Greenhouse Emissions from Nuclear Energy

Ian Hore-Lacy responds to claims that nuclear energy is not the solution to greenhouse gas emissions.

Mark Diesendorf last month brought together several elements of today's anti-nuclear folklore by calculating carbon dioxide emissions from the nuclear fuel cycle and questioning whether there is any substantial net energy gain due to an alleged scarcity of uranium (*AS*, July 2005, pp.39–40). These are important issues.

Carbon emissions from the nuclear fuel cycle and other means of generating electricity have been analysed by energy organisations with no bias towards nuclear power, and the data published in a variety of places. They show that carbon dioxide emissions for the full nuclear fuel cycle are less than 5% of emissions using black coal to generate the same amount of electricity. Natural gas also produces at least 10 times the emissions of nuclear energy.

Energy balances have also been well-examined. For example, a 1000 MWe reactor would require a total input of 52 PJ of energy but produce 3020 PJ over 40 years (www.uic.com.au/nip57.htm). If very low grade material were used (0.01% U), the mining and milling figure increases to about 20 PJ and the total energy input to 70 PJ.

Thus the life cycle energy inputs are 1.7% of output, increasing to 2.3% with hypothetical (and unlikely) use of very low-grade uranium ore. The energy input required to construct the reactor is repaid in less than 6 months.

The issue of scarcity of geological resources (in this case uranium) has not received much attention recently because it was long assumed that the lessons of the "Limits to Growth" fiasco of the 1970s had been learned. But obviously not, so we need to note the following figures.

There are 3.5 million tonnes of known economic uranium resources, with current usage at around 68,000 tonnes per year. This gives a ratio of usage to resources greater than for most metal minerals. Such data for most minerals bear little relationship to what is actually in the outer part of the Earth's crust and is potentially available for use. They are a statement of knowledge, not geology. Geological knowledge evolves and exploration technology improves so that exploration efforts become increasingly sophisticated and effective.

Usage of uranium (or anything else) produces price signals that result in exploration. Historically expenditure on exploration for uranium, as for other metals, results in discovery and replenishment or an increase in known economic resources.

Beyond the 3.5 Mt of known economic resources of uranium are estimates of an additional 9.75 Mt of uranium, which equates to more than 150 years' supply at today's rate of consumption. This still ignores technological advancements and omits resources such as phosphate deposits, from which 22 Mt of uranium can be recovered as a by-product.

With uranium exploration now being mobilised in response to high prices, I would expect known economic resources of uranium to double in the next decade. In the past decade alone they have increased more than 50% even though very little exploration for uranium has been done since the early 1980s.

In addition, used uranium fuel can be recycled to yield an extra 25–30% of energy.

More significantly, fast-neutron reactors can utilise the U-238 component of natural uranium (as well as the 1.2 Mt of depleted uranium now stockpiled). When such units are run as "breeder reactors" to convert non-fissile U-238 to fissile plutonium, they offer the prospect of multiplying uranium resources 50-fold. This technology is well-proven through 300 reactor-years of experience. Although not yet economic, fast reactors are already firmly part of the energy plans of nations such as Russia, Japan and India.

Turning to the other objections to nuclear power:

- it is economic in most parts of the world, and becoming more so;
- it is environmentally clean, and its wastes are contained and managed rather than becoming environmental problems. This is costed into the power;
- civil nuclear power does not produce materials usable for nuclear weapons, and its use enables more rather than less control of proliferation; and
- it is very safe, with 12,000 reactor-years of civil experience showing no uncontrolled problems with any reactor licensable in most of the world.

At present, 30 nations use some 440 nuclear reactors to produce 16% of global electricity. More are being built in 10 countries because they make economic sense.

High-profile environmentalists are supporting this on the grounds that the risks are modest compared with any alternative, particularly the threat of climate change.

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You Can't Nuke Greenhouse Emissions

Mark Diesendorf responds to Ian Hore-Lacy.

Readers can measure the credibility of Ian Hore-Lacy's response to my original article assessing nuclear energy as a greenhouse-friendly energy source (*AS*, July 2005, pp.39–40) by his unsupported statement that "civil nuclear power does not produce materials usable for nuclear weapons". This incorrect claim by nuclear industry representatives has been refuted for decades by scientific, military and regulatory experts such as:

- Dr Theodore Taylor, leading US nuclear bomb designer (1976): "With the spread of peaceful nuclear power, more and more countries have the opportunity to acquire bomb materials";
- Dr Victor Gilinsky, Commissioner of the US Nuclear Regulatory Commission (1977): "As far as reactor-grade plutonium is concerned, the fact is that it is possible to use this material for nuclear warheads at all levels of technical sophistication…Whatever we might once have thought, we now know that even simple designs, albeit with some uncertainties in yield, can serve as effective, highly powerful weapons"; and
- the US Department of Energy (1997): "All of these grades of plutonium (fuel-grade and reactor grade) can be used to make nuclear weapons".

These and many more quotations by experts have been collected with references on the website www.ccnr.org/Findings_plute.html/.

This is not just theory. It is well-documented that the first series (Magnox) of British nuclear power stations, opened with much fanfare by the Queen as "peaceful" nuclear power, were one of the main sources of plutonium for the British nuclear weapons program.

The main point of my article was that the detailed, extensively referenced analysis of Van Leeuwin and Smith (2003), available for all to examine at www.oprit.rug.nl/deenen/, shows that, for low-grade uranium ore, the fossil energy inputs to (and hence CO_2 emissions from) the nuclear fuel cycle are comparable with or greater than those of an equivalent gas-fired power station. Hore-Lacy's response is to:

- present an anonymous estimate of alleged energy inputs to nuclear power using *high-grade* uranium ore. Such estimates are produced routinely by organisations that promote nuclear energy, such as the Uranium Information Centre (UIC), the World Nuclear Association (WNA) and International Atomic Energy Agency, and are scientifically worthless;
- claim without substantiation that the use of *low-grade* uranium does not change the result by much;
- list the well-known large quantities of global uranium resources, which are almost all low or very low grade uranium. But the criterion for uranium resources to become energy resources should be based on the amount of energy required to extract the uranium from the resources; and
- reproduce from the WNA website, without acknowledgement, a "response" to Van Leeuwin and Smith that these authors have already refuted.

Van Leeuwin and Smith show that reserves of high-grade uranium ore will only last about 20 years at the current usage rate. Even if renewed exploration somehow leads to a doubling of reserves of high-grade uranium ore, this would be only enough to fuel one generation of nuclear power stations at the current usage rate. Clearly nuclear energy is not a long-term solution to the greenhouse problem.

The only other means of increasing high-grade nuclear fuel envisaged by Hore-Lacy are the extraction of unused uranium-235 and plutonium from spent fuel, adding "25–30% of energy", and fast breeder reactors. Both of these approaches involve reprocessing of spent fuel, which has been plagued with accidents and enormous costs. These technologies are highly polluting and energy intensive. They also increase the risk of proliferation of nuclear weapons via the plutonium route.

At present there are no commercial-scale fast breeders operating. The Russian 600 MW demonstration fast neutron reactor, Beloyarsk, is operating but has a history of accidents and does not seem to have ever operated as a breeder. The pro-nuclear study by the Massachusetts Institute of Technology does not expect the breeder cycle to come into commercial operation during the next three decades.

Claims that "nuclear power is economic" are often unverifiable bottom-line results or "justified" by analyses with hidden assumptions that are highly favourable to nuclear power, such as:

- choosing an unrealistically low discount rate or using an accounting method that shrinks nuclear power's high annualised capital cost; and
- ignoring many of the huge subsidies to nuclear power and simply not costing some parts of the nuclear fuel cycle.

When the nuclear industry produces a fail-safe, proliferation-proof, economic nuclear fuel cycle with large positive energy balance while using low-grade ore then perhaps it could be considered seriously as part of the future energy mix.

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