Countries and Reasons for Major Changes**

Country	**Production 2000** (tU)	**Production 2002** (tU)	**Change 2000-2002** (tU)	**Reasons for changes in production since 2000**
Australia	7 579	6 854	-725	Production at Olympic Dam was adversely affected by rebuilding the solvent extraction circuits after fires in 1999 and 2001
Brazil	11	272	+261	Operations at the Lagoa Real production centre begun in 2000 reached nominal capacity in 2002
Canada	10 683	11 607	+924	Increases in production at McArthur River and Cluff Lake offset declining production from Rabbit Lake
France	296	18	-278	Uranium production came to an end in 2001
Germany*	28	221	+193	Increased U recovery from mine water treatment
Kazakhstan	1 870	2 822	+952	Increased output to meet improved market conditions and start of Katco and Inkai ISL mining tests
Namibia	2 715	2 333	-382	Reduced production probably due to unfavourable exchange rates between the Namibian and US currencies
Niger	2 914	3 080	+166	Increased output at Arlit and Akouta
Russian Fed.	2 760	2 850	+90	New ISL project at Dalur
Spain	255	37	-218	Uranium production came to an end in 2002
United States	1 522	902	-620	Closure of last conventional uranium mills
Uzbekistan	2 028	1 859	-169	Lower recovery from older wellfields

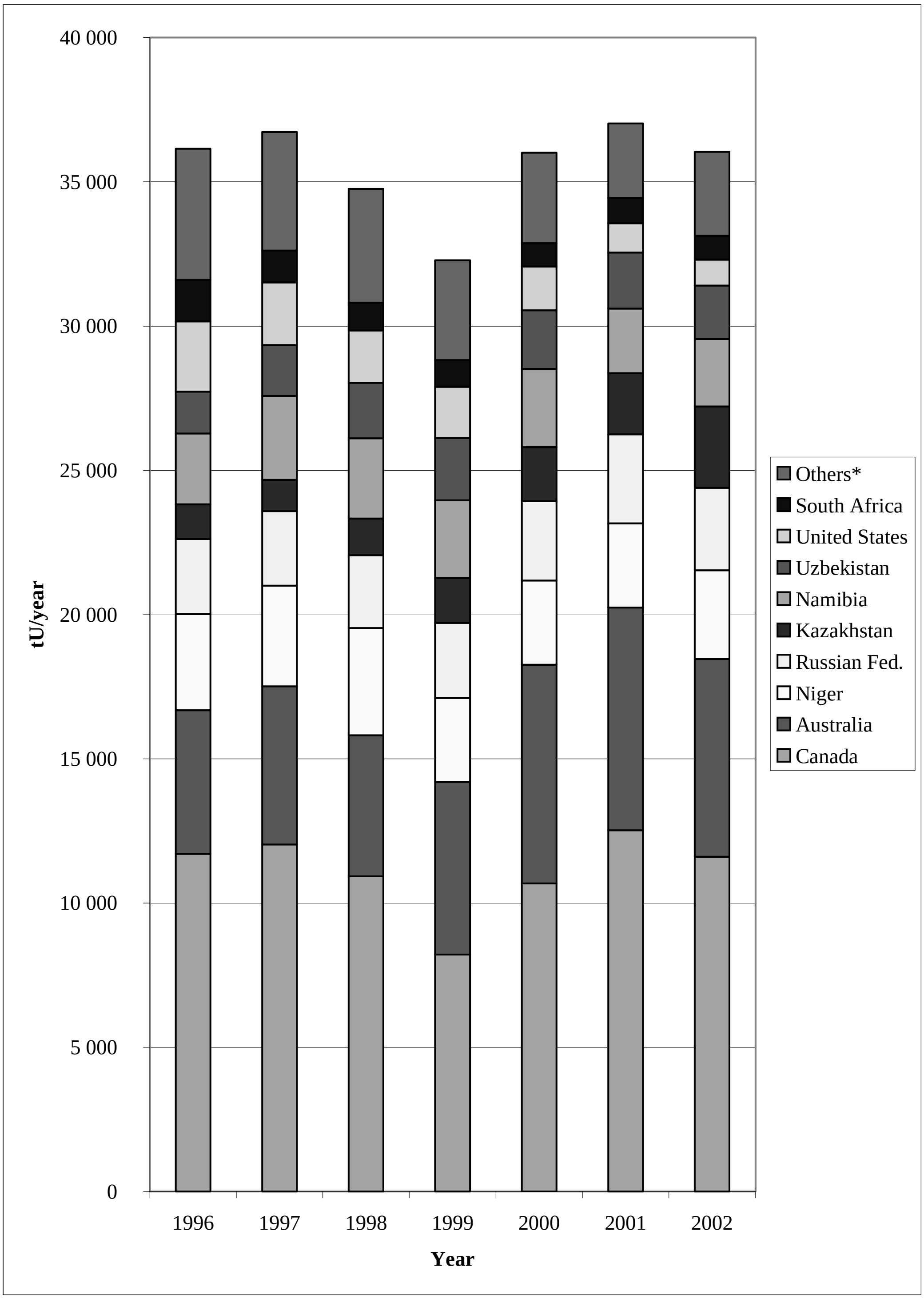
* Production comes from mine rehabilitation efforts only.

Table 12. **Historical Uranium Production**
(tonnes U)

COUNTRY	**Pre-2000**	**2000**	**2001**	**2002**	**Total to 2002**	**2003** (expected)
Argentina	2 509	0	0	0	2 509	0
Australia	83 578	7 579	7 720	6 854	105 731	7 070
Belgium	686	0	0	0	686	0
Brazil	1 030	11	56	272	1 369	340
Bulgaria	16 720	0	0	0	16 720	0
Canada	329 840	10 683	12 522	11 607	364 652	9 700
China (a)	6 735 *	700 *	700 *	730 *	8 865 *	730 *
Congo, Democratic Republic of	25 600	0	0	0	25 600	0
Czech Republic	106 769	507	456	465	108 197	453
Finland	30	0	0	0	30	0
France	73 368	296	184	18	73 866	5
Gabon	26 612	0	0	0	26 612	0
Germany	218 814 (b)	28 (c)	27 (c)	221 (c)	219 090	150 (c)
Hungary	21 020	10	10	10	21 050	4
India	7 066 *	207 *	230 *	230 *	7 733 *	230 *
Japan	84	0	0	0	84	0
Kazakhstan	88 272	1 870	2 114	2 822	95 078	3 315
Mexico	49	0	0	0	49	0
Mongolia	535	0	0	0	535	0
Namibia	69 412	2 715	2 239	2 333	76 699	2 500
Niger	78 946	2 914	2 919	3 080	87 859	3 000
Pakistan	814 *	23 *	46 *	38 *	921 *	40 *
Poland	660	0	0	0	660	0
Portugal	3 703	14	4	0	3 721	0
Romania	17 643	86	85 *	90 *	17 904 *	90 *
Russian Federation	111 263	2 760	3 090	2 850	119 963	3 070
Slovenia (d)	382	0	0	0	382	0
South Africa	150 043	798	878	824	152 543	855
Spain	4 706	255	30	37	5 028	0
Sweden	200	0	0	0	200	0
Ukraine (e)	9 092 *	1 005 *	750 *	800 *	11 647 *	800 *
United States	352 274	1 522	1 015	902	355 713	730 *
Uzbekistan	93 730	2 028	1 945	1 859	99 562	2 300
Zambia	102	0	0	0	102	0
OECD	1 195 781	20 894	21 968	20 114	1 258 757	18 112
TOTAL	**1 902 287**	**36 011**	**37 020**	**36 042**	**2 011 360**	**35 382**

* Secretariat estimate.
(a) Production in China since 1990.
(b) Production includes 213 380 tU produced in the former GDR through 1989.
(c) Production comes from mine rehabilitation efforts only.
(d) Production includes 380 tU produced in Yugoslavia prior to 1991.
(e) Production in Ukraine since 1992.

Figure 4. **Recent World Uranium Production**



* "Others" includes the remaining producers (Table 12).
Values for China, India, Pakistan, Romania and Ukraine are estimated.

Present Status of Uranium Production

North America production, which contributed about 35% to the world total in 2002, increased by over 2% from 2000 (12 205 tU) to 2002 (12 509 tU). **Canada** remained the world's leading producer, as increased McArthur River and Cluff Lake production exceeded the decline in Rabbit Lake output in 2002. Production in 2003 is expected to decline to 9 700 tU, as Cluff Lake was definitively closed at the end of 2002 and operations were suspended at the McArthur River mine in April 2003 for three months due to flooding that inundated a portion of the mine. Production in the **United States** declined to 902 tU in 2002. Almost all the production came from three ISL operations, with a small amount recovered from ISL restoration and mine water treatment activities.

Brazil was the only producing country in **Central** and **South America** in 2001 and 2002. Estimated production increased to 272 tU in 2002, as the Lagoa Real production centre reached full capacity. In **Argentina**, the Sierra Pintada mine, which was placed on standby in 1999, is expected to restart production in 2005.

Output from **Western Europe and Scandinavia** decreased from 593 tU in 2000 to 276 tU in 2002, representing less than 1% of total world production. In **Germany**, 27 tU were recovered from mine rehabilitation efforts in 2001. In 2002, 221 tU were recovered and it is expected that 150 tU will be recovered in 2003, as mine flooding has reached levels containing sulphuric acid and dissolved uranium from previous operations. The remainder of the output from Western Europe (**France** and **Spain**) was also derived from clean-up operations and water treatment. In 2003, all the uranium mines in Western Europe remain closed.

Production in **Central**, **Eastern** and **South-eastern Europe** declined slightly from 4 368 tU in 2000 to 4 215 tU in 2002, or about 12% of world production. In 2003, production is expected to increase to 4 417 tU. The **Czech Republic** produced 507 tU in 2000 and 465 tU in 2002. Annual output in **Hungary** was limited to about 10 tU recovered during reclamation activities at the Mecsek mine. Production in **Romania** was reported as 86 tU in 2000 and estimated as 90 tU in 2002. Production in the **Russian Federation** increased from 2 760 tU in 2000 to 2 850 tU in 2002. Most of this production came from the Priargunski mine, although 100 tU were produced in 2002 at the Dalur ISL facility at the Dalmatovskoe deposit in the Transural district. Production in Russia is expected to increase to 3 070 tU in 2003. Production in **Ukraine** is estimated to have been 750 tU in 2001 and 800 tU in 2002.

Three countries in **Africa**, Namibia, Niger and South Africa, contributed about 17% to world production in 2002. Production in Africa declined from 6 427 tU in 2000 to 6 237 tU in 2002 and production in **Namibia** decreased from 2 715 tU in 2000 to 2 333 tU in 2002. However, Namibia's production could increase by 1 000 tU in 2006 with the opening of a new mine at Langer Heinrich. **Niger**'s output increased from 2 914 tU in 2000 to 3 080 tU in 2002. Production in **South Africa** remained almost unchanged from 798 tU in 2000 to 824 tU in 2002, despite the closure of the uranium recovery facility at the Palabora copper mine.

Production in the **Middle East, Central** and **Southern Asia** increased steadily between 2000 and 2002, totalling 4 949 tU in 2002, or about 14% of the world total, compared to 4 128 tU in 2000. This increase is largely driven by developments in **Kazakhstan**, where production rose from 1 870 tU in 2000 to 2 822 tU in 2002, and is expected to further increase to 3 315 tU in 2003. During the same period, production in **Uzbekistan** decreased from 2 028 tU in 2000 to 1 859 tU in 2002, but is expected to increase to 2 300 tU in 2003. **India** and **Pakistan** do not report production information, but their 2002 output is estimated to have increased slightly from 2000 by 230 tU and 38 tU, respectively.

China, the only producing country in **East Asia**, does not report official production figures. Production is estimated to have been 700 tU in 2001 and 730 tU in 2002.

Australia, the only producing country in the **Pacific** region, reported a decline in output from 7 579 tU in 2000 to 6 854 tU in 2002 (19% of world production), due to constrained production at Olympic Dam following a fire in the solvent extraction circuits. In 2001, ISL production started at the Beverley mine and production in Australia is expected to increase to 7 070 tU in 2003.

Table 13 shows the ownership of worldwide uranium production in 2002, within the 20 countries with production. Domestic mining companies controlled about 64.3% of 2002 production compared to about 62% in 2000. Government-owned and privately owned domestic mining companies shared about equally in the portion of 2002 output that was domestically controlled. Of the remaining 2002 production share, approximately 18.9% was controlled by government-owned companies and 16.7% by private companies.

Table 13. **Ownership of Uranium Production Based on 2002 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	0.0	2 678	39.1	198	2.9	3 978	58.0	6 854
Brazil	272	100.0	0	0.0	0	0.0	0	0.0	272
Canada	0	0.0	6 008	51.8	5 423	46.7	176	1.5	11 607
China*	730	100.0	0	0.0	0	0.0	0	0.0	730
Czech Republic	465	100.0	0	0.0	0	0.0	0	0.0	465
France	16	87.7	2	11.1	0	0.0	0	0.0	18
Germany	221	100.0	0	0.0	0	0.0	0	0.0	221
Hungary	10	100.0	0	0.0	0	0.0	0	0.0	10
India*	230	100.0	0	0.0	0	0.0	0	0.0	230
Kazakhstan	2 726	96.6	0	0.0	0	0.0	96	3.4	2 822
Namibia	82	3.5	2 251	96.5	0	0.0	0	0.0	2 333
Niger	1 015	32.9	0	0.0	1 194	38.8	871	28.3	3 080
Pakistan*	38	100.0	0	0.0	0	0.0	0	0.0	38
Romania*	90	100.0	0	0.0	0	0.0	0	0.0	90
Russian Federation	2 850	100.0	0	0.0	0	0.0	0	0.0	2 850
South Africa	0	0.0	824	100.0	0	0.0	0	0.0	824
Spain	0	0.0	37	100.0	0	0.0	0	0.0	37
Ukraine*	800	100.0	0	0.0	0	0.0	0	0.0	800
United States	0	0.0	0	0.0	12	1.3	890	98.7	902
Uzbekistan	1 859	100.0	0	0.0	0	0.0	0	0.0	1 859
TOTAL	11 404	31.6	11 800	32.7	6 827	18.9	6 011	16.7	36 042

* Secretariat estimate.

Though the data are incomplete, Table 14 shows that employment levels at existing uranium production centres have remained relatively static from 2000 to 2002, and are expected to continue to do so in 2003. This contrasts to the situation between 1994 and 2000, when a steady reduction in employment levels occurred. Table 15 provides, in selected countries, employment directly related to uranium production (excluding head office, R&D, pre-development activities, etc), along with the level of production in that country.

Table 14. **Employment in Existing Production Centres of Countries Listed**
(in person-years)

COUNTRY	1996	1997	1998	1999	2000	2001	2002	2003 (expected)
Argentina	100	80	80	80	70	62	60	60
Australia (a)	464	468	501	565	527	550	502	502
Belgium	5	6	6	6	5	5	4	0
Brazil	305	280	180	110	48 (b)	128 (b)	128 (b)	140 (b)
Canada (c)	1 155	1 105	1 134	1 076	1 026	973	972	1 000
China	8 500	8 500	8 500	8 500	8 500	8 200	8 000	7 700
Czech Republic	3 600	3 580	3 410	3 300	2 887	2 641	2 507	2 445
France	441	141	144	NA	NA	NA	NA	NA
Gabon	259	150	NA	NA	15	15	15	10
Germany (d)	4 200	3 980	3 615	3 149	3 115	3 004	2 691	2 509
Hungary	1 300	900	0	0	0	0	0	0
India	NA	4 000	4 000	4 000	4 000	4 200	4 200	4 200
Kazakhstan	6 000	5 100	4 800	4 600	4 100	4 000	3 770	3 850
Namibia	1 189	1 254	1 104	1 009	902	785	782	780
Niger	2 070	2 033	2 012	1 830	1 680	1 607	1 558	1 547
Portugal	56	57	61	54	47	30	11	NA
Romania	5 000	4 550	3 300	2 800	2 150	2 000 *	2 000 *	2 000 *
Russian Federation	13 000	12 900	12 800	12 700	12 500	12 325	12 800	12 800
Slovenia (d)	115	105	NA	NA	79	69	48	45
South Africa	NA	NA	160	160	160	150	150	150
Spain	178	172	148	135	134	58	56	56
United States (e)	689	793	911	649	401	245	280	280 *
Uzbekistan	8 201	8 230	8 165	7 734	7 331	7 300	8 370	8 500
TOTAL	56 827	58 384	55 031	52 457	49 677	48 347	48 904	48 574

NA 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) Employment directly related to uranium production.
(c) Employment at mine sites only.
(d) Employment related to decommissioning and rehabilitation.
(e) Does not include 429 person-years in 1996, 303 in 1997, 209 in 1998, 199 in 1999, 226 in 2000, 245 in 2001 and >204 in 2002 for employment in reclamation work relating to exploration, mining, milling, and processing.

Table 15. **Employment Directly Related to Uranium Production**

COUNTRY	2001		2002	
	Production employment (person/years)	Production (tU)	Production employment (person/years)	Production (tU)
Australia	NA	7 720	NA	6 854
Brazil	128	56	128	272
Canada	973	12 522	972	11 607
China	7 380	700*	6 300	730*
Kazakhstan	1 160	2 114	1 280	2 822
Namibia	785	2 239	782	2 333
Niger	1 391	2 919	1 348	3 080
Russian Federation	4 800	3 090	5 000	2 850
South Africa	140	878	140	824
United States	164	1 015	204	902
Uzbekistan	7 300	1 945	8 370	1 859

NA Not available. * Secretariat estimate.

Production Techniques

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

Historically, uranium production has principally involved open-pit and underground mining with ore processing in a conventional uranium mill. However, over the past two decades, ISL mining, which uses either acid or alkaline solutions to extract the uranium directly from the deposit, has become increasingly important. The uranium dissolving solutions are injected into, and recovered from, the ore-bearing zone using a system of wells. ISL technology is currently being used to extract uranium from sandstone deposits only.

The distribution of production by type of mining or "material sources" for 1998 through 2003 is shown in Table 16. From 1998 to 2000, "other" includes recovery of uranium as a co-product or by-product of gold, copper and phosphate operations, stope/block leaching, heap leaching and treatment of mine waters as part of reclamation and decommissioning.

As shown in Table 16, open-pit and underground mining and conventional milling continue to be the dominant uranium production technologies, accounting for 70.3% of total production in 2001, and 69.9% in 2002. These values are slightly lower than the 2000 value of 71% due to the closure of open-pit and underground operations in France, Portugal, Spain and Kazakhstan, as well as decreased production in Namibia. The increased ISL component in 2002 is the result of increased production in Kazakhstan and Australia (Beverley) offsetting decreased production in the United States and Uzbekistan. The decreased contribution of co-product/by-product recovery is the result of reduced production in Australia (Olympic Dam) following a fire in the solvent extraction circuits and the closure of the uranium recovery facility at the Palabora copper mine in South Africa. A slight increase of uranium recovered from water treatment is due to increased recovery in Germany, as the flooding of closed mine sites has reached levels containing sulphuric acid and dissolved uranium from previous operations.

In 2003, open-pit and underground mining are expected to continue to account for a majority of the world's uranium production. The underground share is expected to decrease as a result of the temporary closure of the McArthur River mine between April and July 2003, following flooding of part of the mine. Production using ISL technology could increase its relative share, as ISL production is expected to increase in Kazakhstan, the Russian Federation and Uzbekistan. In the near future, the ISL contribution may be much higher if planned new projects in Australia (Honeymoon), Kazakhstan (Akdala, Inkai and Moinkum), and the Russian Federation (Khiagda) are brought into production. Further increases in capacity at Olympic Dam, which is dependent on the price of copper as well as uranium demand, would ensure a continued important role for the co-product/by-product category.

Projected Production Capabilities

To assist in developing projections of future uranium availability, member countries were asked to provide projections of ***production capability*** through 2020. Table 17 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 category through 2020 for all countries that either are currently producing uranium or have the potential to do so in the future.

Table 16. **Percentage Distribution of World Production by Production Method**

Production method	**1998**	**1999**	**2000**	**2001**	**2002**	**2003** (expected)
Open-pit	39	35	28	26.1	26.8	27.9
Underground	40	36	43	44.2	43.1	39.5
In situ leaching	13	17	15	15.5	18.3	20.7
Heap leaching	(a)	(a)	(a)	1.2	1.7	1.9
In place leaching*	(a)	(a)	(a)	0.1	0.1	0.2
Co-product/by-product	(a)	(a)	(a)	12.4	9.1	9.4
U recovered from phosphates	(a)	(a)	0	0	0	0
Other methods**	8	12	14	0.5	0.8	0.5

* Also known as stope leaching or block leaching.
** Includes mine water treatment and environmental restoration.
(a) Included in “Other methods”.

A majority of world production capability through 2005 is based on resources recoverable at costs of <USD 40/kgU. In the A-II category, these proportions are: 2003 (78.5%), 2004 (77.6%), 2005 (74.2%), 2010 (59.1%), 2015 (59.8%) and 2020 (59.0%); and in the B-II category they are: 2003 (77.9%), 2004 (77.3%), 2005 (71.5%), 2010 (62.0%), 2015 (62.7%) and 2020 (59.4%). The lower percentages after 2010 reflect both the depletion of low-cost resources and the fact that Kazakhstan does not report any production capability after 2005.

Uranium producing countries not reporting projected production capabilities include China, India, Iran, Pakistan and Romania. Projections of future production capability for India, Iran, Pakistan and Romania in Table 17 are based on reports that these countries intend to meet their future domestic reactor requirements with domestic production. China reports only a capability to meet its short-term requirements unless new resources are discovered.

The reported production capability of existing and committed production centres in 2003, is about 47 260 tU. For comparison, 2002 uranium production was 36 042 tU, or about 76% of the 2003 production capability. In 2003, expected production (35 382 tU) represents about 75% of the stated production capability. Total production capability for 2003, including planned and prospective centres, is about 47 860 tU, 1 532 tU less than the 2002 total capability (49 392 tU) projected in the 2001 edition of the Red Book.

In 2004, production capability for existing and committed centres is expected to decrease by 1 260 tU, compared to 2003, as a result of small increases in Argentina (120 tU), Kazakhstan (185 tU), the Russian Federation (140 tU) and United States (300 tU) being offset by a larger decrease in Canada (2 005 tU).

The uranium production industry will continue to experience moderate change during the next 10 to 20 years. By 2005, existing and committed capability could decrease to about 45 295 tU. However, additions of planned and prospective centres would make available an additional 5 860 tU per year. The addition of planned and prospective production centres by 2005 would increase total capability to 51 155 tU.

The expected closure of existing mines due to resource depletion would cause existing and committed capability to decrease to 43 059 tU by 2010, a decline of about 4.9% compared to projected capability in 2005. Additions of planned and prospective centres would make available an additional 20 880 tU per year, bringing total capacity to 63 939 tU in 2010. Annual production capability is expected to continue to decline to about 43 612 tU in 2015 to 43 005 tU by 2020.

Changes in Production Facilities

Existing and committed production capability has changed very little between 2001 (45 310 tU) and 2003 (47 260 tU). The addition of new production centres and the expansion of existing capacity in 2001 and 2002 have offset the impact of the closure of production centres. The character of the industry has changed somewhat, however, as smaller, higher-cost facilities have been replaced with larger and more cost effective facilities. Some of the significant changes that have occurred in uranium production facilities in 2001 and 2002 and changes that are expected in the next few years include:

Facility closures

2001	Canada	(Rabbit Lake mill placed on stand-by, 3 900 tU)
	France	(Jouac, 600 tU)
	Portugal	(Urgeirica, 170 tU)
	United States	(Canon City mill placed on stand-by, 210 tU)
2002	Canada	(Cluff Lake, 1 900 tU)
	India	(Uranium recovery from copper tailings at Rakha and Mosaboni mines placed on stand-by, 30 tU)
	Kazakhstan	(KazSubton mine and mill placed on stand-by, 1 270 tU)
	South Africa	(Palabora uranium circuit, 90 tU)
	Spain	(Fe, 800 tU)
	United States	(Highland mill placed on stand-by, 770 tU)
2005	Czech Rep	(Rozna, 400 tU)

Mine re-opening or expansion of existing facilities

2002	Canada	(re-opening of Rabbit Lake, 3 900 tU)
2005	Argentina	(re-opening of Sierra Pintada, 120 tU)
2006	China	(expansion of Fuzhou, 200 tU)
Unknown	Kazakhstan	(expansion of Stepnoye and Mining Group #6, from 1 600 tU/y to 2 500 tU/y)
Unknown	Ukraine	(doubling capacity to 2 000 tU/y)

New mines opening

2001	Kazakhstan	(Akdala, Inkai, Moinkum ISL tests)
	Russia	(Dalmatovskoe, 700 tU)

New mines planned

2003	India	(Turamdih, 40 tU)
2005	Iran	(Saghand, 60 tU)
	Russia	(Khiagda, 1 000 tU)
2006	Canada	(Cigar Lake, 6 900 tU)
	India	(Banduhuran, 150 tU; Lambapur, 130 tU)
	Namibia	(Langer Heinrich, 1 000 tU)
Unknown	Australia	(Honeymoon, 850 tU)

Table 17. **World Uranium Production Capability to 2020**
(in tonnes U/year, from RAR and EAR-I resources recoverable at costs up to USD 80/kgU, except as noted)

COUNTRY	2003		2004		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	120	120	500	500	500	500	500	500	NA	NA
Australia	9 400	9 400	9 400	10 300	9 900	10 700	8 600	12 000	8 600	12 000	8 600	12 000
Brazil	340	340	340	340	510	510	850	1 100	1 100	1 100	1 100	1 100
Canada	14 890	14 890	12 885	12 885	10 275	10 275	7 200	16 425	7 200	16 425	7 200	14 125
China * (a)	850	850	850	850	850	1 050	1 050	1 560	1 050	1 560	1 050	1 560
Czech Republic	440	440	440	440	250	250	84	84	87	87	80	80
India * (b) (c)	230	230	230	230	365	510	510	880	510	1 560	510	2 890
Iran, Islamic Rep. of* (c)	0	0	0	0	60	180	180	410	180	410	180	410
Kazakhstan	3 315	3 315	3 500	3 500	4 000	4 100	4 000 *	4 500 *	4 000 *	4 500 *	4 000 *	4 500 *
Mongolia (d)	0	0	0	0	150 *	1 100 *	150 *	1 100 *	150 *	1 100 *	150 *	1 100 *
Namibia	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	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800
Pakistan * (c)	65	65	65	65	65	110	65	110	65	200	65	250
Romania * (c)	100	100	100	100	100	100	200	300	200	300	300	400
Russian Federation	3 060	3 060	3 200	3 200	3 300	3 300	4 700	4 700	4 700	4 700	4 700	4 700
South Africa (d)	1 270	1 270	1 270	1 270	1 270	1 270	1 270	1 270	1 270	1 270	1 270	1 270
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	2 200	2 800	2 500	3 600	2 600	6 100	1 900	7 200	1 200	5 200	1 000	5 000
Uzbekistan	2 300	2 300	2 300	2 300	2 300	2 300	2 500	2 500	3 000	3 000	3 000	3 000
TOTAL	47 260	47 860	46 000	48 000	45 295	51 155	43 059	63 939	43 612	63 712	43 005	62 185

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 or not reported.

* Secretariat estimate.

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

(b) From resources recoverable at costs of <USD 130/kgU.

(c) Projections are based on reported plans to meet domestic requirements.

(d) From resources recoverable at costs of <USD 40/kgU.

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[3] United Nations Development Program (2000), *World Energy Assessment*, New York, which was based on data from the German Federal Institute for Geosciences and Natural Resources.

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. The data for 2003 and beyond are estimates and the actual figures will often differ.

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

World (363.8 GWe net as of 1 January 2003)

As of 1 January 2003, a total of 441 commercial nuclear reactors were operating worldwide and 33 reactors were under construction (about 27.1 GWe net). Three new power plants were connected to the grid (about 2.8 GWe net) in 2001 and six new reactors were connected in 2002 (about 5.0 GWe net). Over the same period, four reactors were permanently shutdown (two in Bulgaria, representing a combined installed capacity of about 0.8 GWe net, and two in the United Kingdom that combined represented about 0.25 GWe net). Table 18 and Figures 5 and 6 summarise the status of the world's nuclear power plants as of 1 January 2003. These power plants generated about 2 518 TWh of electricity in 2001 and about 2 573 TWh in 2002 (Table 19).

World annual uranium requirements were estimated at about 66 815 tU in 2002 and about 68 435 tU in 2003 (Figure 6).

OECD (306.3 GWe net as of 1 January 2003)

As of 1 January 2003, the 354 reactors in operation in OECD countries constituted about 84% of the world's nuclear electricity generating capacity. A total of seven reactors are under construction with a net capacity of about 6.4 GWe. During 2001 and 2002, four reactors were started up (about 3.7 GWe net) and two reactors were shutdown (about 0.25 GWe net).

Within the OECD there are great differences in nuclear energy policy. Japan and South Korea are committed to continue strong growth in nuclear energy, whereas several member countries in Western Europe and Scandinavia are committed to phasing out nuclear energy, notably Belgium, Germany and Sweden. At the same time, other countries in Europe, such as France, remain strongly committed to the use of nuclear energy. Finland has committed to building a new nuclear power plant to be operational by 2010, discussions on reintroduction of nuclear energy have begun in Italy and the European Commission continues to press for a role for nuclear energy as Europe strives to meet its greenhouse gas emission targets. In North America, the United States government is seeking new partnership arrangements with nuclear generating companies on licensing activities with a goal for a new nuclear power plant to be ordered and licensed for deployment early this decade. In Canada, three reactors that were shut down in 1997 are being brought back into service in 2003 and an additional three may be brought back to service over the next few years.

The OECD reactor-related uranium requirements were 55 490 tU for 2002 and are expected to be about 56 255 tU in 2003.

Table 18. **Nuclear Data Summary**
(as of 1 January 2003)

COUNTRY	**Operating reactors**	**Generating capacity** (GWe net)	**2002 Uranium requirements** (tU)	**Reactors under construction**	**Reactors started up during 2001 and 2002**	**Reactors shutdown during 2001 and 2002**
Argentina	2	0.94	120	1	0	0
Armenia	1	0.38	70	0	0	0
Belgium	7	5.76	1 150	0	0	0
Brazil	2	1.88	450	0	0	0
Bulgaria	4	2.72	840 *	0	0	2
Canada	14	10.30	1 400	0	0	0
China (a)	7	4.40	790	4	4	0
Czech Republic	6	3.47	745	0	1	0
Finland	4	2.60	500	0	0	0
France	59	63.30	8 570	0	0	0
Germany	19	21.30	3 150 +	0	0	0
Hungary	4	1.80	370	0	0	0
India	14	2.50	430	8	0	0
Iran, Islamic Republic of	0	0.00	0	2	0	0
Japan (b)	54	46.19 (b)	7 840	3	1	0
Korea, Dem. People's Rep. of	0	0.00	0	1	0	0
Korea, Republic of	18	15.72	2 780	2	2	0
Lithuania	2	2.76	360	0	0	0
Mexico	2	1.36	330 +	0	0	0
Netherlands	1	0.45	95 +	0	0	0
Pakistan	2	0.43	65 *	0	0	0
Romania	1	0.65	100 *	1	0	0
Russian Federation	30	22.25	4 600	3	1	0
Slovak Republic	6	2.46	500	2	0	0
Slovenia	1	0.68	190	0	0	0
South Africa	2	1.80	280	0	0	0
Spain	9	7.87	1 470	0	0	0
Sweden	11	9.40	1 600	0	0	0
Switzerland	5	3.20	360	0	0	0
Ukraine	13	11.21	2 200	4	0	0
United Kingdom	31	12.50	1 930	0	0	2
United States	104	98.66	22 700	0	0	0
OECD	354	306.34	55 490	7	4	2
TOTAL	**441**	**363.82**	**66 815**	**33**	**9**	**4**

Source: IAEA Power Reactor Information System except for *Generating capacity* and *2002 Uranium requirements*, www.iaea.org/programmes/a2/.

* Secretariat estimate.

\+ Data from NEA *Nuclear Energy Data*, Paris, 2003.

(a) The following data for Chinese Taipei are included in the world total but not in the total for China: 6 nuclear power plants in operation, 4.9 GWe net; 830 tU; 2 reactors under construction; 0 started up or shutdown during 2001 and 2002.

(b) GWe gross.

Figure 5. **2002 World Installed Nuclear Capacity: 363.8 GWe net**

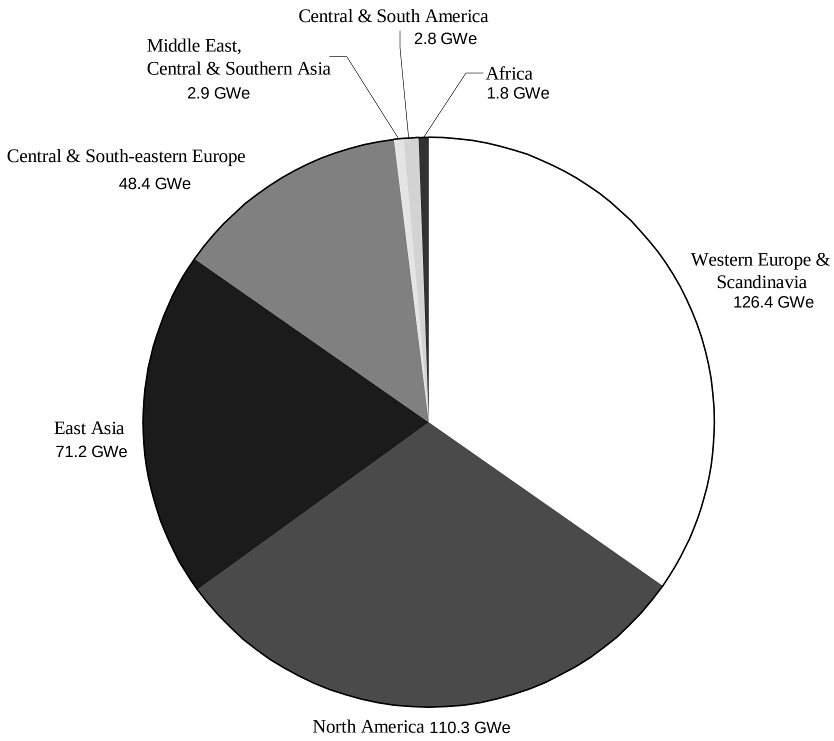

Figure 6. **2002 World Uranium Requirements: 66 815 tU**

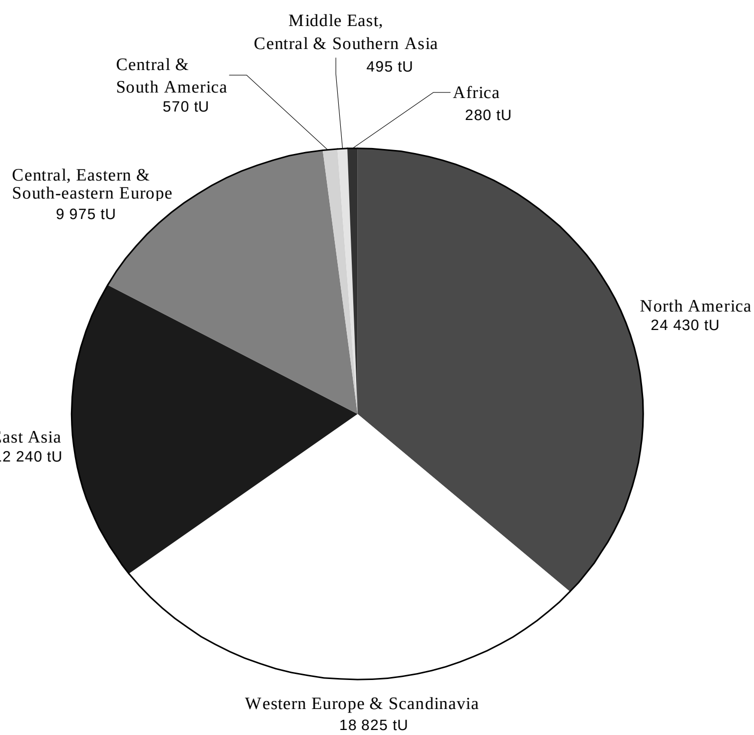

Table 19. **Electricity Generated Using Nuclear Power Plants**
(TWh)

COUNTRY	**2001**		**2002**	
Argentina	6.56	*	5.40	*
Armenia	1.99		2.29	
Belgium	44.10		45.10	(b)
Brazil	14.35		13.84	
Bulgaria	19.60	*	20.20	*
Canada	72.00		70.20	
China	16.80		25.00	
Czech Republic	14.75		18.74	
Finland	22.30	(a)	21.40	
France	399.60		415.50	
Germany	162.30	*	162.25	*
Hungary	14.13		13.95	
India	19.20	(a)	19.56	(a)
Japan	319.00		314.00	
Korea	106.60		119.10	(a)
Lithuania	10.30		12.90	
Mexico	8.37	*	9.36	*
Netherlands	3.75	*	3.69	*
Pakistan	1.98	*	1.80	*
Romania	5.05	*	5.11	*
Russian Federation	136.30		141.20	(a)
Slovak Republic	17.10		17.90	
Slovenia	5.31		5.04	
South Africa	10.70	*	11.99	*
Spain	63.70	(a)	63.00	
Sweden	69.00		70.00	
Switzerland	25.29	(a)	25.69	(a)
Ukraine	76.18		78.00	
United Kingdom	83.00		81.10	(b)
United States	769.00	(a)	780.00	(a)
OECD	2 193.99		2 230.98	
TOTAL	**2 518.31**		**2 573.31**	

* Secretariat estimate.
(a) Generation record.
(b) Provisional data.

North America (110.3 GWe net as of 1 January 2003)

At the beginning of 2003, there were 104 reactors with operating licenses in the **United States**[1] (about 98.7 GWe net), 14 in Canada (about 10.3 GWe net) and two in **Mexico** (about 1.4 GWe net). No reactors were under active construction, connected to the grid or shut down in 2001 and 2002.

In the United States, record levels of nuclear power generation achieved in 2001 and 2002 brought the total to four consecutive record-setting years. Extensions of operating lives and increases in generating capacity continue to increase uranium requirements, even in the absence of new construction. United States regulatory authorities expect to receive 46 applications for power uprates by 2005, equivalent to about 1.6 GWe of net capacity. During 2001 and 2002, regulatory authorities granted three 20-year license extensions and received eight additional applications for similar extensions that covered a total of 16 reactors. Additional capacity is also expected to be added in the nearer term if plans to restart the Browns Ferry-1 plant (shutdown since 1985) by May 2007 are realised.

In **Canada,** following an independent performance assessment in 1997, seven reactors were shutdown for refurbishment (four at Pickering-A site and three at Bruce-A site). Work is underway to restart three of these reactors (two at Bruce and one at Pickering) in 2003 while an assessment of the timing and costs of restarting the remaining three reactors at the Pickering station continues.

Annual requirements for North America were about 24 430 tU in 2002 and are expected to increase slightly to 24 730 tU in 2003.

Western Europe and Scandinavia (126.4 GWe net as of 1 January 2003)

As of 1 January 2003, 146 nuclear reactors were operating in Western Europe and Scandinavia. No new reactors were under construction nor were any connected to the grid in 2001 or 2002. Two reactors in the **United Kingdom** (about 0.25 GWe net combined) were shutdown in March 2002.

In **Belgium**, the government decided to phase out nuclear energy by limiting the operational lives of its reactors to 40 years and permitting no new construction. The first reactor shutdown under this policy would occur around 2015.

Finland became the first country in Western Europe and Scandinavia in over a decade to authorise the construction of a new nuclear power plant through a parliamentary vote on 24 May 2002. Plans call for the reactor to be operational by 2010. Finland’s nuclear power plants generated a record amount of electricity in 2001.

In 2002, the government of **France** announced that it would conduct a national debate on energy policy in 2003, including the role of nuclear energy, as a preliminary step in formulating a new energy law.

In April 2002, the government of **Germany** enacted a new nuclear law that codifies the long-term phase-out nuclear energy. For each plant operating as of 1 January 2000 a residual operating life has been calculated based on a standard operating life of 32 calendar years from the commencement of commercial operation. With the newest German power plant entering commercial operation in 1989, the new law could result in the elimination of nuclear power generation in Germany after 2021. The law also bans the reprocessing of spent fuel after 1 July 2005.

1. The Browns Ferry 1 reactor (1 065 MWe net) is listed as operational in the IAEA Power Reactor Information System though it has been shutdown since June 1985.

The government of **Italy** has begun formulating a new energy policy that may reconsider the use of nuclear energy. This could potentially result in the reversal of the current non-nuclear policy that has been in place since a 1987 referendum that led to the shutdown of all Italian nuclear power plants.

In the **Netherlands**, the planned shutdown of the Borssele nuclear power plant in 2003 was changed by a newly elected government and the plant is now expected to operate through 2013.

In **Spain,** nuclear power plants generated a record amount of electricity in 2001 and produced only a slightly lower amount in 2002.

Sweden remains committed to the phase out of nuclear energy. Closure of a second reactor (Barseback-2) as a result of this policy, originally scheduled for 2002, is now planned for 2003. Late in 2002, the government of Sweden granted permission for the use of ***mixed-oxide fuel*** (MOX) fuel in the Oskarshamn nuclear power plant. This decision allows plutonium recovered from fuel shipped to the United Kingdom for reprocessing before 1982 to be used in Swedish reactors. Since 1982, all used nuclear fuel produced in Sweden has been stored in a central storage facility pending long-term disposal.

In **Switzerland,** nuclear energy remains under public debate as two referenda, initiated in 1999, were voted down in May 2003. The defeated referenda, “Electricity without Atoms” and “Moratorium Plus”, would have effectively signalled a public desire to phase out of nuclear energy if they had been passed. In March 2003, a new nuclear law was accepted by the parliament. It keeps open the option of deploying new nuclear power plant technologies and avoids placing limits on the operational lifetime of a nuclear power plant, but includes a 10-year moratorium on the export of spent nuclear fuel for reprocessing beginning in 2006. The law is expected to become valid in 2005. Swiss power plants generated record amounts of electricity in 2001 and 2002.

In the **United Kingdom** the future of nuclear energy remains uncertain while the government conducts an extensive energy policy review and national energy debate. Although a government policy paper[2] released in February 2003 did not rule out building new nuclear power plants, it provided no commitment or support for their construction. Low wholesale electricity prices have placed pressure on operators to shutdown some nuclear power plants and to accelerate closure dates for others. As a consequence, the two units at Bradwell (about 0.25 GWe net combined) were shutdown in March 2002, the four power plants at Calder Hall (about 0.2 GWe net combined) had their planned shutdown moved forward from 2006 to 2003 and the four units at Chapelcross (about 0.2 GWe net combined) had their planned shutdown moved forward to March 2005 instead of the originally planned 2008.

The reactor-related uranium requirements for Western Europe and Scandinavia in 2002 were about 18 825 tU and are expected to decrease slightly to 18 750 tU in 2003.

East Asia (71.2 GWe net as of 1 January 2003)

As of 1 January 2003, 79 power plants with a capacity of about 71.2 GWe net[3] were in operation in East Asia. In this region, undergoing the strongest growth in nuclear capacity in the world, 10 reactors were under construction that will add about 10 GWe net to the grid. Seven power plants were connected to the grid (about 5.8 GWe net) during 2001 and 2002 while none were shutdown.

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2. United Kingdom, Department of Trade and Industry (February 2003), *Our Energy Future: Creating A Low Carbon Economy*. Available at www.dti.gov.uk/energy/whitepaper.

3. There were also 6 nuclear power plants in operation in Chinese Taipei (about 4.9 GWe net) and 2 plants under construction (about 2.7 GWe net).

In **Japan**, government plans continue to call for 59 power plants to be operational by 2010, an addition of five power plants to the current fleet of 54. Government and industry continue development of an indigenous closed fuel cycle and remain committed to initiate the use of MOX fuel in 16-18 reactors by 2010. The Onagawa-3 reactor (0.8 GWe net) was connected to the grid in May 2001.

In the **Republic of Korea,** two new nuclear power plants were connected to the grid in 2001 and 2002 (Yonggwang units 5 and 6 with about 1.9 GWe net). Current plans call for 27 nuclear reactors to be operational by 2015 as compared to the 18 power plants in operation on 1 January 2003. Korea's power plants generated a record amount of electricity in 2002.

In **China,** four power plants were connected to the grid in 2002 (Lingao-1, Lingao-2, Qinshan 2-1 and Qinshan 3-1 with about 3.2 GWe net combined) bringing its total to seven. The government of China also has reported plans to begin construction of several new reactors (about 10 GW) by 2005.

The 2002 reactor-related uranium requirements for the East Asia region were 12 240 tU and for 2003 are expected to increase to about 13 090 tU.

Central, Eastern and South-eastern Europe (48.4 GWe net as of 1 January 2003)

As of 1 January 2003, 68 nuclear power plants were in operation in 10 countries in this region, representing an installed capacity of about 48.4 GWe net, and the 10 plants under construction will add about 8.1 GWe net. During 2001 and 2002, two plants were connected to the grid (about 1.9 GWe net) and two plants were shutdown (about 0.4 GWe net).

In November 2001, the government of the **Russian Federation** announced plans to build at least 10 large nuclear power plants (about 1 GWe net each) and numerous small reactors (<0.1 GWe net) by 2011. Included in these plans is a new fast breeder reactor, several small floating reactors and reactors intended to produce district heat as the primary product, rather than electricity. In March 2001, the Volgodonsk-1 power plant, formerly known as the Rostov-1 power plant (about 1 GWe net), was connected to the grid. Russian nuclear power plants generated a record amount of electricity in 2002.

In December 2002, the Temelin-2 plant (about 0.9 GWe net) was connected to the grid in the **Czech Republic**.

In December 2002, construction of the Cernavoda-2 plant (about 0.7 GWe net) in **Romania** was resumed after having been suspended due to lack of funds in 1990. The plant is expected to begin operating in 2006.

In **Bulgaria,** two power plants at Kozloduy (about 0.4 GWe net each) were shutdown in December 2002. To compensate for the loss of this generating capacity, the government is planning to complete the partially constructed plant at Belene. Bulgarian power plants set a record for generating electricity in 2002.

In 2001, **Hungary** announced plans to extend the operating life of its Paks nuclear power plant for up to 20 years beyond the originally intended 30 years and to increase the capacity of the plant about 10% (from 460 MWe to up to 510 MWe) by 2007. It is not clear at this time whether the April 2003 fuel cleaning accident that occurred at the Paks site will affect these plans.

In 2002, the government of **Lithuania** approved a strategic plan that would see its two RBMK reactors at Ignalia replaced by modern nuclear plants after their closures in 2005 and 2009.

In 2002, the government of **Turkey** announced plans to construct a nuclear power plant, reversing a 2000 decision to suspend the pursuit of nuclear energy.

Reactor-related uranium requirements in 2002 for this region were about 9 975 tU and are expected to increase to 10 485 tU in 2003.

Middle East, Central and Southern Asia (2.9 GWe net as of 1 January 2003)

As of 1 January 2003, 16 power plants were in operation (about 2.9 GWe net) and 10 were under construction (about 5.7 GWe net) in this region. During 2001 and 2002, no power plants were connected to the grid and none were shutdown.

In **India**, eight power plants with a total capacity of about 3.6 GWe net are under construction with announced plans to increase the country’s nuclear generation capacity to 20 000 MWe by 2020. Construction of a prototype fast breeder reactor (about 0.5 GWe) was begun in early 2003 that potentially initiates a shift to a thorium-based nuclear fuel cycle after its scheduled completion in 2008. Power plants in India achieved record levels of generation in 2001 and 2002.

In 2002, the government of **Pakistan** announced plans to construct two new reactors, one each at the Chasnupp and the Kanupp sites, with a combined capacity of about 0.9 GWe, to supplement the two nuclear power plants (about 0.4 GWe net) currently in operation.

Elsewhere, two reactors (about 2.1 GWe net) remain under construction in **Iran**, with start up of the first expected in 2004. In 2001, the government of **Bangladesh** announced plans to restart construction of the 0.6 GWe Rooppur nuclear power plant with completion possible within 5-6 years of a final decision. In 2002, the government of **Israel** announced plans to initiate construction of a commercial nuclear power plant beginning around 2010. A feasibility study is underway, the results of which are necessary before plans are finalised.

Reactor-related uranium requirements for the Middle East, Central and Southern Asia region were about 495 tU in 2002 and are expected to increase to 530 tU in 2003.

Central and South America (2.8 GWe net as of 1 January 2003)

At the beginning of 2003, there were four nuclear units operating in two countries in this region – two each in Argentina and Brazil. **Brazil** is conducting studies on the viability of construction of a third nuclear power plant with a decision expected in 2003. The uranium requirements for Central and South America were about 570 tU in 2002 and are expected to remain the same in 2003.

Africa (1.8 GWe net as of 1 January 2003)

Nuclear capacity remained constant in Africa with the region's only two reactors located in **South Africa**. South Africa continues to actively develop the Pebble Bed Modular Reactor, a high-temperature, helium-cooled reactor. In 2002, **Egypt** announced plans to have a commercial nuclear power plant in operation northwest of Alexandria by 2010.

Annual reactor-related uranium requirements were about 280 tU/year in 2002 and are expected to remain the same in 2003.

South-eastern Asia (0 GWe net as of 1 January 2003)

This region has no current commercial nuclear capacity. However, **Indonesia** and **Vietnam** are planning the construction of nuclear reactors to satisfy their anticipated increasing demand for electricity. Indonesia has announced its plans to start construction of a commercial nuclear power plant by 2010. Vietnam has established a nuclear power programme that aims to commission the country's first nuclear power plant by 2019 or earlier.

Pacific (0 GWe net as of 1 January 2003)

This region has no commercial nuclear capacity. Although the government of **Australia** prohibits the development commercial nuclear energy, the process of replacing its existing research reactor with a modern research reactor is underway, with construction scheduled for completion in 2005. The government of **New Zealand** also has a policy prohibiting the development of nuclear power.

B. PROJECTED NUCLEAR POWER CAPACITY AND RELATED URANIUM REQUIREMENTS TO 2020

Factors Affecting Capacity and Uranium Requirements

Reactor-related requirements for uranium, over the short-term, are fundamentally determined by installed nuclear capacity, or more specifically by the kilowatt-hours of electricity generated. As noted, the majority of the anticipated near-term capacity is already operating, thus short-term requirements may be predicted with relative certainty. Other factors that affect installed capacity and uranium requirements include plant life extensions; plant retirements; plant power upgrades; plant efficiency; fuel-cycle length and discharge burn-up; and the ratio between natural uranium and enrichment prices.[4]

Many factors that influence decisions on the installation of new nuclear generating capacity must be resolved before there are likely to be any new significant building programmes. These factors include:

- Projected growth of base load electricity demand.
- The cost-competitiveness of new nuclear power plants and fuel compared to other energy sources, particularly with deregulation of electricity markets.
- Concerns about security of fuel supplies.
- Public attitudes and acceptance towards the safety of nuclear energy and proposed waste management strategies.
- Concerns about the connection between the civil nuclear fuel cycle and military uses.
- Environmental considerations, in particular a greater recognition of the role nuclear energy can play in reducing greenhouse gas emissions.

4. 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.

While these factors tend to affect decisions on new construction, the strong performance and economic competitiveness of existing plants, chiefly because of low operating, maintenance, and fuel costs, has made retention of these plants desirable in many countries. This has resulted in the developing trend to keep existing plants operating as long as can be achieved safely. For example, there is a trend in the United States and Russia to extend the lives of existing power 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 worldwide trend toward higher nuclear plant energy availability and capacity factors. In 2001, the world average nuclear energy availability factor reached a record high level of 83.4% continuing a steady upward trend since 1990 when the factor was 72.9%. [1] Longer operating lifetimes and increased availability will both tend to increase future uranium requirements.

Projections to 2020[5]

Forecasts of installed capacity and uranium requirements, although uncertain due to the above-mentioned factors, are indicative of future growth. Installed nuclear capacity could grow from about 364 GWe net at the beginning of 2003 to about 418 GWe net (low case) or 483 GWe net (high case) by the year 2020. The low case represents growth of about 15% from current capacity, while the high case represents a net increase of about 33% (Table 20).

Nuclear capacity projections vary considerably from region to region. The East Asia region is projected to experience the largest increase that, by the year 2020, could result in the incorporation of between about 53 GWe to 80 GWe of new capacity (75% to over 100% increases over current capacity, respectively). Nuclear capacity in Central, Eastern and South-eastern Europe is expected to increase, with a high case forecast of up to 24 GWe of new capacity by 2020 (an increase of about 50%). Other regions projected to experience growth include the Middle East and Southern Asia; Central and South America; Africa and South-eastern Asia. For North America, the increase of projected nuclear capacity for 2020 varies from about 4% to over 7%. This reflects a significant change since the last reporting period where a decrease of about 43 GWe was forecast in 2020 in the low case. In Western Europe and Scandinavia, nuclear capacity is expected to decrease significantly as plans to phase out nuclear energy in Belgium, Germany and Sweden are implemented. Here, decreases of about 17% to 24% are projected for 2020 (Figure 7).

World reactor-related uranium requirements by the year 2020 are projected to increase to 73 495 tU in the low case and to 86 070 tU in the high case, representing about 10% and 29% increases respectively, compared to the 2002 (Table 21). As in the case of nuclear capacity, uranium requirements are expected to vary considerably from region to region. In contrast to increased requirements in the rest of the world, requirements in North America and the Western Europe and Scandinavia region are expected to either remain fairly constant or to decline slightly through the year 2020. Uranium requirement increases will be largest in the East Asia region, where expected increases in nuclear capacity would almost double the 2002 uranium needs by the year 2020 (Figure 8).

5. Projections of nuclear capacity and reactor-related uranium requirements are based on official responses from Member countries to questionnaires circulated by the Secretariat. For countries that did not provide this information, Secretariat projections based on the IAEA *Power Outlook to 2030* were used. Because of the uncertainty in nuclear programmes in the years 2010, 2015 and 2020, high and low values are given.

Table 20. **Installed Nuclear Generating Capacity to 2020**
(MWe net, installed at end of year)

COUNTRY	2002	2003	2005	2010		2015		2020	
				Low	High	Low	High	Low	High
Argentina	940	940	940	940	1 630	940	1 630	600	1 290
Armenia	380	380	380	0	380	0	380	590	1 180
Bangladesh	0	0	0 *	0 *	0 *	0 *	0 *	0 *	100 *
Belgium	5 760	5 760	5 760	5 760	5 760	5 760	5 760	4 010	5 760
Brazil	1 875	1 875	3 120	1 875 *	3 120	3 120 *	3 120	3 120 *	3 120 *
Bulgaria	2 720	2 720	2 720 *	1 910 *	2 720 *	1 910 *	2 720 *	1 910 *	2 315 *
Canada	10 300	12 100	13 900	13 900	15 600	13 900	15 600	13 900	15 600
China (a)	4 400	6 100	8 700	12 700	14 700	18 000	23 000	22 000	32 000
Cuba	0	0	0 *	0 *	0 *	0 *	0 *	0 *	300 *
Czech Rep.	3 470	3 470	3 470	3 470	3 580	3 470	3 580	1 860	3 580
Egypt	0	0	0 *	0 *	0 *	0 *	600 *	0 *	600 *
Finland	2 600	2 600	2 600	2 600	4 100	3 600	4 100	3 600	4 100
France	63 300	63 300	62 950	62 950	62 950	62 950	62 950	62 950 *	65 740 *
Germany	21 300 +	21 300 +	20 300 +	17 500 +	17 500 +	10 500 +	11 800 +	4 000 +	4 000 +
Hungary	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800
India	2 500	2 500	2 500	6 100	6 100	6 100	14 860	19 230	19 230
Indonesia	0	0	0 *	0 *	0 *	0 *	0 *	0 *	900 *
Iran, Islamic Rep.	0	0	915 *	915 *	915 *	915 *	3 305 *	915 *	3 305 *
Japan	46 190 (b)	46 190 (b)	49 580 (b)	61 850 (b)	61 850 (b)	67 330 *	68 630 *	67 330 *	75 130 *
Kazakhstan	0	0	0	0	0	0 *	1 000 *	1 000 *	1 000 *
Korea, DPR	0	0	0 *	0 *	0 *	0 *	1 900 *	950 *	1 900 *
Korea, Rep.	15 720	15 720	17 720	23 120	23 120 *	26 635	27 340 *	26 635	33 535 *
Lithuania	2 760	2 760	1 380	0	1 380 *	0	1 500 *	0	1 500 *
Mexico	1 360	1 360	1 360 *	1 360 *	1 360 *	1 360 *	1 360 *	1 360 *	1 360 *
Netherlands	450	450	450 *	450 *	450 *	0 *	450 *	0 *	450 *
Pakistan	425	425	425 *	725 *	725 *	600 *	600 *	1 300 *	2 000 *
Romania	655	655	655 *	1 305 *	1 305 *	1 305 *	1 305 *	1 955 *	1 955 *
Russian Federation	22 250	22 250	23 000	28 000	28 000	33 000	36 000	37 000	41 400
Slovak Republic	2 460	2 460	2 460	1 640	2 460	1 640	2 460	1 640	2 460
Slovenia	680	680	680	690	700	690	700	690	700
South Africa	1 800	1 800	1 800	1 800	1 910	1 800	2 570	1 800	3 230
Spain	7 870	7 870	7 870	7 870	7 870	7 870	7 870	6 975 *	8 420 *
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	2 120	3 200	2 120	3 200
Turkey	0	0	0 +	0 +	0 +	0 +	0 +	1 400 +	1 400 +
Ukraine	11 210	11 210	12 160	13 110	14 060	10 420	14 060	4 720	14 060
United Kingdom	12 500	12 100	11 900	8 500	8 500	3 700	3 700	3 700	3 700
United States	98 660	98 930	100 200	99 300	99 300	99 500	99 500	99 600	101 300
Vietnam	0	0	0 *	0 *	0 *	0 *	0 *	700 *	700 *
OECD TOTAL	306 340	308 010	314 920	324 070	328 800	320 935	329 500	311 680	340 935
WORLD TOTAL	363 820	367 190	379 180	401 725	414 030	407 320	446 335	417 745	482 605

* Secretariat estimate based on *Energy, Electricity and Nuclear Power Estimates for the Period up to 2030*, IAEA (Vienna), July 2003.

\+ Data from *Nuclear Energy Data*, NEA (Paris), 2003.

(a) The following data for Chinese Taipei are included in the World Total but not in the totals for China 4 885 MWe net in 2002, 2003 and 2005, 7 585 MWe net for the low and high cases of 2010 and 2015, and 7 585 and 8 885 MWe net for 2020 low and high cases, respectively.

(b) MWe gross.

Table 21. **Annual Reactor-related Uranium Requirements to 2020**
(tonnes U)

COUNTRY	2002	2003	2005	2010		2015		2020	
				Low	High	Low	High	Low	High
Argentina	120	120	120	95	250	95	250	60	205
Armenia	70	90	90	0	90	0	90	90	180
Bangladesh	0	0	0 *	0 *	0 *	0 *	0 *	0 *	20 *
Belgium	1 150	1 150	1 150	1 150	1 150	800	1 150	800	1 150
Brazil	450	450	1 040	470	810	470	810	810 *	810 *
Bulgaria	840 *	840 *	840 *	450 *	840 *	450 *	840 *	450 *	550 *
Canada	1 400	1 700	2 000	2 000	2 300	2 000	2 300	2 000	2 300
China (a)	790	1 100	1 570	2 290	2 650	3 240	4 140	3 960	5 760
Cuba	0 *	0 *	0 *	0 *	0 *	0 *	0 *	0 *	50 *
Czech Rep.	745	745	690	690	700	700	710	345	710
Egypt	0	0	0 *	0 *	0 *	0 *	100 *	0 *	100 *
Finland	500	500	500	500	800	700	800	700	800
France	8 570	8 570	8 570	8 170	8 170	7 720	7 720	7 720 *	8 040 *
Germany	3 150 +	3 200 *	2 950 +	2 600 +	2 600 +	1 500 +	1 700 +	600 +	600 +
Hungary	370	370	370	370	370	370	370	370	370
India	430	465	505	880	880	880	2 140 *	2 770 *	2 770 *
Indonesia	0	0	0 *	0 *	0 *	0 *	0 *	0 *	155 *
Iran, Islamic Rep.	0	0	180 *	180 *	180 *	180 *	640 *	180 *	640 *
Japan	7 840	8 380	10 850	11 820	11 820	12 870 *	13 040 *	12 870 *	14 270 *
Kazakhstan	0	0	0	0	0	0 *	190 *	190 *	190 *
Korea, DPR	0	0	0 *	0 *	0 *	0 *	320 *	160 *	320 *
Korea, Rep.	2 780	2 780	3 230	4 120	4 120 *	4 770	4 900 *	4 770 *	6 040 *
Lithuania	360	310	100 *	0 *	180 *	0 *	200 *	0 *	200 *
Mexico	330 +	230 *	360 +	180 +	180 +	180 +	180 +	360 +	360 +
Netherlands	95 +	95 *	95 *	95 *	95 *	0 *	95 *	0 *	95 *
Pakistan	65 *	65 *	65 *	110 *	110 *	90 *	90 *	200 *	300 *
Romania	100 *	100 *	100 *	200 *	200 *	200 *	200 *	300 *	300 *
Russian Federation	4 600	5 100	5 300	5 500	5 500	6 800	7 200	7 300	8 600
Slovak Rep.	500	500	450	300	460	300	460	300	460
Slovenia	190	230	230	230 *	250 *	230 *	250 *	230 *	250 *
South Africa	280	280	280	280	300 *	280	400 *	280	500 *
Spain	1 470	1 500	1 120	1 560	1 560	1 560	1 560	1 400 *	1 680 *
Sweden	1 600	1 600	1 600	1 400	1 600	1 400	1 600	1 400	1 600
Switzerland	360	375	265	585	585	390	585	390	585
Turkey	0	0	0 *	0 *	0 *	0 *	0 *	240 *	240 *
Ukraine	2 200	2 200	2 350	2 500	2 650	1 950	2 600	950	2 600
United Kingdom	1 930	1 760	1 500	1 700	1 700	800	1 000	400	500
United States	22 700	22 800	21 300	18 900	18 900	24 500	24 500	19 500	20 140
Vietnam	0	0	0 *	0 *	0 *	0 *	0 *	120 *	120 *
OECD TOTAL	55 490	56 255	57 000	56 140	57 110	60 560	62 670	54 165	59 940
WORLD TOTAL	66 815	68 435	70 600	70 605	73 280	76 705	84 410	73 495	86 070

* Secretariat estimate based on *Energy, Electricity and Nuclear Power Estimates for the Period up to 2030*, IAEA (Vienna), July 2003.

\+ Data from *Nuclear Energy Data*, NEA (Paris), 2003.

(a) The following data for Chinese Taipei are included in the World Total but not in the totals for China: 830 tU/yr in 2002, 2003 and 2005; 1 280 tU/yr in the low and high cases in 2010 and 2015 and 1 280 tU/yr and 1 510 tU/yr in the low and high cases of 2020, respectively.

Figure 7. **Projected Installed Nuclear Capacity to 2020**
(low and high projections)

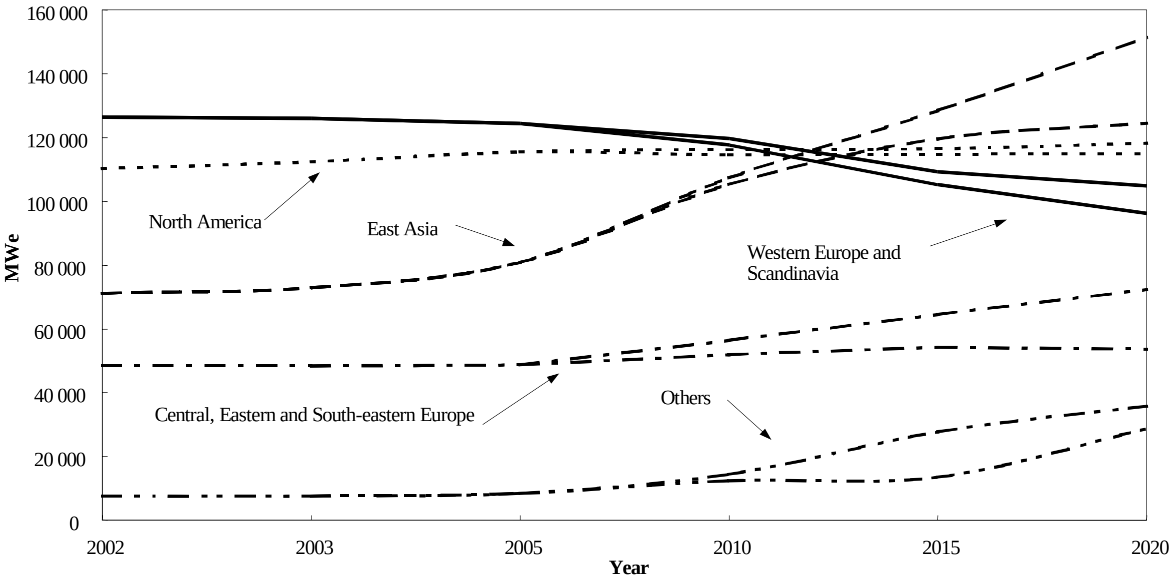
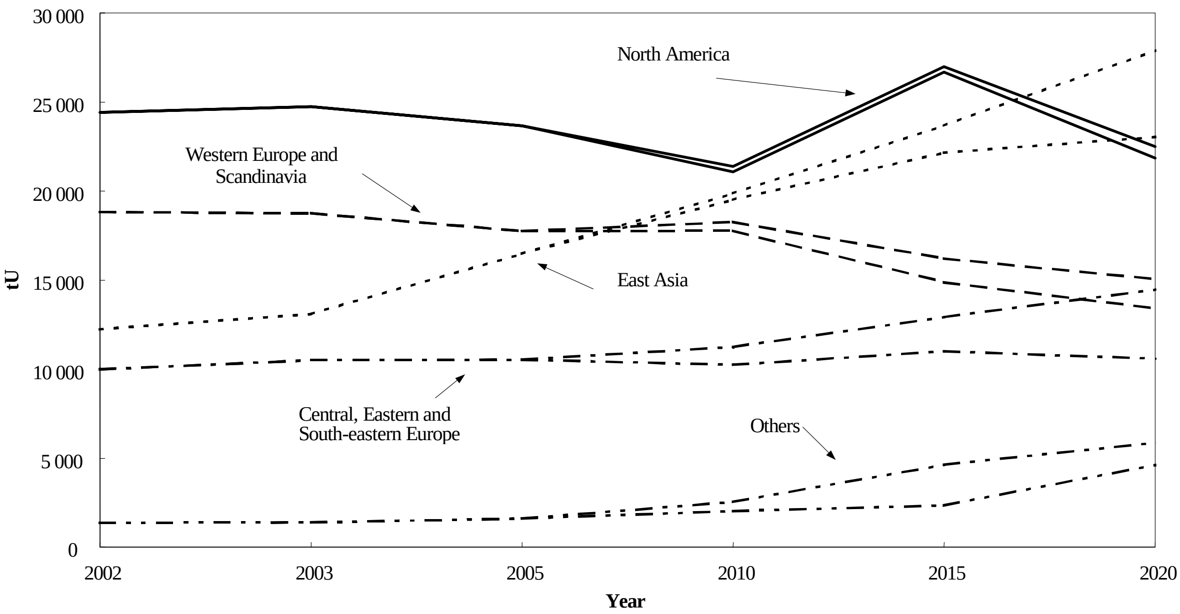


Figure 8. **Annual Reactor Uranium Requirements to 2020**
(low and high projections)



C. URANIUM SUPPLY AND DEMAND RELATIONSHIPS

Uranium supply and demand remain in balance and there have been no supply shortages since the last report. There are several different sources of supply of which the largest is the primary production of uranium that, over the last several years, has satisfied some 50% to 60% of world requirements. The remainder has been provided or derived from secondary sources including stockpiles of natural and enriched uranium, the reprocessing of spent fuel and the re-enrichment of depleted uranium tails.

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 (Figure 9). 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. This over production has created a stockpile of uranium now available for use in commercial power plants.

Following the political and economic reorganisation in Eastern Europe and the former Soviet Union in the early-1990s, major steps toward the development of an integrated commercial world uranium market have been taken. As a consequence there has been greater availability of uranium supplies from the former Soviet Union, particularly in the successor republics of Kazakhstan, the Russian Federation and Uzbekistan. Despite the increased availability of information regarding the amount of uranium held in inventory by utilities, producers and governments, uncertainty remains regarding the magnitude of these inventories (especially in the Russian Federation) and the availability of uranium from other sources. This uncertainty continues to have significant influence on the uranium market.

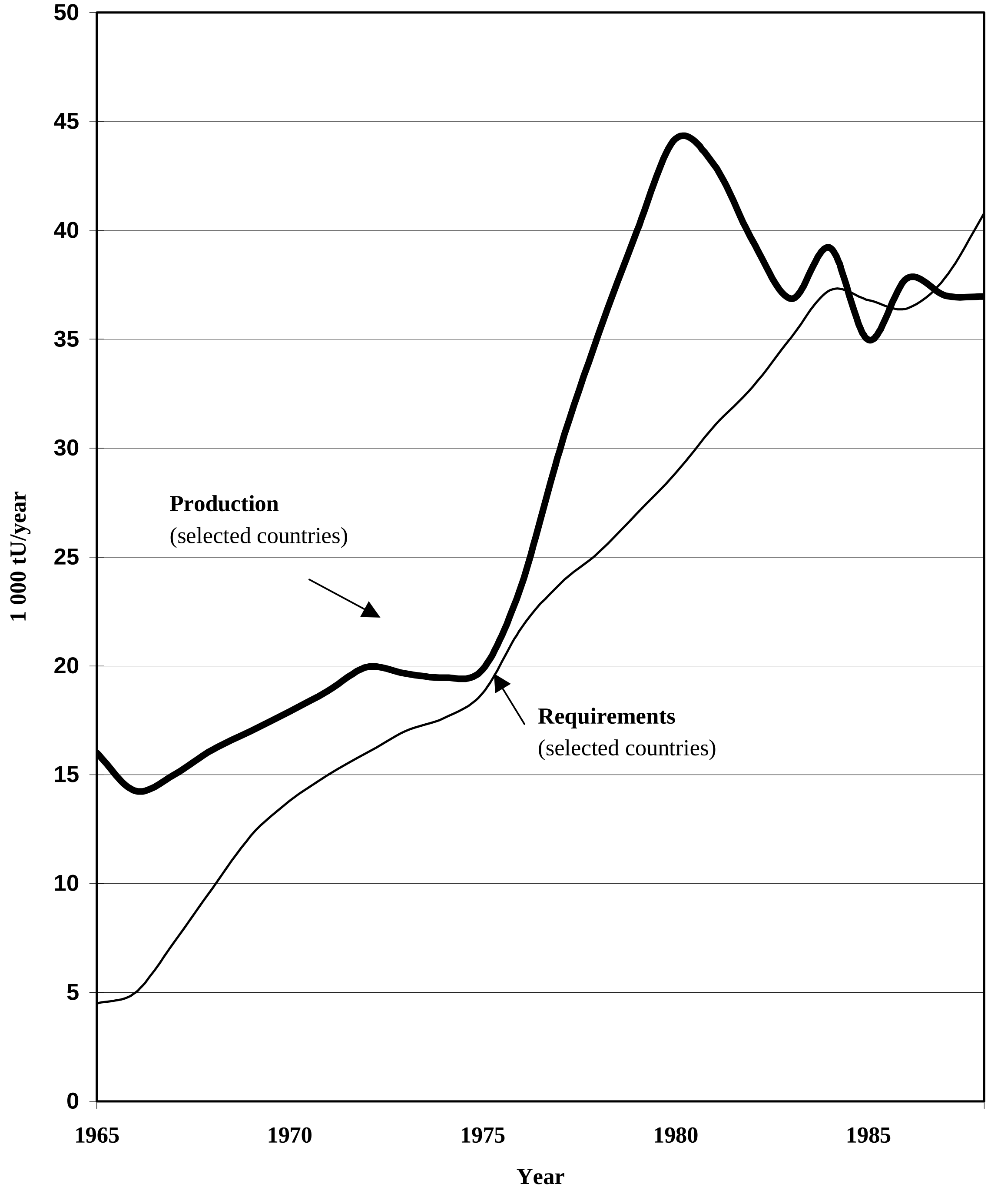
Primary Sources of Uranium Supply

Uranium was produced in 20 countries in 2002, although less than half produced significant quantities. The seven leading producing countries, in descending order of production, are Canada, Australia, Niger, the Russian Federation, Kazakhstan, Namibia and Uzbekistan. Together they provided 87% of the world's uranium mine output. The two largest producers, Australia and Canada, alone accounted for over 50% of the world's production in 2002.

In comparison, 30 countries currently consume uranium in commercial nuclear power plants creating an uneven distribution between producing and consuming countries (Figure 10). In 2002, only Canada and South Africa produced sufficient uranium to meet domestic requirements. All others must use secondary sources or import uranium and, as a result, the international trade of uranium is a necessary and established aspect of the uranium market.

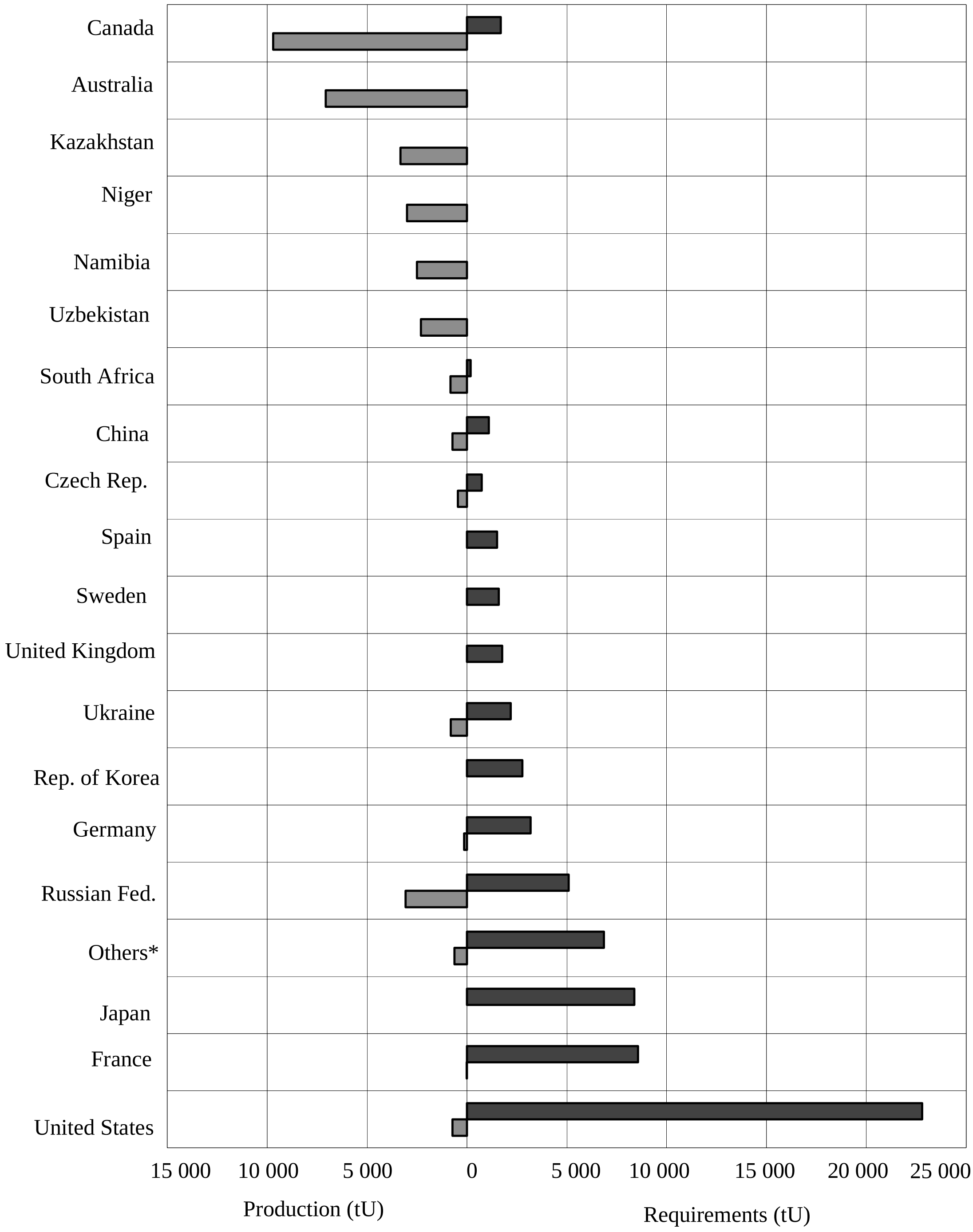
Primary uranium production is insufficient to meet world uranium requirements. In 2002, world uranium production (36 042 tU) provided only about 54% of the world reactor requirements (66 815 tU). In OECD countries, the 2002 production of 20 114 tU provided only about 36% of the demand of 55 490 tU (Figure 11). Remaining requirements were met by secondary sources.

Figure 9. **Historical Uranium Production and Reactor Requirements in Selected Countries**[1]
(1965-1988)



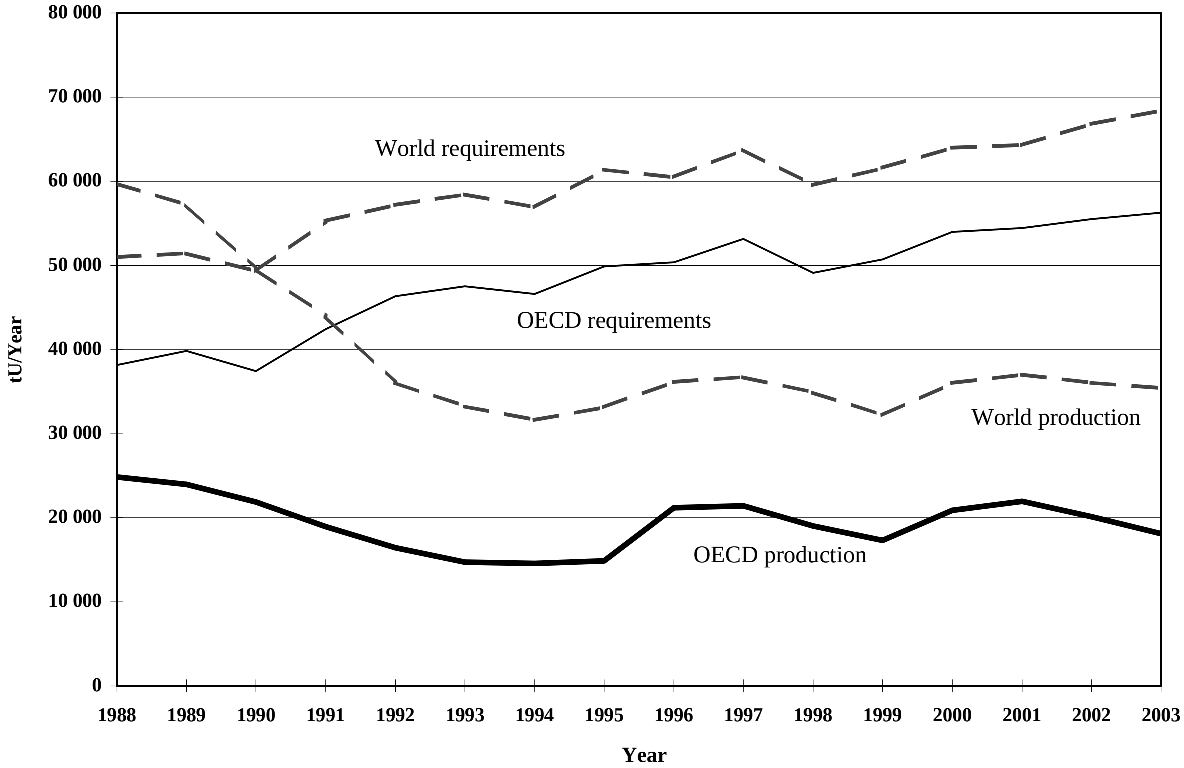
1. Selected countries excludes the following: Bulgaria, China, Cuba, the Czech Republic (and preceding states), former GDR, Hungary, Kazakhstan, Mongolia, Romania, Russian Federation, Slovenia, Ukraine, former USSR, Uzbekistan and Yugoslavia.

Figure 10. **Estimated 2003 Uranium Production and Reactor-related Requirements**



* “Other” producers include Brazil, Hungary, India, Pakistan and Romania.
“Other” consumers include Argentina, Armenia, Belgium, Brazil, Bulgaria, Finland, Hungary, India, Lithuania, Mexico, Netherlands, Pakistan, Romania, Slovak Republic, Slovenia and Switzerland.

Figure 11. **OECD and World Uranium Production and Requirements***
(1988-2003)



* 2003 production values are estimated.

Secondary Sources of Uranium Supply

Uranium is unique among energy fuel resources in that a significant portion of demand is supplied by secondary sources rather than direct mine output. These secondary sources include:

- Stocks and inventories of natural and enriched uranium, both civilian and military in origin.
- Nuclear fuel produced by reprocessing of spent reactor fuels and from surplus military plutonium.
- Uranium produced by re-enrichment of ***depleted uranium*** tails.

1. Natural and enriched uranium stocks and inventories

A major source of secondary supply is derived from stockpiles. Civilian inventories include strategic stocks, pipeline inventory and excess stocks available to the market. Utilities are believed to hold the majority of commercial stocks because many utilities have policies that require carrying the equivalent of one to two years of natural uranium requirements. Despite the importance of this secondary source of uranium, relatively little is known about the size of available stocks because few countries are able to provide detailed information on stockpiles held by producers, consumers or governments mainly due to confidentiality concerns (Table 22).

The Euratom Supply Agency reports that from 1992-2002, over 122 600 t of natural uranium or feed contained in enriched uranium products (in tU) were physically imported by European Union

(EU) operators from the Newly Independent States alone. Of this, 54 400 tU were delivered to EU utilities, leaving a balance of 68 200 tU as stocks available for future use, not accounting for deliveries from other uranium producing countries, such as Australia, Canada, Namibia, Niger and South Africa. Over that same period, the natural uranium equivalent of fuel loaded into EU reactors has been larger than deliveries of natural uranium to EU utilities from all sources, a difference of 35 000 tU. It was concluded the "difference between deliveries and the amount of fuel loaded can be partly explained by the use of reprocessed uranium and drawing down of inventories". [2]

In the United States, the year-end commercial uranium stocks (natural and enriched uranium equivalent) decreased from about 48 680 tU in 1999 to about 38 910 tU in 2002. Government stocks of natural uranium in the United States remained essentially level in 2000 and 2001 at about 20 410 tU, but declined slightly to about 19 755 tU by the end of 2002. The United States government maintains no surplus low-enriched uranium stocks having transferred its inventory to USEC Inc. as part of the privatisation process.

Available information suggests that no significant excess inventories are held in Eastern Europe and Central Asia, with the exception of the Russian Federation. However, the inventory of enriched uranium product and natural uranium held by the Russian Federation, believed to be substantial, has not yet been officially reported.

Large stocks of uranium, previously dedicated to military applications in both the United States and the Russian Federation, have become available for commercial applications introducing a significant source of uranium into the market. Highly-enriched Uranium (HEU) and natural uranium held in various forms by the military sector could total several years supply of natural uranium equivalent for commercial applications. For example, the natural uranium feed component of low-enriched uranium derived from the conversion of surplus nuclear weapons-related HEU from the Russian Federation is being sold in the civilian market through 2013 as the result of a commercial agreement between three western corporations (Cameco, COGEMA and Nukem) and Techsnabexport of the Russian Federation. Similarly, stocks of United States weapons-related HEU are also becoming available. Additional details on these stocks are provided below.

Highly-enriched Uranium from the Russian Federation

In February 1993, the United States and the Russian Federation 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* to blend down 500 metric tons of HEU to low-enriched uranium for peaceful use in commercial reactors over twenty years. The resultant low-enriched uranium represents the equivalent of approximately 153 000 tU and 92 million separative units of enrichment services. As of 30 September 2003, over 193 metric tons of HEU have been downblended and 5 705 metric tons of low-enriched uranium fuel has been delivered to the United States for use in commercial reactors. These deliveries represent the dismantlement of 7 733 nuclear warheads. In 2002, the US and Russian Government approved an amendment to the Agreement's implementing contract, effective January 2003, by establishing market-based pricing terms to the planned delivery of low-enriched uranium derived from 30 tonnes HEU per year. Deliveries under the Agreement will continue through 2013.

It is estimated that the annual deliveries of 30 tonnes HEU would displace about 9 000 tonnes of natural uranium. This represents about 10-13% of world annual uranium requirements through 2013.

Table 22. **Uranium Stocks**
(tonnes natural U equivalent as of 1 January 2003)

COUNTRY	Natural uranium in concentrates	Enriched uranium	Reprocessed uranium
Argentina	> 110	0	0
Armenia	0	0 *	0 *
Australia	NA	0 *	0 *
Belgium	NA	NA	NA
Brazil	20	NA	0
Bulgaria	0 *	0 *	0 *
Canada	NA	0	0
Chile	0 *	0 *	0 *
China	NA	NA	NA
Czech Republic	> 2 000	NA	0
Egypt	0	0	0
Finland (a)	NA	NA	NA
France (b)	NA	NA	NA
Gabon	0	0	0
Germany	NA	NA	NA
Hungary	0	0	0
India	NA	NA	NA
Indonesia	0 *	0 *	0 *
Iran, Islamic Republic of	NA	NA	NA
Italy	0 *	0 *	0 *
Japan	NA	NA	NA
Kazakhstan	NA	0 *	0 *
Korea, Republic of (c)	1 100	2 100	0
Lithuania (d)	0	140	0
Mexico (e)	300 *	0 *	0 *
Mongolia	0 *	0 *	0 *
Namibia	NA	0 *	0 *
Netherlands	0	0	0
Niger	NA	0 *	0 *
Pakistan	NA	NA	NA
Peru	0 *	0 *	0 *
Philippines	0	0	0
Poland	0 *	0 *	0 *
Portugal	286	0	0
Romania	0	0	0
Russian Federation	NA	NA	NA
Slovak Republic	0	0	0
Slovenia	0	0	0
South Africa	0	0	0
Spain	NA	> 380	NA
Sweden	NA	NA	NA
Switzerland (f)	NA	NA	NA
Turkey	2	0	0
Ukraine	0	0	0
United Kingdom	NA	NA	NA
United States	37 845	20 820	NA
Uzbekistan	0	0	0
Vietnam	0	0	0
TOTAL	> **41 663**	> **23 440**	> **0**

* Secretariat estimate. NA Not available or not disclosed.

(a) The nuclear power utilities maintain reserves of fuel assemblies sufficient for 7-12 months use.

(b) A minimum of three years forward fuel requirements is maintained.

(c) About one-year of forward reactor consumption is maintained as a strategic inventory.

(d) Policy is to maintain sufficient stockpile for three months power plant operation.

(e) Maintain one to two reloads of natural uranium at an enrichment facility.

(f) Utilities maintain one to two years supply in form of fuel assemblies.

United States Highly-enriched Uranium

The United States has committed to the disposition of about 174 tonnes of surplus HEU with about 153 tonnes planned to be eventually blended down for use as LEU fuel in research and commercial reactors. About 39 tonnes of this HEU has already been converted. The remainder will be converted over the next several years, through approximately 2016. About 50 tonnes of HEU are being transferred to USEC for down blending to yield approximately 647 tonnes of LEU fuel. This represents about 6 000-7 000 tonnes of natural uranium. Delivery began in May 1999 and is set for completion by 2006. Both sides of the HEU blending point are being safeguards monitored by the IAEA at the USEC-contracted commercial blending facility.

The DOE and Tennessee Valley Authority (TVA) entered an Interagency Agreement in April 2001, whereby TVA will utilise LEU derived from blending down about 33 tonnes of US surplus HEU. This LEU is considered “off-specification” because it contains ^{236}U in excess of the specifications established for commercial nuclear fuel. Different portions of this material are being downblended at DOE’s Savannah River Site (SRS) and at a TVA contractor. Downblending began at SRS in 2003, and will begin at the contractor facility in early 2004. This downblending programme will continue throug approximately 2007, and use of the resultant Blended Low-enriched Uranium (BLEU) fuel at TVA reactors will continue into the middle of the next decade.

About 10 tonnes of surplus HEU will be blended down to make research reactor fuel through approximately 2010. Additional projects leading to disposition of the remaining surplus HEU will be announced as they are developed.

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

A potentially substantial source of fissile material that could displace primary production of uranium lies in the constituents of spent fuel from power plants. When spent fuel is discharged from a commercial reactor it is potentially recyclable, since about 96% of the original fissionable material remains along with the plutonium created during the fission process. The recycled plutonium can be reused as MOX.

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

As of January 2001, over 250 000 tonnes of heavy metal have been discharged from power reactors. About 170 000 t remain in storage as spent nuclear fuel with the remainder having been or intended to be reprocessed. About 12 000 tonnes of heavy metal in spent fuel is discharged annually with about a quarter of this destined to be reprocessed. [3]

In January 2003, there were a total of 34 reactors, about 8% of the world’s operating fleet,[6] licensed to use MOX fuel in Belgium, China, France, Germany, India, Russia, Sweden and Switzerland. Japan is planning to use MOX fuel commercially though its introduction has been delayed. MOX reprocessing and fuel fabrication facilities exist or are under construction in Belgium, China, France, India, Japan, the Russian Federation and the United Kingdom.

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6. In December 2002, Sweden authorised the limited use of MOX fuel at the Oskarshamn nuclear power plant. This decision allows the use of 900 kg of plutonium separated from spent fuel removed from Swedish reactors prior to 1982. Since 1982, Swedish used nuclear fuel has been placed in storage pending final disposal.

The Euratom Supply Agency reported that the use of MOX fuel during 2002 in the EU reduced natural uranium requirements by an estimated 1 190 tU, [2] which represents about 5.7% of the total natural uranium equivalent loaded into EU reactors that year (20 900 tU). Since the majority of MOX use occurs in Western Europe this provides a reasonable estimate of the current impact of MOX use worldwide.

Responses to the questionnaire provided, for the first time, some indication of the production and use of MOX (Table 23). Although limited, (like information on uranium inventories), the available data are in general agreement with those of the EU.

Table 23. **MOX Production and Use**
(in metric tonnes of equivalent natural U)

COUNTRY	Pre-2000	2000	2001	2002	Total to 2002	Expected 2003
MOX production						
Belgium	307	26	79	0	412	90
China	NA	NA	NA	NA	NA	NA
France	NA	NA	NA	1 120 (a)	1 120	1 000 *
India	NA	NA	NA	NA	NA	NA
Japan	650	15	20	0	685	NA
Russian Federation	NA	NA	NA	NA	NA	NA
United Kingdom	300 *	NA	NA	NA	300 *	NA
Total Production	1 257	41	99	1 120	2 517	1 090
MOX use						
Belgium	281	52	0	53	385	26
France	NA	800	800	800	2 400	800
Germany	NA	324 +	324 +	504 +	1 152	NA
India	NA	NA	NA	NA	NA	NA
Japan	NA	NA	NA	NA	NA	NA
Russian Federation	NA	NA	NA	NA	NA	NA
Switzerland	677	151	111	53	992	NA
United Kingdom	NA	NA	NA	NA	NA	NA
Total Use	958	1 327	1 235	1 410	4 929	826

* Secretariat estimate. NA Not available or not disclosed.

\+ Data from NEA (2002/2003) *Nuclear Energy Data*, Paris, (assumes 120 tUnat/tPu).

a) This total includes about 40 t MOX (320 tU nat equivalent) contained in fuel assemblies destined for export.

The uranium recovered through reprocessing of spent fuel, known as reprocessed uranium, has been recycled in the past but is not routinely recycled currently except in the Russian Federation; rather it is stored for future reuse. This is because re-enrichment of the reprocessed uranium contaminates the enrichment and fuel fabrication facilities, complicating their operations. However, a limited amount of reprocessed uranium is reportedly recycled in Russia. Very limited information is available concerning how much reprocessed uranium is used though published reports indicate that it is represents less than 1% of projected world requirements annually.

Mixed-oxide fuel produced from surplus weapons-related plutonium

In September 2000, the United States and Russia concluded a surplus plutonium disposition agreement. Under the agreement, both the United States and Russia will each dispose of 34 tonnes of surplus weapon-grade plutonium within the next 25 years. Both countries agreed to dispose of surplus plutonium by fabricating it into MOX fuel for irradiation in existing, commercial nuclear reactors. This approach will convert the surplus plutonium to a form that cannot be readily used to make a nuclear weapon.

In the United States, a planned MOX fuel fabrication facility located near Aiken, South Carolina would produce MOX fuel beginning in 2007 for use in specially licensed commercial reactors. Plans for fabricating MOX fuel in the Russian Federation in parallel with the United States programme remain under development.

The 68 tonnes of weapons-grade plutonium would displace about 7 000 to 8 000 tonnes of natural uranium over the life of the programme. This represents less than 1% of world annual uranium requirements over that period.

3. Uranium produced by re-enrichment of depleted uranium tails[7]

Depleted uranium stocks represent a major reserve of uranium that could displace primary uranium production. However, the re-enrichment of depleted uranium is limited as a fuel sources since it is only economic in centrifuge enrichment plants that have spare capacity and low operating costs.

As of the beginning of 2000 the inventory of depleted uranium was estimated at about 1 200 000 tU (452 000 tU of equivalent natural uranium).[8] It is estimated to be increasing by up to 57 000 tU annually based on uranium requirements of 65 000 tU per annum. [4] The 2000 inventory is sufficient for about 6 years of operation of the world's nuclear reactors at 2002 uranium requirement levels.

Deliveries of re-enriched tails are a significant source of uranium for the EU representing 6-8% of the natural uranium delivered annually to the EU through 1999-2002 (Table 24).

Additional information on the production and use of re-enriched tails is not readily available. Only Belgium provided detailed information indicating that it had purchased re-enriched tails equivalent to 115 tonnes of natural uranium in 2001 and 2002 with a like amount expected to be purchased in 2003 to be stored for future re-enrichment.

Table 24. **Russian Supply of Re-enriched Tails to the European Union**

Year	**Re-enriched tail deliveries** (tU)	**Percent of natural uranium deliveries**
1999	1 100	7.4
2000	1 200	7.6
2001	1 050	7.6
2002	1 100	5.9

Source: Euratom Supply Agency (2003), *Annual Report 2002*, Luxembourg.

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

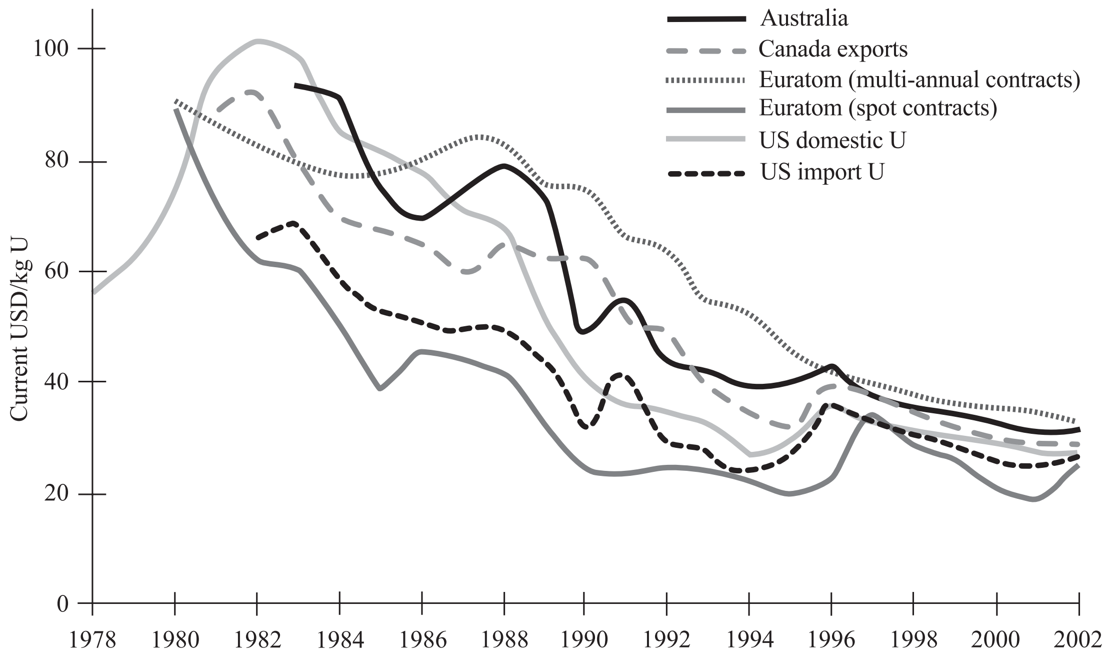
8. OECD Nuclear Energy Agency, (2001) *Management of Depleted Uranium*, Paris, France. This total assumes 1.2 million tU at 0.3% assay re-enriched to produce 336 000 tU of equivalent natural uranium, leaving 864 000 tU of secondary tails with an assay of 0.14%. These secondary tails could then also be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

Uranium Market Developments

Uranium price developments

Some national and international authorities, e.g., Australia, Canada, United States and the EU make available price indicators to illustrate uranium 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), TradeTech and others. Figure 12 shows a comparison of annual average delivered prices reported by various sources.

Figure 12. **Development of Uranium Prices**



Notes: 1. Euratom prices refer to deliveries during that year under multi-annual contracts.
2. Beginning in 2002, Natural Resources Canada (NRCan) has suspended publication of export price for 3-5 years pending a policy review.

Sources: Australia, Canada, Euratom, United States.

The over-production of uranium, which lasted through 1990 (Figure 9), combined with the availability of secondary sources, has resulted in uranium prices trending downward from the early-1980s 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, reversed as increasingly better information about inventories and supplies maintained downward pressure on uranium prices until 2001. After attaining historical lows in several indicators the price of uranium stabilised then rebounded slightly.

This relative price stability resulted from several major market events:

- The October 2001 fire that destroyed the solvent extraction facility at the Olympic Dam mine in Australia.
- Uncertainty about the availability of low-enriched uranium derived from blending down former weapons HEU from the Russian Federation was resolved when the Governments of the United States and the Russian Federation approved an amendment to the commercial implementing agreement in 2002.
- The historically low price of uranium reaching a "floor" as it approached or perhaps even dropped below the production costs of uranium producers.

Other market developments

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, Kyrgyzstan, Russia, and Uzbekistan to limit imports from those republics in exchange for a suspension of the antidumping investigations by the United States 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 United States market transaction must be matched with a quantity of newly produced United States-origin uranium or SWU. The previous ratio had been 1:1 for United States-origin to Russian-origin natural uranium. This agreement was originally to expire in October 2002 but was later amended to expire on 31 March 2004.

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 United States uranium industry.

In August 1999, a further review was undertaken by the United States 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.

In November 2001, the Ministry of Atomic Energy of the Russian Federation requested a review of the suspension agreement though this request was withdrawn in a letter dated 17 July 2002.

Policy measures in the European Union

Since 1992, the Euratom Supply Agency has pursued a policy of diversification of sources of supply in order to avoid over-dependence on any single source, in particular on the Russian Federation, which in recent years has been the largest external supplier to Europe. Enlargement of the EU will add to the number of nuclear power plants in the EU. The Russian Federation has traditionally supplied many of the power plants in the accession countries; therefore the supply policy will have to accommodate this new situation.

In November 2003, the European Council authorised the Commission to begin negotiations for an agreement on trade in nuclear materials with the Russian Federation. These negotiations were due to start in early 2004. The agreement to be negotiated will have to take into account the new conditions of the market in the enlarged EU and of the special relations between the accession countries and the Russian Federation in this field. The agreement will take into consideration the interests of European consumers and the need to maintain the viability of EU industries of the front end of the fuel cycle.

The Supply Agency continues to stress the importance for utilities of maintaining an adequate level of strategic inventory, at all stages of the fuel cycle, consistent with their circumstances. Furthermore, it is recommended that utilities cover most of their needs under long-term contracts with the diversified primary production sources at equitable prices.

Supply and Demand to 2020

Current and planned capacity based on resources recoverable at a cost of <USD 40/kgU (low-cost resources) are adequate to cover about 55% of 2003 uranium requirements. Between 2010 and 2020, low-cost total production capability (existing, committed, planned and prospective) will be adequate to cover between 52% and 58% of the high and low case requirements, respectively.

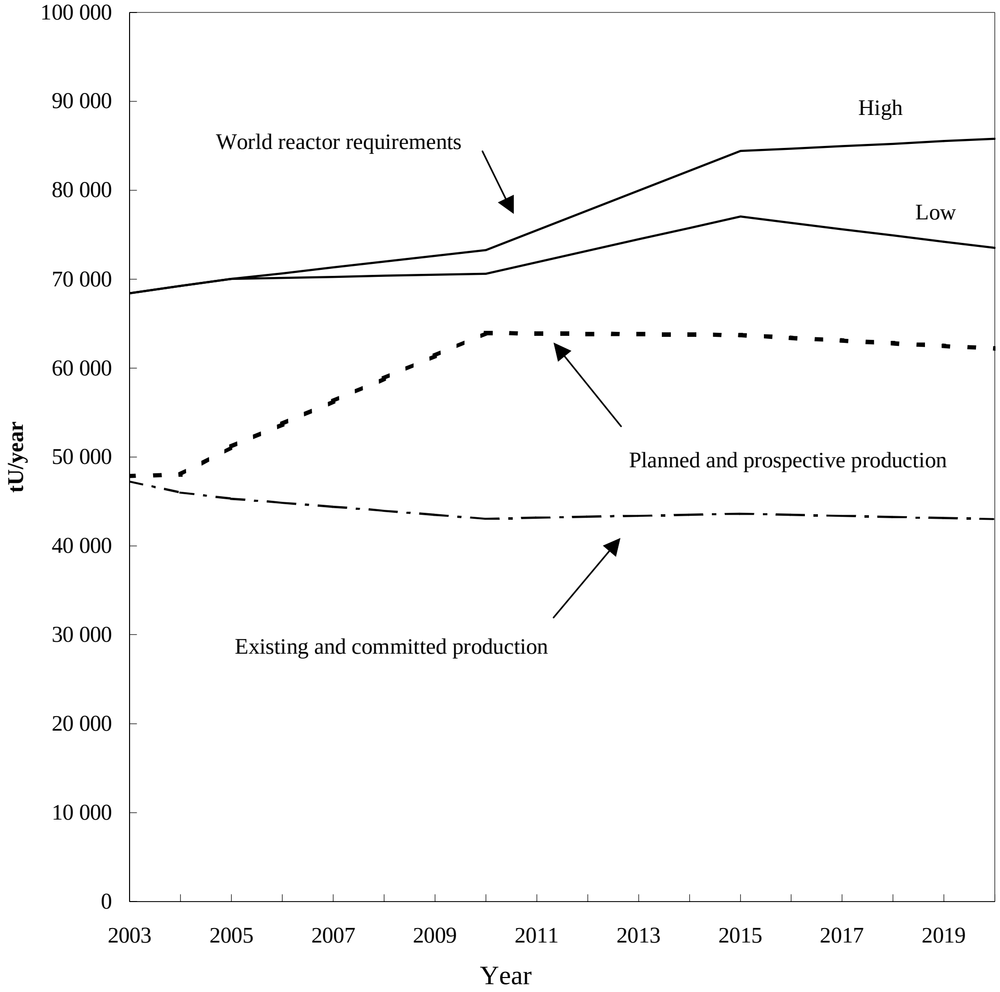
However, even with the addition of resources recoverable at between USD 40-80/kgU, total production capability in 2020 will still only satisfy between 73% and 85% of the high and low case requirements, respectively (Figure 13). Considering that production rarely attains 100% of capacity, this indicates that significant additional production capability and/or additional secondary supply would be necessary to fill the potential production shortfall indicated by these projections. After 2020, when secondary sources of uranium are expected to decline in availability, reactor requirements will have to be increasingly met by primary production. [5] Therefore, primary production capability will need to be increased by expanding existing production centres, opening new production centres or through a combination of the two.

Market conditions are the primary driver of decisions to develop new or expand existing primary production centres. As market prices increase, or expectations of a sustained price increase develop, new production could be developed in order to meet increased demand.

Yet, a key element influencing market price is the availability of secondary sources of uranium, particularly the level of stocks available and the length of time until those stocks are exhausted. However, as Table 22 shows, accurate information on secondary sources of uranium, especially uranium inventory levels, is not yet readily available. Hence, effective decision making on new production capability is hindered.

Another important consideration in evaluating future supply and demand balance is the time needed to discover and develop new uranium production capability. The lead-time for the discovery and development of new uranium production facilities has historically been on the order of one to two decades as a consequence of a number of factors (Table 25). A variety of factors have contributed to these time lags, e.g., business decisions, environmental challenges or technical difficulties.

Figure 13. **Annual World Uranium Production Capability through 2020 Compared with Projected World Reactor Requirements***



Source: Tables 17 and 21.

* Includes all Existing, Committed, Planned and Prospective production centres supported by RAR and EAR-I recoverable at a cost of <USD 80/kgU.

Notwithstanding the variety of causes, these long lead times underscore the importance of making decisions to pursue new production capabilities well in advance of any supply shortfall. Without accurate information on secondary sources there exists the potential for supply-demand imbalances to develop as secondary sources become exhausted. This could result in significant upward pressure on uranium prices.

Table 25. **Key Dates in the Development of Selected Mines**

Country	Deposit/Mine	Exploration begins	Discovery of deposit	Beginning of production
Australia	Beverley (ISL)	1968	1970	2000
Australia	Honeymoon (ISL)	1968	1972	not yet announced
Australia	Jabiluka (UG)	l968	1971	not yet announced
Australia	Olympic Dam (UG)	early-1970's	1976	1988
Australia	Ranger (OP)	1968	1969	1981
Brazil	Lagoa Real	1974	1976	2000
Canada	Cigar Lake	1969	1981	not before 2006
Canada	Key Lake	1968	Gaertner: 1975 Deilmann: 1976	Gaertner: 1983 Deilmann: 1989
Canada	McArthur River	1981	1988	1999
Canada	McClean Lake	1974	1979	1999
Kazakhstan	Inkay (ISL)	1976	1979	2001
Kazakhstan	Kanzhugan (ISL)	1972	1974	1982
Kazakhstan	Mynkuduk (ISL)	1973	1975	1987
Kazakhstan	Uvanas	1963	1969	1977
Niger	Akouta	1956	1972	1978
Niger	Arlit	1956	1965	1970

D. THE LONG-TERM PERSPECTIVE

Uranium demand is driven by the number of operating nuclear reactors, which ultimately is driven by the demand for electricity. World demand for electricity is expected to double from 2001 through 2030 to meet the needs of increasing population and sustained economic growth. Growth is expected to be strongest in developing nations seeking to improve their standards of living. [6] Increasing demand for electricity will require growth in installed generating capacity; some of which will be nuclear. The significance of the role that nuclear energy will play in future electrical generation will depend on how effectively a number of factors discussed earlier are addressed (economics, safety, security, waste disposal, environmental considerations, etc.) as well as public acceptance of nuclear energy.

The extent to which nuclear energy is seen as beneficial in meeting greenhouse gas reduction targets could potentially increase the role of nuclear energy in future electrical generation. A sustained increase in fossil fuel price increases would also tend to increase the role of nuclear energy because of the significant role that fuel costs play in determining fossil energy generation costs. However, if public concerns about safety, security, non-proliferation and waste disposal are not adequately addressed, the contribution that nuclear energy makes to the future energy mix will be limited.

Technological developments could also significantly affect the growth of new nuclear electrical generation capacity. Advancements in reactor and fuel cycle technology not only promise to address economic, safety, security, non-proliferation and waste concerns, but also to radically extend the fuel base and increase the efficiency with which these resources are utilised. The introduction and use of fast reactors could provide significant benefits over the current thermal reactor technology. They could permit the use of other materials as nuclear fuel, such as uranium-238 and thorium, thereby expanding the available resource base. Breeder reactors could produce more fuel than they consume, since spent fuel could be recovered, reprocessed and reused to produce additional energy.

Several alternative uses of nuclear energy have the potential to heighten its role worldwide, such as the production of hydrogen, the desalination of seawater and heat production for industrial or residential purposes. While desalination and heat production will likely remain niche uses, the potential exists for hydrogen production to become a significant role for nuclear energy. Energy use for transportation, which is projected to continue to grow rapidly over the coming decades, is a major source of greenhouse gas emissions. Hydrogen is seen as a potential replacement for fossil fuels, particularly in the transportation sector. High-temperature reactors offer a potential means of producing hydrogen that could make this alternate energy carrier available without the greenhouse gas emissions that are characteristic of current methods of hydrogen production. If this promise is fulfilled, the potential exists for significantly increased uranium demand above that required for electrical generation.

Many national and several major international programmes are working to develop advanced technologies, for example, the Generation IV International Forum (GIF) and the IAEA International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). In 2002, the GIF selected six nuclear energy system concepts to be the focus of continued collaborative research and development. The reactor concepts are a sodium-cooled fast reactor, a very high temperature reactor, a supercritical water reactor, a lead-cooled fast reactor, a gas-cooled fast reactor and a molten-salt reactor. All but one of these concepts involves recycling fuel and several may be suitable for hydrogen production.

Technological advances also hold the potential to significantly expand the uranium resource base. Research in Japan continues to explore methods to tap the uranium resources of the ocean. At present, though, only laboratory-scale quantities have been extracted and the projected cost is approximately 5-10 times the cost of conventionally mined uranium. [7,8]

Do sufficient resources exist to support a significant growth in nuclear capacity for electricity generation or other uses in the long-term? Known conventional resources are sufficient for several decades at current usage rates. Exploitation of undiscovered conventional resources could increase this to several hundreds of years, though significant exploration and development effort would be required to move these resources to more definitive categories. However, since the geographical coverage of uranium exploration is not yet complete worldwide there remains the potential for discovery of new resources that could be exploited.

Unconventional resources, including phosphate deposits and seawater, contain vast amounts of uranium and their use could fuel nuclear energy for millennia if advanced reactor and fuel cycle technologies are deployed (Table 26). Significant effort and/or investment would be needed before these resources could become available.

Thus, sufficient nuclear fuel resources exist to meet energy demands at current and increased demand levels well into the future. However, to reach this potential considerable effort and investment is required, both to develop new mining projects in a timely manner and also to allow promising technologies to reach their potential.

Table 26. **Years of Resource Availability for Various Nuclear Technologies**

Reactor/Fuel cycle[9]	**Years of 2002 world nuclear electricity generation**[10] **with known conventional resources**[11]	**Years of 2002 world nuclear electricity generation**[10] **with total conventional resources**[12]
Current fuel cycle (LWR, once-through)	85	270
Recycling fuel cycle (Pu only, one recycle)	100	300
Light water and fast reactors (mixed with recycling)	130	410
Pure fast reactor fuel cycle with recycling	2 550	8 500

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9. Resources used per TWh taken from OECD/NEA (2001), *Trends in the Nuclear Fuel Cycle*, Paris. [3] These were used to define how much electricity could be generated for the given levels of uranium resources. Years of generation was then developed by factoring in the 2002 generation rate, see below.

10. Total nuclear electricity generation in 2002 of 2 570 TWh (Table 19).

11. Known conventional resources include all cost categories of RAR and EAR-I for a total of 4 588 700 tU (Tables 2 and 3).

12. Total conventional resources includes all cost categories of RAR, EAR and SR for a total of 14 382 500 tU (Tables 2, 3 and 8).

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:

INTERNATIONAL ATOMIC ENERGY AGENCY
Sales & Promotion Unit, Division of Publications
P.O. Box 100
Wagramerstrasse 5
A-1400 Vienna, Austria

Telephone: (43) 1-2600-22529
Facsimile: (43) 1-26007-29302
Electronic Mail: sales.publications@iaea.org

• Algeria •

URANIUM EXPLORATION

Historical review

A brief historical review of uranium exploration in Algeria is provided in the 2001 edition of the Red Book.

Recent and ongoing uranium exploration and mine development activities

From 1998 to 2002 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-Séririne 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)

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

* *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

See the 2001 edition of the Red Book for a historical review of uranium exploration in Argentina.

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 data 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 Exploration and Development Expenditures and Drilling Effort – Domestic
(USD thousands)

	2000	**2001**	**2002**	**2003** (expected)
Total expenditures	791	777	265	276.4
Government exploration drilling (metres)	1 438	541	2 698	NA
Number of exploration holes drilled by government organisations	15	49	136	NA

NA Not available.

URANIUM RESOURCES

Known conventional uranium resources (RAR & EAR-I)

Changes in known resources compared with the 2001 Red Book are based in two points. The first one is the devaluation of the Argentine currency that produces an important movement of resources from one category to another. Additionally, an evaluation programme was completed during the last part of 2002 in Sierra Pintada deposit in Mendoza.

The main objective of this evaluation programme was to define two areas (Sector A and B) for the future exploitation using a specific software as a new tool. Thus, compared with the previous estimate, RAR recoverable were modified as below:

- At <USD 40/kgU reserves increased from 2 640 to 4 780 tU.
- At <USD 80/kgU reserves decreased from 5 080 to 4 880 tU.

The updated evaluation produces a movement of EAR-I resources between the categories of costs, increasing the EAR-I <USD 40/kgU and <USD 80/kgU from 2 030 to 2 860 and from 2 380 to 2 860 tU, respectively. RAR and EAR resources are given as recoverable with mining losses (10%) and processing losses (10%) subtracted.

Reasonably Assured Resources
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
Open-pit	4 780	4 880	7 080
Total	4 780	4 880	7 080

Estimated Additional Resources – Category I
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
Open-pit	2 860	2 860	8 560
Total	2 860	2 860	8 560

Undiscovered conventional resources (EAR-II & SR)

EAR-II at <USD 130/kgU (*in situ*) are estimated at 1 440 tU, unchanged from the 2001 total. These resources occur in the La Volanta deposit, Cerro Solo area. Speculative resources are not reported by Argentina.

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 1953-1970.

Between the mid-1950s and 1999, cumulative uranium production totalled 2 509 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.

Uranium Production
(tonnes U)

Production method	**Pre-2000**	**2000**	**2001**	**2002**	**Total through 2002**	**2003** (expected)
Open-pit mining	1 807	0	0	0	1 807	0
Heap leaching	702	0	0	0	702	0
Total	2 509	0	0	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 1998-2002, using the conventional methods applied in the Centre. However, re-treatment 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.

Ownership structure of the uranium industry

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

Employment in the uranium industry

Employment in uranium supply in Argentina is 267 persons.

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	70	62	60	60

Short-term Production Capability
(tonnes U/year)

2003				**2004**				**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	120	120	120	120	120	120	500	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
120	120	500	500	500	500	500	500	NA	NA	NA	NA

NA Not available.

Secondary sources of uranium

Argentina reported no information on mixed oxide fuels and re-enriched tails production and use.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

On behalf of the INCO-DC project of the European Union named "Innovative Strategies for the Preservation of Water Quality in Mining Areas of Latin America", hydro-geochemical studies were performed in order to define baseline previous to any mining work in the Cerro Solo U-Mo deposit area. The tasks included were as follows: water and stream sediment surveys, chemical and isotopic studies, geochemical interpretation, ground radiometric mapping and environmental impact evaluation.

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

Electricity Generation and Uranium Consumption

	2001	**2002**
Electricity generated (TWh)	0.94	0.94
Uranium consumed (tU)	120	120

Current 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)

2002	**2003**	**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)

2002	**2003**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
120	120	120	95	250	95	250	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 2003, total uranium stocks held by the CNEA amounted to 110 tonnes U.

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	NA	0	0	0	NA

NA Not available.

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.

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 lifetime for this reactor facility, which has an installed capacity of about 375 MWe net.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	1.99	2.29
Uranium consumed (tU)	60	68

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 590 MWe net each. Capacity projections are given in the following tables.

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
375	375	375	0	375	0	375	590	1 180

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
68	89	89	0	89	0	89	91	182

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. There is no stockpile of natural uranium material in Armenia.

• Australia •

URANIUM EXPLORATION

Historical review

A brief historical review of uranium exploration and mine development in Australia is provided in the 2001 edition of the Red Book. For a comprehensive review of the history of uranium exploration and mine development in Australia please refer to "Australia's Uranium Resources, Geology and Development of Deposits" at: http://www.ga.gov.au/pdf/RR0030.pdf.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration expenditure in Australia decreased from AUD 7.59 million in 2000, to AUD 4.80 million in 2001, and AUD 5.34 million in 2002. The expenditure for 2001 was an historic low for uranium exploration expenditure in Australia.

The main areas where uranium exploration was carried out during 2001 and 2002 included:

- Arnhem Land (Northern Territory) – exploration for unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie Sandstone.
- Frome Embayment (South Australia) – exploration for sandstone uranium deposits.
- Gawler Craton/Stuart Shelf region (South Australia) – exploration for breccia complex type deposits.

Heathgate Resources and Southern Cross Resources carried out airborne electromagnetic surveys over exploration tenements in the Frome Embayment in order to define the extent of buried palaeochannels. Exploration targets were identified after assessing results from the airborne geophysical surveys in the light of drilling conducted in the region in the late 1960s. Heathgate completed a programme of exploration drilling in an area a few kilometres south of the Beverley mine.

Prominent Hill discovery

In November 2001, Minotaur Resources Ltd announced the discovery of copper, gold, uranium, rare-earth mineralisation in hematite breccias at the Prominent Hill prospect (South Australia). This mineralisation occurs in Proterozoic basement beneath more than 100 m of younger sedimentary cover. The geological setting, the coincident gravity and magnetic anomalies and style of mineralisation appear broadly similar to the Olympic Dam deposit, approximately 150 km to the southeast. As of August 2002, 15 holes had intersected mineralisation at the prospect over an area of 1.8 km×0.8 km. The mineralised breccia appears to strike west-north-west, sub-parallel to the trend of the magnetic anomaly. Copper, precious metal, rare earth and uranium assemblages appear similar to those at Olympic Dam, although uranium contents are somewhat lower in the current drill results from Prominent Hill. One further difference is that the country rock fragments within the hematite breccias at Olympic Dam are granitic, while at Prominent Hill, the fragments are sedimentary.

A programme of 23 reverse circulation drill holes was completed during 2002 to test a broad envelope of rocks surrounding the known mineralisation at Prominent Hill. This drilling intersected zones of gold mineralisation, with only minor copper and uranium. For further information: http://www.minotaurresources.com.au/PromHillPres_16AGC_July02.pdf.

Uranium exploration and development expenditures – abroad

Paladin Resources Ltd (an Australian exploration company) purchased the Kayelekera uranium deposit, Malawi in 1999, and the Langer Heinrich uranium deposit, Namibia in 2002. Engineering and feasibility studies were carried out at both these projects during 2001 and 2002. Langer Heinrich deposit was previously owned by an Australian exploration company, Aztec Resources Ltd (formerly known as Acclaim Uranium NL) which completed a major drilling programme and feasibility studies at the deposit during 1997 and 1998.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(AUD millions)

	2000	2001	2002	2003 (expected)
Industry expenditures	7.59	4.80	5.34	5.00
Industry surface drilling (metres)	19 293	13 721	24 057	24 000

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

As at 1 January 2003, Australia's known conventional resources recoverable at costs of <USD 40/kgU amounted to 965 000 tU, compared to 839 000 tU at 1 January 2001. This increase of 15% was due mainly to increases in resources at Olympic Dam deposit (South Australia) resulting from a combination of:

- Discovery of additional resources by underground and surface drilling.
- Reclassification (transfer) of resource from the <USD 80/kgU category into the <USD 40/kgU category due to lower mining and processing costs, and devaluation of the Australian dollar over this period.

Most of the increases in resources have been in the Inferred (EAR-I) category. Currency exchange rates have an effect on Olympic Dam reserve/resource estimates because the value of each resource block is based on combined metal value of copper, uranium and gold within the block. The cut-off applied for reserve/resource calculations is a dollar value.

Approximately 97% of Australia's known conventional resources recoverable at <USD 40/kgU are within the following six deposits:

- Olympic Dam, which is the world's largest uranium deposit.
- Ranger, Jabiluka, Koongarra in the Alligator Rivers region (Northern Territory).
- Kintyre and Yeelirrie (Western Australia).

As at 1 January 2003, Australia's known conventional resources recoverable at costs of <USD 80/kgU amounted to 989 000 tU, compared to 863 000 tU at 1 January 2001. This increase of 15% was due mainly to increases in Olympic Dam resources, similar to those described above. At Olympic Dam, uranium is a co-product of copper mining. Gold and silver are also recovered.

Deductions for 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 to recover uranium (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 <USD 40/kgU and 88% <USD 80/kgU are tributary to existing production centres.

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	72 000	72 000	85 000
Open-pit mining	122 000	135 000	149 000
In situ leaching	17 000	17 000	23 000
Co-product	478 000	478 000	478 000
Total	689 000	702 000	735 000

Estimated Additional Resources – Category I
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	51 000	51 000	61 000
Open-pit mining	14 000	25 000	46 000
In situ leaching	13 000	13 000	18 000
Co-product	198 000	198 000	198 000
Total	276 000	287 000	323 000

Undiscovered conventional resources (EAR-II & SR)

Estimates are not made of Australia's uranium resources within the EAR-II & SR categories.

URANIUM PRODUCTION

Historical review

The history of uranium production in Australia was described in the 2001 edition of the Red Book. A more comprehensive review of this history is given in "Australia's Uranium Resources, Geology and Development of Deposits", Aden McKay & Yanis Miezitis. AGSO-Geoscience Australia, Resource Report No. 1. Part A: http://www.ga.gov.au/pdf/RR0030.pdf.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit mining	67 881	3 763	3 564	3 791	78 999	3 790
Underground mining	838	0	0	0	838	0
In situ leaching	0	0	463	632	1 095	850
Co-product (1)	14 859	3 816	3 693	2 431	24 799	2 430
Total	83 578	7 579	7 720	6 854	105 731	7 070

(1) Uranium production at Olympic Dam is a co-product of copper mining.

Status of production capability

Australia has three operating uranium mines: Olympic Dam, Ranger and the Beverley *in situ* leach operation. In 2002, Australia's uranium production amounted to 6 854 tU the lowest level over the last three years, because of constrained production at Olympic Dam.

Olympic Dam

Production from Olympic Dam for 2002 was 2 431 tU, a decrease of 34% compared to 2001 production. In 1999, the project experienced a fire in the copper solvent extraction circuits. A further fire in an area containing both the copper and the uranium solvent extraction circuits occurred in October 2001. Production during 2002 was adversely affected by rebuilding the solvent extraction circuits and also by major repairs to the copper smelter furnace. Production for 2003 will also be constrained by a planned relining of the copper furnace and completion of the solvent extraction rebuild. Following completion of the rebuild and also the completion of an optimisation programme, it is anticipated that, by 2004, the plant will operate at full capacity of 235 000 t copper and 3 930 tU per year.

Ranger

Ranger produced 3 791 tU in 2002, which was 6% above the production for the previous year. Mining of the Ranger No.3 Orebody continued, with 0.8 Mt of ore being mined and 1.8 Mt being milled in 2002. Energy Resources of Australia 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 2011.

Beverley

The Beverley *in situ* leach operation (South Australia) is Australia's latest uranium mine, with production commencing in November 2000. The first full year of production in 2001 amounted to 463 tU, compared with 636 tU in 2002.

Uranium Production Centre Technical Details
(as of 1 January 2003)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4	Centre # 5
Production centre name	Ranger	Olympic Dam	Beverley	Jabiluka	Honeymoon
Production centre classification	existing	existing	existing	planned	committed
Start-up date	1981	1988	2000	NA	NA
Source of ore					
• Deposit name	Ranger 3	Olympic Dam	Beverley	Jabiluka	Honeymoon & East Kalkaroo
• Deposit type	unconformity-related	breccia complex	sandstone	unconformity-related	sandstone
• Reserves	41 674 tU	311 470 tU	8 990 tU	60 208 tU	6 700 tU
• Grade (%U)	0.21	0.04	0.15	0.43	(g)

Uranium Production Centre Technical Details (contd)
(as of 1 January 2003)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4	Centre # 5
Production centre name	Ranger	Olympic Dam	Beverley	Jabiluka	Honeymoon
Mining operation • Type (OP/UG/ISL) • Size (t ore/year) • Average mining recovery (%)	OP 4.5 Mt (a) 90	UG 9 Mt 85	ISL NA 65	UG 450 000 (e) 90	ISL NA 65
Processing plant (acid/alkaline): • Type (IX/SX/AL) • Size (t ore/year) for ISL (kilolitre/ day or litre/hour) • Average process recovery (%)	acid CWG, AL, SX 2.5 Mt/yr 90	acid CWG, FLOT, SX, AL 9.0 Mt/yr 66(c)	acid IX, AL 1.6 Ml/h NA	acid CWG, SX, AL NA 90	acid SX, AL 0.8 Ml/h NA
Nominal production capacity (tU/year)	4 660	3 930	848	2 290	848
Plans for expansion	(b)	(d)	NA	NA	NA
Other remarks	NA	NA	NA	(f)	(h)

(a) Capacity to mine a total of 4.5 million tonnes per year of ore and waste rock.
(b) Under an agreement with the Commonwealth Government, ERA can increase production to 5 090 tU when the company considers it commercially viable to do so.
(c) Source: WMC Holdings Report to the Securities and Exchange Commission, Washington DC, 1992.
(d) WMC Resources is investigating the feasibility of a major expansion to production rates of up to 600 000 t/y copper and 8 480 t/y U.
(e) Jabiluka Mill Alternative: For the Jabiluka mill, ERA proposes to mill 450 000 t of ore/annum (2 290 tU/y) through to the end of stage 1. For stage 2 it is proposed to increase production to 900 000 t ore/year of a lower grade corresponding to an average output of around 3 392 tU/y.
(f) Rio Tinto stated that there would be no further development at Jabiluka without the support of Aboriginal people, through the Northern Land Council, and subject to feasibility studies and market conditions.
(g) Honeymoon deposit has an average grade×thickness of 0.71 m%.
(h) In May 2003, Southern Cross reported that the Honeymoon project has been placed on hold pending improvements in uranium prices and equity markets.
NA Not available.

Short-term Production Capability
(tonnes U/year)

2003				2004				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	10 700	9 900	10 700

Short-term Production Capability (contd)
(tonnes U/year)

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
8 600	12 000	8 600	12 000	8 600	12 000	8 600	12 000	8 600	12 000	8 600	12 000

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 December 2002, 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
COGEMA 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 Resources Ltd, which was formed in 2002 as a result of the demerger of the former WMC Ltd into two companies: Alumina Ltd which holds interests in bauxite mining and alumina refining, and WMC Resources Ltd which constitutes the copper-uranium (Olympic Dam), nickel and phosphate operations.

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

Ownership of Uranium Production in 2002

Domestic				Foreign				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	2 678	39.1	198	2.9	3 978	58.0	6 854	100

Employment in the uranium industry

Employment in Australia's production centres increased in 2001 following the start-up of the Beverley mine. Employment subsequently fell in 2002 because of reductions in employment at the Ranger mine. Figures for employment directly related to uranium production are slightly less than the total employment related to existing production centres.

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	2001	2002	2003 (expected)
Total employment related to existing production centres	527	550	502	502
Employment directly related to uranium production	NA	NA	NA	NA

NA Not available.

Future production centres

Honeymoon

Formal government approval to develop the Honeymoon ISL project (South Australia) was announced in November 2001 following an assessment of the environmental impact statement (EIS) and additional hydrogeological investigations requested by Government. In May 2003, Southern Cross Resources announced that the project had been placed on hold pending improvements in uranium prices and equity markets.

The nominal production rate from the ISL operation was planned to be 850 tU per year. Acid leach solutions will be used to mobilise the uranium in the sandstone aquifers, and solvent extraction technology will be used in the processing plant.

Jabiluka

In view of the depressed market conditions and ERA's undertaking not to have Jabiluka and Ranger uranium mines in full production simultaneously, Jabiluka is likely to remain on stand-by and environmental maintenance for the foreseeable future. Furthermore, Rio Tinto, the major shareholder in the project, has stated that there will be no further development at Jabiluka without the support of Aboriginal people and subject to feasibility studies and market conditions.

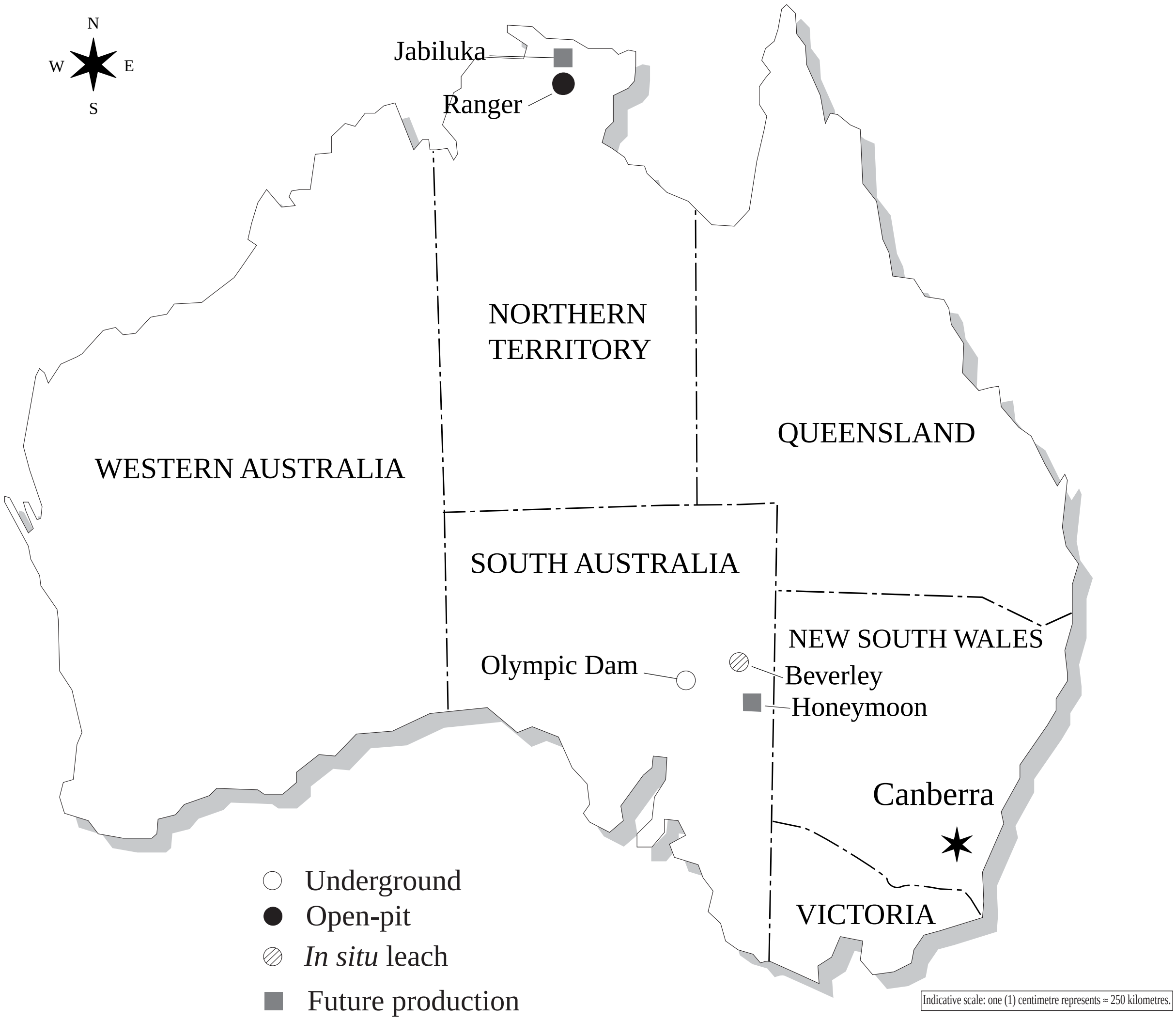
Secondary sources of uranium

Australia has no production or use of mixed oxide fuels. Australia has no production from re-enrichment of tailings.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Comprehensive reviews of environmental activities and socio-cultural issues for Ranger, Jabiluka, Olympic Dam, Beverley and Honeymoon operations were provided in the 2001 edition of the Red Book. These reviews remain valid for 2002 and 2003. A summary of the recent environmental impact assessment for the Honeymoon project follows:

Uranium Production Centres in Australia



Honeymoon project

The Environmental Impact Statement for the Honeymoon *in situ* leach project was assessed jointly by Environment Australia and the South Australian Government during 2000. In February 2001, the Commonwealth Environment Minister announced that before he could make a final decision on the proposal, further detailed information would be 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. During 2001, Southern Cross Resources completed additional stratigraphic drilling and pump tests to better define the shape (and hydraulic boundaries) of the Yarramba palaeochannel and the limits of the Eyre Formation sediments, particularly along the northern and southeastern boundaries of the palaeochannel within the area of the mineral claims. Further investigations of the ground water chemistry and the effectiveness of monitoring wells were also undertaken.

The findings of the stratigraphic drilling programme were in good agreement with the results of the pumping tests; both sets of results indicated that the aquifers are wholly contained within the Yarramba Palaeochannel. The mining solutions and injected liquid wastes can be contained within this hydrogeological environment. The aquifer system is overlaid by about 80 m of clays, which form an effective seal to the Eyre Formation in the Yarramba palaeochannel, and restricts any possible natural movement of water into surface areas.

A multi-layered computer model was used to simulate the effects on groundwater flow conditions resulting from the operations of the project. Results from this modelling provided a quantitative estimate of the migration of groundwater between the aquifers.

A numerical solute transport model was prepared which provided quantitative estimates of the dispersal of metallic ions away from the disposal sites. Based on the modelling studies, most of the injected waste fluids are expected to remain within the boundary of the mineral leases long after the end of mining operations.

The disposal of liquid waste into selected parts of the Basal Sands Aquifer in the Honeymoon project area at a depth of more than 100 m was approved on the basis of the results of the additional studies. From environmental considerations, the re-injection of liquid wastes is a good option compared to other disposal options (including surface storage) because all wastes will be returned to their original source and remain isolated from the biosphere.

Salinity levels in the palaeochannel aquifer are high. Total dissolved solids (TDS) vary from 10 000 to 20 000 mg/l, 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.

Based on the results of the additional work, the Environment Minister cleared the way for the project to proceed in November 2001. The Government issued a five-year export licence that incorporates conditions based on the Environment Minister’s recommendations. In May 2003, the company reported that the project had been placed on hold pending improvements in the uranium price and equity markets.

URANIUM REQUIREMENTS

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

NATIONAL POLICIES RELATING TO URANIUM

The Australian Government’s policy is to approve new uranium mines and uranium exports provided they comply with strict environmental, heritage and nuclear safeguard requirements. Where Aboriginal interests are involved, the Government is committed to ensuring full consultation with the affected Aboriginal communities.

The control over exports reflects both national interest considerations and international obligations. Australia’s uranium policy recognises the needs of customer countries and the nuclear industry for predictability about the way Australia exercises nuclear non-proliferation conditions governing uranium supply.

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)
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
2001	59.07
2002	56.10

• Belgium •

URANIUM EXPLORATION

Historical review

A brief historical review of uranium exploration in Belgium can be found in the 2001 edition of the Red Book.

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. From 1999 to the first quarter of 2002, the facility has been decontaminated and dismantled. All reclamation work is now completed.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
U recovered from phosphates	686	0	0	0	686	0
Total	686	0	0	0	686	0

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	2001	2002	2003 (expected)
Total employment related to existing production centres	5	4	4*	0

* During the first quarter of 2002, corresponding to the end of the decontamination and dismantling activities at Prayon-Rupel Technologies.

Future production centres

No new uranium production capability is currently foreseen in Belgium over the 2001-2020 period.

Secondary sources of uranium

MOX production in Belgium

Belgonucléaire at the Dessel nuclear site, in the Mol region, manufactures plutonium/uranium mixed oxide (MOX) pellets and fuel rods at the P0 plant. It has clients in Belgium, in other European countries and in Japan. The capacity of the Dessel plant is about 40 t/year. Belgonucléaire is owned by Tractebel – Belgian engineering company, Electrabel – Belgian electrical utility and CEN/SCK – Belgian nuclear research centre. Belgonucléaire's production of MOX started in the early 1960s.

After production, the MOX fuel rods are transported to the nearby Franco-Belge de Fabrication de Combustible (FBFC) International assembly plant, where the fuel rods form fuel assemblies. With a quantity of 4.78 tonnes of separated plutonium, 144 MOX elements can be manufactured.

In 1984, Belgonucléaire and COGEMA formed COMMOX to function as the commercial agent for MOX fuel produced by the two companies.

Use of MOX in the Belgian nuclear power plants

At the end of 1993, the Parliament passed a resolution approving the recycling in two reactors, of separated plutonium recovered from spent fuel reprocessed under a contract concluded between SYNATOM and COGEMA in 1978.

Licences to load MOX fuel assemblies were granted in November 1994. Two reactors, Tihange 2 since March 1995, and Doel 3 since May 1995 are burning MOX fuel.

Mixed Oxide Fuel Production and Use
(tonnes of natural U equivalent)

Mixed-oxide fuels	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Production	306.5	26.1	79.0	0	411.6	90.4
Usage	280.5	52.1	0	52.6	385.2	26.4

Re-enriched tails Production and Use
(tonnes of natural U equivalent)

Re-enriched tails	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Production	0	0	0	0	0	0
Usage	0	0	115*	115*	230*	115*

* Purchased for subsequent re-enrichment.

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.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	44.1	45.1*
Uranium consumed (tU)	1 480.0**	1 065.0**

* Provisional figure.
** Uranium loaded in the reactor during the year.

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
5 761	5 761	5 761	5 761	5 761	5 761	5 761	4 014	5 761

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 150	1 150	1 150	1 150	1 150	800	1 150	800	1 150

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

See the 2001 edition of the Red Book for a historical review of uranium exploration in Brazil.

Recent and ongoing uranium exploration and mine development activities

In November 1999, INB carried out an airborne gamma-ray survey, which covered the main areas of the Rio Cristalino Region, located in south of Para State.

The programme identified 240 anomalous peaks included on the uranium channel, which were classified according to three levels of priority for future field exploration.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(BRL)

	2000	2001	2002	2003 (expected)
Industry exploration expenditures				0
Government exploration expenditures				1 300 000
TOTAL EXPENDITURES				1 300 000
Industry exploration drilling (metres)				0
Government exploration drilling (metres)				5 000
Number of government exploration holes drilled				50

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 2003, the known resources of Brazil total 262 200 tU as *in situ* resources recoverable at below USD 80/kgU. Resources estimates do not take into account mining depletion since last assessment. 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)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	7 800	72 800	72 800
Open-pit mining**	12 700	13 100	13 100
Co-product & by-product	35 600	76 100	76 100
Total	56 100	162 000	162 000

* As *in situ* resources.

** The resources reported as open-pit mining are recovered by heap leaching. Mining and milling losses are estimated to amount to 30%.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Open-pit mining**	0	3 400	3 400
Co-product & by-product	0	44 600	44 600
Unspecified method	0	52 200	52 200
Total	0	100 200	100 200

* As *in situ* resources.

** The resources reported as open-pit mining are recovered by heap leaching. Mining and milling losses are estimated to amount to 30%.

40% of the RAR plus EAR-I resources recoverable at USD 40/kgU or less are in existing and committed production centres. 60% of the RAR plus EAR-I resources recoverable at USD 80/kgU or less are in existing and committed production centres.

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

Speculative Resources
(tonnes U)

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

URANIUM PRODUCTION

The Poços de Caldas uranium production facility was closed in 1997, and a decommissioning programme started in 1998. Poços de Caldas facilities are still used for non-nuclear products, mainly for the development of chemical treatment of monazite in order to produce rare earth concentrates.

Lagoa Real production facilities, today called the Caetité Unit, started operation in mid-2000, beginning at a 100 tonnes per annum rate. 270 tU were produced in 2002 and 340 tU are planned to be produced in 2003.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit mining	1 030	0	0	0	1 030	0
Heap leaching	0	11	56	272	339	340
Total	1 030	11	56	272	1 369	340

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.

Ownership of Uranium Production in 2002

Domestic				Foreign				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
272	100	0	0	0	0	0	0	272	100

Uranium Production Centre Technical Details
(as of 1 January 2003)

	Centre #1	Centre #2
Name of production centre	Caetité	Itataia
Production centre classification	existing	planned
Start-up date	1999	
Source of ore:		
• Deposit names	Cachoeira/ Quebradas/Engenho	Itataia
• Deposit types	metasomatic	phosphorite
• Reserves (active resources)	12 700 tU	67 700 tU
• Grade (% U)	0.26	0.08
Mining operation:		
• Type	OP	OP
• Size (tonnes ore/day)	1 000	NA
• Average mining recovery (%)	90	50
Processing plant (acid/alkaline):		
• Type (IX/SX/AL)	HL/SX	HL/SX
• Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour)	1 000	NA
• Average process recovery (%)	80	70

Uranium Production Centre Technical Details (contd)
(as of 1 January 2003)

	Centre #1	Centre #2
Nominal production capacity (tU/year)	340	325
Plans for expansion	yes	NA
Other remarks	underground mining in 2006	by-product with phosphoric acid

NA Not available.

Employment in the uranium industry

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	NA	NA	NA	NA
Employment directly related to uranium production	48	128	128	140

NA Not available.

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.

Short-term Production Capability
(tonnes U/year)

2003				**2004**				**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
340	340	340	340	340	340	340	340	510	510	510	510

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
850	1100	850	1100	1100	1100	1100	1100	1100	1100	1100	1100

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Government Policies and Regulations

Government Policies and Regulations are established by “Comissão Nacional de Energia Nuclear – CNEN”(National Commission for Nuclear Energy), and include a general norm “Diretrizes Básicas de Radioproteção” (Radioprotection Basic Directives) – NE-3.01, dated 1 August 1988, and two specific norms on licensing of mines and mills of uranium and thorium ores, named NE-1.13 “Licenciamento de Minas e Usinas de Beneficiamento de Minérios de Uranio ou Tório”, dated 8 August 1989, and on tailings ponds decommissioning: “Segurança de Sistema de Barragem de Rejeito Contendo Radionuclídeos” (Safety of Radionuclide Bearing Tailing Pond Systems) – NE-1.10, dated 27 November 1980.

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

URANIUM REQUIREMENTS

Brazil's present uranium requirements for the Angra I nuclear power plant, a 630 MWe PWR, are about 120 tU/year. The Angra II nuclear power plant, a 1 245 MWe PWR, requires 310 tU/year. In addition, start-up of Angra III (similar to the Angra II nuclear power plant) operation is expected around 2009.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	14.35	13.84
Uranium consumed (tU)	356.5	354.0

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 875	1 875	3 120	NA	3 120	NA	3 120	NA	NA

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
450	450	1 040	470	810	470	810	NA	NA

NA Not available.

NATIONAL POLICIES RELATING TO URANIUM

INB is planning to increase its uranium production in order to supply internal uranium requirements.

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	20	NA	0	0	20
Total	20	0	0	0	20

NA Not available.

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, which 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 remained focused on areas favourable for the occurrence of deposits associated with Proterozoic unconformities in the Athabasca Basin of Saskatchewan and the Thelon Basin of Nunavut and the Northwest Territories. Limited exploration was also carried out in Labrador and Québec. Surface drilling, as well as geophysical and geochemical surveys of extensions of mineralised zones and other promising areas in the Athabasca Basin, continued to be the main activities.

In 2002, overall Canadian uranium exploration expenditures amounted to about CAD 35 million, while uranium exploration and surface development drilling amounted to some 78 000 m, compared to the 2001 total of 48 000 m. As in recent years, more than half of the overall exploration expenditures can be attributed to advanced underground exploration, deposit appraisal activities, and care and maintenance expenditures associated with projects awaiting production approvals. Basic "grass roots" uranium exploration, therefore, likely reached CAD 15 million in 2002, up slightly from about CAD 14 million in 2001.

Well over 90% of the combined exploration and surface development drilling in 2001 and 2002 took place in Saskatchewan. In 2003, total combined uranium drilling is expected to remain at around 75 000 m.

The top three operators, accounting for nearly all of the CAD 35 million expended in 2002 were Cameco Corporation, COGEMA Resources Inc. and UEX Corporation (a new public company formed by Pioneer Metals Corporation and Cameco that focuses on uranium exploration in the Athabasca Basin). Expenditures by COGEMA Resources Inc. include those of Urangesellschaft Canada Limited.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(CAD millions)

	2000	2001	2002	2003 (expected)
Industry exploration expenditures	18	14	15	11
Government exploration expenditures	<0.1	<0.1	0	0
SUBTOTAL Exploration expenditure	18	14	15	11
SUBTOTAL Development expenditures	28	11	20	19
TOTAL Expenditures	46	25	35	30
Industry exploration drilling (metres)	76 000	47 000	78 000	50 000
Number of industry exploration holes drilled	NA	NA	NA	NA
Government exploration drilling (metres)	0	0	0	0
Number of government exploration holes drilled	0	0	0	0
SUBTOTAL Exploration drilling	76 000	47 000	78 000	50 000
SUBTOTAL Exploration holes	NA	NA	NA	NA
SUBTOTAL Development drilling	1 000	1 000	0	0
SUBTOTAL Development holes	NA	NA	NA	NA
TOTAL Drilling (metres)	77 000	48 000	78 000	50 000
TOTAL Number of holes	NA	NA	NA	NA

NA Not available.

Uranium Exploration and Development Expenditures – Abroad
(CAD millions)

	2000	2001	2002	2003 (expected)
Industry exploration expenditures	5.5	4.0	3.9	4.0
Government exploration expenditures	0	0	0	0
SUBTOTAL Exploration expenditures	5.5	4.0	3.9	4.0
SUBTOTAL Development expenditures	0	0	0	0
TOTAL Expenditures	5.5	4.0	3.9	4.0

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

As of 1 January 2003, Canada's total known uranium resources (i.e., recoverable at a cost of <USD 80/kgU) amounted to about 439 000 tU, compared to 452 000 tU as of 1 January 2002. This downward adjustment of almost 3% is the result of mining depletion and ongoing deposit appraisal. As of 1 January 2003, uranium resources recoverable at a cost of <USD 40/kgU were estimated to be 384 000 tU, down slightly from the 2002 value of 397 000 tU.

The bulk of Canada's known uranium resources occur in Proterozoic unconformity-related deposits of the Athabasca Basin, Saskatchewan, and the Thelon Basin in Nunavut. These deposits host their mineralisation near the unconformity boundary in either monometallic or polymetallic mineral assemblages. Pitchblende prevails in the monometallic deposits, whereas uranium-nickel-cobalt assemblages prevail in the polymetallic assemblages. The average grade varies from 1% U to over 15% U. None of the uranium resources referred to or quantified herein are a co-product or by-product output of any other mineral of economic importance. Mining loses (~20%) and ore processing losses (~3%) were used to calculate known conventional resources.

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	266 810	266 810	266 810
Open-pit mining	30 454	30 454	30 454
Unspecified	0	36 570	36 570
Total	297 264	333 834	333 834

Estimated Additional Resources – Category I
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	86 560	86 560	86 560
Open-pit mining	0	0	0
Unspecified	0	18 150	18 150
Total	86 560	104 710	104 710

Undiscovered conventional resources (EAR-II & SR)

The 1 January 2003 assessment did not result in any change to EAR-II and SR tonnages reported as of 1 January 2001.

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

100% of the RAR & EAR-I recoverable at <USD 40/kgU are in existing or committed production centres, and 88% of RAR and EAR-I recoverable at <USD 80/kgU are in existing or committed production centres.

URANIUM PRODUCTION

Historical review

Refer to the 2001 Red Book for a complete historical review.

Status of production capability

Overview

Since the last Elliot Lake production facility closed in 1996, all active uranium production centres are located in northern Saskatchewan. Current Canadian uranium production remains below full capability, mainly due to market conditions. In 2002, production reached a total of 11 607 tU, as increases at McArthur River and Cluff Lake exceeded the decline in Rabbit Lake output. In 2003, production is expected to decline as the McArthur River mine was closed for three months due to flooding that inundated a portion of the mine.

Historical Uranium Production
(tonnes U)

Production method	**Pre-2000**	**2000**	**2001**	**2002**	**Total through 2002**	**2003** (expected)
Open-pit mining (1)	98 240 (2)	2 710	2 840	2 459	106 249	2 575
Underground mining (1)	230 600 (2)	7 973	9 682	9 148	257 403	7 125
In-place leaching product	1 000 (2)	0	0	0	1 000	0
Total	329 840 (2)	10 683	12 522	11 607	364 652	9 700

(1) Pre-2000 totals may include uranium recovered by heap and in-place leaching.
(2) Estimate.

Saskatchewan

Cameco Corporation is the operator of the McArthur River mine, a Cameco (70%), COGEMA Resources Inc. (CRI, 30%) joint venture. Production at this, the world's largest uranium producing mine, reached 6 639 tU and 7 082 tU in 2001 and 2002, respectively. A high-grade slurry is produced underground, then pumped to automated stations on the surface that load specially-designed containers that are trucked 80 km to the Key Lake mill, where all McArthur River ore is milled. On 6 April 2003, a breach in a development drift at the 530 m level led to some flooding at the base of the mine. Production was curtailed for three months to control inflow and complete repairs.

The Key Lake mill is a Cameco (83%) and CRI (17%) joint venture operated by Cameco. Although mining was completed in 1997, the mill maintained its standing as the world's largest uranium production centre by producing 6 938 tU and 7 199 tU in 2001 and 2002, respectively. These totals represent a blend of high-grade McArthur River ore and stockpiled, mineralised Key Lake waste rock that produces a mill feed grade of about 3.4%U.

The Rabbit Lake production centre, owned and operated by Cameco, produced 1 755 tU and 440 tU in 2001 and 2002, respectively. This sharp decline is the result of a decision to temporarily suspend mining and milling due to market conditions. Following the development of a revised mining plan, the Eagle Point underground mine was re-opened in July 2002 and the mill in August 2002. Poor ground conditions encountered since the re-opening have reduced output.

The McClean Lake 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 in 2001 and 2002 amounted to 2 540 tU and 2 342 tU, respectively. Mining operations were suspended early in 2002 after the Sue C deposit was mined out. The mill is currently fed by stockpiled ore from the Sue C and JEB deposits while plans for mining other deposits on the property are finalised.

The Federal Court of Canada issued an order on September 23, 2002, that quashed a 1999 McClean Lake operating licence on the grounds that an environmental assessment under the *Canadian Environmental Assessment Act* (*CEAA*) had not been conducted prior to issuing the licence. An appeal court subsequently ordered the decision stayed pending the disposition of the appeal, which has not yet been heard. The Court decision is not related to the environmental performance of the facility, but is based upon the interpretation of the transitional provision of the *CEAA*. The entire McClean Lake operation was reviewed by an environmental review panel pursuant to regulatory requirements that preceded the *CEAA*.

The Cluff Lake production centre is owned and operated by CRI. In 2001 and 2002, production amounted to 1 288 tU and 1 626 tU, respectively. Mining was stopped in May 2002 and all stockpiled ore had been milled by the end of December 2002, bringing to a close a long and successful chapter in Canadian uranium mining.

In its 22 years of operation, Cluff Lake production amounted to about 24 000 tU. The mine generated significant employment and business opportunities for residents of northern Saskatchewan and set high standards for uranium production and workplace safety (Cluff Lake won awards for being Canada's safest metal mine in 1998 and 2002). Once an environmental assessment of the decommissioning plan is completed and all regulatory approvals are obtained, CRI will begin the decommissioning process.

The Cigar Lake mine is a Cameco (50.025%), CRI (37.1%), Idemitsu (7.875%) and TEPCO (5%) joint venture. High-tech mining methods specifically adapted to the local geology have been developed through on-site test mining programmes, and the mine could begin production in 2006. The exact schedule to complete construction and begin production depends on market conditions and regulatory approvals. Effective January 1, 2002, Cameco became the operator of the Cigar Lake mine that, until then, had been developed by the Cigar Lake Mining Corporation.

Uranium Production Centre Technical Details
(as of 1 January 2003)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	McArthur/ Key Lake	McClean Lake	Rabbit Lake	Cigar Lake	Midwest
Production centre classification	existing	existing	existing	planned	planned
Start-up date	1999/1983	1999	1976	as early as 2006	2010
Source of ore					
• Deposit name	P2N et al.	Sue A-C, Jeb, McClean	Eagle Point	Cigar Lake	Midwest
• Deposit type	unconformity	unconformity	unconformity	unconformity	unconformity
• Reserves	180 000 tU	NA	6 750 tU	89 000 tU	NA
• Grade (% U)	18	NA	1	18	NA
Mining operation:					
• Type (OP/UG/ISL)	UG	OP-UG	UG	UG	UG/OP
• Size (tonnes ore/day)	NA	NA	NA	NA	NA
• Average mining recovery (%)	NA	NA	NA	NA	NA
Processing plant (Acid/ Alkaline):					
• Type (IX/SX/AL)	AL/SX	AL/SX	AL/SX	McClean and Rabbit Lake	NA
• Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour)	750	300	2 300		NA
• Average process recovery (%)	98	97	97		NA
Nominal production capacity (tU/year)	7 200	3 075	4 615	6 900	2 300 (est)
Plans for expansion		relates to Cigar Lake	relates to Cigar Lake		

NA Not available.

Ownership structure of the uranium industry

On 14 February 2002, Crown Investments Corporation of Saskatchewan sold its remaining 10% ownership in Cameco for CAD 226.4 million. Cameco was formed in 1988 through the merger of the provincial crown corporation, Saskatchewan Mining Development Corporation, with the federal Crown Corporation, Eldorado Nuclear Limited. Since then, the two levels of government have gradually reduced their share holdings. The Government of Canada divested its last remaining shares in Cameco in 1995.

Ownership of Uranium Production in 2002

Domestic				Foreign				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	6 008	52	5 423	47	176	1	11 607	100

Employment in the uranium industry

Direct employment in Canada's uranium industry totalled 973 in 2001 and 972 in 2002 (1 398 in 2002 if head office and contract employees are included). Employment levels changed little because losses resulting from reduced activity at Cluff Lake and the temporary suspension of mining at McClean Lake were balanced by increases resulting from the resumption of operations at Rabbit Lake. Employment is expected to remain relatively steady in 2003 as losses incurred with the Cluff Lake closure will likely be balanced by increases in the Rabbit Lake workforce. Employment levels are not expected to increase until the Cigar Lake and Midwest mines begin production.

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	1 983	1 299	1 398	1 400
Employment directly related to uranium production	1 026	973	972	1 000

Future production centres

The remaining uranium mining projects in Saskatchewan that have cleared the environmental review process and are poised to enter into production will extend the lives of existing production centres. Cigar Lake ore is expected to feed the McClean Lake and Rabbit Lake mills and Midwest is expected to provide additional feed for the McClean Lake mill. Development at Kiggavik is unlikely to proceed in the foreseeable future.

Short-term Production Capability
(tonnes U/year)

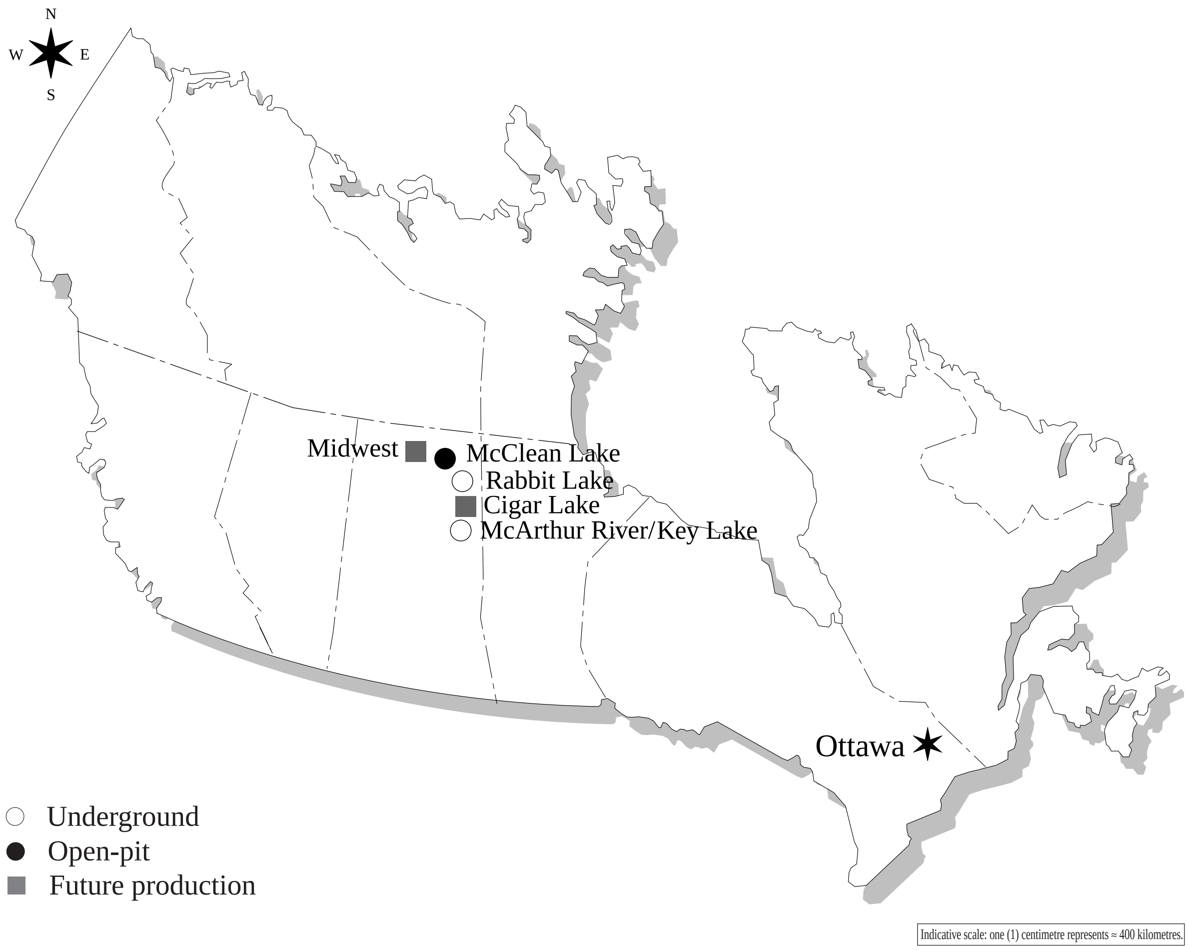
2003				**2004**				**2005**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
14 890	14 890	14 890	14 890	12 885	12 885	12 885	12 885	10 275	10 275	10 275	10 275

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
7 200	16 425	7 200	16 425	7 200	16 425	7 200	16 425	7 200	14 125	7 200	14 125

Secondary sources of uranium

Canada reported that there was no production or use of mixed oxide fuels nor any production or use of re-enriched tailings.

Uranium Production Centres in Canada



ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Environmental assessments

The Federal Court of Canada decision in September 2002 that quashed a McClean Lake operating licence was stayed pending appeal in November 2002. Until the appeal is heard, however, environmental assessment requirements for some uranium projects are uncertain. The effect of the Court decision on other projects that were reviewed by the same Environmental Assessment and Review Process Guidelines Order (EARPGO) Panel that considered the McClean Lake project (e.g., Cigar Lake and Midwest), could depend upon the outcome of the appeal.

COGEMA Resources Inc. (CRI) is preparing an environmental impact statement under the *CEAA* of its plan to close and decommission the Cluff Lake operation. A Comprehensive Study (CS) environmental assessment that outlines, among other issues, the decommissioning plan as well as options and mitigation measures, has been submitted to the Canadian Nuclear Safety Commission (CNSC) for review. Development of this CS has already involved public consultation, and additional public consultation will take place once the CS is finalised.

In July 2002, CRI and Cameco submitted to the CNSC an addendum to 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.

Environmental management

Environmental management systems at the McArthur River mine and the Key Lake mill were certified under the ISO 14001 standard in 2002. The McClean Lake mine and mill, as well as the Blind River refinery and Port Hope conversion plant, have already achieved this internationally recognised standard that outlines key requirements that companies should comply with in order to operate in an environmentally responsible manner. Thus, environmental management of the front end of the nuclear fuel cycle meets rigorous international standards in Canada.

Decommissioning

Canadian uranium mine operators are not only world leaders in production and environmental management, but also in the decommissioning and reclamation of closed production centres. Elliot Lake, Ontario, was the major uranium mining centre in Canada for over 40 years. Since the last facility closed in 1996, uranium mining companies have committed over CAD 75 million to decommission all mines, mills and waste management areas. A comprehensive environmental monitoring programme has recently demonstrated the success of these efforts. Although the impact of mining is recognisable, mainly in the form of above background levels of salts, total dissolved solids and some metals, the local fish, benthic invertebrates and wildlife are displaying no adverse effects.

On 16 August 2002, the CNSC issued a Radioactive Waste Facility Operating Licence to Rio Algom Limited for the management of historic uranium mine wastes at properties near Elliot Lake, Ontario, that ceased operating over 30 years ago (Spanish American, Milliken, Lacnor, Nordic/Buckles and Pronto). These waste management sites are designed for the storage of mine wastes produced during past mining operations and no other wastes may be imported or added.

URANIUM REQUIREMENTS

Canada has 22 CANDU reactors operated by public utilities and private companies in Ontario (20), Quebec (1) and New Brunswick (1). Of these 22 reactors, 14 are currently in full commercial operation, generating on average around 14% of Canada's electricity. Of the 20 reactors in Ontario, 8 are currently out of service, 4 of which are at the Pickering "A" station and 4 at the Bruce "A" station. It is anticipated that all 4 units at the Pickering "A" station and 2 of the units at the Bruce "A" station will be brought back to service over the next few years, subject to regulatory approvals.

In May 2001, the eight units at the Bruce site (A and B) were leased to Bruce Power Inc., a consortium led by British Energy plc. On 23 December 2002, Bruce Power announced that a consortium of Canadian-based companies had agreed in principle to purchase British Energy's share of Bruce Power. After the transaction closed on 14 February 2003, Cameco, TransCanada PipeLines Limited and BPC Generation Infrastructure Trust of Toronto each owned a 31.6% interest in Bruce Power, with the remaining 5.2% held by The Power Worker's Union and The Society of Energy Professionals. Bruce Power anticipates returning both Units 3 and 4 of the Bruce "A" station to service in 2003.

Ontario Power Generation (OPG) is continuing with the refurbishment required to bring the four units of the Pickering "A" nuclear generating station back into service. The first unit is expected to be in service and a detailed assessment of the timing and estimated costs of the return to service of a second unit are expected in 2003.

A decision concerning the refurbishment of the Point Lepreau unit in New Brunswick has not yet been made. If the refurbishment programme goes ahead, the unit's life could be extended beyond 2008 for an additional 25 years. Hydro-Québec is also considering a refurbishment programme for Gentilly 2, and is expected to announce the decision in 2005.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	72.00	70.20
Uranium consumed (tU)	NA	NA

NA Not available.

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
10 300	12 100	13 900	13 900	15 600	13 900	15 600	13 900	15 600

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 400	1 700	2 000	2 000	2 300	2 000	2 300	2 000	2 300

Supply and procurement strategy

From the late-1960s through to 1995, Ontario Hydro (the precursor to OPG) purchased >99% of its uranium requirements through long-term contracts with Canadian suppliers. In 1996, this pattern was broken when contracts with Australian suppliers were signed. Ontario Hydro also entered into a long-term contract with a US broker in 1997. OPG now fills its uranium requirements through these and other long-term contracts, as well as spot market purchases.

In 2001, Cameco assumed full responsibility for the management of all Bruce Power's fuel procurement needs when it became a partner in Bruce Power. In this role, Cameco supplies all uranium and uranium conversion services and contracts all required fuel fabrication services.

NATIONAL POLICIES RELATING TO URANIUM

Bill C-4, *An Act to Amend the Nuclear Safety and Control Act*, received Royal Assent on 13 February 2003. The amendment was required because the original wording of subsection 46-3 of the *Nuclear Safety and Control Act* had the unintended consequence of discouraging private sector lending to the nuclear industry. The amendment changed the wording to limit the liability for lands that are contaminated with nuclear substances to those in a position of management and control. The amendment therefore allows the nuclear industry to attract market capital and equity.

An Act Respecting the Long-term Management of Nuclear Fuel Waste entered into force on 15 November 2002. This legislation calls for nuclear utilities to form a waste management organisation (WMO) to carry out the managerial, financial and operational activities to implement the long-term management of nuclear fuel waste. Pursuant to this legislation, the WMO has been established and the major owners have made the required payments to the trust funds for the long-term management of nuclear fuel waste.

URANIUM STOCKS

The Canadian government does not maintain any stocks of natural uranium and data for producers and utilities are not available. Since Canada has no enrichment or reprocessing facilities, there are no stocks of enriched or reprocessed material in Canada. Although Canadian reactors use natural uranium fuel, small amounts of enriched uranium are used for experimental purposes and in booster rods in certain CANDU reactors.

Total Uranium Stocks
(tonnes natural U-equivalent)

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

NA Not available.

URANIUM PRICES

Uranium export price statistics*

	1995	1996	1997	1998	1999	2000	2001
Average price CAD/kg U	47	53.60	51.30	51.10	49.10	47.70	46.60
Average exchange rate	1.373	1.364	1.384	1.483	1.486	1.485	1.548
Average price USD/lb U_3O_8	13.0	15.10	14.20	13.30	12.70	12.40	11.60
Percentage spot deliveries	2%	1%	<1%	<2%	<1%	<1%	<2%

* Average price of all deliveries under export contract.

Commencing in 2002, Natural Resources Canada decided to suspend the publication of the average price of deliveries under export contracts for uranium for a period of three to five years, pending a policy review and assessment of market conditions.

The price was designed to reflect the international selling price for Canadian uranium. However, the international trend in recent years toward “open-origin” uranium sales contracts has made it increasingly difficult to isolate a figure applicable only to Canadian uranium. Natural Resources Canada may resume publication of pricing information in the future, if changed market conditions allow it to calculate an average price that is clearly applicable to Canadian uranium.

• Chile •

URANIUM EXPLORATION

Historical review

See the 2001 edition of the Red Book for a brief review of uranium exploration in Chile.

Recent and ongoing activities

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

During 2000-2001, a preliminary geological study of U-REE (rare earth elements) at the Cerro Carmen site, located in Atacama III Region, was carried out under the Specific Co-operation Agreement between CCHEN and ENAMI. Also, detailed regional geological information about radioactive minerals, available from CCHEN, was reassessed to improve knowledge of the national uranium potential.

In 2001, the portfolio of projects was submitted. It updates the metallogeny of Chile and the geological areas likely to contain uranium and also proposes 166 research projects, ranging from regional to detailed scientific activities, to be carried out sequentially in accordance with CCHENs capabilities.

In 2002, geophysical surveys were carried out at the Cerro Carmen site. Magnetometric resistivity and chargeability anomalies were identified which, in conjunction with the geological and geochemical information, can be used to define a target of metallic sulphurs with uranium and associated rare earths.

Uranium Exploration Expenditures and Drilling Effort – Domestic
(CLP millions)

	2000	**2001**	**2002**	**2003** (expected)
Total expenditures	110.99	75.85	99.94	81.33

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 1 931 tU, including 748 tU RAR and 1 183 tU EAR-I (no costs are assigned to either category). The combined RAR plus EAR-I total compares with 1 831 tU reported in the 2001 Red Book (RAR: 748 tU; EAR-I: 1 083 tU). The 1 January 2003 estimate includes 68 tU mainly in the low grade (0.02% U) surficial type occurrences Salar Grande and Quillagua, 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 0.17% U, and 100 tU in the Cenozoic volcanic deposit of El Laco which grade ranges between 0.01 and 0.15% U.

Known Conventional Resources*
(tonnes U)

Production method	RAR	EAR-I
Unspecified	748	1 183
Total	748	1 183

* *In situ* resources.

Undiscovered conventional resources (EAR-II & SR)

Undiscovered conventional resources (EAR-II + SR) are estimated to total 4 684 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)

EAR-II	Speculative resources
2 324	2 360

* *In situ* resources.

Unconventional or by-product resources

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.

URANIUM PRODUCTION

None reported.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

Chile does not have any nuclear power plants. The National Energy Commission’s (CNE) medium-term projections (10 years) do not envisage adding a nuclear power plant into the national electricity grid during this period.

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

Before the 1990s, China's uranium resource exploration activities were mainly carried out on hydrothermal-related granite type and volcanic type uranium deposits in Jiangxi, Hunan, Guangdong Provinces and Guangxi Autonomous Region in southern China. With decades of exploration, the Bureau of Geology (BOG), China National Nuclear Corporation (CNNC) had been successful in discovering some significant uranium deposits such as the Xiangshan, Xiazhuang Ore-fields and Chengxian Deposit in the Southern China Fold Belt. These deposits mainly occur in intermediate to acid magmatic rocks such as granitoid and volcanic rocks, where ore bodies are usually in the form of veins. As a number of these deposits are of relative small size, low to middle grade and deep, as well as poor transportation and power supply conditions, the mining cost turned to be much higher than those that could be accepted by the commercial nuclear reactor operators. At the beginning of 1990s, when China initiated its nuclear energy programme, the demand for uranium fuel material from China's nuclear power plants was not so urgent. With the deepening of reforming process, China experienced a relatively high currency inflation in the mid of 1990s during the adjusting of its economic structure, and it resulted in the decrease of uranium exploration activities in China from the mid to the end of 1990s.

Facing financial difficulties as well as the challenge to meet the demand of economic uranium resource for the country's mid-term and long-term nuclear energy development plan, the BOG made the decision of changing its prospecting direction from the "hard rock" type to *in situ* leaching type, and exploration activities were gradually placed towards the Mesozoic-Cenozoic sedimentary basins in northern and northwest China. From the mid-1990s, according to the Chinese government's positive policy on nuclear energy development, the construction of nuclear power plants in coastal areas began to speed up, and accordingly the demand of uranium material started to increase steadily. As the low cost known uranium resource decreased, the BOG initiated some regional geological reconnaissance projects and drilling survey projects in Yili, Turpan-Hami, Junggar, Er'lian and Songliao Basins in northern and northwest China with limited fund from the beginning of 1990s. During the 1990s, due to insufficient budget from the government, the average annual drilling footage was just maintained at about 40 000 m. In 1999, the government conducted a significant structure reform in China's mineral exploration sector, and then a large part of the personnel who had been involved in geological exploration was transferred to local governments. After the transfer of most of the geological organisations, the staff of BOG was reduced from more than 45 000 to about 5 500 persons. At the end of 1990s, the government gradually became aware of the importance of increasing the economic uranium resource to guarantee the demand of uranium from domestic nuclear power industry. Investment on uranium exploration steadily increased since 2000, and drilling experienced a rebound from 40 000 m to 70 000 m in 2000, to about 100 000 m in 2001, and to 120 000 m in 2002. All drilling was aimed at locating *in situ* leaching amenable sandstone type uranium deposits in northern China, the important target areas including Yili, Turpan-Hami, Junggar, Er'lian, Erdos and Songliao Basins.

Recent and ongoing uranium exploration and mine development activities

In the past decade including the recent two years, uranium exploration activities have been mainly conducted in Yili, Turpan-Hami, Junggar Basins in Xinjiang Autonomous Region, and Erdos, Er'lian, Hailar Basins in Inner Mongolia Autonomous Region as well as Songliao Basin in Northeast China. Four uranium deposits and a few potential occurrences have been found in Yili, Turpan and Erdos Basins.

In the Yili Basin, the BOG completed the exploration of a medium-sized sandstone type uranium deposit, the Kujiltai in 1996. Later, this deposit was put into commercial operation using ISL technology. In recent years two other deposits were found in this basin (Zajistan and Wukulqi), which have relatively small dimensions and are being evaluated and under exploration. In the Turpan Basin, the medium-sized Shihongtan deposit was found in 1999 and is currently being evaluated.

Uranium Exploration Expenditures and Drilling Effort – Domestic
(USD millions)

	2000	**2001**	**2002**	**2003** (expected)
Exploration expenditures	4.2	6.0	7.2	7.2
Total surface drilling (metres)	70 000	100 000	120 000	140 000

URANIUM RESOURCES

Uranium resources in China total 77 000 tU. The increase of 4 000 tU compared to the 2001 Red Book is due to the increase in known ISL mining resources in the Yili and Shihongtan deposits, Xinjiang Autonomous Region. For the first time China reported uranium resources using the NEA/IAEA classification scheme.

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

Xiangshan uranium field in Jiangxi Province	26 000 tU
Xiazhuang uranium field in Guangdong Province	12 000 tU
Quinglong uranium field in Liaoning Province	8 000 tU
Ganziping uranium deposit in Guangxi Autonomous Region	5 000 tU
Cengxian uranium deposit in Hunan Province	5 000 tU
Tengchong uranium deposit in Yunnan Province	6 000 tU
Lantian uranium deposit in Shanxi Province	2 000 tU
Yili uranium deposit in Xinjiang Autonomous Region	11 000 tU
Shihongtan uranium deposit in Turpan-Hami Basin in Xinjiang Autonomous Region	2 000 tU
Total	**77 000 tU**

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	10 050	12 050	12 050
In situ leaching	3 000	7 000	7 000
Heap leaching	23 450	29 750	29 750
In-place leaching	400	400	400
Total	36 900	49 200	49 200

* *In situ* resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	3 400	7 400	7 400
In situ leaching	0	3 000	3 000
Heap leaching	2 600	7 700	7 700
In-place leaching	2 000	2 000	2 000
Total	8 000	20 100	20 100

* *In situ* resources.

Undiscovered conventional resources (EAR-II & SR)

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
1 400	3 600	3 600

Speculative Resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
4 100	0	4 100

URANIUM PRODUCTION

Historical review

China's uranium industry was established in 1958. From 1958 to the middle of 1980s, almost all the uranium was produced using conventional methods. After that time, a number of improvements were introduced in production technology and management to meet the requirements of a market economy. In the 1990s, new production centres with new technology such as ISL and heap leaching were put into operation to further reduce the operation costs. The details had been described in 2001 Red Book. In 2001 and 2002, major efforts were made to improve heap leaching technology and ISL technology, such as adding bacteria in heap leaching to shorten the leaching cycle and raise recovery rate.

Status of production capability and recent and ongoing activities

During 2001 and 2002, the existing production centres in China remained the same. Uranium output increased slightly. The feasibility study of a new production centre in Fuzhou was approved. It is now under preparation of construction. Construction may start in 2003.

Uranium Production Centre Technical Details
(as of 1 January 2003)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Fuzhou	Chongyi	Yining	Lantian	Benxi
Production centre classification	existing	existing	existing	existing	existing
Start-up date	1966	1979	1993	1993	1996
Source of ore: • Deposit names • Deposit type • Reserves (active resources) • Grade (%U)	volcanic	granite	Dep 512 sandstone	Lantian granite	Benxi granite
Mining operation • Type (OP/UG/ISL) • Size (t ore/day) • Average mining recovery (%)	UG 700 92	UG 350 90	ISL NA NA	UG 200 80	UG 100 85
Processing plant • Type (IX/SX/AL) • Size (t ore/day) for ISL (kiloliter/day or liter/day) • Average processing recovery (%)	IX, AL 700 90	IX, AL 350 84	IX, AL NA NA	IX,AL NA 90	SX,AL NA 90
Nominal production capacity (tU/year)	300	120	200	100	120
Plans for expansion	NA	NA	to 300 tU	NA	NA

NA Not available.

Ownership structure of the uranium industry

China's uranium industry is a 100% state-owned company.

Employment in the uranium industry

The employment declined slightly in the past two years. Employment is expected to decrease in the future to lower the cost of uranium production.

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	2001	2002	2003 (expected)
Total employment related to existing production centres	8 500	8 200	8 000	7 700
Employment directly related to uranium production	7 650	7 380	6 300	6 930

Future production centres

Construction of a new production centre, in Fuzhou area, is planned to start in 2003. The new centre will share the same milling plant as the old mine. Production will start in three or four years. The capacity of this new mine will be 200 tU per year.

In addition, the ISL pilot test on the Shihongtan deposit is ongoing, and tests on the Dongsheng uranium deposit are planned to start in 2003. If the test results are favourable, they will be the new potential production centres. China provided no quantitative information on short-term production capability to 2020.

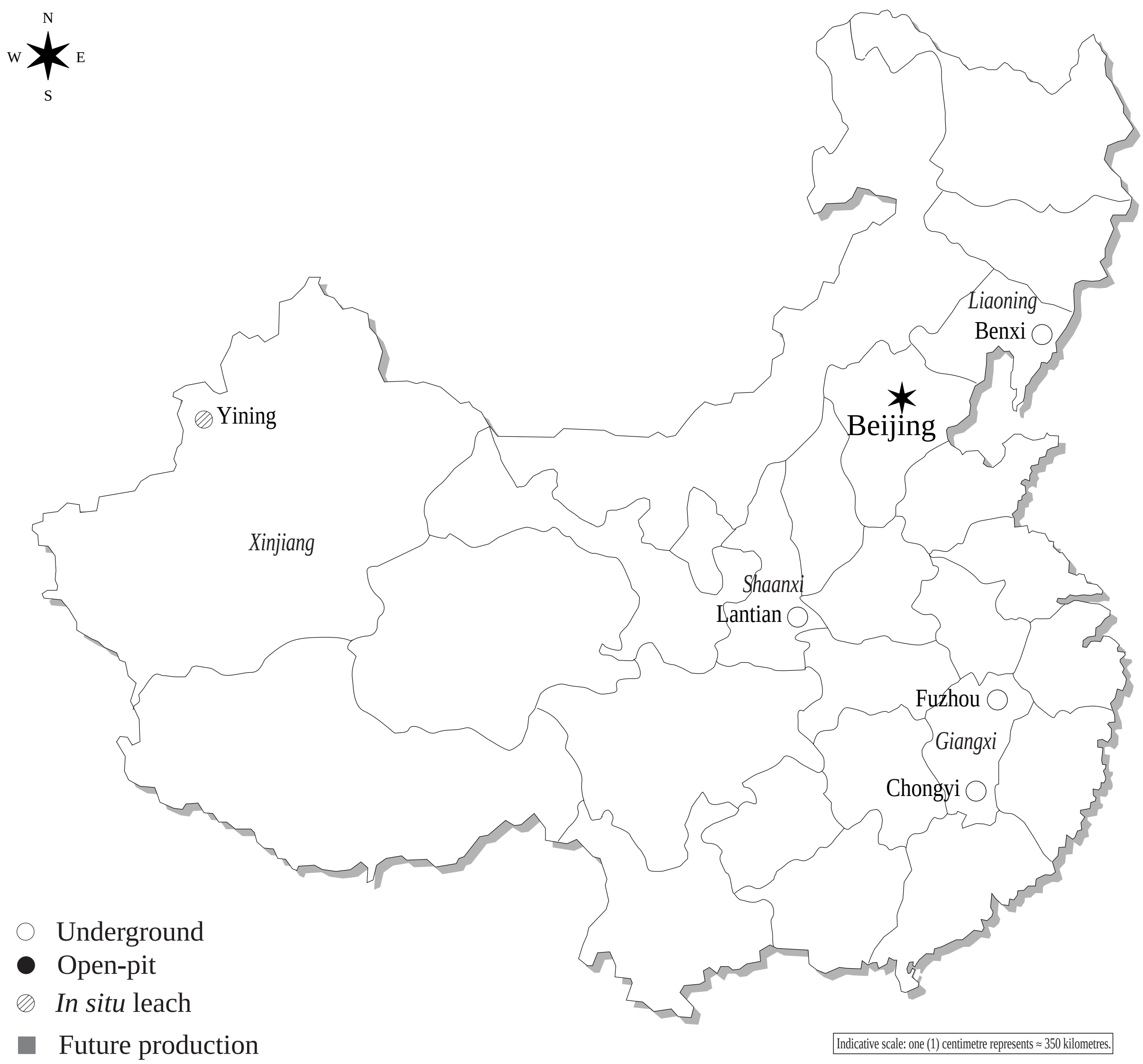
Secondary sources of uranium

China reported that it neither produced nor used mixed oxide fuels in 2001 and 2002 and that none is expected in 2003. No information was provided on the production or use of re-enriched tails.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

In the last two years, new technology and management were applied to protect environment. In-place leaching reduces the transportation of uranium ore to the surface. Less land surface is occupied. For heap leaching, two types of heap are designed and used. One uses a temporary heap with less occupied land, the residue being transported to tailings pond after leaching. The other uses a permanent heap, which is decommissioned and rehabilitated once the leaching operation is finished. With the awareness of environment protection by local farmers, more strict measures should be taken to protect the environment.

Uranium Production Centres in China



URANIUM REQUIREMENTS

During the last two years, three nuclear power plants were put into operation with total capacity reaching 4 400 MWe. As consequence, uranium requirements have doubled since 2001. Five additional power plants are under construction. At the end of 2005, total capacity is planned to be reached 8 700 MW. That will require 1 500 tU to meet the demands of operation.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	16.8	25
Uranium consumed (tU)	435	640

Additional nuclear capacity is being planned between 2005 and 2020, as shown in the following tables.

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
4 400	6 100	8 700	12 700	14 700	18 000	23 000	22 000	32 000

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
792	1 098	1 566	2 286	2 646	3 240	4 140	3 960	5 760

Supply and procurement strategy

The present uranium production capacity, together with discovered uranium resources can sufficiently meet the requirement of NPP in the short term. In the long term, the new reactors-related uranium requirement will be met by expanded uranium production capacity and from undiscovered resources. Emphasis is being placed on conducting feasibility studies of new production centres and on uranium exploration activities. China also would like to co-develop foreign uranium resources to meet the future reactor-related requirements. China reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Czech Republic •

URANIUM EXPLORATION

Historical review

A brief historical review of exploration in the Czech Republic, including the former Czechoslovakia, was given in the 2001 edition of the Red Book.

Recent and ongoing activities

No field exploration has been carried out since the beginning of 1994. 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 2003.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic (CZK millions)

	2000	2001	2002	2003 (expected)
Industry expenditures	0.20	0.10	0.80	1.00
Government expenditures	1.50	1.80	0.00	0.80
TOTAL	1.70	1.90	0.80	1.80

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 the 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 2003 decreased by 1 760 tU in comparison with the previous estimate of 2 680 tU.

In detail, the RAR recoverable at <USD 80/kgU decreased by 1 540 tU, and RAR >USD 80/kgU are no longer reported. The decrease in RAR was the result of the re-evaluation of the Stráz deposit as uneconomic, and the depletion of resources at the Rozná operating production centre.

EAR-I at <USD 80/kgU declined by 220 tU as a result of the depletion of resources at the Rozná production centre. EAR-I resources >USD 80/kgU are no longer reported. All the known conventional resources recoverable at costs <USD 80/kgU are tributary to the existing Rozná and Stráz production centres. Mining losses of 5% and processing losses of 5% have been accounted for in estimating RAR and EAR-I.

Undiscovered conventional resources (EAR-II & SR)

No new areas favourable for the discovery of resources have been identified in the last two years. The undiscovered conventional resources (EAR-II and SR) did not change over the last two years (see details in the 2001 Red Book).

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	0	830	830
Total	0	830	830

Estimated Additional Resources – Category I
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	0	90	90
Total	0	90	90

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
0	180	180

Speculative Resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
0	179 000	179 000

URANIUM PRODUCTION

Historical review

A review of historical uranium production was given in the 2001 edition of the Red Book.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit	NA	0	0	0	NA	0
Underground (1)	89 470	320	330	349	90 469	344
In situ leaching	16 712	170	116	112	17 110	105
Heap leaching	125	0	0	0	125	0
In-place leaching	3	0	0	0	3	0
Other methods (2)	459	17	10	4	490	4
Total	106 769	507	456	465	108 197	453

(1) Pre-2000 total includes uranium recovered by open-pit mining.
(2) Includes mine water treatment and environmental restoration.
NA Not available.

Status of production capability

Production capability has not changed in the last two years. Both Dolni Rozinka and Stráz pod Ralskem are in operation.

With respect to good technical and economical conditions at the Rozná deposit, the government decided on full depletion of the resources by 2005. Annual production will be 340 tU. Uranium from the ISL facility in Stráz pod Ralskem will be produced as part of environmental remediation. Expected production is 100 tU in 2004, then decreasing continuously.

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

Ownership of Uranium Production in 2002

Domestic				Foreign				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
465	100	0	0	0	0	0	0	465	100

Employment in the uranium industry

With the continuing reduction of uranium related activities, direct employment in the Czech uranium industry has declined to 2 507 workers, as of the end of 2002. This employment is engaged in uranium production, decommissioning and restoration activities.

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	2 887	2 641	2 507	2 445
Employment directly related to uranium production	2 504 1 731*	2 292 1 565*	2 087 1 368*	2 033 1 312*

* Undifferentiated (all) employment engaged in both uranium production and remediation programme of the Stráz centre.

Future production centres

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

Short-term Production Capability
(tonnes U/year)

2003				2004				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	440	440	0	0	440	440	0	0	250	250

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 2003**)**

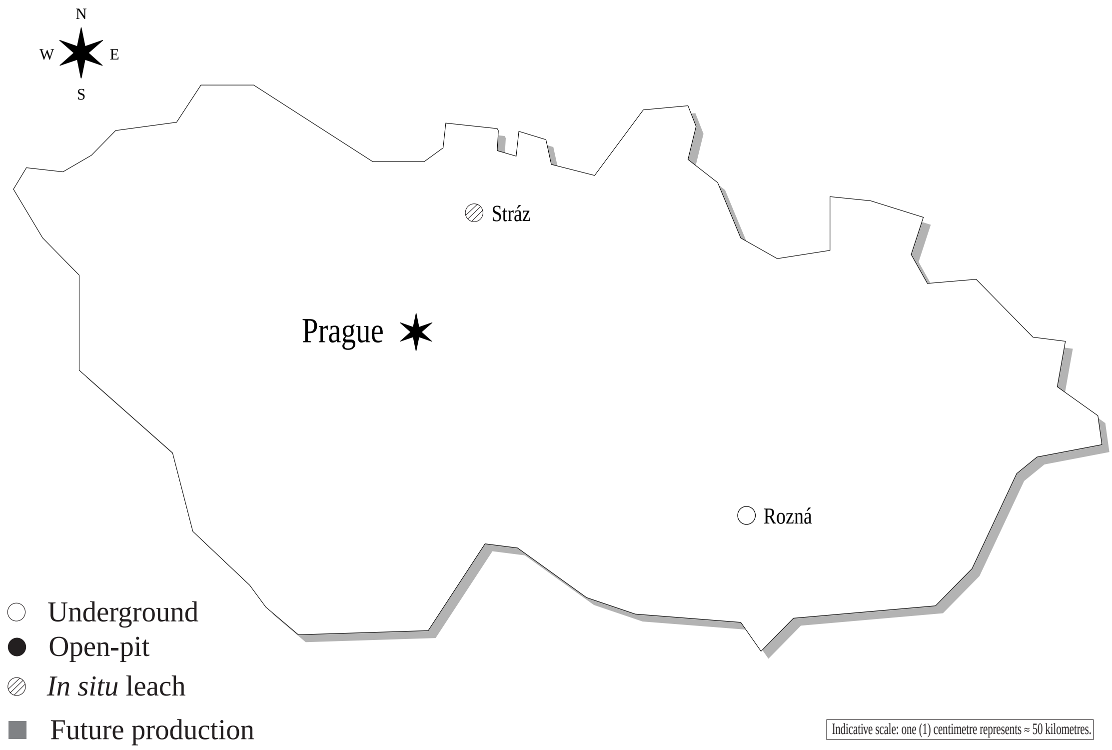
Production centre name	Dolní Rozínka (Rozná)	Stráz
Production centre classification	existing (mining)	existing (restoration)
Start-up date	1957	1967
Source of ore: • Deposit name • Deposit types • Reserves (active resources) • Grade (% U)	 Rozná vein 1 180 tU 0.323	 Stráz sandstone *
Mining operation: • Type (OP/UG/ISL) • Size (t ore/day) • Average mining recovery (%)	 UG 620 95	 ISL – 50 (estimated)
Processing plant: • Type (IX/SX/AL) • Size (t ore/day) for ISL kilolitre/day or litre/hr) • Average processing recovery (%)	 ALKAL/IX/CWG 580 94	 ISL/AL/IX 20 000 kl/day –
Nominal production capacity (tU/year)	400	250
Plans for expansion	none	none

* Extraction continues under remediation regime.

Secondary sources of uranium

No mixed oxide fuels or re-enriched tails have been produced or used by the Czech Republic through 2002 and are not expected in 2003.

Uranium Production Centres in the Czech Republic



ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Both environmental activities and social issues are main parts of contraction programme of the Czech uranium industry, which started in 1989. The environmental remediation activities include planning, administration, environmental impact assessment, decommissioning, waste rock management, rehabilitation of tailings, site rehabilitation, water treatment and long term monitoring. These activities are completely provided at the existing production centres as well as at the sites of former uranium facilities. The fundamental uranium environmental projects are as follows:

- Remediation of the after-effects of the *in situ* leaching in Stráz pod Ralskem (600 ha surface area).
- Rehabilitation of the tailing ponds in Mydlovary, Pribram, Stráz pod Ralskem (584 ha total area).
- Rehabilitation of the waste rock dumps in Pribram, Rozná-Olsí, Hamr and others (in total 46 million m^3).
- Mine water treatment from uranium facilities in Stráz, Olsí, Horní Slavkov, Licomerice and others (total 14 million m^3 per year).

The major part of environmental projects (more than 90%) is being funded by the state budget. The projects will continue until approximately 2040 and should cost more than 60 000 million CZK.

The contraction programme of the uranium industry consists in gradual decreasing of the employment related to uranium production and developing of alternative projects for elimination the social issues. The social part of the contraction programme (compensations, damages, rents etc.) is financed by the state budget. The Czech uranium industry represented by state-owned enterprise DIAMO, s.p., is transforming itself into an environmental engineering company.

Expenditures Related to Environmental Activities and Social Issues
(CZK millions)

	Pre-2002	2002	Total through 2002	2003 (expected)
Uranium environmental remediation	15 793	1 000	16 793	1 013
Social programme and social security	3 968	463	4 431	494
Total	19 761	1 463	21 224	1 507

Detail of the environmental activities and social issues in the Czech uranium industry were given in the 2001 Red Book.

URANIUM REQUIREMENTS

Since the start of operation of the Temelin nuclear power plant (Unit 1 in 2000 and Unit 2 in 2002), uranium requirements of the Czech main electricity producer, ČEZ a.s., have roughly doubled to approximately 700 tonnes per year. Such needs will persist in the long-term perspective, supposing that some minor fluctuation in procurement could appear from year to year due to optimisation of tails, exploitation of contractual flexibilities and as a result of discretionary purchases on the market, when price conditions are favourable.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	14.75	18.74
Uranium consumed (tU)	348	746*

* This quantity includes the first core loaded in the Temelín NPP Unit 2.

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
3 472	3 472	3 472	3 472	3 580	3 472	3 580	1 860*	3 580

Annual reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
746	745	690	690	700	700	710	345*	710

* The low alternative in 2020 reflects the official present 30 year life of the 4 reactors of the Dukovany NPP, and also some probable upgrade of the Temelín NPP. Nevertheless, ČEZ, a.s. aims to extend the lifetime of Dukovany reactors to 40 years and that would result in uranium requirements according to the high alternative in 2020.

Supply and procurement strategy

The vast majority of ČEZ, a.s. uranium needs has been covered from domestic sources to 2003; i.e., mainly from the existing production of DIAMO, s.p. and also recently by purchases of some limited quantities of uranium concentrates from the Government stockpiles. Since supply from DIAMO, s.p. has been continually decreasing with the perspective of almost full cessation in 2005-2006, ČEZ, a.s. will have to cover its future needs by increased purchases on the market, preferentially on the basis of long term contracts. During the period of 2004-2005, ČEZ, a.s. also considers of optimising its uranium stockpiles which have been kept in the "work in progress" status. This shall result in less urgency of seeking new suppliers in the near term.

NATIONAL POLICIES RELATING TO URANIUM

The Czech government decided to implement an extensive contraction programme of the uranium industry at the end of the 1980s. However the government has positive policy in the field of the nuclear power industry. Both last deposits Rozná (underground mine) and Stráz (ISL under remediation regime) will be mined out. No other uranium deposits will be opened in the near future. Czech uranium production is designed first of all for domestic nuclear power industry.

The governmental raw material policy has not interfered with ČEZ, a.s. uranium procurement policy since the beginning of 2001, when the legislation forcing Czech power company ČEZ, a.s. to buy domestic uranium was rescinded.

URANIUM STOCKS

Stocks in the form of natural uranium are held by government (>1 500 tU) as well as by DIAMO, s.p. (500 tU). ČEZ, a.s. does not hold strategic inventories in the form of natural uranium. Its general policy is to keep uranium in the form of fabricated fuel and also to maintain optimum quantities of uranium in processing, which should roughly cover annual needs of ČEZ, a.s. However, such policy is not rigid, so it can be modified according to perceived developments on the market.

Total Uranium Stocks
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	>1 500	0	0	0	>1 500
Producer	500	0	0	0	500
Utility	0	NA	0	0	0
Total	>2 000	0	0	0	>2 000

NA Not available.

URANIUM PRICES

Uranium prices are not available due to confidential business deals.

• Denmark (Greenland) •

URANIUM EXPLORATION

Historical review

Uranium exploration activities have been performed in South, East and West Greenland. In South Greenland exploration of the Kvanefjeld U-Th deposit took place during the 1955-1984 period. This is a large low-grade deposit associated with alkaline intrusive rocks.

Additional activities in South Greenland included a regional exploration programme during the 1979-1986 period. Three prospects were found: 1) uraninite in mineralised fractures and veins; 2) uranium rich pyrochlore mineralisation in alkaline rocks; and, 3) uraninite in hydrothermally mineralised metasediments. These prospects are believed to represent 60 000 tU in the "Speculative Resources" category.

In East Greenland, exploration activities were performed during the 1972-1977 period. The exploration programme concluded with no major discovery. Reconnaissance airborne gamma spectrometry with ground follow-up performed in West Greenland also resulted in no major discovery.

In 1995, a stream sediment survey including analysis for uranium and thorium, and scintillo-metres readings, covered 7 000 km^2 in north-west Greenland, but no prospects were recorded.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Denmark reports known conventional resources totalling 43 000 tU in South Greenland.

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	0	0	27 000
Total	0	0	27 000

* *In situ* resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	0	0	16 000
Total	0	0	16 000

* *In situ* resources.

Undiscovered conventional resources (EAR-II & SR)

Denmark reports speculative resources totalling 60 000 tU in South Greenland.

Speculative Resources
(tonnes U)

Cost ranges	Cost ranges	Total
<USD 130/kg U	Unassigned	
50 000	10 000	60 000

URANIUM PRODUCTION, REQUIREMENTS AND POLICIES RELATING TO URANIUM

Denmark has no uranium production or requirements. Denmark reported no information on national policies relating to uranium, uranium stocks or uranium prices.

• Egypt •

URANIUM EXPLORATION

Historical review

The Nuclear Materials Authority started uranium exploration in the early 1960s. The main prospecting methods included airborne, carborne and footborne surveys over outcrop and subcrob terrains. Hundreds of radioactive anomalies have been discovered in various geological environments. As a result of these regional prospecting efforts a number of uranium occurrences were found in granitoid rocks of the late Proterozoic age. In addition, other occurrences have been delineated in Paleozoic clastic sediments. These uranium occurrences represent the targets for the recent and ongoing exploration, development and evaluation activities.

Recent and ongoing uranium exploration activities

The Nuclear Materials Authority concentrated its main exploration and evaluation activities on three areas:

- Extensive exploration for conventional uranium mineral deposits in the Eastern Desert, Sinai and South-western Desert. These activities concentrate on the younger granites of Pan African type, the associated inter-mountain basins and the Palaeozoic sedimentary sequences as well as the basins in the Phanerozoic cover rocks.
- Evaluation of uranium reserves in some uranium occurrences in the Eastern Desert and Sinai. Small exploratory mines and trenches construction activities are used in these localities for reserve evaluation.
- Evaluation of economic minerals in black sand deposits, at the north of the Nile River Delta and Sinai along the Mediterranean coast, as non-conventional resource for uranium and thorium and other important rare earth elements. The main economic minerals in these deposits are monazite, zircon, rutile, ilmenite and magnetite. A small experimental unit was constructed for research purposes and producing some industrial samples to be tested in the local and international industrial facilities.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(EGP thousands)

	2000	**2001**	**2002**	**2003** (expected)
Development expenditures	36 000	36 300	33 200	33 000
Government exploration drilling (metres)	1 150	2 600	1 300	1 300
Number of government holes drilled	85	200	100	130

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Egypt does not report any known uranium resources according to the standard IAEA/NEA classification system.

Undiscovered conventional resources (EAR-II & SR)

There is a possibility of the presence of about 100 tonnes of uranium (speculative resources) in some uranium occurrences.

Speculative Resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
0	100	100

URANIUM PRODUCTION

Status of production capability, recent and ongoing activities

From 1999 to 2003 the Nuclear Materials Authority worked on the development of a semi-pilot plant for extraction of uranium from phosphoric acid (purification of phosphoric acid through extraction of the uranium). The design capacity of this plant is 15 m^3/day of acid containing about 65 ppm uranium. It was expected that this unit would be commissioned during 1999, but some unexpected technical problems arose, which caused a delay in obtaining the yellow cake product. Despite that, this unit is now utilised for producing of purified phosphoric acid, which is necessary for some agricultural and other industrial uses. The Nuclear Materials Authority is taking over the exploitation of the Egyptian black sands at north Delta and Sinai Mediterranean coast. The evaluated area is estimated to contain about six million tonnes of economic heavy minerals at an average grade of 4.5%. There are no plans to produce uranium from these placer deposits.

URANIUM REQUIREMENTS

There is no nuclear power plant in Egypt. A programme for nuclear power production was initiated in the mid-1980s, but was later put on hold for several reasons. No uranium requirement can be defined. Egypt provided no information on uranium policies, stocks or prices.

• Estonia •

URANIUM PRODUCTION

Historical review[1]

Uranium production in Estonia is associated to the Sillamae Metallurgy Plant, located in north-eastern Estonia at the town of Sillamae, 185 km east of Tallin near the shore of the Gulf of Finland.

The Sillamae plant was constructed in 1948 to process uranium bearing ores. It was first used to recover uranium from alum-shale mined in Estonia. Alum-shale mining continued until 1963, when the mines were closed due to difficulties in recovering the low and variable uranium content of the ore. The concentration of uranium in the Sillamae alum-shale is highly variable from place to place. It averages about 0.03% U, with maximum values of up to 0.1% U. The ore was extracted from underground mines located to the west of the plant. The mines had an area of about 2 km^2 and were accessed through an entrance located about 0.5 km from the plant. During this period about 240 000 tonnes of locally mined alum-shale were processed. Uranium production from the alum-shale is estimated to have been about 65 tU.

1. Most of the information in this report was obtained in interviews with workers at the plant and through investigations and analysis of the plant site. Holdings of the Sillamae Metallurgical Plant archives have been declassified. Documentation on the plant history and uranium production is now available. Several articles, related to uranium production, have been published in Estonian journals. [E. Lippmaa, E. Maremae (1999), *Dictyonema Shale and Uranium Processing at Sillamae*, Oil Shale 1999, Vol.16, No.4].

After 1963, higher grade uranium ores containing up to 1% U were imported from Europe for processing. Uranium production continued until about 1977. Most of the ore was brought from Czechoslovakia (2.2 million t) and from Hungary (1.2 million t). Small amounts were also brought from Poland, Romania, Bulgaria and the former German Democratic Republic. An estimated 4 013 000 t of uranium ores were processed at the plant. Assuming an average recovery of about 92% of the contained U, total uranium production of the plant is estimated to be about 23 000 tU.

In 1970, processing of loparite (an ore of niobium, tantalum and rare earths) from the Kola Peninsula was also started. No uranium was recovered from this material, which contained about 0.03% U and 0.6% thorium. From 1977 to 1989 the waste repository was used for the disposal of wastes from processing loparite, as well as for oil shale ash. Loparite ores were shipped to the plant until 1989. After that date processing of loparite continued from stockpiled ores.

An estimated total of about 12 million tonnes (i.e. about 8 million cubic metres) of tailings and other waste material, including 4 million tonnes of tails from processing uranium ores, are present at the site.

While no enrichment of uranium (with respect to ^{235}U) was carried out at the plant, enriched uranium and its compounds were shipped to the plant from outside of Estonia. Following processing or manufacturing these were shipped out of the country.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

From 1992 to 1994, an international co-operation project assisted Estonian specialists in conducting an environmental site assessment of the Sillamae mill tailings. The results of this assessment have been used to estimate the impact on the environment and for planning site reclamation and long-term closure of the uranium tailing impoundment.

Radon and its progeny are emitted from the uncovered repository. This is the major source of radiological impact on the population of Sillamae. The resulting annual individual doses are of the order of 0.2 mSv. The impact of water leaking through the repository and from the neighbouring closed mines, and discharging into the Gulf of Finland is much less. The resulting impact is observable only near the depository. This discharge results in the collective committed 50-year dose of about 1 man-Sv, and in an individual committed effective dose of about 1 μSv. The main environmental concern defined by the international co-operation project in 1992-1994 was the stability of the repository. There is a potential for the collapse of the dam or of a landslide.

In the summer of 1997, the remediation project of the Sillamae tailings pond was initiated by the Estonian Government, in co-operation with Silmet Grupp AS. Implementation of the project, to stabilise the dam and improve the environmental situation, is now underway. Remediation of the area is managed by AS Okosil.

In spring 1998, the pilot project application, submitted to the Phare Environmental Programme, was approved. In spring 1999, Wismut GmbH delivered the first report on their general conception for the environmental remediation of Sillamae tailings pond. The project is co-financed and supervised by Phare LSIF and the Nordic countries. Reclamation should be completed by end of 2006.

• Finland •

URANIUM EXPLORATION

Historical review

A brief historical review of exploration in Finland can be found in the 2001 edition of the Red Book.

Finland has previously reported 2 900 tU of reasonably assured resources in the cost range USD 130 or more/kgU, included in several deposits. Because this cost category is no longer used in the Red Book, these resources have to be excluded for the present. In addition, for environmental and technical reasons many of these deposits will not be mineable anymore.

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. However, since the times of the IUREP mission 20 years ago, international mining and exploration companies have increasingly been active in Finland, mainly looking for gold, diamonds and platinum group elements. In a lesser amount, their work includes gathering of basic data concerning the occurrence and geology of 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. No EAR-I resources are reported.

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	0	0	1 500
Total	0	0	1 500

* *In situ* resources.

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 ranges	Cost ranges	Total
<USD 130/kg U	unassigned	
0	5 500 to 11 500	5 500 to 11 500

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-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit mining	15	0	0	0	15	0
Underground mining	15	0	0	0	15	0
Total	30	0	0	0	30	0

Secondary sources of uranium

Finland does not produce or use mixed oxide fuels or re-enriched tails.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

The Paukkajanvaara uranium mine area was restored in the 1990s. After the final field measurements in 1999, the Finnish Centre for Radiation and Nuclear Safety gave the certificate of accomplished environmental restoration to the landowner in 2001.

According to legislation in Finland, as of 1996, export of spent nuclear fuel is not permitted. From the beginning of the 1980s, investigations were made to solve the problem of final disposal. Posiva Oy was established by Teollisuuden Voima Oy and Fortum Power and Heat Oy, the power companies responsible for nuclear waste management, in 1996.

In 1999, Posiva filed an application for a decision-in-principle on the building of a final disposal facility. In May 2001, the Finnish Parliament ratified the favourable decision-in-principle made by the Government in December 2000. The final disposal facility will be built in Olkiluoto, at Eurajoki. The decision-in-principle applies to the spent fuel from Finland's present four nuclear power plant units. In May 2002, in parallel with the decision of the fifth Finnish nuclear unit, the Parliament also ratified a decision-in-principle on the final disposal of the spent nuclear fuel of the fifth plant. Thus the spent fuel of the new nuclear power plant unit would also be disposed of in the bedrock in Olkiluoto. In May 2003, Posiva filed the construction permit application for an underground research facility with the Municipality of Eurajoki.

URANIUM REQUIREMENTS

At the beginning of 2003, 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 about 2.6 GWe net. No new reactors are under construction. Uranium requirements are approximately 500 tU/year for the four reactors.

The Finnish Parliament ratified in May 2002 the government's earlier favourable decision-in-principle on the fifth nuclear power unit. TVO is planning to start the construction around 2005, and the unit should be in operation before the end of the decade. The size of the new LWR unit is defined at 1 000-1 500 MW with a technical operating life of 60 years. The uranium requirements for this new unit will range from 200 to 300 tU/year.

Electricity Generation and Uranium Consumption

	2001	**2002**
Electricity generated (TWh)	22.3	21.4
Uranium consumed (tU)	500	500

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	**2003**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 600	2 600	2 600	2 600	4 100	3 600	4 100	3 600	4 100

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
500	500	500	500	800	700	800	700	800

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 and Spain, but until now all the uranium has been from Russia.

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 from 7 months to one year's use.

URANIUM PRICES

Due to confidentiality aspects price data are not available.

• France •

URANIUM EXPLORATION

Uranium exploration 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 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.

Prospecting activities 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.

In 1987, uranium exploration activities started to decline 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 were 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 COGEMA, 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.

Recent and ongoing activities

Abroad, COGEMA 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, COGEMA 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 and Development Expenditures – Abroad
(USD millions)

	2000	**2001**	**2002**	**2003** (expected)
Exploration expenditures	NA	NA	9.4	9.4
Development expenditures	NA	NA	5.0	5.0
Total	7.3	7.7	14.4	14.4

NA Not available.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Following the closure of the last uranium mine in 2001 (Jouac), there are no longer Reasonably Assured Resources in France. EAR-I remain unchanged from the last edition of the Red Book. EAR-I resources in the cost category USD 80-130/kgU were assessed more than five years ago. Deductions for anticipated mining and ore processing losses were determined for each deposit with an estimated 10% loss for each deducted.

Estimated Additional Resources – Category I
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
Open-pit	0	0	11 740
Total	0	0	11 740

Undiscovered conventional resources (EAR-II & SR)

No systematic appraisal is made of undiscovered resources in France.

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)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit mining	NA	0	0	0	NA	0
Underground mining	NA	296	158	0	NA	0
Others*	NA	0	26	18	NA	5
Total	73 368	296	184	18	73 866	5

* Mine water treatment.
NA Not available.

Status of production capability

All ore-processing plants in France have been decommissioned. No other production centre is under construction, planned or envisaged. The Le Bernardan production centre ceased operation in 2001.

Employment in the uranium industry

Only a few people remain at the Bernardan site in order to complete remediation, expected to be complete by 2004.

Future production centres

There are no plans to develop new production centres in the near future.

Secondary Sources of Uranium

Mixed Oxide Fuel Production and Use
(tonnes of natural U equivalent)

Mixed-oxide fuels	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Production	NA	NA	NA	1 120	NA	800-1 120*
Usage**	NA	800	800	800	NA	800

* End of Cadarache commercial production in 2003.
** Annual production above 100 t MOX (800 t of natural U equivalent) is exported.
NA Not available.

Since 1996, part of the depleted UF_6, generated during isotopic enrichment at the Georges Besse plant, EURODIF, is sent to another enrichment plant to be further depleted. Resulting re-enriched uranium is used in the EURODIF plant. No quantitative information was provided on the production and use of re-enriched tails.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Refer to the 2001 Red Book and to the joint NEA/IAEA publication *Environmental Remediation of Uranium Production Facilities,* OECD Paris, 2002, for a complete description of environmental activities and socio-cultural issues.

In August 2002, the CESAAM (Centre de Suivi des Anciennes Activités Minières), COGEMA entity based in Bessines, was certified ISO 14001 for the management and monitoring of reclaimed mining sites in Limousin.

In addition, following the creation of the Areva Group, its Executive Committee engaged the Group in a strategy of continuous progress and sustainable development. The objectives fixed to the mining entities of the Group, planned production and restoration, will be adapted, if necessary, within the framework of this strategy.

URANIUM REQUIREMENTS

Uranium requirements and supply strategy

The total capacity of France's nuclear power plants and their uranium requirements should not change as no reactors are expected to be shut down in the next 15-20 years. As of 1 January 2003 there were 59 nuclear power plants operating in France. France is undertaking a review of its energy policy that may result in a decision to build more power plants

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	399.6	415.5
Uranium consumed (tU)	8 568	8 568

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
63 300	63 300	62 950	62 950	62 950	62 950	62 950	NA	NA

NA Not available.

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
8 568	8 568	8 568	8 168	8 168	7 722	7 722	NA	NA

NA Not available.

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.

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.

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. No data was provided because of confidentiality reasons.

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

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground	0	0	4 830
Total	0	0	4 830

Estimated Additional Resources – Category I
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground	0	0	1 000
Total	0	0	1 000

After mine and mill dismantling, RAR and EAR-I were moved from the <USD 40/kgU cost category, to the <USD 130/kgU cost category.

Undiscovered conventional resources (EAR-II & SR)

With the closure of uranium production facilities in Gabon, uranium resource estimates are no longer updated.

URANIUM PRODUCTION

Historical review

See the 2001 edition of the Red Book for a historical review of uranium production in Gabon.

Historical Uranium Production*
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total trough 2002	2003 (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

* Uranium contained in the ore. Total production of uranium contained in concentrates was 26 612 tU. 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

All mining and milling infrastructures have been dismantled and are being reclaimed.

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.

Employment in the uranium industry

Employment at COMUF was 15 at the end of the year 2002, including 6 directly associated to reclamation.

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 hectares 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 principle). The work is intended also to ensure the physical stability of the impoundments of the residues, and if possible, provide for the future utilisation of the affected area.

The Mounana mill is completely dismantled and restoration of the site is expected to be completed by late 2004. A programme for long-term monitoring and surveillance of the tailings will then be implemented.

Environmental Costs Associated to Uranium Exploitation

	Cost (XOF millions)
Environmental impact assessment	
Tailings reclamation	4 820
Sites reclamation	1 730
Monitoring	500
Others	
Total	7 050

NATIONAL POLICIES RELATING TO URANIUM

Gabon has no uranium requirements and reported no information on national policies relating to uranium or uranium prices. Gabon reported that uranium stocks were zero.

• Hungary •

URANIUM EXPLORATION

Historical review

A brief historical review of uranium exploration in Hungary can be found in the 2001 edition of the Red Book.

Recent and ongoing uranium exploration and mine development activities

Exploration activities ceased in 1989.

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 to 90 m. The ore minerals include uranium oxides and silicates associated with pyrite and marcasite.

Known conventional resources (RAR & EAR-I)

Hungary reports its RAR or EAR-I resources as zero.

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 <USD 130/kgU. These resources are tributary to the Mecsek production centre.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
0	18 399

URANIUM PRODUCTION

Historical review

See the 2001 edition of the Red Book for a review of Hungary's uranium production history.

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 2002 and was the by-product of water treatment activities.

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.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (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	20	10	10	10	50	4
Total	21 020	10	10	10	21 050	4

Employment in the uranium industry

Reported as zero.

Future production centres

None reported.

Secondary sources of uranium

Production and use of mixed oxide fuels and re-enriched tails were reported as zero.

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.

Costs of Environmental Management
(HUF thousands)

	1998	1998-1999	2000	2001	2002
Closing of underground spaces	NA	2 107 897	281 992	0	0
Reclamation of surficial establishments and areas	NA	459 447	589 728	651 766	320 519

Costs of Environmental Management (contd)
(HUF thousands)

	1998	1998-1999	2000	2001	2002
Reclamation of waste rock piles and their environment	NA	222 943	141 253	286 930	82 543
Reclamation of heap-leaching piles and their environment	NA	900 941	608 231	115 936	18 938
Reclamation of tailings ponds and their environment	NA	538 203	741 195	1 304 629	1 869 523
Water treatment	NA	626 649	383 436	243 941	241 686
Reconstruction of electric network	NA	0	98 361	20 790	0
Reconstruction of water and sewage system	NA	1 000	0	0	0
Other infrastructural service	NA	342 000	93 193	42 651	47 329
Other activities including monitoring, staff, etc.	NA	581 197	431 678	461 512	367 677
SUBTOTAL	5 406 468	5 780 277	3 369 067	3 128 155	2 948 275
Reserves for the amount of 1998-2000	0	139 120	0	0	0
TOTAL	5 406 408	5 919 397	3 369 067	3 128 155	2 948 275

NA Not available.

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 net. 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.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	14.13	13.95
Uranium consumed (tU)	370	370

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	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)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
370	370	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. Hungary reported its uranium stocks at zero. No information on uranium prices was reported.

• India •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

The history of uranium exploration in India dates from 1949. A review of the history of uranium exploration and production has been described with details in the 1997 and 2001 editions of the Red Book.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration activities in India have been concentrated in the following areas:

- Proterozoic Aravalli-Delhi basins, Rajasthan.
- Meso-Neoproterozoic Cuddapah basin, Andhra Pradesh.
- Neoproterozoic Bhima basin, Karnataka.
- Cretaceous Mahadek sandstone, Meghalaya.

Proterozoic Aravalli-Dehli basins, Rajasthan

A zone of albitisation, with varying dimensions over 320 km in length, also referred as “albite line”, occurs along the contact of the Mesoproterozoic Dehli Supergroup with the Archean Banded Gneissic Complex (BGC), between Haryana and Rajasthan. A number of uranium and uranium-thorium anomalies were reported along this zone. The anomaly located at Rohil and Ghateshwar, Rajasthan, is being explored in detail for evaluation of the potential of the area.

Meso-Neoproterozoic Cuddapah basin, Andhra Pradesh

The crescent shaped Cuddapah basin is spread over 44 000 km^2 with a thick pile of Meso-Neoproterozoic sedimentary and volcanoclastic rocks of Cuddapah Supergroup exposed in Papaghni, Kurmool, Srisailam and Palnad sub-basins as well as in the Nallamalai fold belt area. The basement Archean gneisses/Dharwar metasedimentaries are thrusted over the Cuddapah Supergroup of rocks in the eastern margin of the basin.

A medium size deposit of moderate grade has been found at Lambapur-Peddagattu close to the northwestern margin of the Cuddapah basin. Evaluation and exploratory drilling of the mineralised unconformity contact between the basement granite and the overlying Srisailam quartzite has firmed up the resource position.

Extensive surface shows of uranium anomalies were located in a similar geological setting up at Chitrial, west of Peddagattu over an area of 60 km^2. This area holds potential for vast uranium resources.

Banganapalli Quartzite (Kurnool Group) and its contact with the basement granite near Koppunuru, host scattered uranium mineralisation over an area of 50 km^2. Exploratory drilling has confirmed the continuity of mineralisation.

Surveys in the northern part of Palnad sub-basin indicated occurrence of uranium anomalies in basement granite, basic dykes and overlying quartzite of Banganapalle formation at Rallavagu Tanda and Damarcherla, Nalgonda district.

Surface anomalies associated with quartz chlorite breccia have been located in Gulcheru quartzite (lowermost member of Cuddapah Supergroup) around Gandi, Madyalabodu and Idupulapaya along the southwestern margin of Cuddapah basin. Exploratory drilling in these areas is under progress.

Neoproterozoic Bhima basin, Karnataka

The Bhima basin covering parts of Karnataka and Andhra Pradesh is spread over 5 200 km^2 along a NE-SW direction, and consists of arenaceous, calcareous, and argillaceous sedimentary rocks of Bhima Group with its northwestern part under the cover of Deccan Traps. The basin is affected by a number of E-W and NW-SE trending major faults.

Brecciated limestone occurring along a major fault, proximal to the unconformity contact of Bhima basin rocks and underlying basement granites, is mineralised near Gogi, Karnataka. The boreholes drilled in the area have intercepted mineralisation both in the limestone and basement granite. Some boreholes have intercepted mineralisation with grades over 1% U, with appreciable thickness. The ore (limestone and granite) is amenable to alkaline leaching.

Cretaceous sandstones of Meghalava

Fluviatile sandstone of Mahadek formation (Cretaceous age), spread over 1 100 km^2, has been established as a potential host for sandstone type uranium deposits. Evaluation drilling at Wahkyn, where a low tonnage, medium grade deposit has been established, is in progress.

Other Proterozoic basins

In addition, potential areas have also been identified in Mesoproterozoic Gwalior basin, Madhya Pradesh and Neoproterozoic Chattisgarh basin, Chattisgarh.

Mine development

The uranium deposit located at Turamdih in Singhbhum east district, Jharkhand, is being developed for underground mining.

Uranium Exploration Expenditures and Drilling Statistics – Domestic
(INR millions)

	2000	**2001**	**2002**	**2003** (expected)
Government expenditures	627.900	586.800	581.200	634.600
Government surface drilling (metres)	32 500	44 400	40 025	50 550

India reported expenditures for exploration abroad as zero.

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 types of deposits: vein-type (53%); sandstone-type (17%); unconformity type (7%); dolostone strata-bound type (15%) and others (8%).

The known resources as of 1 January 2003 include 54 636 tU RAR and 25 245 tU EAR-I as *in situ* resources. The marginal increase of the resources (1 851 tU), compared to 2001 figures is mainly due to the reassessment of some of the deposits, and to the exploitation of some of them by open-pit mining method.

Reasonably Assured Resources*
(tonnes U)

Production method	**Cost ranges unassigned**		
Unspecified	NA	NA	54 636
Total	NA	NA	54 636

* *In situ* resources. NA Not available.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	Cost ranges unassigned		
Unspecified	NA	NA	25 245
Total	NA	NA	25 245

* *In situ* resources.
NA Not available.

Undiscovered conventional resources (EAR-II & SR)

Undiscovered uranium resources were firmed up with higher degree of confidence and some of the resources under SR category were reassigned to EAR-II category, in parts of Rajasthan, Karnataka, Meghalaya and Andhra Pradesh. New potential areas with speculative resources were also identified. This resulted in a slight increase in the resources in the EAR-II category (1 498 tU). There was no change in the SR category. These resources are without cost category assignment.

Undiscovered Resources
(tonnes U)

Cost ranges unassigned	
EAR-II	Speculative resources
15 488	17 000

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 district, Jharkhand State. The ore is treated in the processing plant located at Jaduguda, about 150 km west of Kolkata.

In addition, uranium was 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 was then further processed in the Jaduguda mill. As the copper mining in the area has been scaled down, uranium recovery from tailings has been temporarily suspended.

Status of production capability

The total installed capacity of the Jaduguda mill is about 2 100 t ore/day. Detailed information on the Jaduguda, Narwapahar and Bhatin Mines and the Jaduguda mill was given in the 1997 and 2001 editions of the Red Book.

Uranium Production Centre Technical Details
(as of 1 January 2003)

	Centre #1	Centre #2	Centre #3
Name of production centre	Jaduguda	Bhatin	Narwapahar
Production centre classification	operating	operating	operating
Start-up date	1968	1986	1995
Source of ore • Deposit name • Deposit type	Jaduguda vein	Bhatin vein	Narwapahar vein
Mining operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	UG 600 80	UG 130 75	UG 1 000 80
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	Jaduguda IX/AL 2 100 80		
Nominal production capacity (tU/year)	175		
Plans for expansion	none		

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.

Employment in the uranium industry

About 4 200 people are engaged in uranium mining and milling activities.

Future production centres

Development of the uranium deposit located at Turamdih in Singhbhum east district, Jharkhand is in progress, as an underground mine. The uranium deposit located at Banduhurang in Singhbhum east district, Jharkhand is planned to be mined by the open-pit method. A uranium ore processing plant is proposed to be constructed at Turamdih, in Singhbhum east district, Jharkhand. The plant will process ore from Turamdih and Banduhurang mines. A deposit located at Lambapur-Peddagarru in Nalgonda district, Andhra Pradesh is planned for exploitation by open-pit as well as underground methods.

Secondary sources of uranium

India reported no information on the production and use of mixed-oxide fuels or re-enriched tails.

Uranium Production Centre Technical Details (contd.)
(as of 1 January 2003)

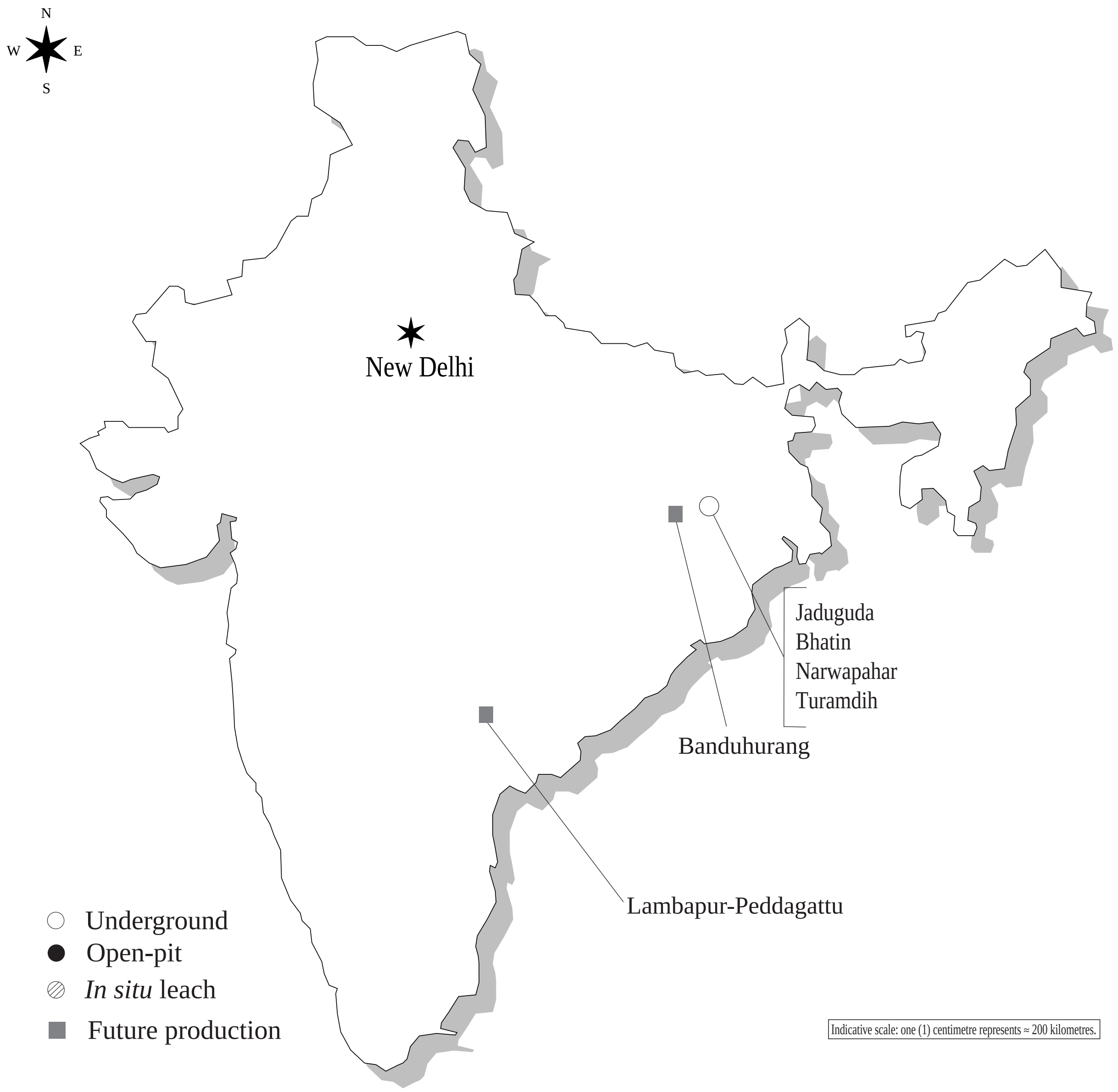
	Centre #4	Centre #5	Centre #6
Name of production centre	Turamdih	Banduhurang	Lambapur-Peddagattu
Production centre classification	development	planned	planned
Start-up date	2003	2006	2006
Source of ore • Deposit name • Deposit type	Turamdih vein	Banduhurang vein	Lambapur unconformity
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	UG 550 75	OP 2 250 75	UG/OP 1 250 75
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	Turamdih IX/AL 3 000 80		Mallapuram IX/AL 1 250 77
Nominal production capacity (tU/year)	190		130
Plans for expansion	none		none

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Environmental impact assessment and monitoring

A well-equipped Environmental Survey laboratory, set-up at Jaduguda by Bhabha Atomic Research Centre, Department of Atomic Energy, monitors the status of the environment around the operating units. Different environmental matrices are taken into account over an area of 20 km radius. Samples of effluents from mine, mill, tailings pond are regularly collected and analysed. The water from different streams and local river system, sediments from river beds are also analysed in different seasons. Samples of soil, grass, vegetables, food and aquatic organisms like algae, fish, etc are collected and analysed. The samples of ground water from wells and hand pumps are periodically collected and analysed for evaluation of radioactive and chemical pollutants. Measurements of gamma radiation, environmental radon concentration, and natural background radiation are carried out using sophisticated instruments and techniques. These surveillances in the area have not shown any significant rise of any harmful elements in the atmosphere in the entire history of UCIL's operations.

Uranium Production Centres in India



Tailings impoundment facility

The tailings impoundment facility created at Jaduguda has high natural hills as barriers on three sides. The embankment has been designed on one side to accommodate the entire tailings for a very long period. The decantation wells in the pond are planned to allow the flow of excess water, preventing any discharge of solid particles. Encroachment into the tailings pond area is prohibited by laying of permanent fences all around. Security personnel are also posted at site as guard against any entry. The pond is located at a safe distance from the population to avoid any direct contamination. Large part of the pound is covered with vegetation to prohibit re-suspension of dust into the atmosphere.

Waste rock management

Waste rocks generated from mining are minimal. There are mainly disposed in underground works for filling the void. Some quantity is also used within premises for filling low-lying areas.

Effluent management

Mine water is treated for use in ore processing plant after clarification. The decanted effluent from the tailings pond is treated further at the effluent treatment plant, and is brought to normal conditions before being used in the process. Remaining water, if any, is discharged into the environment after strict monitoring.

Site rehabilitation

People displaced by construction of mines and plants are suitably re-housed as per the Government rules.

Regulatory activities

There are many independent Central and State regulatory bodies, which regulate the operation of each unit. Atomic Energy Regulatory Board is the apex organisation under DAE to regulate all safety related activities in nuclear units.

Social and cultural issues

Creation of employment, providing education and health care, undertaking infrastructure development, promoting sports, conducting cultural programme, are some of the areas in which UCIL has contributed towards the society around its operating units. Surveys are carried out from time to time in and around the operating units of UCIL. The reports have substantially proved that there is no adverse effect of radiation on health of the residents around the area.

URANIUM REQUIREMENTS

India’s uranium requirement is for its nuclear power programme. Present capacity of 2 720 MWe gross (2 503 MWe net) consists of 2 Boiling Water Reactors (BWR) and 12 Pressurised Heavy Water Reactors (PHWR). Construction of 6 PHWR (TAPP 3&4 – 2×540 MWe, Kaiga 3&4 – 2×220 MWe, and RAPP 5&6 – 2×220 MWE) and two Light Water Reactors (KKNPP 1&2 – 2×1 000 MWE) is in progress. The total nuclear power generating capacity is expected to grow to about 6 680 MWe gross (6 101 MWe net) by December 2008, with progressive completion of projects under construction, and this capacity will continue till 2010. More projects are envisaged to be taken up, however, the programme beyond this period is yet to be finalised.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	19.196	19.556
Uranium consumed (tU)	NA	NA

NA Not available.

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 503	2 503	2 503	6 101		6 101*	14 860*	19 230**	

* Approved plan.
** As per projections.

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
433	465	504	880		880	NA	NA	NA

NA Not available.

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. For planning purposes the lead-time from uranium exploration and development to production is assumed to be seven years. 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 Centre for Development of Nuclear Ore and Geology of National Nuclear Energy Agency (BATAN), started in the 1960s. Up to 1996 the reconnaissance survey has covered 79% of a total of 533 000 km^2, identified on the basis of favourable geological criteria and promising exploration result. Since that year the exploration activities focused in the Kalan area and its surrounding, Kalimantan, in which the most significant indication of uranium mineralisation has been found. During 1998-1999 the exploration activities were carried out at Tanah Merah and Mentawa Sectors of the Kalan area and its surrounding, Kalimantan. The activities consisted of systematic geological and radiometric mapping and of radon survey in order to delineate the mineralised zone Uranium exploration in Mentawa and Tanah Merah has added speculative resources. In 2000-2001, BATAN carried out exploration drilling in Rirang (178 m) and Rabau (115 m) Kalan West Kalimantan.

Recent and ongoing uranium exploration and mine development activities

In 2002, BATAN, carried out exploration drilling in Tanah Merah (181 m) Kalan West Kalimantan. In 2003, that exploration drilling will be continued in Jumbang. Indonesia reported no exploration abroad in 2002 and 2003.

Uranium Exploration Expenditures and Drilling Efforts – Domestic
(IDR thousands)

	2000	**2001**	**2002**	**2003** (expected)
Government expenditures	498 840	265 521	259 172	274 370
Government surface drilling (metres)	453	293	181	300
Number of government holes drilled	10	5	3	5

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

As of January 2003, RAR total 6 797 tU, recoverable at <USD 130/kgU, unchanged from the 2001 Red Book. Of this total, 468 tU is recoverable at <USD 80/kgU.

EAR-I at 1 699 tU remain unchanged from the 2001 Red Book. Recovery costs for EAR-I are projected to be <USD 130/kgU.

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Heap leaching	0	468	6 797
Total	0	468	6 797

* *In situ* resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Heap leaching	0	0	1 699
Total	0	0	1 699

* *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. Recovery costs for the SR have not been assessed.

Speculative Resources
(tonnes U)

Cost ranges	
<USD 130/kgU	Unassigned
0	4 090

No significant environmental issues relating to uranium exploration and resource development have been identified. Indonesia has not reported any plans to produce uranium. Indonesia reported no information on uranium requirements. Indonesia also reported no information on national policies relating to uranium, uranium stocks, or uranium prices.

• Islamic Republic of Iran •

URANIUM EXPLORATION

Historical review

See the 2001 edition of the Red Book.

Recent and ongoing activities

By processing and interpretation remote sensing data and integration with geophysical and exploration data, a major uranium metallogenic zone was defined in central Iran. Evaluation of uranium and associated elements (REE, Th) in this zone is considered as the main objective for recent and future exploration activities. The expected deposits are considered to be metasomatic and hydrothermal vein types.

Data interpretation has also led to define sedimentary basins as favourable areas for sandstone type deposits in central and northwest Iran.

Main working areas in Iran are:

- Exploration and evaluation of uranium resources in Bafq-Posht-e-Badam metallogenic zone, hosting Saghand, Narigan, Zarigan, Chah-Juueh, Khoshumi, Sfordi, Lakeh-Siah and Sechahun discoveries. The expected uranium deposits are metasomatic and hydrothermal types related to the upper Precambrian magmatic and metasomatic complexes.
- Evaluation of alpine intermountain basins for sandstone type deposits in central Iran.
- Evaluation of uranium resources discovered in hydrothermal polymetallic deposits in Azerbaijan, as well as late alpine sedimentary basins in the same region.
- Uranium exploration for coal bearing basins in central and northwest Iran.
- Uranium exploration in the Great Kavir basin and its drainage area.
- Exploration of sedimentary basins in northeast Iran.
- Utilisation of airborne radiometric data for discovery of other mineral deposits, such as copper, potash, gold and uranium in co-operation with other exploration and mining institutes and companies.

Uranium Exploration and Development Expenditures – Domestic
(IRR millions)

	2000	**2001**	**2002**	**2003** (expected)
Government exploration expenditures	1.7*	8 000	11 000	14 000
Government surface drilling (metres)	2 394	1 700	2 380	4 000
Number of government holes drilled	19	5+30**	15+50**	NA

* USD millions.
** Shallow drilling.
NA Not available.

Iran reported no exploration activities abroad.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Known resources totalling 1 427 tU have been attributed to the Saghand 1 and Saghand 2 (491 tU RAR, 876 tU EAR-I) and Narigan I (60 tU EAR-I) deposits. Both resource categories are recoverable at <USD 130/kgU.

Reasonably Assured Resources*
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
Unspecified	0	0	491
Total	0	0	491

* *In situ* resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	0	0	936
Total	0	0	936

* *In situ* resources.

Undiscovered conventional resources (EAR-II & SR)

A total of 13 850 tU have been estimated for the EAR-II and SR categories as of 1 January 2003, an increase of 1 850 tU compared to 2001 Red Book. 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 650 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.
- Chah-Juueh prospect with 1 000 tU speculative resources.
- Khoshumi prospect with 1 000 tU speculative resources.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
0	3 350

Speculative Resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
4 500	6 000	10 500

Iran reported no information on current or future uranium production centres, 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 remained in JNC were 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. Japan did not report the expenditures of this abroad activity. Japan reported industrial and governmental domestic exploration and development expenditures as zero. Abroad, Japanese government expenditures were reported as zero. Japanese industry exploration expenses abroad were not reported.

URANIUM RESOURCES

Known conventional resources

About 6 600 tU of Reasonably Assured Resources have been identified and classified as recoverable at <USD 130/kgU. Mining losses (10%) and processing losses (5%) are accounted for.

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	NA	NA	6 600
Total	NA	NA	6 600

NA Not available.

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)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Underground mining	45	0	0	0	45	0
Heap leaching	39	0	0	0	39	0
Total	84	0	0	0	84	0

Secondary sources of uranium

Production facilities

The plutonium fuel plant of JNC consists of three facilities, the Plutonium Fuel Development Facility (PFDF), the Plutonium Fuel Fabrication Facility (PFFF) and the Plutonium Fuel Production Facility (PFPF).

- The PFDF was constructed for basic research and fabrication of test fuels and started operation in 1966. As of December 2002, approximately two tonnes of MOX fuels have been fabricated in PFDF.
- In the PFFF there are two MOX fuel fabrication lines, one for the experimental Fast Breeder Reactor Joyo (FBR line) with one-tonne MOX/year of fabrication capability and the other for the prototype Advanced Thermal Reactor Fugen (ATR line) with a ten-tonnes MOX/year fabrication capability. The FBR line started its operation in 1973 with Joyo initial load fuel fabrication. The fuel fabrication for the Joyo in the FBR line was finished in 1987, and the role of the fuel fabrication for Joyo was switched to PFPF. The ATR line started its operation in 1972 with MOX fuel fabrication for the Deuterium Critical Assembly (DCA) in O-arai Engineering Center of JNC. The fuel fabrication for ATR Fugen was started in 1975 and was finished in 2001. The total amount of MOX fuel fabricated by both lines was approximately 155 tonnes.
- PFPF FBR line was constructed to supply MOX fuels to the prototype FBR Monju and the experimental FBR Joyo with a five-tonnes MOX/year of fabrication capability. The PFPF FBR line started its operation in 1988 with Joyo reload fuel fabrication and fuel fabrication for the FBR Monju was started in 1989. As of December 2002, approximately 12 tonnes of MOX fuels had been fabricated in the PFPF.

Use of mixed oxide fuels

- Prototype Fast Breeder Reactor Monju

  Monju was first taken critical in April 1994 and generated electricity for the first time in August 1995. Towards the end of the commissioning test, in December 1995, a sodium leak accident occurred. A thorough investigation of the cause of the accident has been carried out, and the safety of all aspects of the Monju design and operation has been reviewed. At present, work is concentrated on countermeasures against sodium leakage. The plant remains shut down pending the completion of this work.

- Experimental Fast Reactor Joyo

  The experimental fast reactor Joyo attained its initial criticality in April 1977 with the MK-I breeder core. As an irradiation test bed, the Joyo MK-II core achieved the maximum design output of 100 MWt in March 1983. Thirty-five duty cycle operations and 13 special tests with the MK-II core were completed by June 2000. The Joyo net operation time exceeds 60 000 hours and 478 fuel subassemblies were irradiated during the MK-I and MK-II core operations. The MK-III high performance irradiation core, of which maximum design output increases to 140 MWt, will achieve its initial criticality in July 2003.

- Prototype Advanced Thermal Reactor Fugen

  The Advanced Thermal Reactor Fugen, developed independently in Japan, is a heavy-water moderated, light-water cooled reactor. Since power generation started in 1979, the reactor has maintained a high operational reliability, equivalent to that of a commercial station. At the same time it has been used to develop new fuels and improve operation and maintenance techniques. In 1979, Fugen started with 96 MOX fuel assemblies loaded in the initial core and since then 30-70% of the fuel used in the core has been MOX. To November 2002, total of 772 MOX fuel assemblies have been loaded equivalent to nearly 119 tonnes of uranium and plutonium, or nearly 1.9 tonnes of plutonium. Fugen has successfully completed the task for which it was constructed. From now on it will be used to train engineers from abroad in operation and control techniques, and will continue to produce a useful supply of electricity, until operation ceases in 2003; it will then be decommissioned.

- Deuterium Critical Assembly DCA

  DCA was constructed in 1969 as a part of experimental facilities for research and development of Advanced Thermal Reactor (ATR). All the missions were finished and decommissioning work was started in March 2002.

Mixed Oxide Fuel Production and Use
(tonnes of natural U equivalent)

Mixed-oxide (MOX) fuels	**Pre-2000**	**2000**	**2001**	**2002**	**Total through 2002**	**2003** (expected)
Production	650	15	20	0	685	NA
Usage	NA	NA	NA	NA	NA	NA

NA Not available.

Japan reported zero production and use of re-enriched tails.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

As of 1 January 2003, Japan had 54 operating nuclear power reactors. Total (gross) electric generating capacity was 46 187 MWe, providing approximately one-third of the electricity generated in Japan. Three additional reactors were under construction and six reactors were planned.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	319	314
Uranium consumed (tU)	9 110	7 840

Installed Nuclear Generating Capacity to 2020
(MWe gross)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
46 187	46 187	49 580	61 850	61 850	NA	NA	NA	NA

NA Not available.

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
7 840	8 380	10 850	11 820	11 820	NA	NA	NA	NA

NA Not available.

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. No information on uranium stocks was reported.

• 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 south-eastern 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 Mastrichtian-Paleocene age. In the southern and southeastern area uranium occurs only as yellowish stains associated with chalk or marl.
- The Chalk Marl sequence in the investigated area is the major constituent of the uranium bearing rocks. The calcite and clay content are low.

- Preliminary leach tests using the alkaline method indicate leacheability 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

1. Surficial uranium deposits

The estimated uranium content in two of the four explored blocks in central Jordan (surficial uranium deposits) is 27 500 tU. However, uranium content in the other blocks have not been estimated because uranium exploration was stopped in 1998 due to NRA policy and projects priority. This project might be refreshed in the coming three or four years.

2. Unconventional or by-product resources

A total of approximately 70 000 tU are associated with phosphate deposits and therefore, they belong in the by-product category. The average uranium concentration 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 concentration 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., 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.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

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

• Kazakhstan •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

A detailed historical review of uranium exploration and mine development in Kazakhstan is provided in the 2001 Red Book.

Recent and ongoing uranium exploration and mine development activities

In 2001-2002, prospecting works were carried on in the Shu-Saryssuiskaia province on Akdala, Inkai and Moinkum deposits. During that period construction of three ISL test sites was completed, and uranium mining tests started. The following joint stock companies financed the prospecting works: NAC "Kazatomprom", joint Kazakhstan-Canadian venture "Inkai" and the joint Kazakhstan-French venture "KATCO". In 2003, mining tests will be pursued on all mentioned deposits, and commercial mining will start on Akdala deposit at the end of the year.

JV "KATCO" carried out prospecting works, along with the preparation of mining, on Torkuduk site of the Moinkum deposit. Governmental approval of additional reserves of RAR and EAR-I categories is expected to be given in 2004.

NAC "Kazatomprom" carried out field (experimental-industrial) works for reserves preparation for ISL mining on Akdala deposit and the JV "Inkai", on Inkai deposit.

Outside of Kazakhstan, no prospecting and mining works were carried out.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(KZT millions)

	2000	**2001**	**2002**	**2003** (expected)
Industry exploration expenditures	27	110	240	97
Government exploration expenditures	0	0	0	0
SUBTOTAL Exploration expenditures	27	110	240	97
SUBTOTAL Development expenditures	1 540	1 807	1 565	1 265
TOTAL Expenditures	1 567	1 917	1 805	1 362
Industry exploration drilling (metres)	0	41 500	49 600	14 100
Number of industry exploration holes drilled	0	129	171	44
Government exploration drilling (metres)	0	0	0	0
Number of government exploration holes drilled	0	0	0	0
SUBTOTAL Exploration drilling (metres)	0	41 500	49 600	14 100

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic (contd)
(KZT millions)

	2000	2001	2002	2003 (expected)
SUBTOTAL Exploration holes	0	129	171	44
SUBTOTAL Development drilling (metres)	13 100	36 550	5 140	14 000
SUBTOTAL Development holes	36	148	11	38
TOTAL Drilling in metres	13 100	78 050	54 740	28 100
TOTAL Number of holes	36	277	182	82

URANIUM RESOURCES

Known conventional uranium resources (RAR & EAR-I)

Known uranium resources of Kazakhstan, recoverable at costs <USD 130/kgU, total 941 800 tU as of 1 January 2003. The resources are reported as *in situ*. However, mining and milling losses are estimated to amount 10%. When compared to the estimate of 1 January 2001, there is an increase of 87 670 tU. Uranium mined and recovered during 2001-2002 amounted 4 936 tU. Known Resources, which can be recovered at costs of <USD 40/kgU total 457 600 tU, or about 50% of the total. EAR-I increased by 93 100 tU from the 2001 estimates in all cost categories.

About 60% of Kazakhstan's known resources recoverable at costs <USD 40/kgU are tributary to existing and committed production centres.

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	0	115 560	277 600
In situ leaching	311 800	311 800	311 800
Total	311 800	427 360	589 400

* *In situ* resources, adjusted for depleted resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	0	118 400	206 600
In situ leaching	145 800	145 800	145 800
Total	145 800	264 200	352 400

* *In situ* resources.

No resources assessment (RAR and EAR-I) was made within the last 5 years.

Undiscovered conventional uranium resources (EAR-II & SR)

Estimates of EAR-II and SR recoverable at costs <USD 130/kgU, remained unchanged.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
290 000	310 000

Speculative Resources
(tonnes U)

Cost ranges		Total
<USD 130/kgU	Unassigned	
500 000	0	500 000

URANIUM PRODUCTION

Historical review

Uranium mining in Kazakhstan started in 1957 by open-pit method in the southern part of the country, on the Kurdai deposit.

Until 1978 four combines, belonging to the USSR Ministry of Machine Construction, mined uranium by underground and open-pit methods: Kyrgyzski Mining Combine, Leninabadski Mining and Chemical Combine in the south, Tselinny Mining and Chemical in the north and Prikaspiiski Mining and Chemical Combine in the west. About 15 deposits, with an approximate cumulative output of 5 000 tonnes, were mined.

Deposits, being mined out during these years, were mainly vein-stockwork mineralisation type. They were located in the Kokshetauskaia and the Pribalkhashskaia uranium provinces. Two syngenetic genesis deposits, where mineralisation was connected with phosphatised bone detritus of fossil fish, were also mined.

ISL uranium mining of sandstone deposits started in 1978. Mineralisation is represented by roll ore bodies of tens kilometres in length. All deposits of the Shu-Saryssuiskaia and Syr-Daryinskaia uranium provinces belong to sandstone type.

Uranium production in 2001 and 2002 totalled 2 114 and 2 822 tU, respectively. Plans for 2003 indicate a significant increase to 3 315 tU.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit mining (1)	21 618	0	0	0	21 618	0
Underground mining (1)	38 853	100	97	0	39 050	330
In situ leaching	27 801	1 770	2 017	2 822	34 410	2 985
Total	88 272	1 870	2 114	2 822	95 078	3 315

* Pre-2000 totals may include uranium recovered by heap and in-place leaching.

Status of production capability and recent and ongoing activities

In 2002, National Atomic Company (NAC) Kazatomprom, whose whole block of shares belongs to the Government, accounted for 96.6% of mined uranium in Kazakhstan. NAC Kazatomprom has three mining and one prospecting centres in the south of Kazakhstan in the Shu-Saryssuiskaia and the Syr-Daynskaia provinces: Stepnoye, Centralnoye, Mining Group No. 6, and Akdala deposit where uranium is being obtained in the process of production testing. Uranium is being mined on Mynkuduk, Uvanas, Kanzhugan, Moinkum, South Karamurun, North Karamurun. All uranium is obtained by ISL method.

The remaining 3.4% of uranium were mined for the first time by ISL method by Kazakhstan-Canadian (Cameco) and Kazakhstan-French (COGEMA) joint ventures on the Inkai and Moinkum deposits.

In 2001, 97 tons of uranium were mined by the joint stock company “Kazsubton” created on the base of the Tselinni Mining and Chemical Combine. Uranium was mined by the underground method on the Vostok deposit (vein-stockwork mineralisation).

Ownership structure of the uranium industry

There were no changes in the ownership structure of the production centres since 1 January 2001.

Ownership of Uranium Production in 2002

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
2 726	96.6	0	0	0	0	96	3.4	2 822	100

Uranium Production Centre Technical Details
(as of 1 January 2003)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6	Centre #7
Name of production centre	Centralnoye Mining Group	Stepnoye Mining Group	Mining Group #6	Akdala site	JV KATKO	JV Inkai	JSC KazSubton
Production centre classification	existing	existing	existing	existing	existing	existing	existing
Start-up date	1982	1978	1985	2001	2001	2001	1958
Source of ore							
• Deposit names	Kanzhugan, Moinkum-site 1	Mynkuduk-Vostochny-site, Uvanas	North & South Karamurun	Akdala	Moinkum-sites 2,3	Inkai-sites 1,2	Vostok
• Deposit type(s)	sandstone	sandstone	sandstone	sandstone	sandstone	sandstone	vein-stockwork
• Reserves (active resources)	35 300 t	32 000 t	35 700 t	15 500 t	57 300 t	42 850 t	4 500 t
• Grade (% U)	0.063	0.042	0.086	0.059	0.064	0.063	0.133
Mining operation:							
• Type (OP/UG/ISL)	ISL	ISL	ISL	ISL	ISL	ISL	UG
• Average mining recovery (%)	90	90	93	85	85	85	90
Processing plant (Acid/ Alkaline):							
• Type (IX/SX/AL)	acid, IX	acid, IX	acid, IX	acid, IX	acid, IX, SX	acid, IX	acid, SX,AL
• Average process recovery (%)	96-99	96-99	96-99	96-99	93-96	93-96	98-99
Nominal production capacity (tU/year)	1 000	1 000	600	700	700	700	1 250*
Plans for expansion	no	1500	1 000	1 000	1 000	1 000	no

* Nominal production capacity is reduced because of change of activity of part of the facility.

Employment in the uranium industry

Employment in Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	4 100	4 000	3 770	3 850
Employment directly related to uranium production	1 080	1 160	1 280	1 330

Future production centres

For the near future, ISL will account for most of Kazakhstan's uranium production.

In 2003, a new production centre for uranium mining by ISL of the Zarechnoye deposit, located in the Syr-Daryinskaia province, was created by a Kazakhstan-Russian joint venture.

Uranium ISL production centres are planned to be created on Zhalpak, Irkol, Kharasan and Budennovskoie deposits. Form and type of property of the planned centres are not fully completed.

In Kazakhstan there are standby deposits not involved in the production plans that could allow the creation of new production centres. These are the Kosachinskoie and Semisbai deposits in the Kokchetauskaia province in the north of Kazakhstan. Kasachinskoie deposit is a deposit of hydrothermal genesis, with vein-stockwork type ores and has about 100 000 tU of reserves, at an average grade of 0.1% U, in the RAR and EAR-I categories. Because of the low world uranium price, there is no plan to develop the Kosachinskoie deposit within the near future. Semisbai deposit, with about 40 000 tU of reserves, at an average grade of 0.1% U, in the RAR and EAR-I categories, belongs to the stratum-infiltration (sandstone) type. Uranium could be mined by ISL. At present, there is no industrial-household infrastructure at Semisbai, and the Kazsubton production centre is not interested in the deposit, despite possible profitable uranium mining.

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.

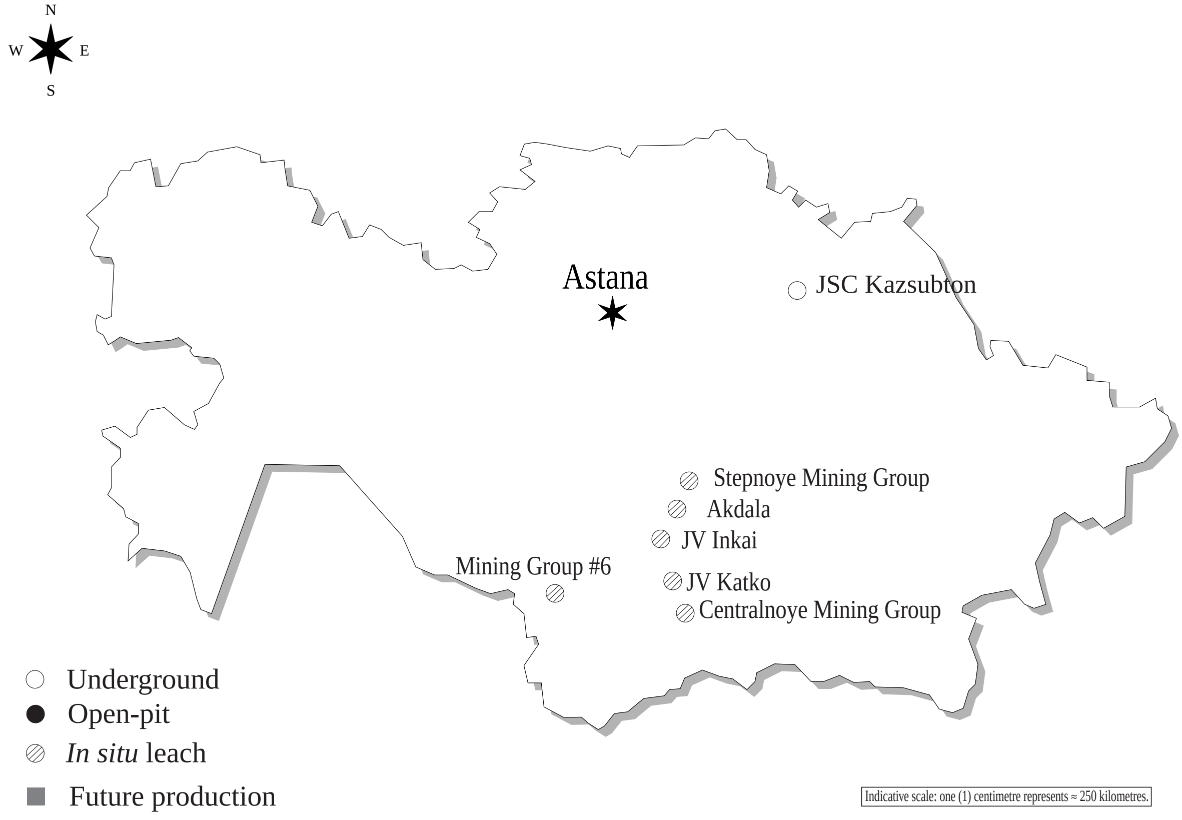
Short-term Production Capability
(tonnes U/year)

2003				**2004**				**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
3 315	3 315	3 315	3 315	3 500	3 500	3 500	3 500	4 000	4 100	4 000	4 100

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
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

In general, Kazakhstan's known uranium resources could support a relatively rapid increase in production in response to an increase in international demand.

Uranium Production Centres in Kazakhstan



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.

In 2001-2002 about 96% of the uranium was mined by the ISL method, which has much less negative environmental impact in comparison with open and underground mining. There were no significant failures of the earth surface, barren rocks, uneconomic ores heaps or tailing dumps. Acid leaching is being applied for ISL process.

Monitoring

Monitoring wells are constructed on all developed and operational ISL sites. Number of wells and well patterns are being determined by the projects, and confirmed by relevant state bodies. Once in a quarter, or more often, water sampling is being made from wells under-ore and above-ore horizons and from ore bodies. Contents of uranium, thorium, radium, sulphate-ion, nitrate-ion, sulphuric acid, pH, Eh, and solid residual are determined in samples.

On developed sites, well monitoring has been made for more than ten years. Industrial solution spreading is not more than tens of metres from ore bodies.

Tailings impoundment

When using conventional mining methods to recover uranium at processing plant, ore is being crushed and milled with tails generation, which are forwarded by hydrotransport to tailing dump in liquid form. Tailing dump is equipped with antifiltration screen and two-level drainage system.

Around tailing dumps, monitoring wells have been constructed, where operations are being performed under the above-described scheme.

Waste rock management

Low level radioactive wastes, generated in small quantities during mining and processing, are disposed in specially equipped points, which have been agreed with regional state sanitary-epidemiological organisations.

Effluent management

Storm and ice waters within the areas of industrial construction are taken away by means of self-flow near buildings and then along specially designed surfaces to natural soils.

Site rehabilitation

Rehabilitation is being done at the developed sites according to specially prepared projects co-ordinated with respective state bodies.

Social and/or cultural issues

All contracts for uranium mining provided by the Government contain provisions for participation in local social and cultural activities by the subsoil users. The subsoil user deducts funds indicated in the contract for the construction of social and cultural objects, professional development of staff, training of students and organisation of different professional seminars.

URANIUM REQUIREMENTS

The Government of Kazakhstan has ordered the fast-breeder reactor BN-350 with a net capacity of 70 MWe, 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	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*
0	0	0	0	0	NA	NA	NA	NA

NA Not available.

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 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. There is no activity regarding uranium exploration and mine development in Korea.

URANIUM RESOURCES

Korea has no known uranium resources.

URANIUM PRODUCTION

Korea has no domestic uranium production capability.

Secondary sources of uranium

Korea reported no information regarding mixed oxide fuels and re-enriched tails production and use.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

As of January 2003, the installed capacity of domestic nuclear power generation was 15.7 GWe with 18 units in operation accounting for about 29% of Korea's total electric power capacity. According to the First Basic Plan for Electricity Supply and Demand, the latest electricity plan in Korea, 10 additional nuclear power plants, including 2 PWR plants already under construction, will be on line by the year 2015 with a total capacity of 27.3 GWe. Along with the steady increase in nuclear capacity, requirements of uranium and fuel cycle services are increasing continuously.

Electricity Generation and Uranium Consumption

	2001	**2002**
Electricity generated (TWh)	106.6	119.1
Uranium consumed (tU)	2 510	2 780

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	**2003**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
15 716	15 716	17 716	23 116	NA	26 637	NA	26 637	NA

NA Not available.

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	**2003**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 780	2 780	3 230	4 120	NA	4 770	NA	4 770	NA

NA Not available.

NATIONAL POLICIES RELATING TO URANIUM

Korea's demand for uranium and nuclear fuel cycle service has continuously increased with the expansion of its nuclear power capacity. The demand accounted for more than 5% of the world's demand from the year 2001. Korea imports uranium concentrates from Australia, Canada, the United Kingdom, France, Russia, the United States and South Africa.

Korea Hydro and Nuclear Power Co., Ltd. (KHNP), the major consumer of nuclear fuel in Korea, has a basic guideline to ensure the nuclear fuel supply and to pursue the economic efficiency at the same time by applying an international open bid. For uranium concentrates, KHNP has tried to maintain the optimal contract condition through both long-term contracts and spot-market purchases. Conversion and enrichment services come from the United States, the United Kingdom, France, Canada and Russia by long-term contracts. Fuel fabrication services are fully localised to meet domestic needs.

URANIUM STOCKS

KHNP 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	1 100	2 100	0	0	3 200
Producers	0	0	0	0	0
Government	0	0	0	0	0
Total	1 100	2 100	0	0	3 200

• Lithuania •

URANIUM EXPLORATION, RESOURCES AND PRODUCTION

Past exploration programmes have been unsuccessful in discovering uranium in Lithuania. Therefore, Lithuania has neither uranium resources nor production and is not currently undertaking any uranium exploration. Lithuania reported mixed oxide and re-enriched tails production and use at zero.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

In the updated National Energy Strategy, which was approved by the Seimas (Parliament), it was stated that Lithuania commits itself to close down its two reactors, on the understanding that a programme, for organising additional financial assistance by the EU to the early closure of the Ignalina nuclear power plant Unit 1 before 2005, and Unit 2 in 2009, will be adequately addressed at a later stage of accession negotiations.

By implementing this programme, Lithuania will resolve the consequences of the closure of the Ignalina nuclear power plants. In the event of a failure to ensure the required financing from the EU and other donors, the operation of units 1 and 2 of the Ignalina nuclear power plant will be extended taking into account their safe operation period. Uranium requirements will depend accordingly.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	10.3	12.9
Uranium consumed (tU)	280	360

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 760	2 760	1 380	0	NA	0	NA	0	NA

NA Not available.

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
360	310	100*	0	NA	0	NA	0	NA

* Only Unit 2 will be in operation, and not fully burned fuel in unit 1, will be transferred to unit 2.
NA Not available.

Supply and procurement strategy

A bilateral agreement, under which the Russian Federation will supply fuel for the Ignalina nuclear plant over the long term, was signed in 1998 between the two countries. A complementary agreement is concluded each year based on planned electricity production.

NATIONAL POLICIES RELATING TO URANIUM

None reported.

URANIUM STOCKS

There is no stockpile of natural uranium material in Lithuania. A three-month stock of enriched fuel (140 tU equivalent) is generally maintained by the Ignalina power plant. No information concerning uranium prices was reported.

• Namibia •

URANIUM EXPLORATION

Historical review

For a complete description of historical uranium exploration, see 2001 edition of the Red Book.

Recent and ongoing uranium exploration and mine development activities

Since the end of the exploration boom in the 1970s, limited uranium exploration has been done. Currently two Mineral Deposit Retention Licenses are valid over the Valencia (intrusive alaskite type) and Langer Heinrich (calcrete hosted surficial) deposits. An Exclusive Exploration License is valid over the Trekkopje deposits, but the exploration work done remains confidential as long as the license is active.

In comparison to pre-1997, there has been an increase in exploration activities into the uranium deposits but this has decreased significantly with the decline of uranium prices.

In August 2002, the Langer Heinrich deposit was bought by an Australian Company, Paladin Resources Ltd. They completed a pre-feasibility study in March 2003, which confirmed a positive project outlook.

URANIUM RESOURCES

A geological description of the uranium resources of Namibia can be found in the 2001 edition of the Red Book.

Known conventional uranium resources (RAR & EAR-I)

Namibia’s known conventional resources as of 1 January 2003 total 278 045 tU recoverable at costs <USD 130/kgU. While the RAR portion totalling to 170 532 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 2001 and 2002 cumulative production of 4 572 tU.

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Open-pit	57 262	139 297	170 532
Total	57 262	139 297	170 532

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Open-pit	70 546	90 815	107 513
Total	70 546	90 815	107 513

* *In situ* resources.

90% of RAR and EAR-I, recoverable at <USD 40/kgU, are associated to existing and committed production centres.

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 t/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)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit mining	69 412	2 715	2 239	2 333	76 699	2 500
Total	69 412	2 715	2 239	2 333	76 699	2 500

Uranium Production Centre Technical Details
(as of 1 January 2003)

Production centre name	Rössing
Production centre classification	operating
Start-up date	1976
Source of ore:	
• Deposit name	Rössing
• Deposit type	intrusive
• Reserves (active resources)	NA
• Grade (% U)	0.03
Mining operation:	
• Type (OP/UG/ISL)	OP
• Size (tonnes ore/day)	41 900
• Average mining recovery (%)	82
Processing plant:	
• Type (IX/SX/AL)	AL/IX/SX
• Size (tonnes ore/day)	30 000
• Average processing recovery (%)	86
Nominal production capacity (tU/year)	4 000

NA Not available.

Status of production capability

In 2001, production was close to 60% of capacity, having increased from 41% in the early 1990s. Similar rates of production are expected in 2003 and 2004.

Over the last three years substantial capital investment has been made to improve cost efficiency. The major capital expenditure items have been replacement of haul trucks and the installation of a pre-screening facility ahead of the fine crushing plant. In addition computerised commercial and management systems (SAP R/3, which stands for Systems Application Product) have been installed to improve operational efficiency and provide for internal Y2K compliance in the commercial and management systems. Similar level of capital expenditure is expected in the next two years.

Short-term Production Capability
(tonnes U/year)

2003				2004				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

Short-term Production Capability (contd.)
(tonnes U/year)

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%

Ownership of Uranium Production in 2002

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
82	3.5	2 251	96.5	0	0	0	0	2 333	100

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 782 in 2002.

Employment in Existing Production Centres
(person-years)

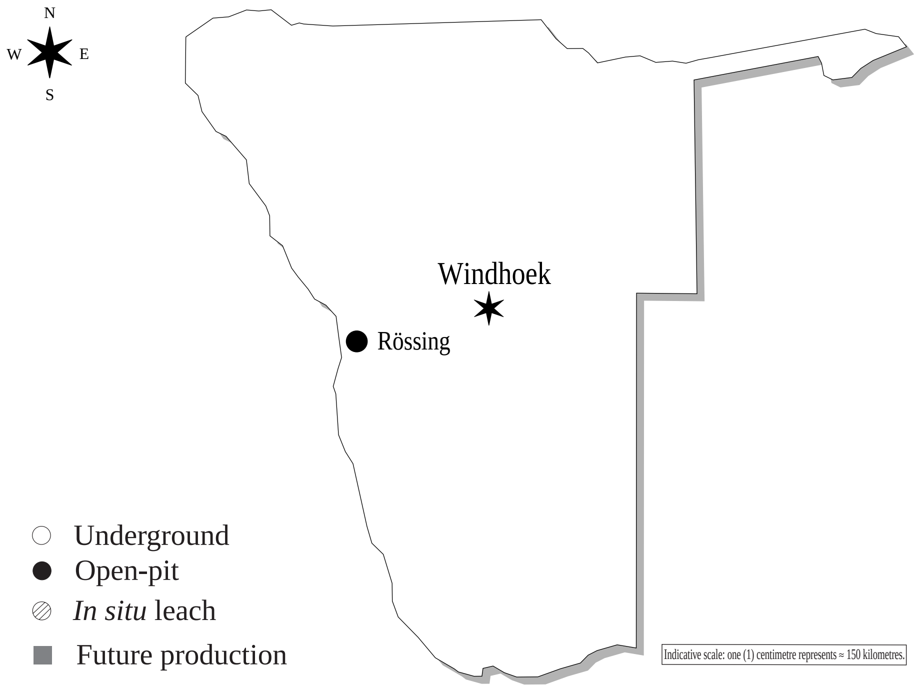
	2000	2001	2002	2003 (expected)
Total employment related to existing production centres	902	785	782	780
Employment directly related to uranium production	902	785	782	780

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 2018.

Favourable market conditions could also allow the development of one additional production centre with a production capacity of 1 000 tU/year (Langer Heinrich).

Uranium Production Centres in Namibia



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.

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 new Act (Atomic Energy Bill-in a final draft), which is due to be promulgated, will address the said problem. Namibia reported no information on uranium stocks or uranium prices.

• Niger •

URANIUM EXPLORATION

Historical review

Refer to the 2001 Red Book for a more complete historical review.

Recent and ongoing uranium exploration and mine development activities

In May 2002, Niger restarted uranium exploration with the Tagora project. This project aims, in a first phase, to better define uranium resources near the Somaïr and Cominak mine sites, and in a second phase to discover additional resources in the region. In 2001 and 2002, 26 188 m and 69 475 m of exploration and development drilling were completed. Five hundred (500) tU were discovered in the Tabelle area, and a potential of 16 000 tU of uranium were confirmed at the Ebba deposit. In 2003, about 85 000 m of drilling have been budgeted, mainly in the Afasto area, including additional development drilling on the Ebba deposit.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(XOF millions)

	2000	**2001**	**2002**	**2003** (expected)
Industry expenditures	444	833	2 272	2 775
Exploration drilling (metres)	NA	0	0	5 000
Number of exploration holes	NA	0	0	33
Development drilling (metres)	9 301	26 188	69 475	80 000
Number of development holes	44	146	501	500

URANIUM RESOURCES

Known conventional uranium resources (RAR & EAR-I)

Reasonably Assured Resources*
(tonnes U)

Production method	< USD 40/kgU	< USD 80/kgU	< USD 130/kgU
Open-pit mining	7 038	7 038	7 038
Underground mining	30 516	40 652	40 652
Unspecified	52 246	54 537	54 537
Total	89 800	102 227	102 227

* Mining losses (5.5%) and ore processing losses (5.5%) were used to calculate recoverable resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	< USD 40/kgU	< USD 80/kgU	< USD 130/kgU
Open-pit mining	15 123	15 123	15 123
Unspecified	110 254	110 254	110 254
Total	125 377	125 377	125 377

* Mining losses (5.5%) and ore processing losses (5.5%) were used to calculate recoverable resources.

Undiscovered conventional resources (EAR-II & SR)

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
9 534	9 534

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 *Société Minière de Tassa N'Taghalgue* (SMTT) assigned its mining rights to Somaïr in 1996. SMTT was subsequently dissolved.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit mining	30 358	994	1 007	1 074	33 433	1 000
Underground	42 803	1 920	1 912	2 006	48 641	2 000
Heap leaching	5 785	0	0	0	5 785	0
Total	78 946	2 914	2 919	3 080	87 859	3 000

Uranium Production Centre Technical Details
(as of 1 January 2003)

Production centre name	Arlit	Akouta
Production centre classification	existing	existing
Start-up date	1970	1978
Source of ore: • Deposit name • Deposit types • Reserves (active resources) • Grade (% U)	Ariege, Tamou sandstone 0.298	Akouta, Akola, Afasto sandstone 30 033 tU 0.486
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	OP 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

The Cominak production centre has been enlarged to include the Afasto area, the northern part of which (North and South Ebba) has reserves estimated at 16 000 tU based on a 2002 feasibility study.

Status of production capability

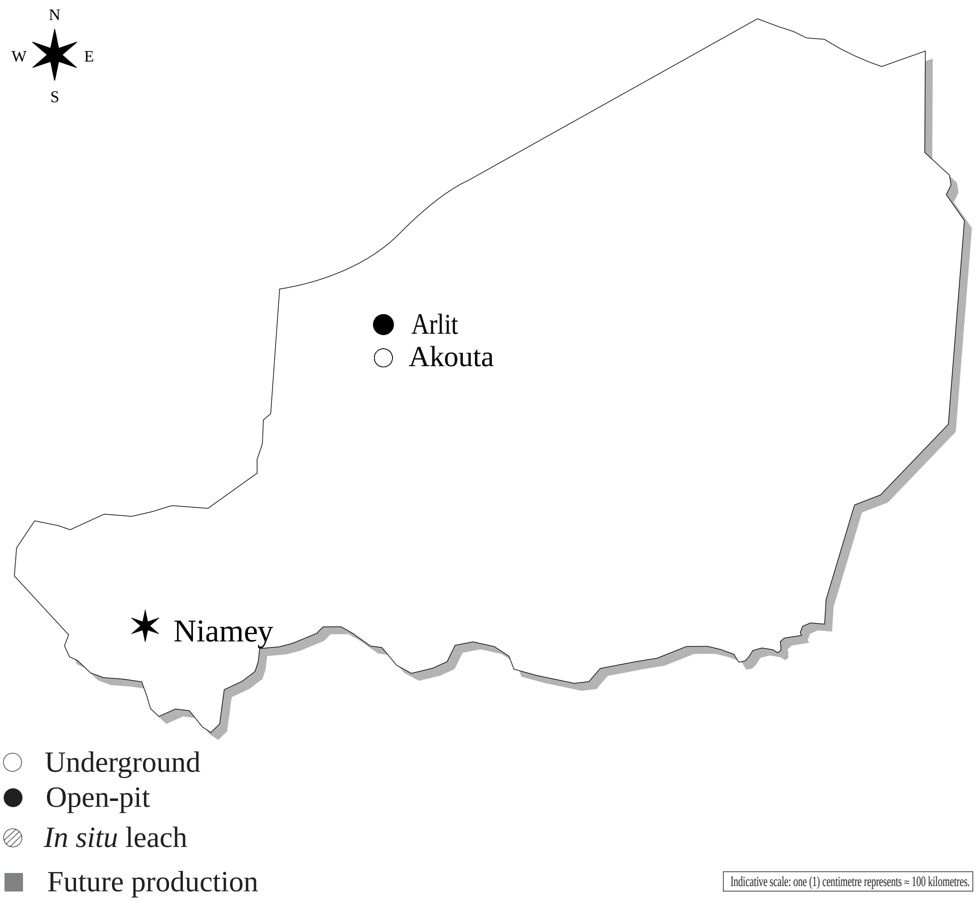
Short-term Production Capability
(tonnes U/year)

2003				2004				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
3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800

Short-term Production Capability (contd)
(tonnes U/year)

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
3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800

Uranium Production Centres in Niger



Ownership structure of the uranium industry

Ownership of Niger’s two production companies is as follows:

Somaïr	Cominak
36.6% Onarem (Niger)	31% Onarem (Niger)
37.5% COGEMA (France)	34% COGEMA (France)
19.4% CFMM (France)	25% OURD (Japan)
6.5% Urangesellschaft	10% Enusa (Spain)

Ownership of Uranium Production in 2002

Domestic				Foreign				Total	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
1 015	32.9	0	0	1 194	38.8	871	28.3	3 080	100

Employment in the uranium industry

The gradual reorganisation of the uranium industry, which has been under way since 1990, has resulted in continuous staff reduction – from 3 173 in 1990 to 1 570 at the end of 2002. This figure is expected to fall to 1 547 in 2003.

Employment in Existing Production Centres
(person-years)

	2000	2001	2002	2003 (expected)
Total employment related to existing production centres	1 680	1 607	1 558	1 547
Employment directly related to uranium production	1 441	1 391	1 348	1 342

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Both Cominak and Somaïr were certified ISO 14001 in 2002.

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

	1999	2000	2001	2002
XOF/kgU_3O_8	22 500	21 700	21 300	21 100

• Peru •

URANIUM EXPLORATION

Historical review

Uranium exploration carried out by the Peruvian Nuclear Energy Institute (IPEN) resulted in the discovery of more than 40 uranium occurrences in the Department of Puno, in the southeastern part of Peru (Macusani district).

The main occurrences include Chapi, Pinocho, Chilcuno VI, Cerro Concharrumio, and Cerro Calvario. Of these, Chapi is considered the most important occurrence. Consequently, most exploration activities took place in this area. These investigations resulted in the identification of uranium mineralisation associated with nearly vertically oriented structures, in acid volcanic rocks from Mio/Pliocene, which fills the Macusani tectonic depression, underlain by Paleozoic basement rocks.

Mineralised structures are distributed in structural lineaments measuring 15-190 m in length and 20-30 m in width. The uranium grades vary between 0.03% and 0.75% with an average of 0.4% U. The mineralisation consists of pitchblende, gummite, autunite, meta-autunite, and other minerals filling nearly vertically and nearly horizontally oriented fractures, in lapillic rock. Based on geological information, it is estimated that the Chapi occurrence has a potential of about 10 000 tU. The entire district of Macusani is estimated to host a potential resource of 30 000 tU. Due to budgetary reductions at IPEN, all uranium exploration activities were stopped in 1992.

URANIUM RESOURCES

The conventional uranium resources of Peru are primarily located in the Macusani area, Department of Puno.

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Heap leaching	0	1 790	1 790
Total	0	1 790	1 790

* *In situ* resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Heap leaching	0	1 860	1 860
Total	0	1 860	1 860

* *In situ* resources.

Undiscovered conventional resources (EAR-II & SR)

Undiscovered conventional resources are estimated to be 26 350 tU, 6 610 tU as EAR-II in the Chapi deposit area, and 19 740 tU as SR, based on the distribution of the volcanic host rock in the rest of the Macusani uraniferous district (1 000 km^2).

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
6 610	6 610

Speculative Resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
19 740	0	19 740

Non-conventional resources

The uranium contained in phosphates (phosphates with an average content of 90 ppm U) or in polymetallic deposits (Cu-Pb-Zn-Ag-W-Ni) is estimated to be 20 540 to 25 600 tU.

Peru has never produced uranium and reported no plans to do so. Additionally, Peru has no uranium requirements nor reported any plans to develop a nuclear generation capacity.

NATIONAL POLICIES RELATING TO URANIUM

All state-owned mining properties in Peru are in the process of being offered for privatisation within a political and economical framework that ensures long-term stability and guarantees to private investors. Currently, the Peruvian Government is expecting offers from foreign and national private companies interested in the exploration and exploitation of mineral resources including uranium. To facilitate the assessment of potential uranium occurrences, IPEN is prepared to provide the necessary technical information. Peru reported no information on uranium stocks or prices.

• Philippines •

URANIUM EXPLORATION

Historical review

See the 2001 edition of the Red Book.

Recent and ongoing uranium exploration and mine development activities

From 1998 to 2000, carborne radiometric survey was carried out in the whole Marinduque Island. More than 2 000 km of traverse line were covered with the collection of about 20 400 gamma ray measurements. No area was found to have uranium potential. Since 2000, uranium geochemical and radiometric exploration on a detailed scale have been undertaken in the San Vicente area, north of the Palawan province.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(PHP thousands)

	2000	**2001**	**2002**	**2003** (expected)
Government exploration expenditures	200	200	200	200

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

There are no 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.

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.

• Portugal •

URANIUM EXPLORATION

Historical review

See the 2001 edition of the Red Book for a review of Portugal's history of uranium exploration.

Recent and ongoing uranium exploration and mine development activities

During 2000-2002 period, no uranium exploration or exploitation activities were conducted in Portugal or abroad. Several environmental studies were conducted by EXMIN, the concessionaire for the rehabilitation of mine sites, including uranium old mines. Rehabilitation field works are expected to start 2003.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Portugal reports RAR of 7 470 tU recoverable at costs of <USD 80/kgU. Additionally, 1 450 tU are reported as EAR-I recoverable at costs <USD 80/kgU. Processing losses of about 10% have been accounted for in the RAR and EAR-I estimates.

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	0	7 470	7 470
Total	0	7 470	7 470

Estimated Additional Resources – Category I
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	0	1 450	1 450
Total	0	1 450	1 450

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 <USD 130/kgU.

Estimated Additional Resources – Category II
(tonnes U)

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

Speculative Resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
5 000	0	5 000

URANIUM PRODUCTION

Historical review

Between 1951 and 1962, the Companhia Portuguesa de Radium Limitada (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 Junta de Energia Nuclear (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 2001, Empresa Nacional de Urânio, S.A. (ENU) produced 1 773 tU.

Historical Uranium Production (tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Underground mining*	3 127	0	0	0	3 127	0
In place leaching	250	0	0	0	250	0
Heap leaching	317	4	0	0	321	0
Other methods**	9	10	4	0	23	0
Total	3 703	14	4	0	3 721	0

* Pre-2000 total includes uranium recovered by open-pit mining.
** Includes mine water treatment and environmental restoration.

Status of production capabilities

Production of uranium concentrates ceased in 2001. Demolition/reclamation of the Urgeiriça production mill is in a project phase. Reclamation will start with the confinement of the tailings pond at a budget of five million euros.

Ownership structure of the uranium industry

According to the Portuguese law all mining and milling activities are entrusted to ENU, a fully state-owned company. ENU was integrated in 1992 into the Portuguese state mining holding, Empresa de Desenvolvimento Mineiro (EDM) which decided to extinguish ENU until the end 2004. No further development is foreseen for the Portuguese uranium mining industry.

Employment in the uranium industry

Employment has been reduced from 47 in 2000 to 11 in 2002.

Employment in Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	47	30	11	NA

NA Not available.

Future production centres

No future production centres are foreseen.

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.

Production of uranium concentrates ceased in 2001, but the responsibility for all safety and environmental problems will remain. Environmental activities consist of monitoring, effluent management and site rehabilitation.

The environmental problems connected with mining activity since the middle of the 20th century come from the exploitation of the radium, leaving the uranium in situ or in the landfills. After the 1970s the activity was mainly related to the recovery of all radioactive metals, and the environment problems come from the residues of the benefaction, which are dispersed close to several old mines.

Today, EXMIN, owned by EDM, is in charge of the environment problems of the uranium mines. EXMIN is preparing the procedures and the projects for reclamation of all radioactive sites. They will study the methodology and the budget for about 70 mines.

URANIUM REQUIREMENTS

Portugal has no uranium requirements.

NATIONAL POLICIES RELATING TO URANIUM

The national authorities responsible for national policies concerning uranium are the Ministry of Economy and the General Directorate of Geology and Energy (DGGE). 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. ENU is expected to be extinct by the end 2004. Exploration is free and is granted by General Directorate of Geology and Energy (DGGE) that received the competences of the extinct 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
Government	276	0	0	0	276
Producer	0	0	0	0	0
Utility	0	0	0	0	0
Total	276	0	0	0	276

URANIUM PRICES

None reported.

• Russian Federation •

URANIUM EXPLORATION

Historical review

Since the beginning of uranium exploration in 1944, more than 100 uranium deposits have been discovered within fourteen districts in the Russian Federation. These deposits can be classified into three major groups: (i) the Streltsovsk district, which includes 19 volcanic caldera related deposits where the mining of some deposits is ongoing; (ii) the Transural and Vitim districts where sandstone basal-channel type deposits are developed or are planned for uranium production by *in situ* leach (ISL) mining and (iii) eleven other uranium bearing districts containing numerous deposits of vein, volcanic and metasomatite types with higher cost uranium resources (i.e. >USD 80/kgU) that may have economic potential in the future.

Recent and ongoing uranium exploration and mine development activities

Exploration activities in the Russian Federation in the last 5 years have primarily focused on sandstone basal channel deposits amenable for *in situ* leach mining and on unconformity-related deposits with high-grade ores. These activities were conducted by the local geological exploration subsidiaries of the government organisation "Central Geological Expedition" (former "Geologo-razvedka"), which is responsible for uranium exploration in Russia.

New areas favourable for sandstone type uranium mineralisation have been identified in the Transural and Vitim uranium districts. In the Transural district, exploration of Khokhlovskoe deposit, located some 80 km south of the similar Dalmatovskoe deposit that is currently operated by the "Dalur" mining company, was completed in 2001. Preliminary pilot tests have demonstrated the amenability of Khokhlovskoe deposit for *in situ* leach mining.

Exploration for unconformity-related deposits was conducted within the Baltic, Aldan and Anabara Shields. In the Ladoga area of northwestern Russia, in a geological setting similar to the Athabasca Basin of Canada, three ore bodies with high-grade mineralisation (up to 0.97% U and over 4.5 m thick) were discovered at the Karku deposit. Prognosticated resources here are estimated at 7 000 tU with a grade of 0.1% U. Exploration in the area will continue. Favourable areas for unconformity-related deposits were also detected in the Bulbukhtin area in the Irkutsk district.

Annual uranium exploration expenditures in the Russian Federation varied between USD 6 and 8 million over the last 3 years. The Ministry of the Atomic Energy of Russia provided the industry exploration capital in 2000. No exploration expenditures were made outside the Russian territory during the 2000-2003 period.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(RUR thousands)

	2000	**2001**	**2002**	**2003** (expected)
Industry exploration expenditures	146 480	0	0	16 000
Government exploration expenditures	157 520	248 800	181 100	225 000
Subtotal exploration expenditures	304 000	248 800	181 100	241 000
Subtotal development expenditures	72 000	85 000	145 000	302 000
TOTAL Expenditures	376 000	333 800	326 100	543 000
Industry exploration drilling (metres)	85 200	0	0	2 000
Government exploration drilling (metres)	68 300	118 875	75 060	84 370
Subtotal exploration drilling (metres)	153 500	118 875	75 060	86 370
Subtotal development drilling (metres)	NA	20 700	35 000	45 000
Subtotal development holes	NA	46	78	106
TOTAL Drilling (metres)	NA	139 575	110 060	131 370

NA Not available.

Russian nuclear fuel production company "TVEL" funded the development of new uranium *in situ* leach mining facilities. All drilling activities were carried out at the "Dalur" mine, which began commercial mining of the Dalmatovskoe deposit in the Transural district in 2003. *In situ* leach pilot tests were continued at the "Khiagda" facility in the Vitim district.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

As of 1 January 2003, Russia's total known uranium resources recoverable at <USD 80/kgU amounted to 168 770 tU. All are related to existing producing centres. Compared to the Red Book 2001, the downward adjustment of about 3% is the result of mining depletion and ongoing deposit appraisal. For the first time, information on resources in the USD 80-130/kgU cost category is provided. The State Committee on Reserves of the Russian Federation makes the resource assessment each year in an annual report.

The Streltsovsk uranium ore district, the base of the Priargunsky production centre, makes up 94% of Russia's known resources categorised at a cost of <USD 80/kgU. This district contains 19 volcanic molybdenum-uranium caldera-related deposits, of which 17 are situated in volcanic rocks and sediments (13 in effusives of layered facies and 4 in effusives of neck facies), and the remaining two are large deposits in the basement granite and marble. Mineralisation is largely controlled by structures, although some ore bodies are stratabound. The average grade is about 0.2% U. Known resources in the Streltsovsk district can satisfy Priargunsky's planned production for more than 20 years at current production rates. In 2004, uranium exploration will be renewed in the Streltsovsk district and surrounding areas to identify additional resources.

Some 10 100 tU of known resources in the <USD 80/kg cost category, recoverable by *in situ* leach mining, are related to the basal channel sandstone type Dalmatovskoe deposit in the Transural district operated by JSC "Dalur".

About 130 000 tU of additional RAR and EAR-I in the USD 80-130/kgU category are included in more than 20 small and middle-size, low-grade deposits of vein, volcanic, sandstone and metasomatic types located mainly in the Transbaikal and Vitim districts. Most were studied in the 1960s and 1970s but deemed unfavourable for production at that time. More detailed exploration and economic re-evaluation is planned, taking into account current economic conditions and new mining technologies. For example, this category includes preliminary estimates of more than 50 000 tU in sandstone basal channel deposits in the Vitim district, of which 11 000 tU related to the Khiagda deposit have already been re-evaluated. After approval of the State Reserve Committee, Khiagda resources will be moved to the <USD 80/kgU category.

All resources are reported as *in situ*. The recovery factors depending of mining losses and ore processing losses are presented in the following table.

Mining and Milling Method	**Overall Recovery Factor** (%)
Underground mining with conventional milling	95
In situ leaching (acid)	75
Heap leaching	70
Block and stope leaching	70

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	49 300	124 500	139 650
In situ leaching	7 700	7 700	13 800
Total	57 000	132 200	153 450

Estimated Additional Resources – Category I
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	14 800	34 170	58 700
In situ leaching	2 400	2 400	79 900
In-place leaching (stope/block leaching)	NA	NA	7 900
Total	17 200	36 570	146 500

NA Not available.

Undiscovered conventional resources (EAR-II & SR):

The EAR-II resource base has not changed in the last 5 years. It is comprised of 44 000 tU in sandstone basal channel type and 12 000 tU in unconformity related mineralisation. In 1998, the assessment of Speculative Resources was completed according to cost categories. Most of these resources (92%) are equally divided between two types of mineralisation.

- Basal channel sandstone type within the Transural (105 000 t), West-Siberian (35 000 t), Vitim (95 000 t) and other (20 000 t) uranium districts.
- Unconformity-related occurrences within the Baltic shield (80 000 t), the Irkutsk (50 000 t), the Chita (35 000 t) and the Khabarovsk regions (80 000 t).

The remaining 45 000 tU of speculative resources relate to the vein type mineralisation in the Chita region.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
56 300	104 500

Speculative Resources
(tonnes U)

Cost ranges	
<USD 130/kgU	Unassigned
545 000	0

URANIUM PRODUCTION

Historical review

Cumulative production through 2002 in the Russian Federation totalled about 120 000 tU, which makes it the fifth largest uranium producer in the world. The history of uranium production is described in the previous editions of the Red Book.

Status of production capability and recent and ongoing activities

The Joint Stock Company "Priargunsky Mining-Chemical Production Association" (PPGHO) remains the main uranium production centre in Russia. It is located in the Chita region, 10-20 km from the town of Krasnokamensk, which has a population of about 60 000. Production is derived from the Streltsovsk uranium district deposits, which have an overall average uranium grade of about 0.2%. Mining has been conducted since 1968 in two open-pits (both are depleted) and three underground mines (mines #1 and #2 are active, whereas mine #4 is closed). Open-pit mining was stopped in 1997. New mines are planned to begin operation after 2010. Milling and processing has been carried out since 1974 at the local hydro-metallurgical plant using sulphuric acid leaching with subsequent recovery by ion exchange extraction technology. More than 100 000 tU have been produced at Priargunsky, making it one of the most productive centres in the world. Annual production during the last 5 years remained between 2 700 to 3 100 tU. Nearly all production comes from two conventional underground mines, except for a small amount that is produced from low-grade ores by heap and stope/block leaching since the 1990s. Currently a large-scale commercial stope/block leaching pilot test is in progress.

In 2002, the new JSC "Dalur" uranium production centre located in the Kurgan region, began commercial *in situ* leach extraction of the Dalmatovskoe deposit. Currently 83 recovery and 219 injection wells are in operation. In 2002, 82 tU were produced and 140 tU are planned for 2003. Additional *in situ* leach sites at the Dalmatovskoe deposit and the new Khokhlovskoe deposit will be brought into production by 2010 in order to increase annual production capability of the "Dalur" production centre to 700 tU. The project is funded by JSC "TVEL".

Historical Uranium Production
(tonnes U)

Production method	**Pre-2000**	**2000**	**2001**	**2002**	**Total through 2002**	**2003** (expected)
Open-pit mining	38 655	0	0	0	38 655	0
Underground mining	68 652	2 600	2 850	2 630	76 732	2 750
In situ leaching	3 186	50	62	100	3 398	160
Heap leaching	570	100	178	120	968	130
In-place leaching	200	10	0	0	210	30
Total	111 263	2760	3 090	2 850	119 963	3 070

Ownership structure of the uranium industry

Joint Stock Company "TVEL" is a government-owned corporation that incorporates Russian nuclear fuel and uranium production facilities. It also co-ordinates uranium related exploration, mining and production activities for the Ministry of Atomic Energy of the Russian Federation.

Ownership of Uranium Production in 2002

Domestic				**Foreign**				**Totals**	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
2 850	100	0	0	0	0	0	0	2 850	100

Employment in the uranium industry

The staff of Priargun Mining-Chemical Production Association included about 12 800 employees in 2002, an increase of 475 since 2001. Only 38% of the staff is involved directly in uranium production at the mines and mill, while the rest are employed in non-uranium activities, such as operating the power plant, working at the coal, manganese and sand open-pits, or the sulphuric acid plant, etc. Since 2002, the total employment figures include 205 employees working at the new "Dalur" facility.

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	12 500	12 325	12 800	12 800
Employment directly related to uranium production	4 900	4 800	5 000	5 000

Future production centres

Current plans call for the "Khiagda" ISL centre, located in northeast Buryatiya within the Khiagda uranium district, to be brought into production in the next 5 years. Pilot ISL production has been in progress since April 1999. Using 7 recovery and 26 injection wells in 2002, 19 tU were produced during tests with an average U concentration in production solutions of 101 mg/L. Data obtained to date show favourable technical and economic parameters for ISL mining in spite of the very low temperature of the leaching solutions (about 4°C). Pilot test results were used now to develop a feasibility study of construction and production. The planned production capacity is currently under consideration. JSC "TVEL" provides funding for this project

Short-term production capability projection

Current plans are to increase domestic production in Russia to 4 700 tU by 2010, and to maintain this level for the following 10 years. This amount will consist of 3 000 to 3 500 tU produced by Priargunsky, 700 tU by "Dalur" and the rest by "Khiagda" facility.

In addition, the Russian Federation plans to develop joint uranium production in Kazakhstan. At the end of 2001 Russian-Kyrgyzstan-Kazakhstan joint venture "Zarechnoe" was established to mine the deposit of the same name in Southern Kazakhstan. Pilot uranium production is planned for 2004, and in about 2 years may reach nominal capacity of 500 tU/year.

Short-term Production Capability
(tonnes U/year)

2003	2004	2005	2010	2015	2020
3 060	3 200	3 300	4 700	4 700	4 700

Secondary sources of uranium

None reported.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

Uranium Production Centre Technical Details
(as of 1 January 2003)

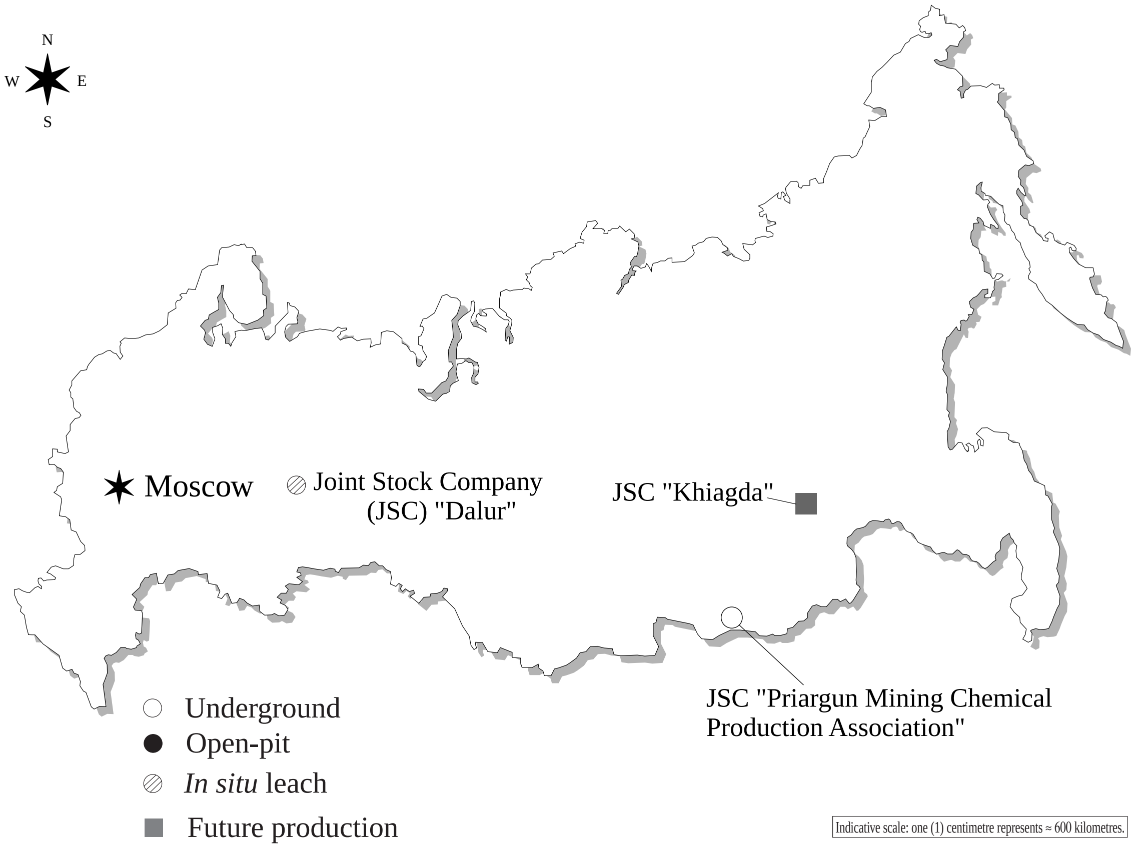
	Centre #1	Centre #2	Centre #3
Name of production centre	JSC "Priargunsky Mining-Chemical Production Association"	JSC "Dalur"	JSC "Khiagda"
Production centre classification	existing	existing	planned
Start-up date	1968	2002	2005
Source of ore • Deposit names • Deposit types • Reserves • Ore grade (%U)	 Antei, Streltsovskoe, Oktyabrskoe, etc. volcanic caldera related 124 500 tU 0.2	 Dalmatovskoe, Khokhlovskoe sandstone basal channel 10 100 tU 0.04	 Khiagda sandstone basal channel under estimation 0.06
Mining operation: • Type (OP/UG/ISL) • Size (t ore/day) • Average mining recovery (%)	 UG, IPL, HL 6 700 97	 ISL NA 75	 ISL NA 75
Processing plant: • Type (IX/SX/AL) • Size (t ore/day) • Average process recovery (%)	 AL, IX 4 700 95	 AL, IX NA 95-99	 AL, IX NA 95-99
Nominal production capacity (tU/year)	3 500	700	under consideration
Plans for expansion	new mine development to maintain production of 3 000 tU/yr to 2030	development of Khokhlovskoe district deposits	development of Vitim district deposits

URANIUM REQUIREMENTS

The Russian Federation has 30 nuclear power plants located at nine sites with a total gross installed capacity of 22 242 MWe, consisting of:

- 14 water-cooled, water-moderated reactors (six VVER-440 units and eight 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.

Uranium Production Centres in the Russian Federation



In 2002, nuclear power plants in the Russian Federation produced 141.2 TWh, an increase of 3.5% compared to 2001 output. Nuclear power generation contributes about 15% of total Russian electricity energy production. The average capacity factor for Russian nuclear power reactors was 72.3% in 2002, up 1.2% from that in 2001. Minatom plans to generate 144 TWh of electricity in 2003, 220 TWh by 2010 and up to 350 TWh by 2020.

Installed nuclear generating capacity is expected to be boosted from 22 GWe to 28 GWe by 2010 and will be expanded thereafter. The annual requirements of domestic nuclear power plants will grow respectively from 4 600 tU in 2002 to 5 500 tU in 2010 and up to 8 600 tU in 2020.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	136.3	141.2
Uranium consumed (tU)	NA	NA

NA Not available.

Installed Nuclear Generating Capacity to 2020
(MWe net)

2002	2003	2005	2010	2015		2020	
				Low	*High*	*Low*	*High*
22 242	22 242	23 000	28 000	33 000	36 000	37 000	41 400

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010	2015		2020	
				Low	*High*	*Low*	*High*
4 600	5 100	5 300	5 500	6 800	7 200	7 300	8 600

NATIONAL POLICIES RELATING TO URANIUM

Russia reported no information on national policies relating to uranium, uranium stocks 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.

Secondary sources of uranium

The Slovak Republic reported mixed oxide fuel and re-enriched tails production and use as zero.

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.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	17.1	17.9
Uranium consumed (tU)	480	500

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 460	2 460	2 460	1 640	2 460	1 640	2 460	1 640	2 460

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
500	500	450	300	460	300	460	300	460

NATIONAL POLICIES RELATING TO URANIUM

The Slovak Republic utility purchases complete fuel assemblies for all operating units from Russian manufacturers. Therefore, there are no special contracts on uranium, conversion and enrichment services.

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.

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)

Resource assessment of the Zirovski deposit was carried out 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 <USD 80/kgU category. EAR-I of 5 000 tU in the <USD 80/kgU category and 10 000 tU in the <USD 130/kgU category are also reported. The average grade of these resources is 0.13% U. The deposit occurs in the grey sandstone of the Permian Groeden formation. The orebodies occur as linear arrays of elongated lenses within folded sandstone. RAR and EAR-I estimates are recoverable, adjusted for 35% mining and 10% processing losses.

Reasonably Assured Resources
(tonnes U)

Production Method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	0	2 200	2 200
Total	0	2 200	2 200

Estimated Additional Resources – Category I
(tonnes U)

Production Method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Underground mining	0	5 000	10 000
Total	0	5 000	10 000

Undiscovered conventional resources (EAR-II & SR)

The 1994 estimate of resources includes EAR-II of 1 060 tU in the <USD 130/kgU class. No SR have been reported. EAR-II resources were adjusted for estimated mining and processing losses of 35% and 10%, respectively.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
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. Cumulative production from the Zirovski Vrh mine-mill complex totalled 382 tU (620 000 tonnes of ore at an average grade of 0.072% U).

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Underground mining	382	0	0	0	382	0
Total	382	0	0	0	382	0

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.

Secondary sources of uranium

Slovenia reported no information on the production and use of mixed oxide fuels or re-enriched tails.

Employment in the uranium industry

Employment in Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to production centres	79	69	48	45
Employment directly related to uranium production	0	0	0	0

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Zirovski Vrh Mine Company manages all activities connected with the rehabilitation of the former uranium production site. It provides all required remediation permits, monitors the environmental impact of the mine effluents by air and water pathway, and maintains the area to prevent damage to the environment.

Annual effective dose contribution from all mine objects is between 0.2 and 0.4 mSv/a (during operation it was 0.5 mSv/a), and decreases due to remediation activities. Background annual effective dose is 5 mSv/a in the area surrounding the mine.

620 000 tonnes of tailings (70 gU/t) and 80 000 tonnes of mine waste are located on the slope of a hill between 530 and 560 m a.s.l., over an area of 4.5 ha. The critical factor is the stability of the site (landslide). The mine waste pile is located in a former ravine, and contains 1 650 000 tonnes of mine waste and mill debris, over an area of 5 ha. The mine effluents are monitored on regular monthly basis, due to uranium, radium and other chemical contaminants.

Remediation of the Zirovski Vrh mine site is expected to be completed by 2006. There is a plan to turn over the mine’s remediated property to the community to develop an industrial centre.

URANIUM REQUIREMENTS

The sole nuclear power plant in Slovenia is based at Krsko and started commercial operation in January 1983. The Krsko reactor was modernised in 2000, increasing its capacity from 632 to 676 MWe. The power plant is owned 50% each by Slovenia and Croatia.

Electricity Generation and Uranium Consumption

	2001	**2002**
Electricity generated (TWh)	5.31	5.04
Uranium consumed (tU)	146	194

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
676	676	676	693	700	693	700	693	700

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

Uranium requirements are based on 18 months operating cycles. There is no requirement in years 2004, 2007, 2010, 2013, 2016 and 2019.

Year	tU
2003	230
2004	–
2005	230
2006	247
2007	–
2008	230
2009	247
2010	–
2011	230

Year	tU
2012	247
2013	–
2014	230
2015	247
2016	–
2017	230
2018	247
2019	–
2020	230

NATIONAL POLICIES RELATING TO URANIUM

There is no uranium stock policy in Slovenia. The company that owns and operates the Krsko plant will import uranium to cover future reactor-related uranium requirements. Uranium is purchased at an approximate cost of USD 20 per kg of UF_6.

• South Africa •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration in South Africa commenced in 1944. After a worldwide investigation of uranium resources, exploration focused attention on the occurrence of uranium in the gold bearing Witwatersrand quartz-pebble conglomerates. Exploration for uranium in the Witwatersrand Basin was always in consequence of gold exploration until the oil crisis emerged in 1973. With the price of uranium increasing more than five fold in a short space of time, uranium exploration activities have intensified which led to the commissioning of South Africa's first primary uranium producer, Beisa Mine, in 1981.

However, the crash in uranium market shortly thereafter not only resulted in the closure of Beisa's uranium production in 1985, but also had a detrimental effect on the exploration for uranium. Incidental discoveries of new uranium resources, nevertheless, were made during the exploration for gold due to the ubiquitous presence of uranium in the quartz-pebble conglomerates. The static gold price in the 1990s has led to a substantial curtailment of gold exploration activities in the Witwatersrand Basin.

The discovery of uranium in the Karoo sediments whilst drilling for oil in the early 1970s, resulted in a diversification of uranium exploration activities in South Africa. Although initially at a low level, exploration activities increased until the incident at Three Mile Island in 1979, which sent the overheated uranium market plummeting. Exploration activities in the Karoo basin declined rapidly thereafter and finally ceased in the mid-1980s.

Exploration activities for uranium outside of these two basins resulted in the discovery of uranium deposits associated with coal seams, carbonatites, granites, marine phosphates as well as deposits of a surficial nature. Such exploration has always been undertaken on a low-key basis and rendered very limited success in terms of additional uranium resources.

Recent and ongoing uranium exploration activities

No exploration for uranium as a primary product was carried out since 1988 (Springbok Flats). Exploration activities in the Witwatersrand Basin, where gold is targeted, has been limited due to a depressed gold price prior to the recent upsurge in 2002 and 2003. Enquiries from gold mining groups revealed that due to the depressed state of the world uranium market, the uranium content of gold reefs is as a rule no longer determined.

Information regarding uranium exploration by South African based companies outside of South Africa is not available due to company confidentiality.

The statutory responsibility for uranium exploration and development has been transferred from the Atomic Energy Corporation of South Africa Limited to South African Nuclear Energy Corporation Limited and National Nuclear Regulator during 1999, whilst the responsibility for updating the Red Book information will in future vest with the Council for Geoscience.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

By far the largest portion (about 63%) of South Africa's known conventional uranium resources comprises low-grade concentrations in the gold-bearing Witwatersrand quartz-pebble conglomerates. Where uranium is recovered as a by-product of gold operations, it generally accounts for less than 10% of the total revenue from the ore mined.

The exploration for gold has further been curtailed in recent years, as the gold price dropped below USD 300/troy ounce. Therefore, there has been little change to the South African uranium resource base since 1999.

Since uranium is only produced as a by-product, the ZAR/USD exchange rate, gold and uranium prices and mining and processing costs have a significant effect on South Africa's uranium resource figures and cost category allocation.

A large proportion (about 42%) of South Africa's known uranium resources recoverable at <USD 80/kgU, is associated with gold resources hosted by the Witwatersrand deposits. However, since only one mine, Vaal River Operations, has a uranium recovery circuit in operation, large amounts of uranium are being discarded in tailing dams where the recovery of such uranium resource will depend on the degree of dilution by non-uraniferous tailings and its possible use as backfill in mined-out areas.

More than 43% of the total South African known uranium resources recoverable at <USD 40/kgU are tributary to South Africa's only production centre. Almost 25% of the incremental known resources recoverable at <USD 80/kgU are tributary to this same production centre.

Reasonably Assured Resources
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
By-product	101 534	165 090	228 855
Open-pit mining	1 643	22 543	24 938
Unspecified	19 259	47 283	64 789
Total	122 436	234 916	318 582

Estimated Additional Resources – Category I
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
By-product	44 433	53 888	59 952
Open-pit mining	2 974	7 376	7 894
Unspecified	1 906	5 676	12 494
Total	49 313	66 940	80 340

A resource assessment was made within the last five years, however, resources have not been adjusted for mining depletion.

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 funding for this speculative type of exploration has, however, hindered the achievement of any meaningful results.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges		
<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
27 914	34 901	110 310

Speculative Resources
(tonnes U)

Cost range	Total
Unassigned	
1 112 900	1 112 900

URANIUM PRODUCTION

Historical review

Uranium production in South Africa commenced in 1952 with the commissioning of a uranium plant at West Rand Consolidated Mine extracting uranium from quartz-pebble conglomerates of the Witwatersrand Supergroup. During 1953 four additional plants came into production at various centres. Total production peaked in 1959 when 4 957 tU was produced from 17 uranium plants being fed from 26 mines around the Witwatersrand Basin. Production thereafter declined to 2 263 tU in 1965.

The world oil crisis which emerged in 1973 stimulated the demand for uranium as an energy source and led to an increase in uranium production which again peaked in 1980 (6 028 tU).

Large tailings stockpiles containing uranium accumulated from mining activities within the Witwatersrand Basin over many decades. During the boom in the uranium market these dumps were reprocessed at Welkom (Joint Metallurgical Scheme – 1977), the East Rand (ERGO – 1978) and at Klerksdorp (Chemwes – 1979).

In 1967 there were seven producers (2 585 tU); this number increased to 14 in 1983 (5 880 tU). Since 1983 there was a steady decline in the number of producers, with only three remaining in 1994 (1 550 tU). All uranium currently produced in South Africa is derived as a by-product of one gold mine in the Witwatersrand Basin (2002: 824 tU). Palabora Mining Company, which commenced uranium production in 1994, was the only mine outside of the Witwatersrand Basin to produce uranium, namely as a by-product of copper mining. This mine yielded a cumulative production of 640 tU until it ceased its uranium production in 2002.

Historical Uranium Production
(tonnes U)

	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
By-product production	150 043	798	878	824	152 543	855
Total	150 043	798	878	824	152 543	855

Status of production capability

At the end of 2002, Vaal River Operations near Klerksdorp was the only uranium producing mine in South Africa. Here uranium is being produced as a by-product of gold mining. Two uranium recovery plants are in operation, capable of treating 10 000 t of ore per day with a production capacity of about 1 270 tU per annum. No additional production centres are planned.

Uranium Production Centre Technical Details
(as of 1 January 2003)

Name of production centre	Vaal River Operations
Production centre classification	operating
Start-up date	1977
Source of ore: • Deposit names • Deposit type • Reserves • Grade (%U)	 Vaal Reef quartz-pebble conglomerate NA NA
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	 UG 10 000 variable
Processing Plant: • Type • Size (tonnes ore/day) • Average processing recovery (%)	 AL/SX 10 000 variable
Nominal production capacity (tU/year)	1 272
Plans for expansion	none
Other remarks	none

NA Not available.

Ownership structure of the uranium industry

AngloGold Limited, a public company quoted, inter alia, on the Johannesburg Securities Exchange and the London Stock Exchange, is the holding company of Vaal River Operations. The State does not participate in any uranium production activities.

Ownership of Uranium Production in 2002

Domestic				Foreign				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	824	100	0	0	0	0	824	100

Employment in the uranium industry

Vaal River Operations employs a total of 100 persons in the uranium plant. An additional 50 individuals are employed at Nuclear Fuels Corporation of South Africa (Pty) Limited, where calcining is being undertaken.

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	150	150	150	150
Employment directly related to uranium production	140	140	140	140

Future production centres

The by-product nature of the majority of uranium resources in South Africa makes it impossible to predict whether prospective production centres could be supported by existing known resources in the RAR and EAR-I categories recoverable at a cost of <USD 80/kgU. The cost of producing uranium is to a large extent determined by the gold content of the ore, the gold price, working costs as well as the ZAR/USD exchange rate. Given favourable conditions in respect of these variables and a higher uranium price, it is not inconceivable for South Africa to achieve uranium production figures in excess of 6 000 tU per annum, as attained in 1980. South African producers have further significant quantities of uranium contained in mine tailing dams, which could be extracted given stable and predictable long-term contracting conditions. In addition, new shafts are currently in the process of being established in areas that contain viable uranium grades. It is likely that this additional source of uranium can be developed as and when the market stabilises.

Short-term production capability

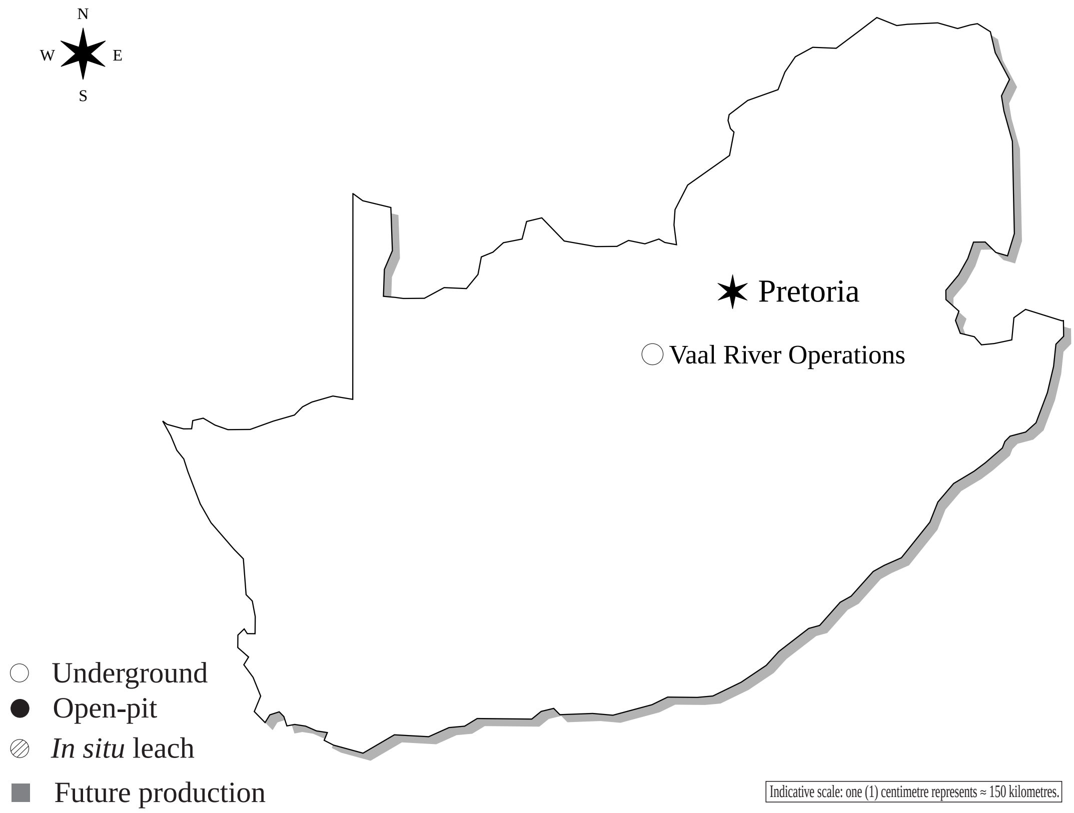
South Africa's projected capability to the year 2020 is shown in the following table:

Short-term Production Capability
(tonnes U/year)

2003				**2004**				**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
1 272	1 272	0	0	1 272	1 272	0	0	1 272	1 272	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
1 272	1 272	0	0	1 272	1 272	0	0	1 272	1 272	0	0

Uranium Production Centres in South Africa



ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Within South Africa mine related land exists which has been contaminated by radioactivity, particularly where existing and previous uranium plants are or were located. If development takes place on former mine land, the area is radio-metrically surveyed and, where necessary, decontaminated. The National Nuclear Regulator is the body responsible for the implementation of nuclear legislation related to these activities, and the standards conform to international norms. Large areas around gold/uranium mines are covered with slimes dams and rock dumps. South Africa has strict environmental legislation, which ensures that such areas are suitably rehabilitated after closure.

Environmental issues relating to gold/uranium mining within Witwatersrand Basin are dust pollution, surface and ground water contamination and residual radioactivity. Scrap materials from decommissioned plants may only be sold after these have been decontaminated to internationally acceptable levels.

The by-product status of uranium production in South Africa makes it impossible to establish what portion of the total expenditure on environmental related activities specifically pertains to uranium. The South African mining industry, however, allocates considerable resources for environmental rehabilitation from the exploration stage, through to mining and finally mill closure.

Secondary sources of uranium

South Africa has never produced or utilised mixed oxide fuels and has no plans to do so in future. South Africa decommissioned and dismantled its uranium enrichment plant at Pelindaba in the period 1997/1998 and does not undertake any enrichment activities at present.

URANIUM REQUIREMENTS

South Africa has only one nuclear power plant, Koeberg, which has two reactors. Koeberg I was commissioned in 1984 and Koeberg II in 1985. They have a combined installed capacity of 1 800 MWe and collectively consume about 280 tU per annum.

Nuclear fuel will also be required for the commissioning of a Pebble Bed Modular Reactor (PBMR) demonstration plant to be constructed at Koeberg. The PBMR is designed to produce 110 MWe. It is believed that construction of the demonstration plant could start in 2004. Commercial PBMR reactors planned are to produce about 165 MWe each. To maximise the sharing of support systems, however, the PBMR has been configured into a variety of options, such as 2, 4 and 8 pack layouts. It is believed that between 10 and 50 modules a year could be exported from South Africa once the technology has been demonstrated successfully.

Supply and procurement strategy

Whereas fuel for the Koeberg nuclear power plant used to be manufactured at Pelindaba near Pretoria prior to 1997, it is now being imported. Except for normal IAEA safeguard conditions, Eskom, the electricity supply utility operating Koeberg, has no restriction from where it can procure its uranium. Requests for tenders were in the past issued to all applicable suppliers. Procurement policy is based on commercial considerations. This approach will be maintained in future. Fuel for the demonstration PBMR plant will be manufactured at Pelindaba from radioactive material to be imported.

Electricity Generation and Uranium Consumption

	2001	**2002**
Electricity generated (TWh)	NA	NA
Uranium consumed (tU)	282	282

NA Not available.

Installed Nuclear Generating Capacity to 2020
(MWe net)

2002	**2003**	**2005**	**2010**		**2015**		**2020**	
			Low	***High***	***Low***	***High***	***Low***	***High***
1 800	1 800	1 800	1 800	1 910	1 800	2 570	1 800	3 230

NATIONAL POLICIES RELATING TO URANIUM

The Nuclear Energy Act No 131 of 1993, as amended, provided expression to South Africa's national policies relating the prospecting for and mining of uranium, foreign participation in such activities, the State's role in this regard, as well as the export of uranium and the disposal of spent nuclear fuel.

This Act has been replaced by the Nuclear Energy Act No 46 of 1999 and the National Nuclear Regulator Act No 47 of 1999. The former act provides for the establishment of the South African Nuclear Energy Corporation Limited (NECSA) to replace Atomic Energy Corporation of South Africa Limited, a public company wholly owned by the State to, inter alia, regulate the acquisition and possession of nuclear fuel, the import and export of such fuel and to prescribe measures regarding the discarding of radioactive waste and the storage of irradiated nuclear material. The latter Act provides for the establishment of a National Nuclear Regulator to regulate nuclear activities, to provide for safety standards and regulatory practices for protection of persons, property and the environment against nuclear damage.

URANIUM STOCKS

At present Koeberg maintains no uranium stockpiles to provide for forthcoming consumption.

URANIUM PRICES

None reported.

• Spain •

URANIUM EXPLORATION

Historical review

See the 2001 edition of the Red Book.

Recent and ongoing uranium exploration activities

No exploration and mine development activities were carried out in 2001 and 2002. The last expenditures were in 1998.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Both of the RAR and EAR-I resources remain unchanged from the 2001 Red Book, and are reported as recoverable by open-pit mining.

Reasonably Assured Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Open-pit mining	0	2 460	4 925
Total	0	2 460	4 925

Estimated Additional Resources – Category I
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Open-pit mining	0	0	6 380
Total	0	0	6 380

Undiscovered conventional resources (EAR-II & SR)

No resources for these categories 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. The license for a definitive shut-down of the production was submitted to Regulatory authorities in December 2002.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total through 2002	2003 (expected)
Open-pit mining*	4 706	255	0	0	4 961	0
Other methods**	0	0	30	37	67	0
Total	4 706	255	30	37	5 028	0

* Pre-2000 total includes uranium recovered by heap leaching.
** Includes mine water treatment and environmental restoration.

Status of production capability

Mining activities were terminated in December 2000. The processing plant finished the production of uranium concentrates in November 2002. A plan for its decommissioning will be presented to the Regulatory Authorities in 2003.

Future production centres

No new production centres are being considered.

Ownership structure of the uranium industry

The only production facility in Spain belongs to the company Enusa Industrias Avanzadas, S. A., owned (60%) by Sociedad de Participaciones Industriales (SEPI) and Centro de Investigaciones Energéticas Medioambientales y Tecnologicas (CIEMAT), with 40%.

Ownership of Uranium Production in 2002

Domestic				Foreign				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	37	100	0	0	0	0	37	100

Employment in the uranium industry

Employment at the Fe Mine was 56 at the end of the year 2002.

Employment in Existing Production Centres
(person-years)

	2000	2001	2002	2003 (expected)
Total employment related to production centres	134	58	56	56
Employment directly related to uranium production	56	14	13	0

Secondary sources of uranium

Spain reported mixed oxide fuel and re-enriched tails production and use as zero.

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 supervision programme (groundwater quality, erosion control, infiltration and radon control) until 2003.

- Old Mines (Andalucía and Extremadura Regions): Underground and open-pit mines are restored, with work being completed in 2000.
- Elefante Plant (Salamanca Province): Decommissioning Plan has been approved by Regulatory Authorities (heap leaching plant) in January 2001. The plant was dismantled in 2001. Ore stockpiles (used for heap leaching) have been regraded and are being covered with a protection layer.
- Quercus Plant (Salamanca Province): Mining activities ended in December 2000. The processing plant finished the production of uranium concentrates in November 2002. A plan for its decommissioning will be submitted to the Regulatory Authorities in 2003.

URANIUM REQUIREMENTS

The net capacity of Spain's nuclear plants is about 7.9 GWe with 9 operating reactors. No new reactors are expected to be built in the near future.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	63.7	63.0
Uranium consumed (tU)	1 600	1 470

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
7 870	7 870	7 870	7 870	7 870	7 870	7 870	NA	NA

NA Not available.

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 470	1 500	1 120	1 560	1 560	1 560	1 560	NA	NA

NA Not available.

Supply and procurement strategy

All uranium procurement activities are carried out by ENUSA representing the companies that own the nine operating nuclear power plants in Spain.

NATIONAL POLICIES RELATING TO URANIUM

Spain's uranium import policy provides for diversification of supply. The Spanish legislation leaves uranium exploration and production open to national and foreign companies.

URANIUM STOCKS

Present Spanish regulation provides that a strategic uranium inventory of at least 382 tU (450 t U_3O_8), contained in enriched uranium, should be held jointly by the utilities that own nuclear power plants. Additional inventories could be maintained depending on uranium market conditions. No information on uranium prices was reported.

• Sweden •

URANIUM EXPLORATION

Historical review

See the 2001 edition of the Red Book.

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)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	0	0	4 000
Total	0	0	4 000

Estimated Additional Resources – Category I
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	0	0	6 000
Total	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.

Historical Uranium Production
(tonnes U)

Production method	**Pre-2000**	**2000**	**2001**	**2002**	**Total through 2002**	**2003** (expected)
Open-pit mining	200	0	0	0	200	0
Total	200	0	0	0	200	0

Status of production capability

There is no uranium production in Sweden and there are no plans for production.

Secondary sources of uranium

Sweden reported mixed oxide fuel and re-enriched tails production and use as zero.

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.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	69	70
Uranium consumed (tU)	1 600	1 600

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	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)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 600	1 600	1 600	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. Sweden reported no information on uranium stocks.

URANIUM PRICES

As Sweden is now part of the deregulated Nordic electricity market, costs of nuclear fuel are no longer reported.

• Switzerland •

URANIUM EXPLORATION

Historical review

Refer to the 2001 Red Book for a complete historical review.

Recent and ongoing activities

Since 1985 all domestic exploration activities have been stopped. Private industry was engaged in uranium exploration, mining and milling in the western United States from 1983 to 1995.

URANIUM RESOURCES

No uranium resources have been reported for Switzerland.

URANIUM PRODUCTION

Switzerland does not produce uranium and no future production centres in Switzerland are envisaged at this time.

Secondary sources of uranium

Mixed Oxide Fuel Production and Use
(tonnes of natural U equivalent)

Mixed-oxide (MOX) fuels	**Pre-2000**	**2000**	**2001**	**2002**	**Total through 2002**	**2003** (expected)
Production	0	0	0	0	0	0
Usage	677.1	150.7	110.7	53.0	991.5	NA

NA Not available.

Re-enriched Tails Production and Use
(tonnes of natural U equivalent)

Re-enriched tails	**Pre-2000**	**2000**	**2001**	**2002**	**Total through 2002**	**2003** (expected)
Production	0	0	0	0	0	0
Usage	0	0	0	0	0	NA

NA Not available.

URANIUM REQUIREMENTS

Switzerland has five operating nuclear power stations located at Beznau (Units 1 and 2), Muehleberg, Goesgen and Leibstadt. In 2002, total installed nuclear capacity was about 3 200 MWe net.

Electricity Generation and Uranium Consumption

	2001	**2002**
Electricity generated (TWh)	25.293	25.7
Uranium consumed (tU)	66 as EUP	66 as EUP

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	**2003**	**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)

2002	**2003**	**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. In Switzerland, uranium stocks, if they exist, are held only by the utilities. No detailed information is available on utility 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	0	0	0	0	0
Producer	0	0	0	0	0
Utility	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA

NA Not available.

URANIUM PRICES

None reported.

• Turkey •

URANIUM EXPLORATION

Historical review

See the 2001 edition of the Red Book.

Recent and ongoing uranium exploration and mine development activities

Exploration in Turkey ended in 1998. Granite and acidic intrusive rocks will be explored for radioactive raw material around Saricakaya-Mihaliccik (Eskisehir) region. For this a prospecting study throughout 1 000 km^2 area will be carried out in 2003 and 2004.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

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)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	0	9 129	9 129
Total	0	9 129	9 129

* *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 REQUIREMENTS

Turkey has no operating nuclear power plants.

URANIUM STOCKS

The Government holds a stock of 1.9 tU in the form of natural uranium. No information was reported on Turkey's national policies relating to uranium or uranium prices.

• Turkmenistan* •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration in Turkmenistan started in the 1940s, and was mainly carried out by Uzbek geologists who discovered the Cernoye deposit, which was later mined out from 1952 to 1967.

Uranium occurrences in Turkmenistan are located in the north-west part of the country, associated to the dome of Touarkir, on the western limit of the Kara-Koum desert. They are associated to Permian formations (Cernoye, Novogodny, Amanboulak) as well as to Carboniferous black shales (Bailik).

The Cernoye deposit was characterised by a radiometric anomaly along an east-west fault. The deposit, 20-40 m wide, extending at least 245 m deep, with a horizontal extension of 200 m along the fault. Uranium mineralisation, mainly coffinite associated to molybdenum and copper sulphides, was located in oxydised conglomerates and coarse sandstones, with numerous pebbles of acid volcanic rocks (ignimbrites, rhyolites), which could be the source of uranium.

The Novodgony deposit is located at the north-west end of the Permian horst of Touarkir. The anomalous area is 2 km long and 200 m wide. Uranium mineralisation is associated to reduced facies of a large sequence of conglomerates. Uranium (urano-vanadates) is associated to molybdenum, zinc, lead and silver. Uranium resources are 2 000-2 500 tonnes, at an average grade of 0.03% U. The deposit would also contain 10 to 15 000 tonnes of molybdenum.

Uranium mineralisation are also reported at Amanboulak over an extension of 1.6 km. These occurrences are associated to the contact between Permian sandstones and argillites. Mineralisation was developed and partially mined (average grade 0.1% U, over a maximal thickness of 13 m) in the 1950s, during exploitation of the Cernoye deposit.

The Bailik site is located north-east of the Permian dome of Touarkir, in carboniferous formations. Uranium mineralisation, associated to black shales and metamorphosed pelites, are located immediately under the unconformity with Jurassic conglomerates, between 130 and 180 m deep. Uranium, mainly coffinite, is associated with vanadium, nickel and cobalt. Uranium mineralisation has been intersected along a north-west/south-east trend, 400 m wide and over 5 km long. Uranium potential is over 5 000 tU, but at low grade.

URANIUM RESOURCES

Turkmenistan has no reported mineable uranium resources.

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* This report is based on Secretariat estimates.

URANIUM PRODUCTION

Discovered in 1952 by the Uzbeks, the Cernoye deposit was mined from 1952 to 1967 by open-pit and underground methods.

After enrichment by radiometric ore sorting on site, ore concentrates were shipped at the Mungishlak plant in Kazakhstan for yellow cake production.

Total production from the Cernoye deposit would have been between 5 000 and 7 000 tU, at an average grade of 0.4-0.5% U, with grades between 0.1 and 20% U.

• Ukraine •

URANIUM EXPLORATION

Historical review

Exploration for commercial uranium deposits began in Ukraine in 1944. History of uranium deposits discovery in the Northern Krivoy Rog area, the Kirovograd region, and in sedimentary formations of the Ukrainian Shied has been well described in the 2001 edition of the Red Book.

Taking into account that the profitability of uranium deposits discovered in Ukraine is low, due to the low uranium grades in ores, a decision was taken in 1995 to search for rich uranium ores. Discovery of rich uranium deposits is one of the most important tasks of Kirovgeology.

Recent and ongoing uranium exploration and mine development activities

In 2001, Kirovgeology's geologists completed the compilation of a new prediction map of Ukraine for uranium, at the scale 1:500 000, where ore areas and potential ore regions and nodes have been distinguished, with potential for vein-type and unconformity-related deposits. Areas for top priority preparation and exploration tasks have been defined.

Exploration activity has started for discovery of unconformity-related deposits within the Dubrovitskaya and Krylovsko-Hotynskaya areas within the northeastern slope of the Ukrainian Shield. Exploration is also planned for vein-stockwork type mineralisation within the Kazankovsko-Zheltorechenskaya area of the West Inguletskaya zone of the Ukrainian shield.

New data were obtained as a result of limited uranium exploration activity in 2001 and 2002, but their impact on uranium resources is to be discussed.

Government and private companies in Ukraine do not conduct any exploration and research activity for uranium in other countries. Neither foreign governments nor private companies conduct research or exploration activity for uranium in Ukraine.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(UAH thousands)

	2000	**2001**	**2002**	**2003** (expected)
Government expenditures	11 400	9 200	10 100	8 000
Government exploration drilling (metres)	38 702	13 625	20 914	14 200
Number of government holes drilled	326	41	133	108

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Since the last edition of the Red Book a revision of those resources was conducted in Ukraine.

As a result, the resources of Adamovskoye, Krasnooskolskoye, Berekskoye deposits in bitumen; Yuzhnoye, Lozovatskoye, Kalinovskoye in metasomatite; Markovskoye deposit within coaly layers of carboniferous age on the northern slope of the Dnieper-Donets depression, were excluded from IAEA inventory, because they would not be economically mined even if prices of uranium were to rise. Mining costs for these deposits, according to preliminary assessment, would be much higher than for albitite-type deposits, which resources are considerably higher.

Resources of deposits being currently mined, Vatutinskoye and Michurinskoye, were left unchanged, in the <USD 40/kgU cost category, as a result of better exploration results. RAR and EAR-I in sandstone deposits in the Ukrainian shield, potentially amenable to ISL extraction, were attributed to the <USD 40/kgU cost category.

Of the total amount of RAR and EAR-I with mining cost above USD 80/kgU, resources of metasomatite deposits (15 000 tU), bitumen deposits (3 400 tU) and of the Markovskoye deposit (2 400 tU) were deducted. Compared to 1 January 2001, RAR increased by 900 tU and EAR-I decreased by 35 150 tU.

Reasonably Assured Resources*
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
Underground mining	13 250	38 250	77 250
In situ leaching	6 900	6 900	6 900
Total	20 150	45 150	84 150

Estimated Additional Resources – Category I*
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
Underground mining	0	4 250	13 650
In situ leaching	1 200	1 200	1 200
Total	1 200	5 450	14 850

* *In situ* resources, mining depletion deducted.

Undiscovered conventional resources (EAR-II & SR)

As a result of resources reassessment, resources in these categories have been increased by 20 000 tU in relation to expected unconformity-related resources, in accordance with their estimation during compilation of a prediction map compilation for uranium at a scale 1:500 000, completed by Kirovgeology.

The total amount of these resource categories is estimated as 256 600 tU:

- In the EAR-II category, perspective resources at the flanks of the Severinskoye deposit (1 600 tU).
- In the SR category (255 000 tU), metasomatite (albitite) type deposits (133 500 tU), sandstone-type deposits within sedimentary cover of the Ukrainian shield (20 000 tU), unconformity-related type deposits (40 000 tU), vein-type deposits (30 000 tU), metasomatite-type deposits (15 000 tU) and bitumen-type deposits (16 500 tU).

Taking into account that these deposits are only expected and not yet discovered, their mining cost cannot be assessed.

For discovery of new metasomatite deposits the areas within the central part of Kirovograd ore region between Vatutinskoye and Michurinskoye deposits are the most promising.

For discovery of deposits with rich ores, the northwestern slope of the Ukrainian shield (unconformity-type) and the West-Inguletskaya structural-facial zone (vein-type), situated west of the Krivorozhsky iron ore basin are considered as the most perspective.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
0	1 600

Speculative Resources
(tonnes U)

Cost ranges	
<USD 130/kgU	Unassigned
0	255 000

URANIUM PRODUCTION

Historical review

In the middle of 1951 a decision was taken by the Council of Ministers of the Former Soviet Union to create the Vostochnyi mining and processing Combinat (VostGOK) in the city Zholtye Vody in the northern Krivoy Rog area, for mining uranium ores from the Pervomayskoye and Zhcltorechcnskoye deposits, which had been explored by Kirovgeology. The Pervomayskoye deposit was mined out completely in 1967 and the Zheltorechenskoye was mined out in 1989.

Status of production capability

Uranium deposits, in the Kirovograd ore area, are operated by VostGOK: Michurinskoye situated 21 km from the city of Kirovograd and Vatutinskoye near the town of Smolino.

The Michurinskoye deposit was discovered in 1964, mine construction began in 1967, and in 1971 the mine, which was called Ingul'skaya, started mining operations. The target level production of 1 million tonnes/year of ore had been reached by 1976. Uranium content in ore bodies was about 0.1%. Mining dilution was about 29%. Radiometric sorting of mine-car size lots within the mine increases the grade of uranium ore up to 0.1-0.2%.

Ore is mined using conventional drill and blast operations with backfill. The mine is operated by three shifts with a total staff of about 850 persons. Following blasting the ore is moved to loading pockets and loaded to mine-cars, and then it is transported by electric powered trains to the main shaft where it is crushed prior to hoisting to the surface.

The hydrometallurgical plant of VostGOK is situated in Zheltiye Vody. Its design capacity is 1 million tonnes/year. Ore is hauled to the mill by dedicated trains from the two mines Ingul'skaya (100 km west) and Smolina (150 km west).

In situ leaching uranium mining was conducted in Ukraine from 1966 to 1983 at the Devladove and Bralske deposits using acid leach technology. These are sandstone-hosted deposits within sedimentary cover of the Ukrainian shield occurring at depths of about 100 m. This uranium production was stopped mainly due to environmental considerations.

Short-term Production Capability
(tonnes U/year)

2003				2004				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	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	1 500	0	0	0	2 000	0	0	0	2 000	0	0

Ownership of the uranium industry

All enterprises related to uranium recovery and nuclear fuel cycle in Ukraine are owned by the State, and are subsidiaries of the Department of Nuclear Energy Ministry of Fuel Supply and Energy of Ukraine.

VostGOK is responsible for uranium recovery in Ukraine and is a subsidiary of the Department of Nuclear Energy. In addition to mining and milling activities, VostGOK operates a large sulphuric acid plant as well as produces mining equipment and related spare parts.

The State Geological Enterprise "Kirovgeology" is responsible for conditions of raw materials for uranium recovery (exploration, assessment and development activities) and is a subsidiary of the State Department of Geology Ministry of Ecology and Natural Resources of Ukraine.

Uranium Production Centres Technical Details
(as of January 2003)

Name of production centre	Zheltive Vody
Production centre classification	existing
Start-up date	1959
Source of ore: • Deposit names • Deposit type • Grade	 Michurinskoye Vatutinskoye metasomatite 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/day) • Average processing recovery (%)	Zheltiye Vody AL/IX and SX NA 95
Nominal production capacity (tU/year)	1 000
Plans for expansion	doubling capacity to 2 000 tU/year

Secondary sources of uranium

The production and use of mixed oxide type fuels (MOX) and recycled tailings is not conducted in Ukraine.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Negative environmental impact associated with uranium production in Ukraine 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.

In a new Constitution of Ukraine, enacted in 1996, a legislative base was provided to conduct rehabilitation activities on the territory polluted by radioactive wastes. The new laws are provided for regulation of radiation safety, environmental recreation and rehabilitation, and belongs to industrial activity related to liquidation and closure of the facilities for mining, processing and handling radioactive ores. A programme is being conducted by VostGOK to clean up and rehabilitate sites in Zheltiye Vody contaminated by radioactive wastes. The Programme was established by the Council of Ministers of Ukraine on 8 July 1995.

A State programme for improvement of radiation protection at all facilities of the atomic industry was also established. It is conducted within the ecologically hazardous sites of uranium mining and milling. It 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.

Uranium Production Centres in Ukraine

URANIUM REQUIREMENTS

Reactor-related uranium requirements for Ukraine are based upon an installed nuclear generating capacity of 11 207 MWe net in 2002, increasing to 13 107 MWe net in 2010 in the low case and further increasing up to 14 057 MWe net in 2020.

Annual uranium requirements to supply all the operating NPPs with nuclear fuel in 2002-2020 will be from 2 200 to 2 600 tU.

Electricity Generation and Uranium Consumption

	2001	**2002**
Electricity generated (TWh)	76.18	78.00
Uranium consumed (tU)	2 148	2 200

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	**2003**	**2005**	**2010**		**2015**		**2020**	
			Low	*High*	*Low*	*High*	*Low*	*High*
11 207	11 207	12 157	13 107	14 057	10 422	14 057	4 722	14 057

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 200	2 200	2 350	2 500	2 650	1 950	2 600	950	2 600

NATIONAL POLICIES RELATING TO URANIUM

Operating enterprises for mining and recovery of uranium in Ukraine provide less than 50% uranium required for production of nuclear fuel for operating nuclear power plants. All uranium concentrate recovered in Ukraine is owned by State and is shipped to the Russian Federation for final processing and reactor fuel production. The shortfall between the national production and reactor-related requirements is met through purchases from Russia.

National policy of Ukraine on further development of nuclear power energy supply of the country foresees the increase of its own uranium production up to a complete supply of operating nuclear power plants. In addition Ukrainian Government announced a programme for establishing the technical capabilities for a complete fuel cycle in Ukraine by 2010.

URANIUM STOCKS

No uranium stockpiles are kept in Ukraine. No information was provided on 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 2002, nor were there 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. There has been no geological reappraisal of the UK uranium resources since 1980.

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: The metalliferous mining region of southwest England (Cornwall and Devon and North Scotland including Orkneys (see 2001 Red Book).

URANIUM PRODUCTION

Status of production capability

The United Kingdom is not a uranium producer.

Secondary sources of uranium

MOX fuel has been utilised in fast reactor and, on a trial basis, gas-cooled reactor programmes in the United Kingdom in the past. None of the reactors in the UK currently use MOX fuel and this is not expected to change in the near future. In October 2001, the Government announced the approval for MOX fuel manufacture in the United Kingdom. In December 2001, BNFL started the first stage of plutonium commissioning of the Sellafield MOX Plant (SMP), following the granting of licence consent by the UK Health and Safety Executive's Nuclear Installations Inspectorate. The plant will manufacture MOX fuel from plutonium oxide separated from the reprocessing of spent fuel and tails of depleted uranium oxide. SMP has a nominal capacity of 120 tHM/yr and is in the early stages of its MOX fuel manufacturing programme.

Over 30 tHM of MOX fuel was produced in the United Kingdom before 2000, principally for use in fast reactors at Dounreay and for export for use in LWRs. Detailed programmes for the SMP are commercially confidential.

Urenco has a long-term contractual agreement to upgrade tails material, but considers this to be commercially confidential.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

None reported.

URANIUM REQUIREMENTS

In April 2002, BNFL announced that it would not be extending the lives of its two largest Magnox reactors. The UK's nuclear power stations supplied 81.10 TWh in 2002, compared with 83.00 TWh in 2001. This represented 22% of total electricity supplied in 2002 (compared with 23% in 2001).

In June 2001, the Prime Minister commissioned the Cabinet Office Performance and Innovation Unit (PIU) to carry out a review of the longer term, strategic issues surrounding energy policy for the UK, within the context of meeting the challenge of global warming, while ensuring reliable and competitive energy supplies. The aim of the review was to set out the objectives of energy policy for the UK to 2050 and develop a strategy that ensures current policy commitments are consistent with longer-term goals. The review considered the role of coal, gas, oil and renewables for the future energy balance for the UK and what role, if any, the nuclear industry should play in meeting environmental and security of supply objectives. The PIU report was published in February 2002. Following this, in May the government launched a public consultation aimed at developing a new energy strategy. A government statement with the consultation stressed the need to move toward a low-carbon economy and greater energy efficiency to respond to climate change targets with sustainable energy being the key. Over 6 000 responses were submitted. These have been analysed and a White Paper outlining a long-term policy should be issued early in 2003.

BNFL had intended to extend the life of Wylfa to at least 2016 and of Oldbury to 2013. The reactors will now close in 2010 and 2013 respectively. This is to allow BNFL and the UK to meet obligations under OSPAR to curtail discharges to the Irish Sea, through the closure of the Sellafield Magnox reprocessing plant by 2012. In June 2002, BNFL announced that Calder Hall would be shut in March 2003 and not 2006 and Chapelcross would close in March 2005 and not 2008. These accelerated closures were in response to a fall in electricity prices.

Electricity Generation and Uranium Consumption

	2001	2002
Electricity generated (TWh)	83.00	81.10 (p)
Uranium consumed	1 520	1 930 (p)

(p) preliminary.

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
12 500	12 100	11 900	8 500	8 500	3 700	3 700	3 700	3 700

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 930	1 760	1 500	1 700	1 700	800	1 000	400	500

Supply and procurement strategy

Following a deterioration in its financial situation, British Energy approached the UK Government in early September 2002 seeking immediate financial support and discussions about longer term restructuring. The Government's overriding priorities are to ensure the safety of nuclear power and security of electricity supplies. In accordance with these priorities, the Government provided a short-term loan to the company in order to give sufficient time to clarify the company's full financial position and to come to a clear view on the options for restructuring the company. The European Commission approved the loan as "rescue aid" on 27 November. On 28 November 2002, British Energy announced a restructuring plan intended to achieve its long-term viability. On the same day, the Government set out the limits of what it was willing to do to support a solvent restructuring by taking financial responsibility for British Energy's historic spent fuel liabilities; underwriting, to ensure safety and environmental protection, new and enhanced arrangements by the company to fund decommissioning and other nuclear liabilities; and continuing to fund the company's operations while the plan is agreed and implemented. British Energy must achieve agreement in principle to its plan with its major financial creditors by mid-February 2003. The Government will then notify the restructuring plan to the European Commission under state aid rules.

In the Anti-Dumping and Countervailing duty investigations initiated by USEC for imports of low enriched uranium from the Netherlands, Germany and the United Kingdom, the US International Trade Commission found that these imports had caused, or threaten to cause injury to USEC and imposed a definitive duty of 2.23%. Urenco has appealed the ITC decision.

In July 2002, Urenco signed a Memorandum of Agreement (MOA) together with Cameco Corporation, Westinghouse Electric Company, Fluor Daniel and the affiliates of three US energy companies, Exelon, Entergy and Duke, as an initial step towards restructuring the LES Partnership. The MOA marks the first step towards a formal partnership to design, construct and operate a new uranium enrichment facility based on the Urenco centrifuge technology in the United States. On 6 October 2002, Urenco and AREVA signed a Memorandum of Understanding with the aim to establish a joint venture in the field of centrifuge technology for uranium enrichment.

As regards the future of a new BNFL, the company's own target is a move into the private sector via a Public Private Partnership (PPP) incorporating its commercial businesses and site management contracts with the Nuclear Decommissioning Authority (NDA). The Government recognises that in the right circumstances this could bring benefits for BNFL's businesses and for the management of nuclear liabilities at Sellafield. It will take decisions in the best interests of the taxpayer and on the basis that its primary concern is with the most effective management of the nuclear legacy. The challenge for BNFL is to demonstrate in the course of the next three years that it can be, and should be the supplier of choice to the NDA for the management of the site and to seize the opportunity for a PPP.

It should also be noted that the Government made it clear in November 2001 that it will next consider future management arrangements at Sellafield and the future of BNFL in 2004/5. In so doing, the Government will take account of advice from the NDA on its assessment of BNFL's performance as a liabilities manager.

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

See the 2001 edition of the Red Book for an historical review of uranium exploration in the United States.

Recent and ongoing uranium exploration and mine development activities

In the United States (US), the total uranium surface drilling (exploration and development) completed during 2001 and 2002 declined each year when compared with the prior year, continuing the trend observed since 1997 when 1 488 km in 7 793 bore holes were drilled. For 2001, a total of 201 km in surface drilling was completed in 1 023 bore holes. For 2002, the surface-drilling total was withheld to avoid disclosure of individually identifiable data. The amount of drilling completed for uranium-production control at *in situ* leach projects and underground and open-pit mining projects is not included in the US uranium surface-drilling total.

US industry reported total exploration expenditures for 2001 of USD 4.8 million, a decrease of 28% from the level reported for 2000. The expenditure total was distributed as follows: "surface drilling" accounted for about USD 2.7 million. Land acquisition combined with "other" exploration accounted for the balance of about USD 2.2 million. Total expenditures in 2002 were about USD 0.4 million. In 2001 and 2002, there were no exploration expenditures for uranium by the US Government. Foreign contributions in 2001 and 2002 to domestic total exploration expenditures were less than USD 1 million in each year.

The total land area in the United States held for uranium exploration by domestic and foreign firms was about 2 765 km^2 at year-end 2001, a slight decrease below the 2000 total, and at year-end 2002 it was about 3 342 km^2, an increase of about 21%.

The US Government no longer reserves land for uranium production. Under the Atomic Energy Act of 1954, about 100 km^2 of public land in the Colorado Plateau in Colorado and Utah were set aside for uranium-vanadium exploration and production. From 1974 to 1994, the withdrawn lands, divided into 43 tracts, were leased to private industry. In 1994, all existing leases were allowed to expire. A programmatic Environmental Assessment study led to a finding in August 1995 of No Significant Impact, and leasing was resumed for a ten-year period for production of uranium and vanadium ores. At year-end 2002, the US Department of Energy (DOE) still administered about 12 active leases under its Uranium Lease Management Programme. Leaseholders can conduct ongoing uranium production on these leases. As leases become inactive and are returned to the DOE, it will not lease them anew. After reclamation, the land associated with the DOE lease tracts is eligible for return to the public domain under the administrative jurisdiction of the Bureau of Land Management of the US Department of the Interior.

The US Government did not carry out uranium exploration abroad during 2000, 2001 and 2002. Data on industry exploration expenses abroad was withheld.

Uranium Exploration and Development Expenditures and Drilling Effort – Domestic
(USD millions)

	2000	**2001**	**2002**	**2003** (expected)
Industry exploration expenditures	W	W	W	NA
Government exploration expenditures	0	0	0	NA
SUBTOTAL Exploration expenditures	W	W	W	NA
SUBTOTAL Development expenditures	W	W	W	NA
TOTAL Expenditures	6.694	4.827	0.352	NA
Industry exploration drilling (metres)	W	0	W	NA
Number of industry exploration holes drilled	W	0	W	NA
Government exploration (metres)	0	0	0	NA
Number of government exploration holes drilled	0	0	0	NA
SUBTOTAL Development drilling (metres)	W	201 000	W	NA
SUBTOTAL Development holes	W	1 023	W	NA
TOTAL Drilling (metres)	312 000	201 000	W	NA
TOTAL Number of holes	1 550	1 023	W	NA

W = withheld. 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 2001 was 103 000 tU and at year-end 2002 was 102 000 tU. Similarly, the estimate for RAR for the <USD 130/kgU category at the end of 2001 was 346 000 tU and at the end of 2002 was 345 000 tU.

For 2001 and 2002, active mine properties were re-evaluated to take into account the annual mine production and new information on mining costs. The result for each year was a reduction in the total estimated resources at the national level for each maximum-forward-cost reserve category. The 2001 and 2002 reserve estimates reported here have been adjusted to account for mining dilution (10 to 40%) and processing losses (10 to 15%).

Reasonably Assured Resources
(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**
Underground mining	NA	53 000	178 000
Open-pit mining	NA	11 000	99 000
In situ leaching	NA	38 000	66 000
Other methods*	NA	<1 000	1 000
Unspecified	NA	0	<1000
Total	NA	~102 000	~345 000

* Mine water treatment, environmental restoration. NA Not available.

Undiscovered conventional resources (EAR & SR)

For the United States, the estimates of EAR and SR resources for 2001 and 2002 are unchanged from the prior estimates. The United States does not report its EAR in separate EAR-I and EAR-II categories.

Estimated Additional Resources
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
839 000	1 273 000

Speculative Resources
(tonnes U)

Cost ranges		**Total**
<USD 130/kg U	<USD 260/kg U	
858 000	482 000	1 340 000

URANIUM PRODUCTION

Historical review

See the 2001 Red Book for a more complete historical review of uranium production in the United States.

Uranium production in the United States has supported the commercial market since 1970. After the peak production of 16 810 tU was achieved in 1980, the US industry has experienced generally declining annual production in the period 1981-2002. Production from all sources in 2001 was 1 015 tU and in 2002 was 902 tU. Since 1991, production from *in situ* leach mining and other non-conventional production methods has dominated US annual production. In 2001, non-conventional production was 944 tU from plants in the States of Nebraska and Wyoming compared with production of 71 tU from conventional mills in Colorado, New Mexico, and Washington. A further breakdown of 2002 concentrate production data was withheld to avoid disclosure of individually identifiable data.

Status of production capability

At year-end 2001, no conventional uranium mills were operating in the United States. The six existing mills with a combined capacity of 12 340 tonnes per day (TPD) ore were being maintained on standby status. During 2002, two mills (combined capacity of 1 090 TPD) were permanently closed, and at year end four mills (combined capacity of 11 250 TPD) were being maintained on standby.

The status of the 10 *in situ* leach mining facilities (3 885 tU per year combined capacity) at year-end 2001 was as follows: three (1 920 tU) were operating; two (885 tU) were closed indefinitely; one (385 tU) was closed permanently; and four (690 tU) were undergoing restoration. At year-end 2002, the status of the 10 facilities was: two (~1 155 tU) were operating; one (770 tU) was closed temporarily: two (885 tU) were closed indefinitely; one (385 tU) was closed permanently; and four (690 tU) were undergoing restoration.

Historical Uranium Production
(tonnes U)

Production method	**Pre 2000**	**2000**	**2001**	**2002**	**Total through 2002**	**2003** (expected)
Open-pit mining	NA	0	0	0	NA	NA
Underground mining	NA	W	0	0	NA	NA
In situ leaching	NA	1 131	944	W	NA	NA
In-place leaching	NA	W	W	W	NA	NA
U recovered from phosphates	NA	0	0	0	NA	NA
Other methods*	NA	81	71	W	NA	NA
Total	352 274	1 522	1 015	902	355 713	NA

* Includes mine water treatment and environmental restoration. NA Not available.
W = withheld.

Ownership of uranium production in 2002

With the sale of the Smith Ranch, Wyoming, uranium facility to Cameco, foreign held firms accounted for all of the uranium concentrate production in the United States during 2002, as no domestic firms reported production for the year. The production amounts for 2002 attributable to foreign-private and foreign-government interests are withheld to avoid disclosure of individually identifiable data.

Domestic				Foreign				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	0	0	W	W	W	W	W	W

W = withheld.

Employment in the uranium industry

Employment in the raw materials sector of the United States uranium industry (not counting manpower expended on reclamation) has generally declined each year during the period 1998-2001. At year-end 1998, the employment was reported as 911 person years expended. A total of only 245 person years was reported for 2001, a decline of 39% from the total for 2000. During 2002, employment in this sector, when compared with 2001, increased by 14% to 280 person years. The level of employment directly in uranium production centres declined by 33% from 2000 (243 person years) to 2001 (164 person years), and it then increased by 24% to 204 person years during 2002.

Employment in Existing Production Centres
(person-years)

	2000	**2001**	**2002**	**2003** (expected)
Total employment related to existing production centres	401	245	280	NA
Employment directly related to uranium production	243	164	204	NA

Future production centres

No plans regarding construction of new uranium concentrate production facilities were announced by the domestic uranium industry in the United States during 2001 and 2002.

Short-term Production Capability
(tonnes U/year)

2003				2004				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
1 800	2 000	2 200	2 800	2 100	2 600	2 500	3 600	2 000	3 500	2 600	6 100

Short-term Production Capability (contd.)
(tonnes U/year)

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
1 300	2 100	1 900	7 200	900	1 500	1 200	5 200	700	1 300	1 000	5 000

Uranium Production Centre Technical Details
(as of 1 January 2003)

	Centre # 1	Centre # 2
Name of production centre	Crow Butte	Highland/ Smith Ranch
Production centre classification	existing	existing
Start-up date	1991	1986
Source of ore:		
• Deposit names	Crow Butte	Highland/ Smith Ranch
• Deposit type(s)	sandstone	sandstone
• Reserves (active resources)	NA	NA
• Grade (% U)	NA	NA
Mining operation:		
• Type (OP/UG/ISL)	ISL	ISL
• Size (tonnes ore/day)	NA	NA
• Average mining recovery (%)	NA	NA
Processing plant (Acid/ Alkaline):		
• Type (IX/SX/AL)	ISL	ISL
• Size (tonnes ore/day) for ISL (kilolitre/day or litre/hour)	NA	NA
• Average process		
• Recovery (%)	NA	NA
Nominal production capacity (tU/year)	380	770
Plans for expansion	unknown	unknown
Other remarks	none	none

NA Not available.

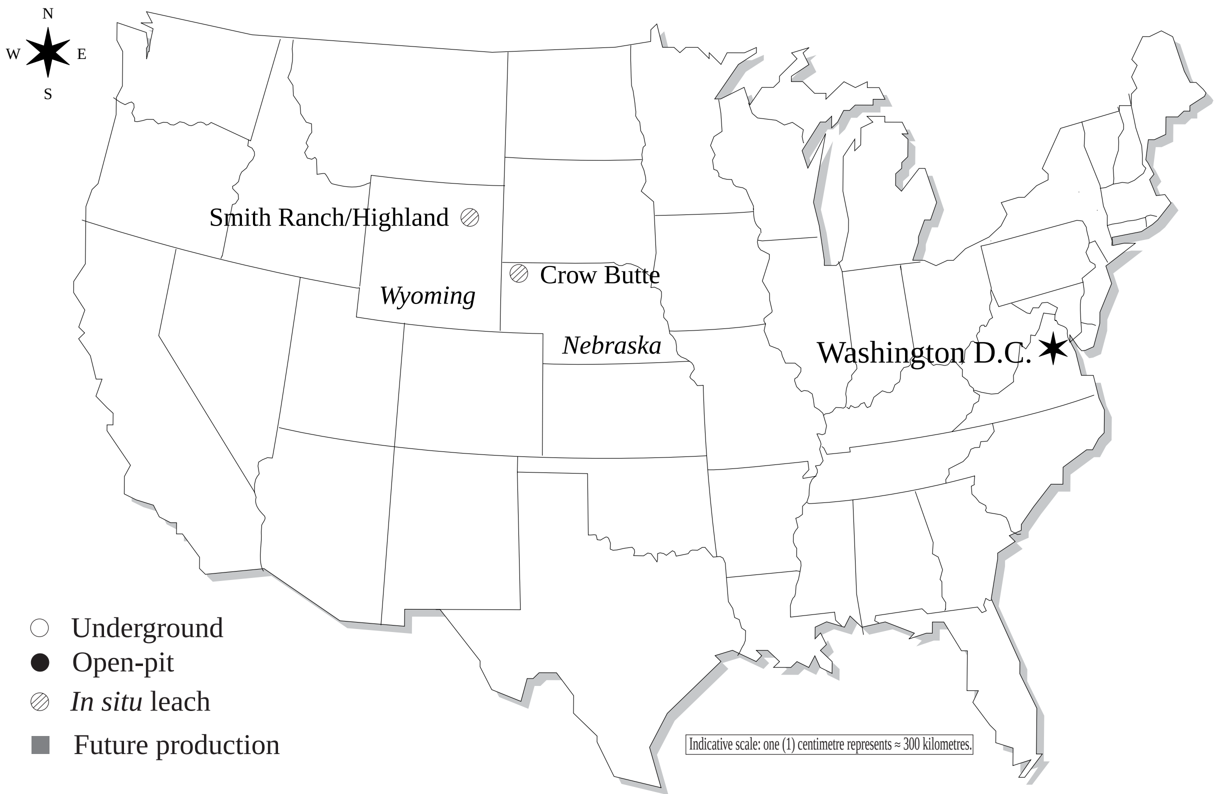
Secondary sources of uranium

The United States reported mixed oxide fuel and re-enriched tails production and use to be zero.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

For a complete description of environmental and socio-cultural issues in the United States, see the 2001 edition of the Red Book.

Uranium Production Centres in the United States of America



URANIUM REQUIREMENTS

Annual uranium requirements for the United States for the period 2002 through 2020 are projected to peak in 2015 at 24 500 tU (low and high cases). Requirements are projected to decline to about 19 500 tU (low case) or 20 140 tU (high case) in 2020 in line with the anticipated closings of some commercial 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.

Electricity Generation and Uranium Consumption

	2001	**2002**
Electricity generated (TWh)	769	780
Uranium consumed (tU)	20 283	22 025

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2003	2004	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
98 660	98 930	100 200	99 300	99 300	99 500	99 500	99 600	101 300

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2003	2004	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
22 700	22 800	21 300	18 900	18 900	24 500	24 500	19 500	20 140

NATIONAL POLICIES RELATING TO URANIUM

In February 1993, 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 (HEU Purchase Agreement) was signed by the United States and the Russian Federation providing for the blending down of 500 tons of HEU to low-enriched uranium (LEU) over 20 years. The US Enrichment Corp (USEC) Inc., serving as the US Government's sole executive agent for implementing the HEU Purchase Agreement, receives deliveries of LEU from the Russian Federation for sale to commercial nuclear power plants. As USEC purchases and sells under existing contracts, the enrichment component only of this LEU, a separate agreement has been agreed for the natural uranium component. An agreement for the maintenance of a domestic uranium enrichment industry that was signed by the Department of Energy and USEC Inc. on 17 June 2002, contains conditions for USEC Inc. to continue as the US Government's sole executive agent for the HEU Purchase Agreement.

The natural uranium feed component is sold under a commercial agreement between three western corporations (Cameco, COGEMA, and Nukem) and Techsnabexport of the Russian Federation. The quantity of natural uranium feed component of low-enriched uranium derived from the conversion of surplus HEU from the Russian Federation that can enter the U.S. market is restricted to a quota under the USEC Privatization Act. The quota for 2003 is about 4 600 tU in 2003, gradually expanding to 7 700 tU in 2009 and subsequent years.

Outside of the natural uranium feed component of HEU-derived LEU, imports of uranium from the Russian Federation have been limited by the Agreement Suspending the Antidumping Duty Investigation on Uranium from the Russian Federation (Suspension Agreement) signed between the Department of Commerce (DOC) and the Ministry of Atomic Energy of the Russian Federation in 1992. As a result of the Suspension Agreement, DOC has suspended antidumping investigations as the Russian Federation agreed to sell uranium to the United States under a quota system whereby Russian imports would have to be matched by an equivalent quantity of newly produced U.S. uranium. An amendment to the suspension agreement in 1994 contains language specifying an expected termination date of 31 March 2004. However, Russia has not requested the DOC to undertake a termination review, one of the requirements for termination.

In February 2002, the DOC issued final determinations in antidumping and countervailing duty investigations involving LEU from France, Germany, the Netherlands, and the United Kingdom. As a result, DOC placed an antidumping duty order on LEU imports from France while all four countries were issued countervailing duty orders. The DOC determinations have been challenged at the U.S. Court of International Trade (CIT). Legal proceedings are expected to continue during 2004 with the date of a final ruling by the CIT not yet determined.

URANIUM STOCKS

At the end of 2001, total commercial stocks of uranium (natural and enriched uranium equivalent) were about 39 920 tU, which represented a decline of 7% below the level at the end of 2000. At year-end 2002, total commercial stocks stood at 38 910 tU, a decline of 3% from the level reported for 2001.

Utility stocks held at year-end 2001, about 21 400 tU, were 2% greater than at year-end 2000, reflecting a 12% gain in stocks of enriched uranium compared with the level for 2000. By year-end 2002, total utility stocks had declined by 4% to 20 490 tU. These totals include amounts reported as inventories at enrichment supplier facilities.

Producer total stocks at year-end 2001, 18 520 tU, declined by 15% from the prior year, and by year-end 2002 these stocks had declined an additional 1% to 18 420 tU. Producer natural uranium stocks increased by 63% during 2002, which tended to offset a decline of 16% during 2002 reported for their stocks of enriched uranium. The totals reported for producer stocks include amounts owned by the US Enrichment Corporation.

Total uranium stocks held by the US Government at the end of 2001, about 20 410 tU, were unchanged from the 2000 level. During 2002, US Government stocks of natural uranium declined by 2% to about 19 920 tU.

Total Uranium Stocks as of 1 January 2003*
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	19 755	0	NA	NA	19 755
Producer	5 760	12 660	NA	NA	18 420
Utility	12 330	8 160	NA	NA	20 490
Total	37 845	20 820	NA	NA	58 665

* Totals are rounded to the nearest 10 tonnes U. Totals might not equal sum of components because of independent rounding.

NA Not available.

URANIUM PRICES

Average US Uranium Prices, 1991-2002
(USD per kilogram U equivalent)

Year	Domestic utilities from domestic suppliers	Domestic utilities and suppliers from foreign suppliers
2002	26.91	26.14
2001	27.17	24.74
2000	29.77	25.58
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

Historical review of uranium exploration of the sedimentary formations, and of the basement of the Central Kyzylkum desert of Uzbekistan, as well as main exploration results, are available in the 2001 edition of the Red Book.

Recent and ongoing uranium exploration and mine development activities

In 1999-2000, “Kyzyltepageologia SGE” completed exploration of the Severnyi Kanimekh and Ulus deposits. Resources were turned over to Navoi Mining Metallurgical Integrated Works for commercial development. Exploration and resources estimation of the flanks of the Kendyktyube deposit continued.

In 2002, prospecting works were carried out on the Tohumbet deposit. Part of the resources was transferred to Mining Division No 5 for commercial development. Exploration and resources estimation of the extension of the Sabursai and Shark deposits continued. Exploration and resources estimation of the Yangy site of the Tutly deposit started.

As a result of Kyzyltepageologia SGE and Navoi Mining Metallurgical Integrated Works (NMMIW) exploration works, EAR-I resources were converted into RAR resources, new areas were identified.

The following table provides statistical data on uranium exploration and development between 2001 and 2002. It includes the activities and expenditures of both the industrial organisation NMMIW and the government exploration branch Kyzyltepageologia.

Uranium Exploration and Development Expenditures and Drilling Statistics – Domestic
(UZS thousands)

	2000	**2001**	**2002**	**2003** (expected)
Exploration expenditures	940 824	1 607 886	2 712 871	3 992 133
Development expenditures	2 328 326	4 268 178	6 881 560	9 514 248
TOTAL Expenditures	3 269 150	5 876 064	9 594 431	13 506 381
Exploration surface drilling (metres)	217 804	255 193	265 308	245 432
Development surface drilling (metres)	385 887	369 740	352 055	355 000
Number of exploration holes	1 165	1 236	1 278	1 055
Number of development holes	1 988	1 872	1 786	1 739
TOTAL Surface drilling (metres)	603 691	624 933	617 363	600 432
TOTAL Number of holes	3 153	3 108	3 064	2 794

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 roll fronts (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, 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/t. The ore bodies occur at depths ranging from 20 to 450 m. There are five 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 2003, known uranium resources (RAR & EAR-I) recoverable at costs <USD 130/kg U totalled 164 364 tU, a decrease of 7 701 tU compared to the 2001 Red Book. Of the known resources, 117 340 tU occur in sandstone deposits and 47 024 tU in breccia complex deposits.

Deposit type	<USD 40/kgU	USD 40-USD 130/kg U
Sandstone	93 300	24 040
Breccia complex	36 000	11 024
Total	129 300	35 064

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.

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
In situ leach	63 489	63 489	79 738
Open-pit/heap leaching	20 431	20 431	29 140
Total	83 920	83 920	108 878

* *In situ* resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
In situ leach	29 772	29 772	37 602
Open-pit/heap leaching	15 597	15 597	17 884
Total	45 369	45 369	55 486

* *In situ* resources.

Undiscovered conventional uranium resources (EAR-II & SR)

Undiscovered resources are estimated to total 231 520 tU, of which 84 969 tU are EAR-II recoverable at costs of <USD 130/kg U, while the remaining 146 551 tU are SR unassigned to any cost category. Of the total undiscovered resources, 177 626 tU are assigned to sandstone uranium deposits. Ore depths and characteristics are expected to be similar to known resources.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
56 306	84 969

Speculative Resources
(tonnes U)

Cost ranges	
<USD 130/kg U	Unassigned
0	146 551

URANIUM PRODUCTION

Historical review

Historical review of uranium production activities is given in the 2001 edition of the Red Book.

Status of production capability

Uranium, in the Republic of Uzbekistan, is produced by the State Concern Kyzylkum-redmetzoloto, which includes Navoi Mining and Metallurgical Integrated Works (NMMIW).

As of 1 January 2003, three mining divisions are producing uranium by *in situ* leaching: the Northern Mining Division (Uchkuduk), Mining Division No. 5 (Zafarabad) and the Southern Mining Division (Nurabad). The Eastern Mining Division was closed for economical reasons. Uranium concentrates are processed in the hydrometallurgical plant in Navoi.

Historical Uranium Production
(tonnes U)

Production method	Pre-2000	2000	2001	2002	Total to 2002	2003 (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	37 762	2 028	1 945	1 859	43 594	2 300
Total	93 730	2 028	1 945	1 859	99 562	2 300

Uranium Production Centre Technical Information
(as of 1 January 2003)

	Centre #1	Centre #2	Centre #3
Name of production centre	Northern Mining Division	Southern Mining Division	Mining Division #5
Production centre classification	existing	existing	existing
Start-up date	1964	1966	1968
Source of ore: • Deposit names • Deposit type	 Kendyktube Sugraly sandstone	 Sabyrsaj Ketmenchi Shark sandstone	 Severnyi Bukinai Yuzhny Bukinai Beshkak, Lyavlyakan sandstone
Mining/Milling operation: • Type • Average recovery (%) • Annual U production (tU)	 ISL 70% 800	 ISL 70% 700	 ISL 70% 800
Hydro-metallurgical plant (Navoi) • Average process recovery • Nominal capacity (tU/year)	 99.5 3 000		

Ownership structure of the uranium industry

NMMIW is part of the government holding company Kyzylkumredmetzeloto. Consequently, the entire uranium production of NMMIW is owned by the Government of Uzbekistan.

Ownership of Uranium Production in 2002

Domestic				**Foreign**				**Totals**	
Government		**Private**		**Government**		**Private**			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
1 859	100	0	0	0	0	0	0	1 859	100

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 NMMIW's stable and highly skilled work force.

Uranium Industry Employment at Existing Production Centres
(person-years)

	2000	2001	2002	2003 (expected)
Total employment related to existing production centres	7 331	7 300	8 370	8 500

Future production centres

Future uranium production in Uzbekistan will come entirely from ISL operations. There is no information as to the expected lifetime 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. Start of operations at the Severnyi Kanimekh is planned for the near future.

Short-term Production Capability
(tonnes U/year)

2003				2004				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	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300

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
2 500	2 500	2 500	2 500	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000

Secondary sources of uranium

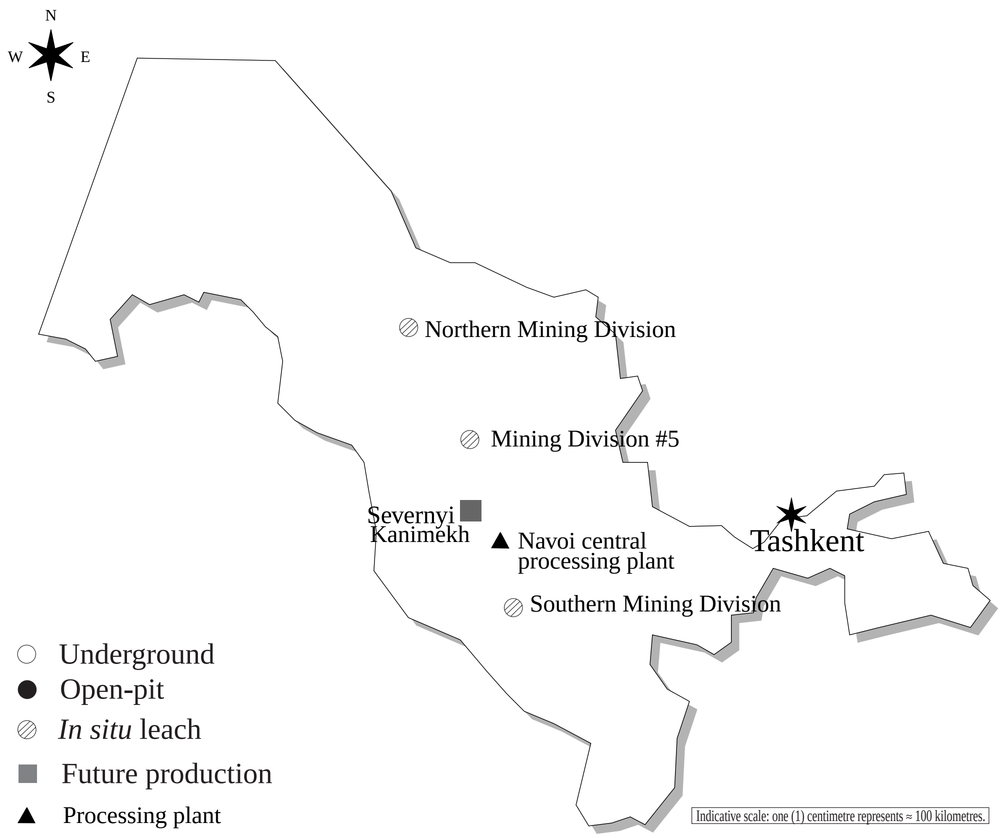
Uzbekistan did not and does not deal with the enrichment of depleted uranium.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Environmental protection activity is covered in detail in the last edition of the Red Book.

- Environmental aspects related to uranium resources:
  - Ecological conditions in the deposits areas have been adverse before mining operations. Underground waters are characterised by high mineralisation content (3-5 mg/l) and high concentrations in sulfate, chlorine, strontium, selenium, iron and manganese. *In situ* content of radionuclides in water is 5-10 times as much as the concentration limit.
- Environmental aspects related to uranium production:
  - Navoi Mining and Metallurgical Integrated Works are changing production method from air-lift to submersible pumps, which reduces atmospheric and soil pollution, equips production holes with devices that prevent solution overflow. In order to reduce underground water contamination in ore-bearing formations, the weak acid leaching method is used where it is possible.

Uranium Production Centres in Uzbekistan



- Environmental aspects related to mine closure:

  Following activities are put into practice at the closure of uranium mining and processing infrastructures:

  – Research on closure works development.

  – Design of facilities closure and land restoration activities.

  – Co-ordination of the project with the State Environmental Committee of the Republic of Uzbekistan.

  – Completion of uranium ore mining and processing infrastructure closure, and land restoration activities according to the project.

  – Assignment of re-soiled lands to local authorities.

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.

Uzbekistan reports that it holds no stocks of uranium, all being exported. No information on uranium prices was reported.

• Vietnam •

URANIUM EXPLORATION

Historical review

Uranium exploration in selected areas of Vietnam 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. From 1997 through 2002, exploration has been concentrated on evaluation of the uranium potential of the Nong Son basin, Quang Nam province. Exploration activities are concentrated on three projects: (1) evaluation of the An Diem deposit hosted in sandstone; (2) exploration of the Pa Rong area and (3) exploration of the Dong Nam Ben Giang area in the South-East Ben Giang-Nong Son basin.

The following table lists exploration expenditures and drilling statistics for the 2000-2002 period.

Uranium Exploration Expenditures and Drilling Statistics – Domestic
(USD millions)

	2000	2001	2002	2003 (expected)
Government expenditures	0.10	0.10	0.13	0.19
Government surface drilling (metres)	0	300	900	1 500

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Vietnam reports RAR recoverable at <USD 130/kgU of 1 337 tU, as *in situ* resources. EAR-I of 6 744 tU are reported in the Khe Hoa-Khe Cao deposit, and of 500 tU at an average grade of 0.034% U in the An Diem deposit, Nong Son basin. A total of 7 244 tU of EAR-I, recoverable at a cost of <USD 130/kgU, is reported, including 1 091 tU recoverable at a cost of <USD 80/kgU. No mining method is specified. An overall recovery of 75% of the uranium is expected.

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	0	0	1 337
Total	0	0	1 337

* *In situ* resources.

Estimated Additional Resources – Category I*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unspecified	NA	1 091	7 244
Total	NA	1 091	7 244

* *In situ* resources.

Undiscovered conventional resources (EAR-II & SR)

EAR-II increased by 1 000 tU (An Diem area) in the <USD 130/kgU category compared to the 2001 Red Book. The EAR-II recoverable at costs <USD 130/kgU are located mainly in the Tabhing occurrence of the Nong Son basin. Speculative Resources are the same as reported in the 2001 Red Book.

Estimated Additional Resources – Category II
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
0	7 860

Speculative Resources
(tonnes U)

Cost ranges		Total
<USD 130/kg U	Unassigned	
100 000	130 000	230 000

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

Vietnam is not a uranium producing country.

ENVIRONMENTAL ACTIVITIES AND SOCIO-CULTURAL ISSUES

Environmental monitoring is carried out to assess the environmental impacts resulting from exploration activities.

URANIUM REQUIREMENTS

The Government is planning to construct a nuclear power plant before 2015.

Installed Nuclear Generating Capacity to 2020
(MWe Net)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
0	0	0	NA	NA	NA	NA	NA	NA

NA Not available.

Annual Reactor-related Uranium Requirements to 2020
(tonnes U)

2002	2003	2005	2010		2015		2020	
			Low	*High*	*Low*	*High*	*Low*	*High*
0	0	0	NA	NA	NA	NA	NA	NA

NA Not available.

NATIONAL POLICIES RELATING TO URANIUM

Vietnam 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. Vietnam has no uranium stocks and reported no information on uranium prices.

Annex 1

MEMBERS OF THE JOINT NEA-IAEA URANIUM GROUP

Argentina	Mr. A. CASTILLO	Comisión Nacional de Energía Atómica Unidad de Proyectos Especiales de Suministros Nucleares, Buenos Aires
Armenia	Mr. A. GEVORGYAN	Ministry of Energy, Department of Atomic Energy, Yerevan
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Belgium	Ms. F. RENNEBOOG	Synatom, Brussels
Brazil	Ms. K. MONIZ DA SILVA	Comissão Nacional de Energia Nuclear (CNEN), Rio de Janeiro
	Mr. G. CAMARGO Mr. M. OLIVEIRA	Industria Nucleares do Brasil INB-S/A, Rio de Janeiro
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France	Mr. P. ARONDEL Ms. A. LE DARS	Commissariat à l'énergie atomique Centre d'études de Saclay
	Mr. G. CAPUS **(Vice-Chair)**	COGEMA, Vélizy
Germany	Mr. V. THOSTE	Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover
Hungary	Mr. G. ÉRDI-KRAUSZ	Mecsekuran Ltd. Pécs
India	Mr. R. M. SINHA	Atomic Minerals Directorate for Exploration and Research, Mumbai
Iran, Islamic Republic of	Mr. A. R. ASHTIANI Mr. S.V. KALANTARI	Atomic Energy Organisation of Iran Tehran

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	Mr. H. MIYADA	Tono Geoscience Center Japan Nuclear Cycle Development Institute, Gifu
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Kazakhstan	Mr. V. YAZIKOV **(Vice-Chair)**	National Atomic Company “KAZATOMPROM”, Almaty
Lithuania	Mr. K. ZILYS	State Nuclear Power Safety Inspectorate, Vilnius
Namibia	Mr. A. IILENDE	Ministry of Mines and Energy, Windhoek
Netherlands	Mrs. M. HOEDEMAKERS	Ministry of Economic Affairs, The Hague
Niger	Mr. A. OUSMANE	Division of Mines, Niamey
Portugal	Mr. R. DA COSTA	Instituto Geológico e Mineiro, Lisbon
Romania	Mr. P.D. GEORGESCU	R&D Institute for Rare and Radioactive Metals – ICPMRR S.A., Bucharest
Russian Federation	Mr. A.V. BOITSOV **(Vice-Chair)**	JSC TVEL, Moscow
	Mr. A.V. TARKHANOV	All-Russian Institute of Chemical Technology, Ministry of Atomic Energy, Moscow
South Africa	Mr. P. WIPPLINGER	Council for Geoscience, Pretoria
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United Kingdom	Mr. K. WELHAM	Rio Tinto plc, London
	Mr. Craig JONES	UK Delegation to the OECD
United States	Mr. J. JOOSTEN	Energy Information Administration US Department of Energy, Washington
	Mr. W. FINCH	US Geological Survey, Denver
Uzbekistan	Mr. H. HALMURZAEV	State Geological Enterprise “Kyzyltepageologia”, Tashkent
European Commission	Mr. J. VIHANTA	Euratom Supply Agency, Brussels

IAEA	Mr. J. R. BLAISE **(Scientific Secretary)**	Division of Nuclear Fuel Cycle and Waste Technology, Vienna
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Annex 2

LIST OF REPORTING ORGANISATIONS AND CONTACT PERSONS

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Armenia	Ministry of Energy, Deptartment of Atomic Energy, Government House, 2 Republic Square, 375010 Yerevan Contact person: Aram Gevorgyan
Australia	Department of Industry, Tourism and Resources, Resources Development Branch GPO Box 9839, Canberra, ACT 2601 Contact person: Aden D McKay
Belgium	Ministère des affaires économiques, Administration de l'énergie, Division des applications nucléaires, 16 Boulevard du Roi Albert II, B-1000 Bruxelles Contact person: Françoise Renneboog
Brazil	Industrias Nucleares do Brasil S/A, INB Mineral Resources Director, Rua Mena Barreto, 161, 4 andar-Botafogo, Rio de Janeiro, RJ-Brasil-22271-100 Contact person: Guilherme Camargo
Canada	Natural Resources Canada, Uranium and Radioactive Waste Division, Electricity Resources Branch, 580 Booth Street, Ottawa, Ontario K1A OE8 Contact person: Robert Vance
Chile	Comisión Chilena de Energía Nuclear, Departamento de Materiales Nucleares, Unidad de Geologia Y Mineria, Centro Nuclear Lo Aguirre, Ruta 68, km 28 Region Metropolitana Contact person: Claudio Tenreiro Leiva
China	China Atomic Energy Authority, Division of Nuclear Affairs and International Organisations, A8, Fuchenglu, Haidian District, Beijing 100037 Contact person: Xiu Binglin
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Denmark	GEUS, Danmarks OG Gronlands, Geologiske Undersogelse, Miljoministeriet, Ostervoldgade 10, 1350 Kobenhavn K Contact person: Karsten Secher
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Estonia	Estonian Radiation Protection Centre, Kopli 76, 10416 Tallinn Contact person: Iige Maalmann

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France	Commissariat à l'énergie atomique, 31-33, rue de la Fédération, F-75752 Paris Cedex 15 Contact person: Patrick Arondel
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Iran, Islamic Rep. of	Atomic Energy Organisation of Iran, Nuclear Fuel Production Deputy, Exploration and Mining Affairs, P.O. Box 14155/1339, Tehran Contact person: Abbas Rezaee Ashtiani
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Kazakhstan	National Atomic Company "Kazatoprom", 168 Bogenbai batyr Street, Almaty, 480012 Contact person: Victor G. Yazikov
Korea, Rep. of	Ministry of Science and Technology, Atomic Energy International Co-operation Division, Government Complex, Gwachun, Kyunggi-Do 427-715 Contact person: Soon-Jung Hong
Lithuania	State Nuclear Power Safety Inspectorate (VATESI), Nuclear Material Control Department, Sermuksniu 3, LT-2600 Vilnius Contact person: Marius Davainis
Namibia	Ministry of Mines and Energy, Directorate of Mines, P/Bag 13297, Windhoek Contact person: Abraham Iilende
Niger	Ministère des Mines et de l'Energie, B.P. 11700, Niamey Contact person: Massalabi Oumarou
Peru	Instituto Peruano de Energia Nuclear, Direccion General de Seguridad Radiologica/Direccion de Aplicaciones, Av Canada, 1470, San Borja, Lima Contact person: Jacinto Valencia Herrera

Philippines	Philippine Nuclear Research Institute, Commonwealth Avenue, Diliman, Quezon City 1101 Contact person: Rolando Y. Reyes
Portugal	Ministério da Economia, Instituto Geológico e Mineiro, 38 Rua Almirante Barroso, P-1000 Lisbon Contact person: Luis José Rodrigues da Costa
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Slovenia	Rudnik Zirovski Vrh, d.o.o., Todraz 1, 4224 Gorenja vas Contact person: Matej Pozun
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Spain	ENUSA Industrias Avanzadas, S. A., Santiago Rusiñol, 12, 28040 Madrid Contact person: Francisco Tarin
Sweden	Vattenfall Fuel, Jamtlandsgatan 99, SE-162 87 Stockholm Contact person: Ali Etemad
Switzerland	Nordostschweizerische Kraftwerke (NOK), Parkstrasse 23, CH-5401 Baden Contact person: Guido Klaiber
Turkey	Turkish Atomic Energy Authority, Eskisher Yolu No. 9, 06530 Ankara Contact person: Sema Zararsiz
Ukraine	SGE Kirovgeology, 8/9 Kikvidze str., Kiev 01103, Ukraine. Contact person: Yuri A. Bakarzhiyev Department of Nuclear Energy, Ministry of Fuel Supply and Energy of Ukraine, 34 Khreschatyk Street, Kyiv 01601, MCP Contact person: Nikolay A. Shteinberg
United Kingdom	Department of Trade and Industry, 1 Victoria Street, London SW1H OET Contact person: Gerry Franks
United States	Energy Information Administration, Coal, Nuclear, Electric and Alternate Fuels (EI- 50), U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, D.C. 20585 Contact person: James Joosten
Uzbekistan	The State Committee of the Republic of Uzbekistan on Geology and Mineral Resources, 11 Shevchenko st., 700060 GSP, Tashkent Contact person: Ilhom Turamuratov
Vietnam	Geological Division for Radioactive and Rare Elements, Department of Geology and Minerals of Vietnam, Ministry of Natural Resources and Environment, Xuan Phuong, Tu Liem, Hanoi Contact person: Nguyen Quang Hung

Annex 3

GLOSSARY OF DEFINITIONS AND TERMINOLOGY

UNITS

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

1 short ton U_3O_8	= 0.769 tU
1 percent U_3O_8	= 0.848 percent U
USD/lb U_3O_8	= USD 2.6/kg U
1 tonne	= 1 metric ton

RESOURCE TERMINOLOGY

Resource estimates are divided into separate categories reflecting different levels of confidence in the quantities reported. The resources are further separated into categories based on the cost of production.

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 A.

Reasonably Assured Resources (RAR) refers to uranium that occurs in known mineral deposits of delineated size, grade and configuration such that the quantities which could be recovered within the given production cost ranges with currently proven mining and processing technology, can be specified. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of deposit characteristics. Reasonably Assured Resources have a high assurance of existence. Unless otherwise noted RAR are expressed in terms of quantities of uranium recoverable from mineable ore (see Recoverable Resources below).

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 deposit's characteristics are considered to be inadequate to classify the resource as RAR. Estimates of tonnage, grade and cost of further delineation and recovery are based on such sampling as is available and on knowledge of the deposit characteristics as determined in the best known parts of the deposit or in similar deposits. Less reliance can be placed on the estimates in this category than on those for RAR. Unless otherwise noted, EAR-I are expressed in terms of quantities of uranium recoverable from mineable ore (see Recoverable Resources below).

Figure A. **Approximate Correlation 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	Demonstrated: Measured	Demonstrated: Indicated	Inferred	Undiscovered		
Canada (NRCan)	Measured	Indicated	Inferred	Prognosticated	Speculative	
United States (DOE)	Reasonably Assured		Estimated Additional		Speculative	
Russian Federation, Kazakhstan, Ukraine, Uzbekistan	A + B	C 1	C 2	P1	P2	P3
UNFC[1]	EF1		EF2	EF3	EF4	

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.

1. UNFC correlation with NEA/IAEA and national classification systems is still under consideration.

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. EAR-II are normally expressed in terms of uranium contained in mineable ore, i.e., *in situ* quantities.

Speculative Resources (SR) refers to uranium, in addition to 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. SR are normally expressed in terms of uranium contained in mineable ore, i.e., *in situ* quantities.

b) Cost categories

The cost categories, in United States dollars (USD), used in this report are defined as: <USD 40/kgU, <USD 80/kgU, and <USD 130/kgU. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant

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

Conversion of costs from other currencies into USD is done using an average exchange rate for the month of June in that year except for the projected costs for the year of the report, which uses the exchange rate of 1 January 2003 (Annex 7).

When estimating the cost of production for assigning resources within these cost categories, account has been taken of the following costs:

- The direct costs of mining, transporting and processing the uranium ore.
- The costs of associated environmental and waste management during and after mining.
- The costs of maintaining non-operating production units where applicable.
- In the case of ongoing projects, those capital costs that remain non-amortised.
- The capital cost of providing new production units where applicable, including the cost of financing.
- Indirect costs such as office overheads, taxes and royalties where applicable.
- Future exploration and development costs wherever required for further ore delineation to the stage where it is ready to be mined.
- Sunk costs were not normally taken into consideration.

c) Relationship between resource categories

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

Figure B. **NEA/IAEA Classification Scheme for Uranium Resources**

Recoverable at costs					
	USD 80-130/kgU	REASONABLY ASSURED RESOURCES	ESTIMATED ADDITIONAL RESOURCES I	ESTIMATED ADDITIONAL RESOURCES II	SPECULATIVE RESOURCES
	USD 40-80/kgU	REASONABLY ASSURED RESOURCES	ESTIMATED ADDITIONAL RESOURCES I	ESTIMATED ADDITIONAL RESOURCES II	
	<USD 40/kgU	REASONABLY ASSURED RESOURCES	ESTIMATED ADDITIONAL RESOURCES I		

Decreasing economic attractiveness

Decreasing confidence in estimates

The shaded area indicates that known conventional resources (i.e., RAR plus EAR-I) recoverable at costs of <USD 80/kgU 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".

d) Recoverable resources

RAR and EAR-I estimates are expressed in terms of recoverable tonnes of uranium, i.e. quantities of uranium recoverable from mineable ore, as opposed to quantities contained in mineable ore, or quantities *in situ*, i.e., not taking into account mining and milling losses. Therefore both expected mining and ore processing losses have been deducted in most cases. If a country reports its resources as *in situ* and the country does not provide a recovery factor, the Secretariat assigns a recovery factor to those resources based on geology and projected mining and processing methods to determine recoverable resources. The recovery factors that have been applied are:

Mining and Milling Method	**Overall recovery factor** (%)
Open-pit mining with conventional milling	81
Underground mining with conventional milling	77
ISL (acid)	75
ISL (alkaline)	70
Heap leaching	68
Block and stope leaching	75
Co-product or by-product	66
Unspecified method	75

SECONDARY SOURCES OF URANIUM TERMINOLOGY

a) Mixed Oxide Fuel (MOX): MOX is the abbreviation for a fuel for nuclear power plants that consists of a mixture of uranium oxide and plutonium oxide. Current practice is to use a mixture of depleted uranium oxide and plutonium oxide.

b) Depleted uranium: Uranium where the ^{235}U assay is below the naturally occurring 0.7110%. (Natural uranium is a mixture of three isotopes, uranium 238 – accounting for 99.2836 %, uranium 235 – 0.7110 %, and uranium 234 – 0.0054 %). Depleted uranium is a by-product of the enrichment process, where enriched uranium is produced from initial natural uranium feed material.

PRODUCTION TERMINOLOGY[2]

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:

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

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 <USD 80/kgU.

Production: Denotes the amount of uranium, in tonnes U contained in concentrate, output by an ore processing plant or production centre, that is, with milling losses deducted.

c) Mining and milling

***In situ* leaching (ISL)**: The extraction of uranium from sandstone using chemical solutions and the recovery of uranium at the surface. ISL extraction is conducted by injecting a suitable uranium-dissolving leach solution (acid or alkaline) into the ore zone below the water table thereby oxidising, complexing, and mobilising the uranium; then recovering the pregnant solutions through production wells, and finally pumping the uranium bearing solution to the surface for further processing.

Heap leaching (HL): Heaps of ore are formed over a collecting system underlain by an impervious membrane. Dilute sulphuric acid solutions are distributed over the top surface of the ore. As the solutions seep down through the heap, they dissolve a significant (50-75%) amount of the uranium in the ore. The uranium is recovered from the heap leach product liquor by ion exchange or solvent extraction.

In place leaching (IPL): involves leaching of broken ore without removing it from an underground mine. This is also sometimes referred to as Stope Leaching or Block Leaching.

Co-product: Uranium is a co-product when it is one of two commodities that must be produced to make a mine economic. Both commodities influence output, for example, uranium and copper are co-produced at Olympic Dam in Australia. Co-product uranium is produced using either the open-pit or underground mining methods.

By-product: Uranium is considered a by-product when it is a secondary or additional product. By-product uranium can be produced in association with a main product or with co-products, e.g., uranium recovered from the Palabora copper mining operations in South Africa. By-product uranium is produced using either the open-pit or underground mining methods.

Uranium from phosphates: Uranium has been recovered as a by-product of phosphoric acid production. Uranium is separated from phosphoric acid by a solvent extraction process. The most frequently used reagent is a synergetic mixture of Tri-m-Octyl Phosphine Oxide (TOPO) and Di 2-Ethylhexyl Phosphoric Acid (DEPA)

Ion exchange (IX): Reversible exchange of ions contained in a host material for different ions in solution without destruction of the host material or disturbance of electrical neutrality. The process is accomplished by diffusion and occurs typically in crystals possessing – one or two – dimensional channels where ions are weakly bonded. It also occurs in resins consisting of three-dimensional hydrocarbon networks to which are attached many ionisable groups. Ion exchange is used for recovering uranium from leaching solutions.

Solvent extraction (SX): A method of separation in which a generally aqueous solution is mixed with an immiscible solvent to transfer one or more components into the solvent. This method is used to recover uranium from leaching solutions.

DEMAND TERMINOLOGY

a) Reactor-related requirements: Refers to natural uranium acquisitions *not* necessarily consumption during a calendar year.

ENVIRONMENTAL TERMINOLOGY[3]

a) 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.

b) Decommissioning: Actions taken at the end of the operating life of a uranium mill or other uranium facility in retiring it from service with adequate regard for the health and safety of workers and members of the public and protection of the environment. The time period to achieve decommissioning may range from a few to several hundred years.

c) Decontamination: The removal or reduction of radioactive or toxic chemical contamination using physical, chemical, or biological processes.

d) 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.

e) Environmental restoration: Cleanup and restoration, according to predefined criteria, of sites contaminated with radioactive and/or hazardous substances during past uranium production activities.

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3. Definitions based on those published in OECD (2002), *Environmental Remediation World Uranium Production Facilities*, Paris.

f) 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.

g) Groundwater restoration: The process of returning affected groundwater to acceptable quality and quantity levels for future use.

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

i) 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.

j) 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.

k) Tailings impoundment: A structure in which the tailings are deposited to prevent their release into the environment.

l) Unrestricted release (or use): A designation, by the regulatory body of a country, that enables the release or use of equipment, buildings, materials or the site without any restriction.

GEOLOGICAL TERMINOLOGY

a) Uranium occurrence: A naturally occurring, anomalous concentration of uranium.

b) Uranium deposit: A mass of naturally occurring mineral from which uranium could be exploited at present or in the future.

c) Geologic types of uranium deposits[4]

Uranium resources can be assigned on the basis of their geological setting to the following categories of uranium ore deposit types (arranged according to their approximate economic significance):

1. Unconformity-related deposits.
2. Sandstone deposits.
3. Hematite breccia complex deposits.
4. Quartz-pebble conglomerate deposits.
5. Vein deposits.
6. Intrusive deposits.
7. Volcanic and caldera-related deposits.
8. Metasomatite deposits.
9. Surficial deposits.
10. Collapse breccia pipe deposits.
11. Phosphorite deposits.
12. Other types of deposits.
13. Rock types with elevated uranium content.

4. This classification of the geological types of uranium deposits was developed by the IAEA in 1988-89 and updated for this edition of the Red Book.

1. **Unconformity-related deposits**: Unconformity-related deposits are associated with and occur immediately below and above an unconformable contact that separates a crystalline basement intensively altered from overlying clastic sediments of either Proterozoic or Phanerozoic age.

   The unconformity-related deposits includes the following sub-types:

   - *Unconformity contact*
     i. Fracture bound deposits occur in metasediments immediately below the unconformity. Mineralisation is monometallic and of medium grade. Examples include Rabbit Lake and Dominique Peter in the Athabasca Basin, Canada.
     ii. Clay-bound deposits occur associated with clay at the base of the sedimentary cover directly above the unconformity. Mineralisation is commonly polymetallic and of high to very high grade. An example is Cigar Lake in the Athabasca Basin, Canada

   - *Sub-unconformity-post-metamorphic deposits*
     Deposits are strata-structure bound in metasediments below the unconformity on which clastic sediments rest. These deposits can have large resources, at low to medium grade. Examples are Jabiluka and Ranger in Australia.

2. **Sandstone deposits:** Sandstone uranium deposits occur in medium to coarse-grained sandstones deposited in a continental fluvial or marginal marine sedimentary environment. Uranium is precipitated under reducing conditions caused by a variety of reducing agents within the sandstone, for example, carbonaceous material, sulphides (pyrite), hydrocarbons and ferro-magnesium minerals (chlorite), etc. Sandstone uranium deposits can be divided into four main sub-types:

   - *Roll-front deposits*: The mineralised zones are convex down the hydrologic gradient. They display diffuse boundaries with reduced sandstone on the down-gradient side and sharp contacts with oxidised sandstone on the up-gradient side. The mineralised zones are elongate and sinuous approximately parallel to the strike, and perpendicular to the direction of deposition and groundwater flow. Resources can range from a few hundred tonnes to several thousands of tonnes of uranium, at grades averaging 0.05% to 0.25%. Examples are Moynkum, Inkay and Mynkuduk (Kazakhstan); Crow Butte and Smith Ranch (United States) and Bukinay, Sugraly and Uchkuduk (Uzbekistan).

   - *Tabular deposits* consist of uranium matrix impregnations that form irregularly shaped lenticular masses within reduced sediments. The mineralised zones are largely oriented parallel to the depositional trend. Individual deposits can contain several hundreds of tonnes up to 150 000 tonnes of uranium, at average grades ranging from 0.05% to 0.5%, occasionally up to 1%. Examples of deposits include Westmoreland (Australia), Nuhetting (China), Hamr-Stráz (Czech Republic), Akouta, Arlit, Imouraren (Niger) and Colorado Plateau (United States).

   - *Basal channel deposits*: Paleodrainage systems consist of several hundred metres wide channels filled with thick permeable alluvial-fluvial sediments. Here, the uranium is predominantly associated with detrital plant debris in ore bodies that display, in a plan-view, an elongated lens or ribbon-like configuration and, in a section-view, a lenticular or, more rarely, a roll shape. Individual deposits can range from several hundreds to 20 000 tonnes uranium, at grades ranging from 0.01% to 3%. Examples are the deposits of Dalmatovskoye (Transural Region), Malinovskoye (West Siberia), Khiagdinskoye (Vitim district) in Russia and Beverley in Australia.

- *Tectonic/lithologic deposits* occur in sandstone related to a permeable zone. Uranium is precipitated in open zones related to tectonic extension. Individual deposits contain a few hundred tonnes up to 5 000 tonnes of uranium at average grades ranging from 0.1% to 0.5%. Examples include the deposits of Mas Laveyre (France) and Mikouloungou (Gabon).

3. **Hematite breccia complex deposits:** Deposits of this group occur in hematite-rich breccias and contain uranium in association with copper, gold, silver and rare earths. The main representative of this type of deposit is the Olympic Dam deposit in South Australia. Significant deposits and prospects of this type occur in the same region, including Prominent Hill, Wirrda Well, Acropolis and Oak Dam as well as some younger breccia-hosted deposits in the Mount Painter area.

4. **Quartz-pebble conglomerate deposits:** Detrital uranium oxide ores are found in quartz-pebble conglomerates deposited as basal units in fluvial to lacustrine braided stream systems older than 2.3-2.4 Ga. The conglomerate matrix is pyritiferous, and gold, as well as other oxide and sulphide detrital minerals are often present in minor amounts. Examples include deposits found in the Witwatersrand Basin where uranium is mined as a by-product of gold. Uranium deposits of this type were mined in the Blind River/Elliot Lake area of Canada.

5. **Vein deposits:** In vein deposits, the major part of the mineralisation fills fractures with highly variable thickness, but generally important extension along strike. The veins consist mainly of gangue material (e.g. carbonates, quartz) and ore material, mainly pitchblende. Typical examples range from the thick and massive pitchblende veins of Pribram (Czech Republic), Schlema-Alberoda (Germany) and Shinkolobwe (Democratic Republic of Congo), to the stockworks and episyenite columns of Bernardan (France) and Gunnar (Canada), to the narrow cracks in granite or metamorphic rocks, also filled with pitchblende of Mina Fe (Spain) and Singhbhum (India).

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 Rossing and Trekkopje deposits (Namibia), the uranium occurrences in the porphyry copper deposits such as Bingham Canyon and Twin Butte (United States), the Ilimaussaq deposit (Greenland), Palabora (South Africa), as well as the deposits in the Bancroft area (Canada).

7. **Volcanic and caldera-related deposits**: Uranium deposits of this type are located within and nearby volcanic caldera filled by mafic to felsic volcanic complexes and intercalated clastic sediments. Mineralisation is largely controlled by structures (minor stratabound), occurs at several stratigraphic levels of the volcanic and sedimentary units and extends into the basement where it is found in fractured granite and in metamorphites. Uranium minerals are commonly associated with molybdenum, other sulphides, violet fluorine and quartz. Most significant commercial deposits are located within Streltsovsk caldera in the Russian Federation. Examples are known in China, Mongolia (Dornot deposit), Canada (Michelin deposit) and Mexico (Nopal deposit).

8. **Metasomatite deposits**: Deposits of this type are confined to the areas of tectono-magmatic activity of the Precambrian shields and are related to near-fault alkali metasomatites, developed upon different basement rocks: granites, migmatites, gneisses and ferruginous quartzites with production of albitites, aegirinites, alkali-amphibolic and carbonaceous-ferruginous rocks. Ore lenses and stocks are a few metres to tens of metres thick and a few

hundred metres long. Vertical extent of ore mineralisation can be up to 1.5 km. Ores are uraninite-brannerite by composition and belong to ordinary grade. The reserves are usually medium scale or large. Examples include Michurinskoye, Vatutinskoye, Severinskoye, Zheltorechenskoye and Pervomayskoye deposits (Ukraine), Lagoa Real, Itataia and Espinharas (Brazil), the Valhalla deposit (Australia) and deposits of the Arjeplog region in the north of Sweden.

9. **Surficial deposits:** Surficial uranium deposits are broadly defined as young (Tertiary to Recent) near–surface uranium concentrations in sediments and soils. The largest of the surficial uranium deposits are in calcrete (calcium and magnesium carbonates), and they have been found in Australia (Yeelirrie deposit), Namibia (Langer Heinrich deposit) and Somalia. These calcrete-hosted deposits are associated with deeply weathered uranium-rich granites. They also can occur in valley-fill sediments along Tertiary drainage channels and in playa lake sediments (e.g., Lake Maitland, Australia). Surficial deposits also can occur in peat bogs and soils.

10. **Collapse breccia pipe deposits:** Deposits in this group occur in circular, vertical pipes filled with down-dropped fragments. The uranium is concentrated as primary uranium ore, generally uraninite, in the permeable breccia matrix, and in the arcuate, ring-fracture zone surrounding the pipe. Type examples are the deposits in the Arizona Strip north of the Grand Canyon and those immediately south of the Grand Canyon in the United States.

11. **Phosphorite deposits**: Phosphorite deposits consist of marine phosphorite of continental-shelf origin containing syn-sedimentary stratiform, disseminated uranium in fine-grained apatite. Phosphorite deposits constitute large uranium resources, but at a very low grade. Uranium can be recovered as a by-product of phosphate production. Examples include New Wales Florida (pebble phosphate) and Uncle Sam (United States), Gantour (Morocco) and Al-Abiad (Jordan). Other type of phosphorite deposits consists of organic phosphate, including argillaceous marine sediments enriched in fish remains that are uraniferous (Melovoe deposit, Kazakhstan).

12. **Other deposits**

    Metamorphic deposits: In metamorphic uranium deposits, the uranium concentration directly results from metamorphic processes. The temperature and pressure conditions, and age of the uranium deposition have to be similar to those of the metamorphism of the enclosing rocks. Examples include the Forstau deposit (Austria) and Mary Kathleen (Australia).

    Limestone deposits: This includes uranium mineralisation in the Jurassic Todilto Limestone in the Grants district (United States). Uraninite occurs in intra-formational folds and fractures as introduced mineralisation.

    Uranium coal deposits: Elevated uranium contents occur in lignite/coal, and in clay and sandstone immediately adjacent to lignite. Examples are uranium in the Serres Basin (Greece), in North and South Dakota (United States), Koldjat and Nizhne Iliyskoe (Kazakhstan) and Freital (Germany). Uranium grades are very low and average less than 50 ppm U.

13. **Rock types with elevated uranium contents:** Elevated uranium contents have been observed in different rock types such as pegmatite, granites and black shale. In the past no economic deposits have been mined commercially in these types of rocks. Their grades are very low, and it is unlikely that they will be economic in the foreseeable future.

Rare metal pegmatites: These pegmatites contain Sn, Ta, Nb and Li mineralisation. They have variable U, Th and rare earth elements contents. Examples include Greenbushes and Wodgina pegmatites (Western Australia). The Greenbushes pegmatites commonly have 6-20 ppm U and 3-25 ppm Th.

Granites: A small proportion of un-mineralised granitic rocks have elevated uranium contents. These "high heat producing" granites are potassium feldspar-rich. Roughly 1% of the total number of granitic rocks analysed in Australia have uranium-contents above 50 ppm.

Black Shale: Black shale-related uranium mineralisation consists of marine organic-rich shale or coal-rich pyritic shale, containing syn-sedimentary disseminated uranium adsorbed onto organic material. Examples include the uraniferous alum shale in Sweden and Estonia, the Chatanooga shale (United States), the Chanziping deposit (China), and the Gera-Ronneburg deposit (Germany).

Annex 4

ACRONYM LIST

AGR	Advanced gas reactor
AL	Acid leaching
ALKAL	Alkaline atmospheric leaching
BWR	Boiling water reactor
CANDU	Canadian deuterium uranium
CEC	Commission of the European Communities
CWG	Crush-wet grind
DOE	Department of Energy (United States)
EAR-I	Estimated additional resources-category I
EAR-II	Estimated additional resources-category II
EIA	U.S. Energy Information Administration
EU	European Union
EUP	Enriched uranium product
FLOT	Flotation
Ga	Giga-years
GDR	German Democratic Republic
GIF	Generation IV International Forum
GNSS	Global Nuclear Services and Supply
GWe	Gigawatt electric
HEU	Highly Enriched Uranium
HL	Heap leaching
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
INPRO	International project on innovative nuclear reactors and fuel cycles
IPL	In place leaching
ISL	*In situ* leaching
IX	Ion exchange
KCR	Known conventional reserves
kg	Kilograms
km	Kilometre
LEU	Low enriched uranium
LWR	Light water reactor

MAGNOX	Magnesium oxide
MOX	Mixed oxide fuel
MWe	Megawatt electric
NEA	Nuclear Energy Agency
OECD	Organisation for Economic Co-operation and Development
OP	Open-pit
ppm	Part per million
Pu	Plutonium
PHWR	Pressurised heavy-water reactor
PWR	Pressurised water reactor
RAR	Reasonably assured resources
RBMK	Water-cooled, graphite-moderated reactor (Russian acronym)
SR	Speculative resources
SWU	Separative work unit
SX	Solvent extraction
t	Tonnes (metric tons)
Th	Thorium
tHM	Tonnes heavy metal
TOE	Tonnes oil equivalent
tU	Tonnes uranium
TVA	Tennessee Valley Administration
TWh	Terrawatt-hour
U	Uranium
UG	Underground mining
USSR	Union of Soviet Socialist Republics
U_xC	U_X Consulting Company
VVER	Water-cooled, water-moderated reactor (Russian acronym)

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.

ENERGY VALUES FOR URANIUM USED IN VARIOUS RECTOR TYPES[1]

Country	Canada	France	Germany		Japan		Russian Federation		Sweden		United Kingdom		United States	
Reactor type	CANDU	N4 PWR	BWR	PWR	BWR	PWR	VVER-1000	RBMK -1000	BWR	PWR	MAGNOX	AGR	BWR	PWR
Burn-up [Mw/day/tU]														
a) Natural uranium or natural uranium equivalent	7 770	5 848	5 665	5 230	5 532	4 694	4 855	4 707	6 250	5 780	5 900	NA	4 996	4 888
b) Enriched uranium	–	42 500	40 000	42 000	33 000	43 400	42 000	22 000	40 000	42 000	–	24 000	33 000	40 000
Uranium enrichment [%^{235}U]	–	3.60	3.2	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 initial core load, which would reduce the equivalence by about 6%, if based on a plant life of about 30 years with a 70% capacity factor.
2. Does not take into account the energy consumed for ^{235}U enrichment in LWR and AGR fuel. The factor to be applied to the energy equivalent under the condition of 3% ^{235}U enrichment and 0.2% tails assay should be multiplied by 0.957.

NA Not available.

Conversion Factors and Energy Equivalence for Fossil Fuel for Comparison

1 cal	=	4.1868 J
1 J	=	0.239 cal
1 tonne of oil equivalent (TOE)(net, LHV)	=	42 GJ[1] = 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 liquid natural gas (LNG)	=	45 GJ
1 000 kWh (primary energy)	=	9.36 MJ
1 TOE	=	10 034 Mcal
1 TCE	=	7 000 Mcal
1 000 m^3 natural gas	=	8 600 Mcal
1 tonne LNG	=	11 000 Mcal
1 000 kWh (primary energy)	=	2 236 Mcal[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 000kWh (final consumption) = 860 Mcal as WEC conversion factor.

Annex 6

INDEX OF NATIONAL REPORTS IN RED BOOKS

(The following index lists all national reports by the year in which these reports were published in the Red Books. A listing of all Red Book editions is shown at the end of this Index.)

	1965	**1967**	**1969**	**1970**	**1973**	**1975**	**1977**	**1979**	**1982**	**1983**	**1986**	**1988**	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2002**	**2004**
Algeria						1975	1977	1979	1982										2002	2004
Argentina		1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
Armenia																		2000	2002	2004
Australia		1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
Austria							1977													
Bangladesh											1986	1988								
Belgium									1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
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	2004
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	2004
Central African Republic				1970	1973		1977	1979			1986									
Chile							1977	1979	1982	1983	1986	1988		1992	1994	1996	1998	2000	2002	2004
China													1990	1992	1994	1996	1998	2000	2002	2004
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	2004
Czech and Slovak Republic													1990							
Denmark (Greenland)	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986		1990	1992		1996	1998			2004
Dominican Republic									1982											
Ecuador							1977		1982	1983	1986	1988								
Egypt							1977	1979			1986	1988	1990	1992	1994	1996	1998	2000		2004
El Salvador										1983	1986									
Estonia																	1998			2004
Ethiopia								1979		1983	1986									
Finland					1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
France	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
Gabon		1967		1970	1973				1982	1983	1986					1996	1998	2000	2002	2004
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	2004
India	1965	1967		1970	1973	1975	1977	1979	1982	1983	1986		1990	1992	1994	1996	1998	2000	2002	2004
Indonesia							1977				1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
Iran, Islamic Republic of							1977										1998	2000	2002	2004
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	2004
Jordan							1977				1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
Kazakhstan															1994	1996	1998	2000	2002	2004
Korea, Republic of						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
Kyrgyzstan																1996			2002	
Lesotho												1988								
Liberia							1977			1983										
Libyan Arab Jamahirya										1983										
Lithuania															1994	1996	1998	2000	2002	2004
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	2004
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	2004
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		2004
Philippines							1977		1982	1983	1986		1990		1994	1996	1998	2000	2002	2004
Poland																		2000	2002	
Portugal	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
Romania														1992	1994	1996	1998	2000	2002	
Russian Federation															1994		1998	2000	2002	2004
Rwanda											1986									
Senegal									1982											
Slovak Republic															1994	1996	1998	2000	2002	2004
Slovenia															1994	1996	1998		2002	2004
Somalia							1977	1979												
South Africa	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986			1992	1994	1996	1998	2000	2002	2004
Spain	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
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	2004
Switzerland						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
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	2004
Turkmenistan																				2004
Ukraine															1994	1996	1998	2000	2002	2004
United Kingdom						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004

United States	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004
Uruguay							1977		1982	1983	1986	1988	1990							
USSR														1992						
Uzbekistan															1994	1996	1998	2000	2002	2004
Venezuela											1986	1988								
Vietnam														1992	1994	1996	1998	2000	2002	2004
Yugoslavia														1992						
Zaire		1967			1973		1977					1988								
Zambia											1986	1988	1990	1992	1994	1996	1998			
Zimbabwe									1982			1988		1992	1994	1996	1998			

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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
20. OECD/NEA-IAEA Uranium 2003: Resources, Production and Demand, Paris, 2004

Annex 7

CURRENCY EXCHANGE RATES*
(in national currency units per USD)

COUNTRY (currency abbreviation)	**June 2000**	**June 2001**	**June 2002**	**January 2003**
Algeria (DZD)	73.120	76.950	78.920	78.360
Argentina (ARS)	0.998	0.998	3.300	3.370
Armenia (AMD)	537.000	556.000	581.000	578.000
Australia (AUD)	1.730	1.947	1.769	1.780
Austria (EURO)	1.068	1.167	1.065	0.958
Belgium (EURO)	1.068	1.167	1.065	0.958
Brazil (BRL)	1.850	2.300	2.500	3.500
Bulgaria (BGN)	2.140	2.250	2.105	1.890
Canada (CAD)	1.500	1.540	1.530	1.570
Chile (CLP)	518.000	600.000	650.000	705.000
China (CNY)	8.267	8.266	8.266	8.266
Colombia (COP)	2 085.000	2 304.000	2 339.000	2 810.000
Congo, Republic of (XOF)	700.562	765.502	726.800	628.407
Costa Rica (CRC)	305.650	325.600	355.300	377.070
Cuba (CUP)	1.000	1.000	1.000	1.000
Czech Republic (CZK)	38.730	39.840	32.500	30.250
Denmark (DKK)	7.970	8.700	7.920	7.120
Egypt (EGP)	3.429	3.860	4.620	4.620
Finland (EURO)	1.068	1.167	1.065	0.958
France (EURO)	1.068	1.167	1.065	0.958
Gabon (XOF)	700.562	765.502	726.800	628.407
Germany (EURO)	1.068	1.167	1.065	0.958
Greece (EURO)	1.068	1.167	1.065	0.958
Hungary (HUF)	277.000	296.000	260.000	226.000
India (INR)	43.700	46.570	48.750	47.680
Indonesia (IDR)	8 236.000	11 350.000	8 750.000	8 600.000
Italy (EURO)	1.068	1.167	1.065	0.958
Iran, Islamic Rep. of (IRR)	8 200.000	7 965.000	7 920.000	7 992.000
Japan (JPY)	107.000	120.000	123.000	119.000
Jordan (JOD)	0.708	0.708	0.708	0.708
Kazakhstan (KZT)	142.000	145.500	152.500	155.300
Korea, Republic of (KRW)	1 121.000	1 270.000	1 233.000	1 190.000
Kyrgyzstan (KGS)	48.100	49.200	47.770	45.900

CURRENCY EXCHANGE RATES* (contd)
(in national currency units per USD)

COUNTRY (currency abbreviation)	**June 2000**	**June 2001**	**June 2002**	**January 2003**
Malaysia (MYR)	3.774	3.790	3.770	3.770
Mauritania (MRO)	239.980	253.460	265.000	267.000
Mexico (MXN)	9.420	9.000	9.400	10.100
Mongolia (MNT)	1 010.000	1 091.000	1 101.000	1 123.000
Morocco (MAD)	10.668	11.604	11.150	10.300
Namibia (NAD)	7.070	7.970	9.850	8.830
Netherlands (EURO)	1.068	1.167	1.065	0.958
Niger (XOF)	700.562	765.502	726.800	628.407
Norway (NOK)	8.910	9.230	7.920	6.980
Peru (PEN)	3.510	3.580	3.460	3.500
Philippines (PHP)	42.800	50.450	49.270	53.430
Poland (PLN)	4.400	3.890	4.030	3.780
Portugal (EURO)	1.068	1.167	1.065	0.958
Romania (ROL)	20 553.000	28 568.000	33 592.000	33 772.000
Russian Federation (RUB)	28.270	29.100	31.300	31.840
Slovak Republic (SKK)	47.686	49.170	47.010	40.280
Slovenia (SIT)	221.000	254.000	244.000	221.000
Somalia (SOS)	9 700.000	18 590.000	20 738.000	18 818.000
South Africa (ZAR)	7.070	7.970	9.850	8.830
Spain (EURO)	1.068	1.167	1.065	0.958
Sweden (SEK)	8.950	10.570	9.700	8.770
Switzerland (CHF)	1.670	1.780	1.560	1.390
Syria (SYP)	46.000	46.000	46.000	51.500
Tajikistan (TJS)	–	2.500	2.880	3.150
Thailand (THB)	39.065	45.415	42.730	42.920
Turkey (TRL)	621 000.000	1 090 000.000	1 400 000.000	1 640 000.000
Ukraine (UAH)	5.410	5.410	5.320	5.330
United Kingdom (GBP)	0.666	0.710	0.680	0.624
United States (USD)	1.000	1.000	1.000	1.000
Uruguay (UYU)	11.880	13.000	17.300	28.000
Uzbekistan (UZS)	231.000	690.000	723.840	948.940
Vietnam (VND)	14 028.000	14 550.000	15 130.000	15 232.000
Yugoslavia (YUM)	11.660	67.000	65.420	59.760
Zambia (ZMK)	2 870.000	3 340.000	4 215.000	4 650.000
Zimbabwe (ZWD)	37.182	55.000	55.000	1 210.000

* Source: The Department of Finance of the United Nations Development Programme, New York.

Annex 8

GROUPING OF COUNTRIES AND AREAS WITH URANIUM-RELATED ACTIVITIES

The countries and geographical areas referenced in this report are listed below. Countries followed by "*" are members of OECD.

1. North America

Canada*	Mexico*	United States of America*

2. Central and South America

Argentina	Bolivia	Brazil
Chile	Colombia	Costa Rica
Cuba	Ecuador	El Salvador
Guatemala	Jamaica	Paraguay
Peru	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 and South-eastern Europe

Armenia	Bulgaria	Croatia
Czech Republic*	Estonia	Greece*
Hungary*	Lithuania	Poland*
Romania	Russian Federation	Slovak Republic*
Slovenia	Turkey*	Ukraine

5. Africa

Algeria	Botswana	Central African Republic
Congo, Democratic Republic	Egypt	Gabon
Ghana	Lesotho	Libya
Madagascar	Malawi	Mali
Morocco	Namibia	Niger
Nigeria	Somalia	South Africa
Zambia	Zimbabwe	

6. Middle East, Central and Southern Asia

Bangladesh	India	Iran, Islamic Republic of
Israel	Jordan	Kazakhstan
Kyrgyzstan	Pakistan	Sri Lanka
Syria	Tajikistan	Turkmenistan
Uzbekistan		

7. South-eastern Asia

Indonesia	Malaysia	Philippines
Thailand	Vietnam	

8. Pacific

Australia*	New Zealand*

9. East Asia[1]

China	Japan*	Mongolia
Korea, Republic of*		
Korea, Democratic People's Republic of		

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
Azerbaijan	Kyrgyzstan	Turkmenistan
Belarus	Moldavia	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 Taipei.

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....

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