

Uranium – 2012 Annual Review

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CANADIAN PRODUCTION AND DEVELOPMENTS

In 2012, Canadian uranium production totaled 8,998 tonnes of uranium metal (tU), a 1.6% decrease from 9,145 tU in 2011. Canada was the world's second largest uranium producer in 2012 with 15.4% of the world's total production of 59,934 tU. All current producing mines and most new projects awaiting development are located in the Athabasca Basin of northern Saskatchewan (Figure 1).

Since 1996, all Canadian uranium production has been from the Athabasca Basin where three production centres are operated by Cameco Corporation and Areva Resources Canada Inc., two of the world's largest uranium-producing companies. Employment and production data are provided in Table 1. Direct employment in Canada's uranium mining industry was 1,361 in 2012. The share of the total production of 8,998 tU in 2012 for Cameco and Areva was 74.8% and 25.2%, respectively. Despite lower production in 2012, the total value of uranium shipments, at \$1.2 billion, was relatively unchanged from the previous year due to higher long-term uranium prices. Uranium continues to rank among Canada's top 10 metal commodities in terms of output value.

Athabasca Basin, Saskatchewan

The **McArthur River** mine, which has the world's largest high-grade uranium deposit and is the world's leading producer of uranium, produced 7,460 tU in 2012. The mine is a Cameco (70%) and Areva (30%) joint venture operated by Cameco. Raise bore mining of the high-grade ore (14% uranium metal [U] average grade) is conducted behind a freeze curtain created to control groundwater inflow. A high-grade ore slurry is then pumped to the surface and loaded into specially designed containers that are trucked 80 kilometres (km) to Key Lake where all McArthur River ore is milled.

The **Key Lake** mill is a Cameco (83%) and Areva (17%) joint venture operated by Cameco. Although mining at Key Lake was completed in 1997, the mill maintained its standing as the world's largest

uranium production centre by producing 7,520 tU in 2012. This total represents a combination of high-grade McArthur River ore slurry and stockpiled, mineralized Key Lake special waste rock that is blended to produce a mill feed grade of about 3.4% U.

A proposal to extend the lifespan and increase the production capacity of the Key Lake milling operation by 33% (from 7,200 to 9,600 tonnes of uranium metal per year [tU/y]) was submitted to the federal nuclear regulator, the Canadian Nuclear Safety Commission (CNSC), in May 2010. The proposal includes increasing the storage capacity of the Deilmann tailings management facility and modifications to the mill to allow treatment of a wider range of ore and waste rock from other deposits.

The **McClean Lake** production centre, operated by Areva, is a joint venture between Areva (70%), Denison Mines Inc. (22.5%), and OURD (Canada) Co. Ltd., a subsidiary of Overseas Uranium Resources Development Corporation of Japan (7.5%). There was no production in 2012. Mining at the Sue E and B pits was finished in 2008 and about 375,600 tonnes (t) of ore containing 2,500 tU were stockpiled for processing at the McClean Lake JEB mill. All production since 2008 has been from this stockpiled ore. In July 2010, the mill was placed into care and maintenance because it was not economically worthwhile to extract the remaining 500 tU from the low-grade ore remaining in the stockpile. Production is expected to resume in 2014 when high-grade ore from Cigar Lake becomes available for processing. Modifications to the mill to increase its capacity to 4,600 tU/y and to process ore from the Cigar Lake mine have been completed and there are plans to increase the capacity further.

The **Rabbit Lake** production centre, wholly owned and operated by Cameco, produced 1,479 tU in 2012. Surface exploratory drilling at the Eagle Point mine during 2010 delineated additional resources and extended the life of the mine until at least 2017. Cameco plans to continue surface and underground exploratory drilling to define additional resources at Rabbit Lake.

Additional Production Possibilities

The Cigar Lake mine is scheduled to begin providing feed for the McClean Lake mill in mid-2014. This will significantly increase Canada's production. Beyond Cigar Lake, there are two uranium mining projects in Saskatchewan that could enter into production within a few years provided they receive regulatory approvals and are economically feasible. Ore from the Midwest mine would provide additional feed for the McClean Lake mill, and ore from the proposed Millennium mine would be processed at the Key Lake mill. In addition, there are several exploration projects in the Athabasca Basin that have identified significant high-grade uranium mineralization that may develop into proposals for new mines.

Cigar Lake, with reasonably assured resources (measured plus indicated) of 81,000 tU, at an average grade of approximately 14.4% U, is the world's second-largest high-grade uranium deposit. The mine is a Cameco (50.025%), Areva (37.1%), Idemitsu (7.875%), and TEPCO (5%) joint venture operated by Cameco. When completed, the mine is expected to have a production capacity of 6,900 tU/y that will be transported as ore slurry to the McClean Lake JEB mill for processing.

The Midwest project is a joint venture between Areva (69.16%), Denison Mines Inc. (25.17%), and OURD (Canada) Co. Ltd. (5.67%). The proposal is to mine the Midwest deposit (13,300 tU averaging 4.6% U) by open pit and to transport the ore to McClean Lake for milling. In 2008, Areva announced that development of the project would be postponed due to low uranium prices, although the environmental assessment process would continue. The environmental assessment of the project received regulatory approval in September 2012, allowing it to proceed to licensing. If the economics of the project improve

and Areva decides to proceed with developing the mine, it would take two years to construct the mine and a further two years to mine the ore. Milling of the Midwest ore is expected to take from five to seven years.

In August 2009, Cameco submitted a proposal to the CNSC to develop the Millennium deposit located 35 km north of Key Lake. The Millennium deposit has reasonably assured resources of 19,600 tU averaging 3.8% U. The Millennium underground mine would produce 150,000-200,000 t of ore annually for six to seven years. The ore and associated waste materials, other than clean waste rock, would be transported to the Key Lake mill along a new 21-km-long access road. In late 2012, Cameco announced that development of the Millennium deposit would be postponed due to low uranium prices, although the environmental assessment of the project would continue.

There is the possibility of uranium mines being developed outside of Saskatchewan in the near future. Areva is proposing to develop the Kiggavik and Sissons deposits in Nunavut, which contain an estimated 44,000 tU at an average grade of 0.47% U. The project is currently undergoing an environmental assessment and a feasibility study.

Other Developments Affecting Canada's Uranium Industry

Nuclear energy represents an important component of Canada's electricity sources. In 2012, nuclear energy provided close to 15% of Canada's total electricity needs (over 50% in Ontario) and should continue to play an important role in supplying Canada with power in the future. Canada has a fleet of 22 CANDU reactors, of which 19 are currently in full commercial operation in Ontario (18) and New Brunswick (1). One unit in Quebec was shut down at the end of December 2012 and two units in Ontario have been placed in guaranteed safe shut-down state.

In 2012, the environmental assessment associated with the development of new nuclear power at the Darlington nuclear power plant in Ontario was approved by the Government of Canada. The CNSC issued a site preparation licence for Darlington, which is the first of three licences required to build and operate a new nuclear facility in Canada. In June 2013, detailed analyses were submitted to Ontario Power Generation by the two prospective vendors. However, on October 10, 2013, the Government of Ontario announced that plans to build two new nuclear reactors at Darlington will be shelved due to the lack of growth in power demand in the province. Plans for refurbishing existing reactors will proceed. Details from the Government of Ontario on its future plans for nuclear new-builds and refurbishments are expected with the release of its updated Long-Term Energy Plan in late 2013.

Refurbishment projects in New Brunswick (Point Lepreau) and Ontario (Bruce A units 1 and 2) have been successfully completed and the reactors returned to service in the fall of 2012. Ontario's 2010 Long-Term Energy Plan, currently under review, foresees the refurbishment of up to 10 nuclear reactors (4 at Darlington, 2 at Bruce A, and 4 at Bruce B) by 2025 and the decommissioning of the Pickering nuclear station to start in 2020. The CNSC announced the approval of the environmental assessment for the proposed Darlington refurbishment project on March 14, 2013. Before the project can proceed, Ontario Power Generation will need to submit a licence application to the CNSC to be considered in a public hearing.

EXPLORATION

During 2012, exploration efforts continued to focus on areas favourable for the occurrence of deposits associated with Proterozoic unconformities in the Athabasca Basin of Saskatchewan and, to a lesser extent, similar geologic settings in the Thelon Basin of Nunavut and the Northwest Territories. Uranium exploration also remained active in the Otish Mountains of Quebec and in the Central Mineral Belt of Labrador. Very little exploration activity occurred in other areas of Canada in 2012.

Surface drilling, geophysical surveys, and geochemical surveys continued to be the main tools used to identify new uranium occurrences, define extensions of known mineralized zones, and reassess deposits that were last examined in the 1970s and 1980s.

Domestic uranium exploration expenditures were \$205 million in 2012, up 3.5% from 2011 expenditures of \$198 million. Over 70% of the combined exploration and development drilling in 2012 took place in Saskatchewan.

RESOURCES

Natural Resources Canada's (NRCan) annual assessment of domestic uranium supply capability provides a compilation of Canada's "known" uranium resources based on the results of an evaluation of company data. Uranium supply from Canada in the next decade will come from known resources, estimates of which are divided into three major categories (measured, indicated, and inferred) that reflect different levels of confidence in the reported quantities. Most of these resources are associated with deposits identified in Figure 1.

Recent NRCan assessments of Canada's uranium resources have been restricted to those recoverable from mineable ore at prices of \$300 per kilogram of uranium metal (kgU) or less. Table 2 shows the breakdown of the latest resource estimates, compared with those of the previous three years. As of January 1, 2013, total recoverable known uranium resources, recoverable at prices of less than \$150/kgU, were estimated at 495,000 tU, compared with 466,000 tU as of January 1, 2012. This increase is due to the identification of additional resources as a result of recent exploration activity.

SUPPLY CAPABILITY

Canada's supply capability will increase with the opening of the Cigar Lake mine and with approval of the proposal to expand McArthur River production by almost 20%. Timely licensing approvals and continued positive market conditions will be required to allow Canada's production capability to expand to its full potential of over 18,000 tU annually.

Table 3 currently ranks Canada second among the world's major producers based on actual uranium production from 2005 through 2012. Figure 2 illustrates Canada's share of world output in 2012 compared with other major producing countries.

URANIUM MARKET

Figure 3 shows the uranium spot market price from January 1996 to June 2013. During 2012, the price decreased from US\$51.75/per pound (lb) of uranium concentrate (U_3O_8) in December 2011 to US\$43.50/lb in December 2012. Long-term contract prices for uranium decreased from US\$62.50/lb

U₃O₈ to US\$56.00/lb during the same period. World production increased from 54,610 tU in 2011 to 58,394 tU in 2012, primarily due to increases in production from Kazakhstan, Australia, and Namibia.

The uranium supply is expected to increase slowly over the next few years as low uranium prices are limiting the development of new mines. Demand for mined uranium is expected to increase as the supply of secondary uranium from the United States-Russia agreement to disarm nuclear missiles will come to an end in 2013. Canada's production will increase significantly in 2014 when the Cigar Lake mine begins production, and much of that production could replace secondary supplies.

REFINING AND CONVERSION

Cameco operates Canada's only uranium refining and conversion facilities located at Blind River and Port Hope, Ontario, respectively. At the Blind River refinery, which is the world's largest, uranium mine concentrates from Canada and abroad are refined to uranium trioxide (UO₃), an intermediate product. The UO₃ is then transported to the Port Hope conversion facility, which has about one quarter of the Western World's annual uranium hexafluoride (UF₆) conversion capacity and currently provides the only commercial supply of fuel-grade natural uranium dioxide (UO₂). UF₆ from the Port Hope facility is exported and enriched outside Canada for use in foreign light-water reactors, while natural UO₂ is used to fabricate fuel bundles for CANDU reactors in Canada and abroad. About 80% of the UO₃ from Blind River is converted to UF₆, while the remaining 20% is converted to UO₂.

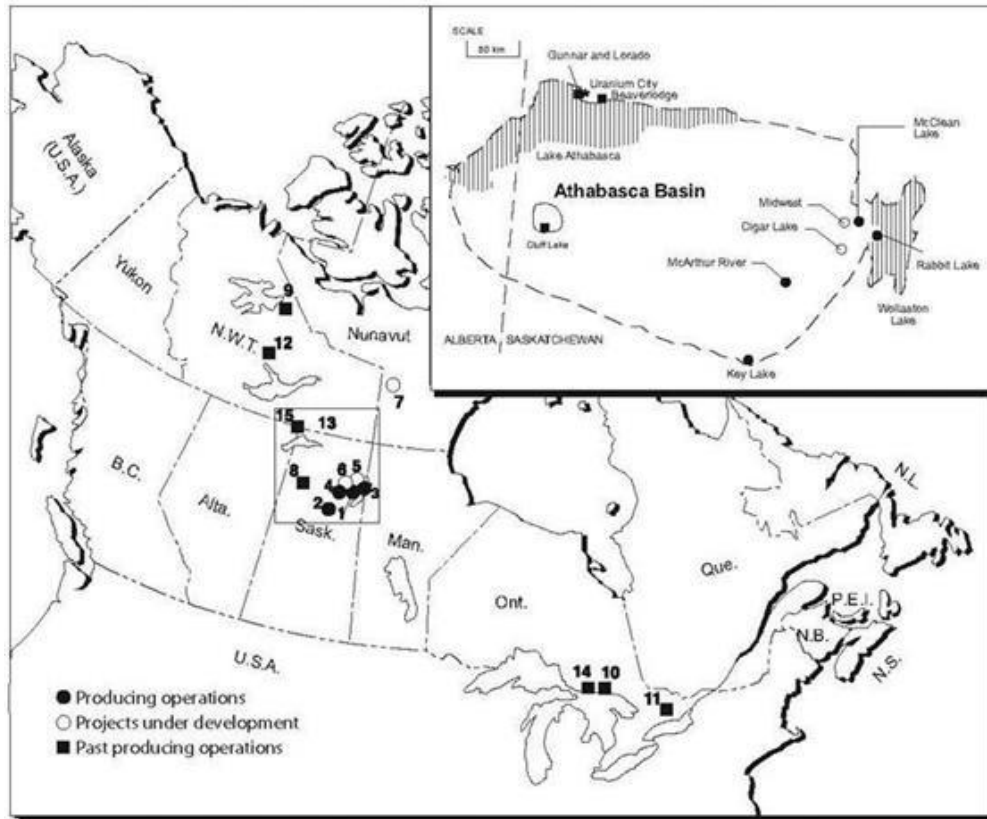
OUTLOOK

The prospect of a worldwide increase in the use of nuclear power, especially in Asia, indicates that future demand for Canadian uranium will increase. Significant quantities of Canadian uranium will be required to meet global demand well into the foreseeable future. With a large, low-cost uranium resource base, Canada is well positioned to remain a leading uranium producer for several decades.

¹The Ux Consulting Company, LLC (UxC) was founded in March 1994 as an affiliate of The Uranium Exchange Company (Ux). UxC publishes *The Ux Weekly* and the *UxC Market Outlook Reports* on uranium, enrichment, and conversion.

Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to the document entitled "Definitions and Valuation: Mineral Production, Shipments, and Trade." (2) Information in this review was current as of October 31, 2013. (3) This paper, and other information on developments in Canadian nuclear policy, can be accessed at nuclear.nrcan.gc.ca. (4) This and other reviews, including previous editions, are available on the Internet at www.nrcan.gc.ca/mining-materials/markets/commodity-reviews/8360.

Figure 1
Uranium Mining in Canada, 2012



Numbers refer to locations on map above.

PRODUCING OPERATIONS

1. Rabbit Lake
2. Key Lake
3. McClean Lake
4. McArthur River

PROJECTS UNDER DEVELOPMENT

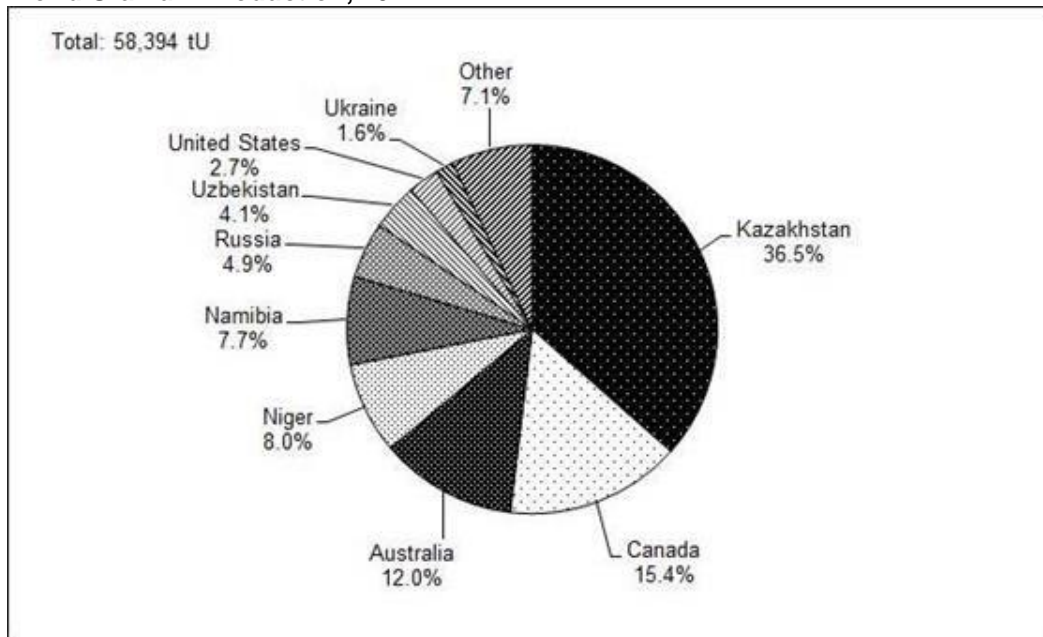
5. Midwest
6. Cigar Lake
7. Kiggavik

PAST PRODUCING OPERATIONS

8. Cluff Lake
9. Port Radium
10. Agnew Lake
11. Madawaska et al (Bancroft)
12. Rayrock (Marian River)
13. Beaverlodge et al
14. Quirke/Panel/Denison and Stanleigh et al (Elliot Lake)
15. Gunnar and Lorado et al

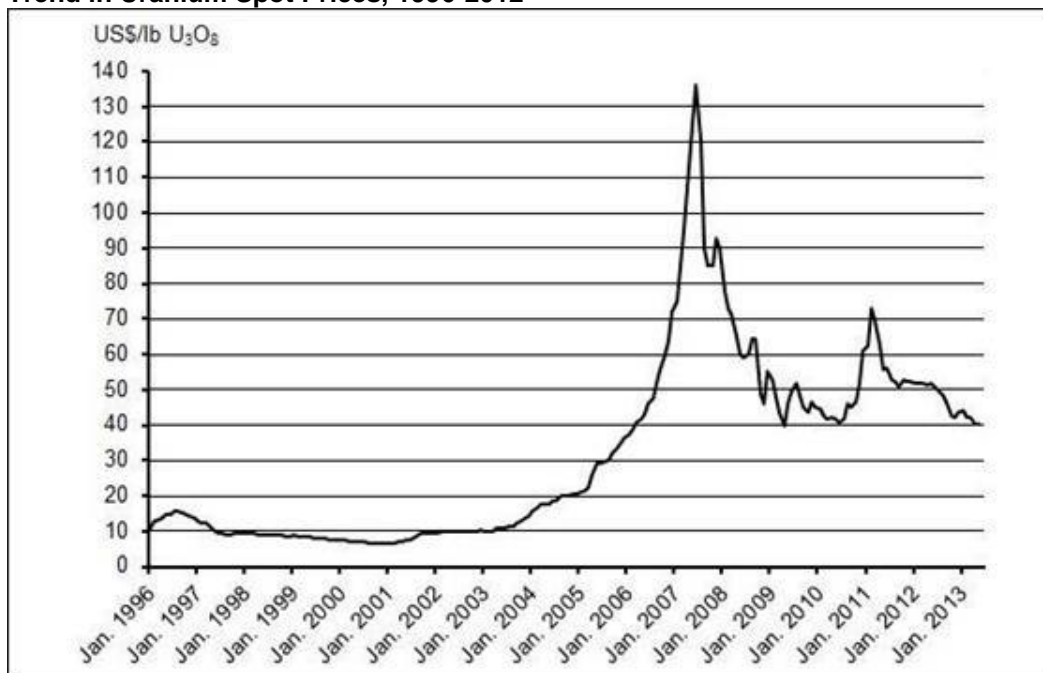
Source: Uranium and Radioactive Waste Division, Natural Resources Canada.

Figure 2
World Uranium Production, 2012



Source: World Nuclear Association.

Figure 3
Trend in Uranium Spot Prices, 1996-2012



Source: Ux Consulting Company.

TABLE 1. URANIUM PRODUCTION AND ASSOCIATED WORK FORCE IN CANADA, 2008-12

Production Centre and Producer	Company Work Force (1) (December 31)					Annual Output (2) (tU)				
	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
ATHABASCA BASIN, SASKATCHEWAN										
Rabbit Lake (Cameco, * 100%)	317	314	318	321	290	1,368	1,447	1,463	1,459	1,479
McClean Lake (Areva, * 70%; Denison Mines, 22.5%; Overseas Uranium Development Corp., 7.5%)	348	268	136	139	200	1,249	1,388	657	—	—
McArthur River-Key Lake (Cameco, * 70%; Areva, 30%)	751	797	851	856	871	6,383	7,339	7,654	7,686	7,520
Total	1,416	1,379	1,305	1,316	1,361	9,000	10,174	9,775	9,145	8,998
Total producer shipments (3)						8,703	10,131	9,927	8,690	(p) 9,661
Total value of shipments (4)						\$1,038,000	\$1,231,000	\$1,208,000	\$1,110,000	\$1,195,000

Sources: Natural Resources Canada; company annual reports.

* Operator; — Nil; (p) Preliminary; lb U₃O₈ Pounds of uranium concentrate; tU Tonnes of uranium metal (1 tU = 2,600 lb U₃O₈).

(1) Figures are for company payroll employees only; on-site contractors (mining, construction, services, etc.) are not included. (2) All McArthur River ore is blended with Key Lake special waste rock before milling at Key Lake. (3) Shipments are in tonnes of uranium contained in concentrate from ore-processing plants. (4) The value of shipments is estimated from a weighted average market price (spot price and long-term price).

TABLE 2. ESTIMATES OF CANADA'S URANIUM RESOURCES RECOVERABLE FROM MINEABLE ORE, (1) JANUARY 1, 2010; JANUARY 1, 2011; JANUARY 1, 2012; AND JANUARY 1, 2013

Price at Which Mineable Ore Is Assessed (2)	Measured				Indicated				Inferred				Total			
	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013
	(000 tU)															
Up to \$50/kgU	216	216	214	229	16	22	43	28	111	113	85	66	343	351	342	323
\$50 to \$100/kgU	—	—	—	—	29	54	54	62	11	11	14	34	40	65	68	96
\$100 to \$150/kgU	5	4	4	4	25	23	24	35	14	25	28	37	44	52	56	76
Subtotal	221	220	218	233	70	99	121	125	136	149	127	137	427	468	466	495
\$150 to \$300/kgU	5	3	4	4	27	100	95	93	104	44	57	60	136	147	156	157
Total	226	223	222	237	97	199	215	218	240	193	181	196	563	615	618	651

Source: Natural Resources Canada.

— Nil; kgU Kilograms of uranium metal; lb Pound; tU Tonnes of uranium metal; U₃O₈ Uranium concentrate.

(1) Actual or expected losses in mining recovery and ore processing have been accounted for; these factors were individually applied to resources tributary to existing or prospective production centres. In underground operations, mineable ore is generally 75-85% of the ore-in-place; higher mining recoveries are achievable in open-pit operations. Canada's weighted average ore processing recovery for existing conventional operations exceeded 97% over the survey period. (2) The Canadian dollar figures reflect the price of a quantity of uranium concentrate containing 1 kg of elemental uranium. The prices were used in determining the cut-off grade at each deposit assessed, taking into account the mining method used and the processing losses expected.

Note: \$1/lb U₃O₈ = \$2.6/kgU.

TABLE 3. PRODUCTION OF URANIUM IN CONCENTRATES BY SELECTED MAJOR PRODUCING COUNTRIES, 2005-12

Country	2005	2006	2007	2008	2009	2010	2011	2012
	(tU)							
Canada	11,628	9,862	9,476	9,000	10,174	9,775	9,145	8,998
Australia	9,512	7,593	8,602	8,433	7,934	5,918	5,983	6,991
China	750	750	710	770	1,200	1,350	1,500	1,500
Kazakhstan	4,346	5,281	6,633	8,512	14,020	17,803	19,451	21,317
Namibia	3,146	3,076	2,832	4,365	4,626	4,503	3,258	4,495
Niger	3,322	3,443	3,193	2,993	3,425	4,197	4,351	4,667
Russia	3,285	3,190	3,413	3,520	3,565	3,562	2,993	2,872
South Africa	673	534	540	566	563	582	582	465
United States	1,171	1,805	1,747	1,492	1,594	1,630	1,537	1,596
Uzbekistan	2,300	2,270	2,270	2,283	2,657	2,874	3,000	2,400
Other	1,810	1,813	1,828	1,824	1,768	2,476	2,810	3,093
Total	41,943	39,617	41,244	43,758	51,526	54,670	54,610	58,394

Sources: *Uranium: Resources, Production and Demand*, a biennial report published jointly by the Nuclear Energy Agency of the OECD and the International Atomic Energy Agency; miscellaneous corporate, national, and international reports.

tU Tonnes of uranium metal.