Uranium Supply and Mining

- The uranium mining industry is booming, with around 50 mines in 16 countries.
- Three companies, Cameco, Rio Tinto and Areva, account for almost half of global uranium production.
- More than half of uranium supplies come from Canada and Australia.
- Digging uranium out of the ground is extremely environmentally damaging and even more damaging leaching processes are being introduced.
- Uranium milling leaves behind millions of tonnes of radioactive and toxic sludge or tailings, which remain hazardous for thousands of years.
- Central and eastern Europe has 7000 old mines, dumps, ponds and plants which need cleaning up.
- Canada has three mines in Northern Saskatchewan. One is about to close. The other two have only recently opened but have already been criticised for bad waste management practises. Ontario has 170 million tonnes of radioactive tailings.
- Australia also has three mines; Ranger in Kakadu National Park has 30 million tonnes of tailings and has had over 120 leaks, spills and licence breaches; Olympic Dam has produced 60 million tonnes. Australian uranium mining has a pattern of non-compliance with regulations.
- Within the lifetime of reactors built today, the grade of uranium ore being dug out of the ground could fall dramatically causing an increase in carbon dioxide emissions from nuclear fuel manufacture. By about 2070 carbon emissions from the nuclear cycle could be about the same as from a gas-fired power station.

The Uranium Mining Industry

Uranium mining is a major worldwide industry with about 50 mines in 16 countries producing more than 40,000 tonnes of uranium per year. Business is booming. Uranium production increased 11 per cent between 2002 and 2004, and could double by 2010 to feed new nuclear reactors. (1) Industry consolidation left eight mining companies accounting for 78% of production by 2005, including Cameco (20%), Rio Tinto (13%), and Areva (12%).

More than half of the world's uranium supplies come from Canada and Australia. Canada produces 28% and Australia 23%. Kazakhstan is the third largest supplier producing 10% followed by Russia and Namibia who produce 8% each. (2)

Environmentally damaging

Digging uranium out of the ground is an even messier business than mining other ores, but mining methods have been changing over the last decade, as even more environmentally damaging processes are introduced. In 1990, 55% of world production came from underground mines, but this has shrunk dramatically to 38%. An increasing proportion (21%) is produced by in-situ leaching and open cast mining (30%).

New uranium deposits discovered in Canada have uranium ores with a uranium content of several percent, but most ores have a uranium content between only 0.1% and 0.2%. So large amounts of ore have to be mined to get at the uranium. (3)

Waste rock produced during open cast mining, or when driving tunnels underground, often contain elevated concentrations of radioisotopes compared to normal rock. Other waste piles consist of ore with concentrations of uranium too low for processing. These wastes are a threat to health and the environment after closure of the mine due to their release of radon gas and the leaching of water containing radioactive and toxic materials. To keep groundwater out of the mine during operation, large amounts of contaminated water are pumped out and released to rivers and lakes. When the pumps are shut down after closure of the mine, there is a risk of groundwater contamination from the rising water level.

With in-situ leaching (ISL), a leaching liquid (e.g. ammonium-carbonate or sulphuric acid) is pumped into underground uranium deposits, and the uranium bearing liquid is pumped out from below. This technology can only be used for some uranium deposits. ISL is used at the new Beverley mine in South Australia, where the uranium bearing acid which is pumped back to the surface also contains other heavy metals. The small amount of uranium is separated at the surface. The liquid waste — which contains radioactive particles, heavy metals and acid — is simply dumped in groundwater. Inert and immobile in the ore body, the radionuclides and heavy metals are then bioavailable and mobile in the aquifer. The mine owners have no plans to clean up the aquifer. There have been over 20 spills of radioactive solutions at Beverley. For example, in January 2002, 62,000 litres of contaminated water was spilt after a pipe burst, followed by a spill of 15,000 litres of contaminated water in May 2002. (4)

Uranium Milling

Ore mined in open cast or underground mines is crushed and leached in a uranium mill, usually located near the mine. Sulphuric acid or an alkaline is used as the leaching agent. As in the ISL process, the leaching agent extracts uranium from the ore, along with several other constituents like molybdenum, vanadium, selenium, iron, lead and arsenic. So uranium must be separated out from the leaching solution. The final product, commonly referred to as "yellow cake" (U_3O_8 with impurities), is packed and shipped in casks.

Tailings

When closing down a uranium mill, large amounts of radioactively contaminated scrap are produced, which have to be managed safely. But there will also be large quantities of contaminated leachate known as tailings. These tailings are normally dumped as a sludge in special ponds or piles, where they are abandoned. The largest such piles in the US and Canada contain up to 30 million tonnes of solid material. In Saxony, Germany the Helmsdorf pile near Zwickau contains 50 million tonnes, and in Thuringia the Culmitzsch pile near Seelingstädt has 86 million tonnes of solids. (5)

The amount of sludge produced is nearly the same as the original ore milled. For example if the grade of uranium is 0.1%, then 99.9% of the ore becomes waste. The tailings also contain radionuclides such as thorium-230 and radium-226. In fact the sludge contains 85% of the initial radioactivity of the ore, as well as heavy metals and other contaminants such as arsenic, and the chemical reagents used during the milling process. Tailings are often held in place by tailings dams, which may not be stable constructions, and failures of tailings dams have occurred on numerous occasions. (6)

Mining and milling moves hazardous constituents in the ore from their relatively safe underground location and converts them to a fine sand, then sludge, making them more susceptible to dispersion in the environment. The chemical processes used to extract the uranium also cause additional hazards to the environment. Radioactive radon-222 gas emanates from tailings piles presenting a long-term hazard for around 1 million years. Tailings are subject to various kinds of erosion: wind, rain, burrowing animals, penetration by plant roots. These can enhance radon emissions or cause radioactive contamination of groundwater through seepage.

Europe - seven thousand uranium clean-up projects.

An unpublished survey for the European Union completed in 2002 found over 7000 old mines, dumps, ponds and plants that needed cleaning up in 11 central European countries. (7)

In the mountain village of Kara Agach in Kyrgyzstan, for example, there are 23 uranium waste dumps in a region prone to landslides and earthquakes. If one of them were to be dislodged, the Mailuu Suu river could be contaminated and threaten the health of the 25,000 people who live 3 kilometres downstream. Worse, it could carry pollution 20 kilometres over the border into Uzbekistan's Fergana valley, the country's main agricultural region (8) A study by Belgian and Kyrgyz scientists has shown that villagers are receiving radiation doses up to 40 times the internationally recommended safety limit, mostly from the food they grow. There are similar communities at risk elsewhere in Europe and Russia. In the former East Germany there is a $9 billion clean-up programme under way to tackle over 170 million tonnes of tailings dumped at 12 sites between 1946 and 1990. (9)

Canada

Canada is the world's largest producer and exporter of uranium. In 2004 it produced 11,597 tonnes U (tU/yr). Although Australia has far larger known resources, Canada is spending more on exploration. Most Canadian uranium now comes from rich surface deposits in Northern Saskatchewan.

Saskatchewan has two relatively new mines. Cameco's McArthur River is an underground mine which started up in 2000 producing 7200 tU/yr making it the largest mine in the world producing 17.3% of world supplies. Areva's McClean Lake is an open cast mine which started up in 1999 and is producing almost 2100 tU/yr (5.1% of world supply). A third mine at Rabbit Lake, also in Saskatchewan, run by Cameco, is expected to close in 2007. Cameco was planning to open another massive underground mine at Cigar Lake (also in Saskatchewan) in 2007 producing around 7000 tU/yr. (10) But, highlighting the vulnerability of new uranium supplies Cigar Lake became flooded in 2006 which means that production is not now expected to start before 2010. Cigar Lake was to account for nearly 40% of all new output, globally, forecast to come on stream within the next three years. (11)

There are also proposed mines in British Columbia and the Northwest Territories. The province of British Columbia has had a long history with uranium. A Public Inquiry was conducted into Uranium Mining in the late 1970’s, but the Provincial Government shut it down in 1980 before it could report and placed a seven-year moratorium on exploration and mining. The issue has now re-surfaced in the province with exploration going on in the area around Kelowna. (12)

Mines at Elliot Lake in Ontario illustrate the waste legacy left behind by uranium mines. These mines had massive but low-grade reserves of uranium, which were unable to compete with higher grades from North Saskatchewan and Australia, so they were all closed by 1996, leaving surrounding communities with 170 million tonnes of radioactive tailings, with a half-life of hundreds of thousands of years, which will "present a perpetual environmental hazard." (13)

Waste management standards are also criticised at the two recently opened mines. The Inter-Church Uranium Committee Educational Cooperative (ICUCEC) is concerned that uranium tailings at Areva’s McClean Lake Mine will contaminate groundwater with toxic chemicals including arsenic, radium & heavy metals, and that Canadian laws are grossly inadequate to protect the health of people and the environment. (14) Cameco’s McArthur River mine has also been criticised by the Canadian Nuclear Safety Commission for its handling in 2003 of a cave-in and flood of radioactive water. (15)

Australia

Australia holds around 40 per cent of the world's uranium deposits. The current federal government actively supports the development of new mines (in addition to existing mines Ranger, in the Northern Territory, and Olympic Dam (Roxby Downs) in South Australia). However, only one new mine has opened in the past decade — Beverley, also in South Australia. Opposition to any new mines from the Labor Party has helped to stifle expansion. Labor currently holds power in all States and territories, so its policy is crucial. The Party is now under intense pressure to change its position at its April 2007 conference. (16)

The adverse environmental impacts of uranium mining in Australia have been significant. In 2005, Energy Resources of Australia (ERA), which operates the Ranger mine, and is majority owned by Rio Tinto, was prosecuted following a series of severe radiation safety failures. (17) Ranger has, so far, produced over 30 million tonnes of radioactive tailings, and there have been more than 120 documented leaks, spills and licence breaches at the Ranger uranium mine in Kakadu National Park since the mine opened in 1981. The incidents have got more severe and more frequent as the infrastructure has aged. (18)

Olympic Dam has produced 60 million tonnes, growing at 10 million tonnes per year, with no plans for its long-term management. Serious questions over the long-term management of these toxic tailings remain unanswered. The mine's daily extraction of over 30 million litres of water from the Great Artesian Basin has adversely impacted on the fragile ecology, and the mine is a large consumer of electricity and a major contributor to South Australia's greenhouse gas emissions. (19)

The current regulatory environment is inadequate. For example, the Olympic Dam mine enjoys a range of exemptions from the South Australian Environmental Protection Act, the Water Resources Act, the Aboriginal Heritage Act and the Freedom of Information Act. A 2003 Senate inquiry into the regulation of uranium mining in Australia reported "*a pattern of under-performance and noncompliance*". It identified many gaps in knowledge and found an absence of reliable data on which to measure the extent of contamination or its impact on the environment, and it concluded that changes were necessary "*in order to protect the environment and its inhabitants from serious or irreversible damage*". The committee concluded "*that short-term considerations have been given greater weight than the potential for permanent damage to the environment*". (20)

Aboriginal communities have spoken out against uranium mining for decades. The industry's dealings with traditional owners and communities have prompted broader public unease. For example, members of the Adnymathanha community have described the Beverley consultation process of the late 1990s as top-down, divisive, and engineered to 'disempower' the Adnymathanha people that opposed the mine. (21)

The three Australian mines produce some 9500 tU/yr, just under a quarter of world production. But there are plans to triple the output of Olympic Dam, to about 12,700 tU/yr, and three new mines have been proposed since the Liberal Government was elected in 1996. Aside from Beverley which is already operational, there is Jabiluka in the Northern Territories, and like Ranger in the Kakadu National Park, which awaits aboriginal approval, and Honeymoon in South Australia, which has received approval but is having reserves reassessed before it becomes operational. (22)

Expanding production

According to the World Nuclear Association new mines started up in the West over the past 20 years are properly managed to high standards. (23) But few of the new mines planned to meet increasing demand, are in the West. The OECD-NEA lists 20 mines scheduled to open before 2030, including one each in Russia, India, Namibia, Niger and Brazil, two in Canada, two in Iran and 11 in Kazakhstan.

At the moment uranium recycled from old military programmes and civil stockpiles makes up 40 per cent of world supplies, but this is due to decline after 2015. This means that an increasing proportion will have to be dug out of the ground. Couple this with increasing prices because of growing demand, and it is inevitable that environmental standards will fall.

Will there be enough uranium?

If the use of nuclear power expands, it will become increasingly ineffective at combating climate change, warns a report by the Oxford Research Group. (24) Dutch nuclear expert Jan Willem Storm van Leeuwen (25) says that, after 2034, the grade of uranium ore being dug out of the ground will fall dramatically. This will cause nuclear power to become increasingly inefficient and expensive, leading to an increase in carbon dioxide emissions, because more energy will be required to extract and process the uranium.

According to the International Atomic Energy Agency (IAEA) the total identified amount of conventional uranium, is about 4.7 million tonnes, which is sufficient, at current demand, for 85 years. (26) But world resources are thought to be much higher. The OECD-NEA says more than 35 million tonnes are available for exploitation. A significant number of new mining projects have also been announced that could substantially boost world uranium production capacity. The NEA expects annual uranium requirements to increase to between 80 000 and 100 000 tonnes by 2025, but says the currently identified resources are adequate to meet this expansion.

NEA says there are an estimated 10 million tonnes of "undiscovered resources" and 22 million tonnes of unconventional resources, associated for example with phosphates, which can be extracted for around the same price as the conventional resources - less than $130/kg. At current rates of consumption this means we have enough uranium to last over 600 years, or 350 years at the projected rate of consumption in 2025 (27)

However, as the richer ores become exhausted and poorer and poorer ores are used, the continuing use of nuclear reactors will finally result in the production of more CO_2 than if fossil fuels were to be burned directly. Neither the IAEA nor the NEA address the ore quality question. According to Van Leeuwen ores with a uranium content less than 0.02% (or 0.01% for easily mined soft ores) require more energy to produce and exploit than can be generated from it. Falling ore grade leads to rapidly rising CO_2 emissions from the nuclear energy cycle. Assuming world nuclear generating capacity remains at 2005 levels, after about 2016 the mean grade of uranium ore will fall significantly from today's levels, and even more so after 2034. After about 60 years the world nuclear power system will fall off the 'Energy Cliff' – meaning that the nuclear system will consume as much energy as can be generated from the uranium fuel. Whether large and rich new uranium ore deposits will be found or not is unknown.

Within the lifetime of new reactors built today, sufficiently high-grade uranium resources will become severely depleted. The use of lower grade uranium would increase nuclear CO_2 emissions to the level of a gas-fired power station by 2070. (28)

Ores being mined for uranium currently are generally well above the critical value of 0.01% uranium, and average over 0.1%. However, some ores are relatively low grade, such as 0.03 to 0.07% at Olympic Dam in South Australia, and 0.02% in South Africa. It is tempting the view the uranium resource figures provided by the IAEA and NEA as showing that the amounts of uranium available for generation of nuclear energy are practically limitless. From a geological point of view there are no reasons to dispute their accuracy. However, it is a misconception to believe that every uranium atom in the accessible earth's crust would be extractable from its host rock at no net energy cost. The implications of this are that it is very unlikely that an energy gain can be obtained by mining the vast quantities of uranium in unconventional resources. (29)

We could of course attempt to use fast reactor technology to lengthen the life of world uranium resources. These reactors can theoretically convert the non-fissile portion of uranium (U-238) into fissile plutonium, and thus lengthen the 85-year life of conventional uranium resources to 2,500 years. (30) But this would involve returning to the separation and transport of weapons-useable plutonium from spent nuclear waste fuel with all the attendant security problems that would entail. The United Nations IPCC said the security threat of trying to tackle climate change with a global fast reactor programme "would be colossal" (31)

Fifty years of intensive research in seven countries (USA, UK, France, Germany, former USSR now Russia, Japan and India), with investments of many of tens of billions of dollars has so far have failed to demonstrate that fast reactor technology is technically feasible. Even if the technology were to start working flawlessly next year, the share of fast reactor power could only become significant by the end of this century. A recent Massachusetts Institute of Technology study concluded that fast reactors would not come into operation for at least thirty years. (32)

Conclusion

The nuclear industry has seized on climate change to promote nuclear power as a "sustainable" and climate friendly energy source. This is nonsense. Nuclear power relies for its fuel on an extremely environmentally damaging mining process, producing huge quantities of waste which will remain hazardous for thousands of years. In addition it is highly likely that due to the falling quality of uranium ores, carbon emissions from the nuclear cycle will climb to such an extent that, within the lifetime of reactors built today, nuclear electricity will be producing the same level of carbon dioxide emissions as a gas-fired power station.

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