VAGARIES OF THE URANIUM MARKET

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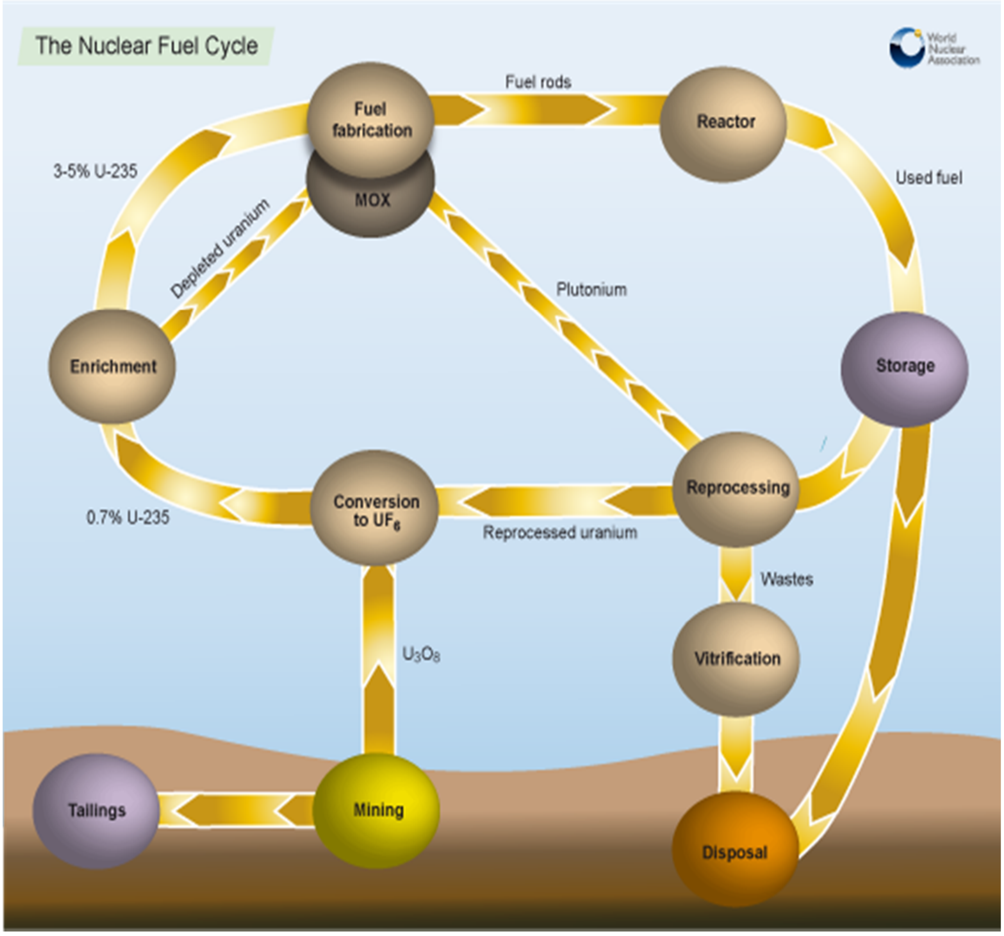
Introduction

There are essentially two uses for uranium: weapons and electricity. These have often been interconnected. The **market for weapons** only emerged globally in the wake of the Manhattan Project in the latter half of the 1940s, and was spurred on by the arms race associated with the Cold War, after Truman made the decision not to internationalise the weapons by placing them under the control of the UN. **Nuclear electricity** found its first commercial expression in 1956, when Queen Elizabeth II opened the first civilian nuclear reactor at Calder Hall in northern England. There are now approximately 435 civilian nuclear power plants in the world.

Both weapons and energy are derived from the processes entailed in the **nuclear fuel chain**[1]. The front end of the chain refers to the links evident in the run up to energy production in the reactor, whereas the back end refers to the proliferation of weapons and the disposal of nuclear waste.

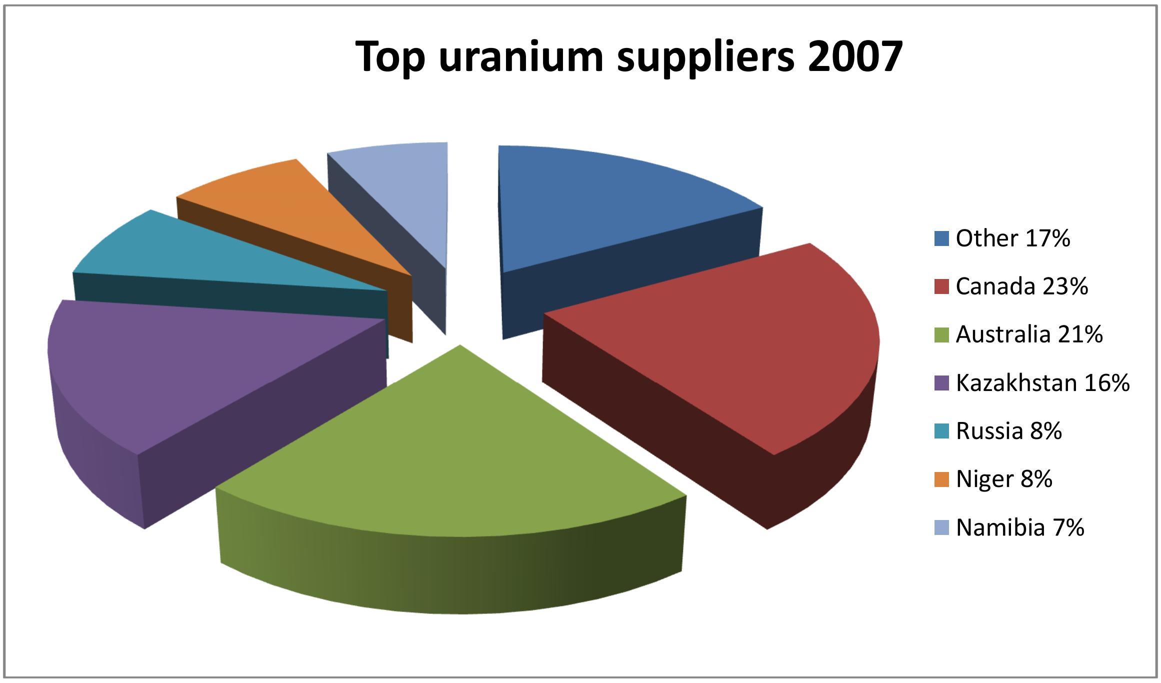


Mining of uranium is the first link in the chain. Up to 1945 the industry was aware of small deposits in Czechoslovakia, Germany, Portugal and the Belgian Congo. In fact the uranium for the first nuclear weapons came from the mines in the Congo's Katanga

[1] Interesting how the nuclear industry calls this the nuclear fuel **cycle** on the pretext that a cycle is in harmony with other natural processes (cf. the water cycle).

province. From 1945, production was globalised. Large deposits were obtained from Australia, Canada, South Africa, the USA and the USSR.

The more recent picture currently looks something like this:



Uranium mining is a very ecologically damaging link in the nuclear chain. For every tonne of uranium oxide (U_3O_8) produced, hundreds of thousands of tonnes of wastes, or tailings, remain. Inevitably the tailings are mismanaged by being dumped on the land near the mine and exposed to weather, waste spills and erosion. The mine wastes or tailings still contain about 80% of the radioactivity of the original ore. Uranium-238, the most prevalent isotope in the ore, has a half-life of about 4.5 billion years; that is, only half the atoms will decay in that amount of time. Radioactive dust as well as radioactive radon gas are found in the tailings and are carried by wind for great distances. Miners and householders are exposed to the radon gas, and consistently suffer increased rates of lung cancer.

Uranium mining requires a great deal of water. For example, BHP Billiton's Olympic Dam mine in South Australia, the country's driest state, uses 33 million litres of water per day. A proposed expansion of the mine would increase this to up to 162 million litres per day. This water becomes radioactive waste, placed into evaporation ponds that are inadequately secured from leaking and flooding. Contaminated rainwater can and does enter the soil and, eventually, the food chain, endangering health.

In addition, indigenous peoples' lands have been used to mine uranium, dump radioactive wastes and to test nuclear weapons, both above-ground and below-ground, resulting in massive radioactive contamination.

But what are the key characteristics of the uranium market today? We know that mined uranium only supplies about 75% of the electricity industry's needs, the rest being provided by the use of uranium derived from dismantled nuclear weapons and other existing inventories including:

- recycled uranium and plutonium from spent fuel, as mixed oxide (MOX) fuel,
- re-enriched depleted uranium tails,
- ex-military weapons-grade uranium,
- civil stockpiles, and
- ex-military weapons-grade plutonium, as MOX fuel.

Major commercial reprocessing plants are operating in France and UK, with capacity of over 4000 tonnes of used fuel per year. The product from these re-enters the fuel cycle and is fabricated into fresh mixed oxide (MOX) fuel elements. About 200 tonnes of MOX is used each year, equivalent to less than 2 000 tonnes of U_3O_8 from mines.

Military uranium for weapons is enriched to much higher levels than that for the civilian reactors. Weapons-grade is about 97% U-235, and this can be diluted about 25:1 with depleted uranium (or 30:1 with enriched depleted uranium) to reduce it to about 4%, suitable for use in a power reactor. From 1999 to 2013 the dilution of 30 tonnes of such material is displacing about 10,600 tonnes per year of mine production.

The USA and Russia have agreed to dispose of 34 tonnes each of military plutonium by 2014. Most of it is likely to be used as feed for MOX plants, to make about 1 500 tonnes of MOX fuel which will progressively be burned in civil reactors.

Uranium pricing

Usually mineral commodity markets fluctuate regularly over time, with a trend towards long-term decline depending on the level of technological progress and other factors. In the uranium market, however, depressed prices were evident throughout the 1980s and 1990s, with spot prices generally below the cost of production for all but the lowest cost mines. The spot market prices usually represent less than 20% of supply, since most trade is via 3- to 15- year contracts with producers selling directly to utilities. The contacted price in these contracts is, however, often related to the spot price at the time of delivery.

The spot price

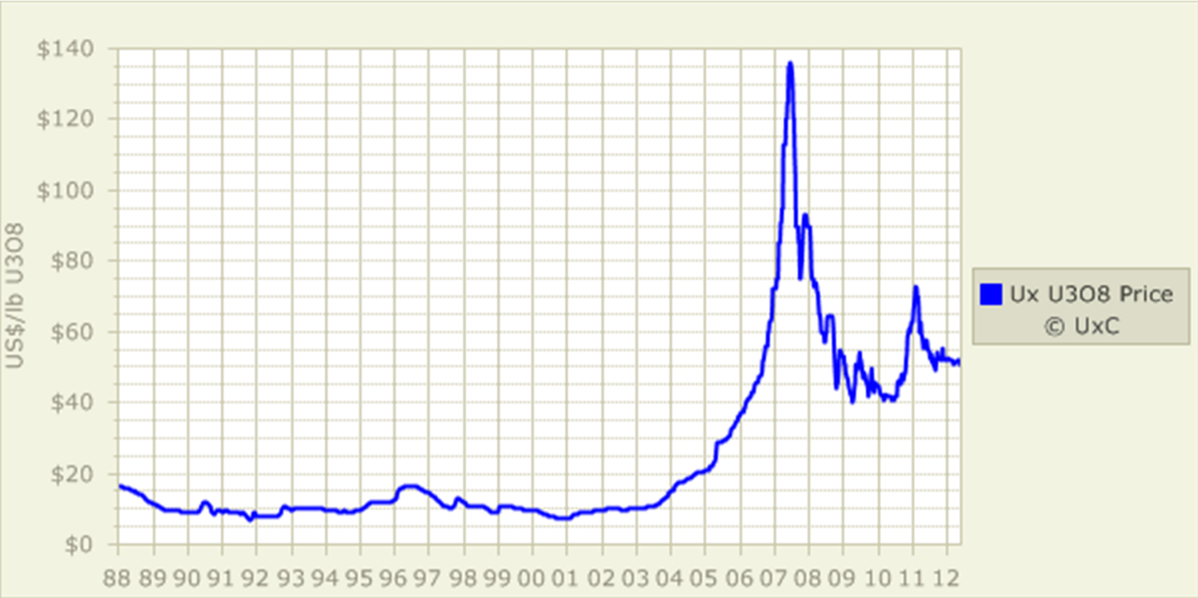
As mentioned, the depressed spot price for uranium stayed steady for over two decades, at around US$20/lb of uranium oxide ($U_3O_8$). The sudden surge from 2006-09 may be accounted for by a similar surge in petroleum prices globally, and a generalised commodities boom. However, the surge in the uranium spot market did not prove sustainable. Part of the reason for the original rise was the 'nuclear renaissance' talk within the industry which assumed sustained and massive future growth. This renaissance concept was finally put to bed in the wake of the serious accidents at Fukushima, Japan.

The short-lived boom had a number of consequences: it allowed for new investment, particularly in vulnerable African countries, where it was invited in by local elites who saw it as a great opportunity for enrichment (in the name of socio-economic development[2]). Sudden expansion in uranium mining was experienced in Africa despite a deficit in regulatory control, poor infrastructure (leading to water and other crises), and land grabs (including concessions granted inside national parks which African countries had heretofore pledged to protect.)

In some cases, older mines that had reached the extent of their economic viability under the old pricing, found that with the boom they were able to extend the life of their operations for a number of decades into the future.

[2] Although, owing to the 'resource curse', expansion of the industry seldom leads to resolution of mass poverty and unemployment in the country that hosts the resource.

Spot price for uranium, 1988-2012.



In general, larger investors had room to cease the mothballing of existing investments, or to extend their operations in specific countries. However, the boom attracted a new set of investment companies, quoted either on the Canadian or Australian stock exchanges, and which had very little available capital, orr uranium mining experience. By securing concessions in Africa at an early stage in the upward wave, they were placed in a position of being able to offer new investors a chance to benefit from the boom. Opportunist companies evolved out of very little practical background in mining. Nevertheless, some, like Paladin Resources, an Australian enterprise, were able to build new mines in Africa relatively quickly, and therefore transformed from a paper company with few holdings, to one which was fully regarded as being in the business.

Example of the expansion of uranium mining in Africa during the boom:

1. Namibia --- around twenty new concessions granted, mostly in the arid Namib desert, where fresh water has proven to be a limiting factor. One extra mine, Langer Heinrich, has been opened inside the Namib-Naukluft National Park. Other mines may open, but under constraints. The longstanding Rossing mine, whose life was extended for eighteen years, is not proving as profitable as predicted. Areva, operator of the as yet unopened Trekkopje mine, has had to claw back on its investments.
2. Malawi --- Paladin has opened a mine in the north-western corner of the country, but this has already been the site of reported poor working conditions and environmental spills.
3. Tanzania --- prospecting has been occurring in the Bahi swamps in Central Tanzania, while a concession has been provided for mining inside the Selous National Park, a world heritage site registered with UNESCO.
4. Niger --- a large global supplier through the existing two mines of Areva, which have caused environmental and social havoc in the Touareg-inhabited areas of the north, and where the population is now dependent on the mining company for

drinking water. Areva has slowed down on the development of a third mine in the country.

5. Mali --- prospecting is occurring in the villages of the Falea commune in south-east Mali, much against the wishes of the community and traditional authorities, by an unknown Canadian company called Rockgate.
6. Zambia --- uranium obtained from a copper mine is being stockpiled above ground with little protection for citizens or environment.
7. Central African Republic --- the Bakouma mine, operated by Areva, is a constant target of a number of rebel groups; Areva is scaling down its operations in view of a slump in the uranium price after Fukushima.
8. Elsewhere --- Exploration and exploitation of the uranium resources of DRC, Senegal, Zimbabwe, Cameroun, Chad and South Africa are continuing to some extent.

Key players in uranium mining:

In 2005, eight global mining companies comprised 78% of uranium production:

COMPANY	BASE	NATURE	MINING
Cameco **www.cameco.com**	Canada	Publicly quoted company	Production in Canada, Australia, Kazakhstan
Rio Tinto **www.riotinto.com**	UK/Australia	Publicly quoted company	Production in Australia, Namibia (16% of global production)
Areva **www.areva.com**	France	State owned company, apart from mining is engaged in reactor production and the provision of nuclear services	Exploration &/or production in Australia, Canada, Jordan, Kazakhstan, Mongolia, Namibia, Niger, Senegal, S Africa and USA
KazAtomProm **www.kazatomprom.kz**	Kazazhstan	State-owned company	Production in six ore provinces of Kazakhstan (19% of global uranium reserves)
BHP Billiton **www.bhpbilliton.com**	UK/Australia	Publicly-quoted company	Production at Olympic Dam, Australia
TVEL www.tvel.ru (Russian)	Russia	Part of Atomenergoprom holding company, 100% state-owned	Production in Russia
Navoi **www.nkmk.uz**	Uzbekistan	State mining combinat	Production from 20 sites in Uzbekistan

Demand

About 435 reactors with combined capacity of over 370 gigawatts (GWe), require 77,000 tonnes of uranium oxide concentrate containing 65,500 tonnes of uranium (tU) from mines (or the equivalent from stockpiles or secondary sources) each year. The capacity is growing slowly, and at the same time the reactors are being run with higher capacity factors, and reactor power levels. However, these factors increasing fuel demand are offset by a trend for increased efficiencies, so demand is dampened - over the 20 years from 1970 there was a 25% reduction in uranium demand per kWh output in Europe due to such improvements, which continue today.

Each GWe of increased capacity will require about 200 tonnes of uranium per year of extra mine production routinely, and about 400-600 tonnes for the first fuel load.

Because of the cost structure of nuclear power generation, with high capital and low fuel costs, the demand for uranium fuel is fairly predictable over time. It is very cost-effective to keep reactors running at high capacity, but some older reactors have to be shut for some months every cycle of eighteen months in order to replace the fuel. Demand forecasts for uranium thus depend largely on installed and operable capacity, regardless of economic fluctuations.

Prior to Fukushima, it was expected that the ‘renaissance’ would see the market grow significantly. The World Nuclear Association (reactor operators) constructed a reference scenario showing a 33% increase in uranium demand over 2010-20 (for a 27% increase in reactor capacity - many new cores will be required). Demand thereafter will depend on new plant being built and the rate at which older plant is retired - the reference scenario has a 16% increase in uranium demand for the decade to 2030. Licensing of plant lifetime extensions and the economic attractiveness of continued operation of older reactors are critical factors in the medium-term uranium market. However, with electricity demand by 2030 expected (by the OECD's International Energy Agency, 2008) to double from that of 2004, there seemed plenty of scope for growth in nuclear capacity. However, the industry failed to take into account the latest serious nuclear catastrophe in Japan (March 2011).

Responses to Fukushima

Demand is likely to fall in a number of countries that have considered their options since responding to the Fukushima accident. Principal of these is **Germany**, which has opted to scale down its nuclear energy production to zero within a decade, closing down the remaining 9 out of 17 reactors still operating (22% of the country's electricity production).

Switzerland also acted to Fukushima by announcing a phase-out of its 5 existing reactors, which produce up to 44% of the country's electricity. **Italy** confirmed its commitment to a non-nuclear future in a referendum of June 2011, which scotched plans by prime minister Berlusconi to revive the local industry.

Japan closed its last functioning nuclear reactor on 5 May 2012, but it is likely to reopen a couple run by Kansai Electrical Power Co. for contractual reasons. Even if two units reopen, the vast bulk of Japan's reactors (over 50) will remain closed.

China's new nuclear-build programme has been slowed down considerably in the face of concerns over safety raised by the Fukushima accident. This slow-down mirrors the slow-down in GDP growth in China, indicating a phase of economic recession which may affect the nuclear-build programme in the medium term.

Brazil has announced it will be completing a longstanding nuclear reactor under construction (Angra III) but then abandoning further plans to expand its industry.

The year 2011 was the first year in the history of nuclear power plants that construction of no new plants was initiated.

President Obama has continued the programme initiated by George Bush jr to give high federal subsidies to the construction of new reactors. The UK, whose industry is now controlled by French state-owned EdF and Areva, has said that it would replace any reactors phased out due to old age with new models. It remains to be seen whether Britain's austerity measures will be able to allow the country to afford to replace its ageing fleet.

The French-built EPR, the European pressurised reactor, is in deep trouble wherever construction of it has been attempted. The two existing examples are Finland and France itself, where design flaws have led to considerable cost and time overruns. The extreme costs of the EPR was a factor which led the United Arab Emirates to choose a South Korean rival (KEPCO) to build its two nuclear reactor orders.

In **South Africa**, government is bent on ordering 9,6 GWe (9600 megawatts) of new installed reactors, amounting to between six and eight reactors, depending on size and cost. An amount of R300 billion (€30bn) has been set aside for this in the latest budget, although estimates for the full programme have been as large as R1 trillion (€100bn). There are huge concerns about questions of international indebtedness, lack of energy security (construction will be by transnationals), deep centralisation of energy supply, huge cost and time overruns, possibilities for enormous corruption (the infamous 'arms deal' which is still under judicial enquiry was over a much smaller amount of R67 billion or €7bn), weak regulation, big contribution to fossil fuel burning (mining, enrichment, decommissioning, etc.) and clear alternatives in the form of renewable energy and energy savings.

Who might supply South Africa's future reactors?

SUPPLIER	HOST COUNTRY	REACTOR	COMMENT
Areva	France	EPR	Built Koeberg in 1980s. Difficulties in construction currently experienced. Expensive. Former CEO Lauvergeon had seat on Pres. Zuma's international investment council.
China Guangdong	China	CPR1000	Based on earlier Framatome model, same as at Koeberg
KEPCO	South Korea	OPR1000 or APR1400	Won contract in UAE
Rosatom	Russia	VVER	
Westinghouse	US, owned by Toshiba, Japan	AP1000	Facing regulatory roadblocks in US
GE- Hitachi	US & Japan	ABWR, ESBWR	Constructors of the Fukushima reactors

Bidding or tendering is said to be scheduled for later in 2012.

Lessons of Fukushima in the marketplace for uranium

In the aftermath of the disaster at Fukushima, many reactor projects worldwide have been delayed, and in some cases, new reactors have been cancelled. The reduction in demand stemming from the Fukushima accident essentially negates much of the reduction in supply resulting from the end of the HEU deal over the next few years. Inventories will likely play a larger role in the near term with reactors being shut down permanently or kept offline for extended periods to address safety concerns. However, with downward pressure on U3O8 prices, planned production and exploration will be delayed/deferred until inventories are absorbed. To the extent that production growth stalls in the near term (as we have already witnessed in 2011), this sets up for a potentially volatile second half of this decade since uranium demand is projected to recover rapidly with China's nuclear generation expanding at a rapid rate and new countries, such as the U.A.E. and Saudi Arabia, expected to advance their nuclear power programs.

Even if there is a uranium demand foreseen by optimists in the industry as increasing by 27% in 2020 and by 56% in 2030, it will be critical for new production to come online. But meeting this higher demand could prove very challenging given the difficulty to finance new projects in the current market environment. And as exploration slows, this also pushes off the development time for the next wave of new uranium projects. There are also the complex economic, environmental, strategic and geopolitical issues facing various operating and planned uranium projects over the next 10 years.

Early evidence of the difficulties faced by uranium suppliers include the following:

At its AGM in Paris in May 2012, Areva announced it was cutting back on its Africa uranium mining investments, particularly in Niger, Namibia, South Africa and the Central African Republic. Share prices dropped about 45% between January and May 2012.

At Rossing, Namibia's largest uranium mine, majority owned and operated by Rio Tinto, the results were also a setback for those believing in a 'renaissance": in 2011 the mine made a loss of N$471 million, ten times greater than the loss of N$43 million the previous year. MD Chris Salisbury largely attributed this to lower global demand in the wake of the Fukushima disaster.

In practice, global prices are likely to weaken to the point where expanded production is no longer economically feasible, even for existing well-endowed mining giants, unless major state subsidies are forthcoming, as in the USA.