

Uranium resources: plenty to sustain growth of nuclear power

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What are the main drivers for price increases in recent years?

One reason is the rising expectations today for nuclear power. These in turn are driven by growing global energy needs, concerns about the security of energy supplies, specific plans for nuclear expansion in a number of countries, and increasingly stringent environmental constraints, such as the entry into force of the Kyoto Protocol last year and the launch of the EU Emissions Trading Scheme. Second is the lack of exploration and new mine development because the price has been so low so long. It has been low partly because the industry has been working down big inventories that had been built up in earlier years when production consistently exceeded demand. And it has been low partly because after the Cold War uranium has been released to the market from military programmes. But now those so-called secondary sources appear to be drying up, and that has contributed to the steady increase in prices since 2001. Also the weakness of the United States dollar, which experienced a significant decline against major world currencies beginning in 2002 and is the currency used in many uranium transactions, has also contributed. Additionally, a series of events in recent years have created uncertainty that has helped push prices upwards. These include: a fire at the Olympic Dam mine in Australia, flooding in the McArthur River mine in Canada, uncertainties concerning continued operation of the Rössing mine in Namibia and the temporary shutdown of the Metropolis uranium conversion facility in the United States.

What impact does the price of uranium have on the price of electricity?

The cost of uranium represents only a few percent of the total cost of generating nuclear electricity and therefore uranium price volatility is not a major concern for nuclear power plant owners/operators. The cost of reactor fuel represents about 15% of the cost of nuclear electricity, and a third of the fuel cost is due to uranium. In comparison, doubling the price of natural gas would increase the cost of electricity produced by natural gas by about 75%.

How high can prices go and at what price do they start to become a problem for expanding the use of nuclear energy?

Given that uranium is a marketable commodity subject to many different factors, it is not possible to forecast prices. What can be done is to provide some context for recent price increases. Uranium prices reached their historic high in the mid-1970s as a result of general concerns about a possible uranium supply shortfall related to growing reactor orders, coinciding with significant military requirements. Prices began to stagnate in 1982, drifting down to an historic low in late 2000 before beginning an upward trend that continues today. In both current and constant dollars the uranium market price peaked between 1976 and 1978. The most recent spot market price of about USD 112/kgU (USD 43/lb U3O8)¹ is under half the inflation-adjusted peak price of USD

¹ Spot price as of 26 May 2006 from TradeTech, LLC (www.unuranium.info)

243/kgU in 1976 and 1977. Given the relatively moderate impact that uranium price has on electricity costs and the effect these price increases have had on stimulating needed exploration and production, there appears to be small cause for concern at the moment despite this recent steep price rise.

What are secondary sources?

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 spent reactor fuels and from surplus military plutonium.
- Uranium produced by re-enrichment of depleted uranium tails.

How long will secondary sources last?

Secondary sources are expected to decline, but right now it's impossible to predict exactly how long they will last.

Remaining stocks that *might* become available for commercial reactors are estimated at 666 000 tU. These would last for 10 years if they supplied 100% of 2004 reactor requirements and for 20 years if they covered 50% of requirements as has been the case in the recent past. However, some portion of this 666 000 tU will likely always remain reserved for military uses.

Are any new mines planned on being opened in the near future?

By 2010, about 20 new or expanded production centres are expected to be put into operation, which, if all successfully begin production and reach full capacity, would add around 30 000 tU of production capacity. This would be a 60% increase over 2005 production capacity.

How long does it take to put a new mine into production?

The time from discovery to operation has steadily increased from just a few years in the early 1950s to as much as 20-30 years today. But it varies depending on commercial considerations; environmental challenges; technical difficulties; national policies and regulatory requirements.

Who are the major producers of uranium?

The seven leading producers, in descending order, are Canada (29% of 2004 world production), Australia (22%), Kazakhstan (9%), the Russian Federation (8%), Niger (8%), Namibia (8%) and Uzbekistan (5%). Together these seven countries provided 89% of the world's output. Uranium was produced in 19 countries altogether in 2004, although less than half produced significant quantities. World uranium production was 40 263 tU. In OECD countries, 2004 production was 21 956 tU.

Who are the major users of uranium?

The largest users in 2004 were the United States (24 145 tU), France (7 185 tU), Japan (7 140 tU), Russia (4 740 tU) and the Republic of Korea (3 200 tU). Thirty-one countries used uranium in commercial nuclear power plants in 2004, with total requirements of 67 320 tU.

Are there security of supply issues?

Two important advantages of nuclear energy in regard to security of supply are, first, ready access to the raw material – natural uranium – because of the geopolitical distribution of uranium resources and production capabilities and, second, the ease with which users can maintain strategic stockpiles of fuel. The geopolitical distribution of uranium resources and production reduces the risk of supply disruption. Significant uranium resources exist in countries as diverse as Australia, Canada, Kazakhstan, Namibia, Niger, Russian Federation, South Africa and the United States.

The two major producers, Canada and Australia with 29% and 22% respectively of total production in 2004, are OECD countries and most other major producing countries, e.g., Kazakhstan, Niger, Namibia, Russian Federation and Uzbekistan, each contribute less than 10% of the total.

Additionally, the other steps in turning raw uranium into finished fuel are also geographically diversified and often contained entirely within OECD member countries. Enrichment and fuel fabrication production capacity exceeds requirements in the OECD, making it self-sufficient in these areas. Conversion services capacity roughly matches requirements in Europe and America regions. Only the Pacific OECD region requires imports.

Any risk to supply security is not related to uranium availability or political stability, but to the time required to move from discovery to production, particularly if demand increases rapidly.

This has become an increasingly lengthy process, and governments have a role in ensuring that licensing requirements are efficient and timely while meeting all environmental needs.

Some people are saying there is not enough uranium to make a significant difference to the world's energy problems in the medium term. Is that correct?

Identified resources are sufficient for over eight decades at current usage rates. This compares very favourably with most other resources. As is the case with other mineral commodities, companies are not inclined to fund exploration for new resources too far in advance of actual need. Exploitation of Prognosticated and Speculative resources could increase this to several hundred years, though significant exploration and development would be required to move these resources to more definitive categories. However, given the limited maturity and geographical coverage of uranium exploration worldwide, there is considerable potential for discovery of new resources of economic interest.

There are also considerable other resources, labelled "unconventional", including uranium associated with phosphate deposits. These could lengthen the time that nuclear energy could supply energy demand using current technologies to more than 600 years. Further, deployment of advanced reactor and fuel cycle technologies could multiply all these numbers by a factor of at least 30. Fast reactors have been built and operated on a developmental basis, but are not yet commercially available. Development work to bring them to the point of commercial availability is continuing.

In addition, thorium, which is more geologically abundant than uranium in the earth's crust, is also a potential source of nuclear fuel, if alternative fuel cycles are introduced. Thorium-fuelled reactors have already been demonstrated and operated commercially in the past.

What are the major challenges to expanding production of uranium in the near future?

There are country-specific challenges such as adequacy of infrastructure (e.g. Kazakhstan), government policy (e.g. Australia) and public concerns (e.g. Canada). Other challenges are more general. They include:

- A potential lack of experienced personnel. An expanding industry needs qualified personnel, without which, longer lead times are needed and fewer projects can be developed. A large number of qualified personnel will be needed to ensure the necessary expansion in production. It will take time to develop these human resources.
- Possible policy uncertainty. Reducing regulatory uncertainty and minimising non-competitive governmental market interventions should be considered as key elements in promoting confidence in the long-term economic viability of the industry.
- Infrastructure requirements. In some cases, uranium mining occurs in remote locations where it is difficult to provide the necessary infrastructure.
- Price stability. Confidence in the long-term stability of higher uranium prices will be necessary to provide the required time and capital to significantly expand production.

Have recent price increases led to increased exploration?

Yes, the increase in the uranium spot price has stimulated interest and exploration. Worldwide exploration expenditures in 2004 totalled over USD 133 million, an increase of almost 40% compared to 2002 expenditures. Most major producing countries reported significant increases in exploration expenditures, perhaps best exemplified by the United States, where exploration expenditures in 2002 amounted to less than USD 1 million but by 2004 had jumped to over USD 10 million. About 50% of the exploration expenditures in 2004 were devoted to domestic activities. Non-domestic exploration expenditures, although reported by only Australia, Canada, France and Switzerland, rose to over USD 70 million in 2004, more than four times the non-domestic exploration expenditures reported in 2002, although only Canada and France reported data for 2002. Exploration spending is expected to significantly increase again in 2005, with total (domestic and non-domestic) expenditures projected to amount to over USD 195 million.

How much uranium is out there?

Uranium resources are reported by confidence level and production cost category. In 2005, 32 countries reported total conventional resources in all confidence and cost categories of 14.8 million tU. This is enough for over 250 years at current consumption rates and over 8 000 years if fast reactor technology and recycling are used.

Total World Uranium Resources (1 Jan 2005)

Resource Category	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	
Reasonably Assured	1 947 000	2 643 000	3 297 000	
Inferred	799 000	1 161 000	1 446 000	
Prognosticated	NA	1 700 000	2 519 000	
Speculative	NA	NA	4 557 000	
Total	2 716 000	5 504 000	11 819 000	14 798 000*

* Includes 2 979 000 tU of Speculative Resources with no recovery cost estimate is assigned.

Phosphate deposits, which contain large quantities of uranium exploitable at around the current spot price, could add a further 22 million tonnes to these estimates.

How about thorium resources? Does the Red Book cover Thorium Resources? What is the present status of thorium resources and what role could thorium play in a nuclear power programme?

Thorium is more abundant than uranium, widely dispersed and could also be used as a nuclear fuel source. Historically, the first edition of the Red Book, published in 1965, was titled, *World Uranium and Thorium Resources*. Because of the near absence of a commercial market for thorium, though, the second edition of Red Book, published in 1967, was re-titled *Uranium Resource Revised Estimates*, where thorium occupied only a short section of the report. The last specific information published on thorium in the Red Book was in 1986.

Existing estimates of thorium resources total more than 4.5 million tonnes (reserves and additional resources). 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.

Thorium-based fuels and fuel cycles have been used in the past and are being developed in a few countries but have yet to be commercialised.