PANDORA'S FALSE PROMISES
INTEGRAL FAST REACTOR: FACTS AND MYTHS
A Beyond Nuclear Fact Sheet
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AN INTRODUCTORY NOTE

Pandora's Promise is a new documentary that endeavors to make the case that nuclear power should be embraced as a solution to climate change. While adopting many of the known propaganda lines of the nuclear industry and its boosters, the film also touts the sodium-cooled Integral Fast Reactor (IFR), a breeder reactor design long abandoned and which does not exist today anywhere in the world. This fact sheet is intended to set the record straight on the IFR. A separate fact sheet answering the misleading statements made in the film can be found in the Fact Sheet section of the Beyond Nuclear website.

Beyond Nuclear recommends that any viewing of *Pandora's Promise* be done from an informed position and with a great deal of skepticism as to the veracity of its contents.

THE BASICS

The proposed US Integral Fast Reactor:

- is a sodium-cooled reactor that is fueled with a metallic alloy of uranium and plutonium.
- is a fast reactor — i.e. neutrons are not slowed down — and "breeds" or creates more plutonium than is used as fuel. [1]
- is integral because it operates in conjunction with an on-site "pyro-processing" facility to separate plutonium and other long-lived isotopes from spent fuel. The transmutation process also converts the long-lived waste radioisotopes into shorter-lived waste products. [2]
- was developed as a prototype at the Argonne National Laboratory between 1983 and 1994 but much of its technology was based on development programs used in the 1950s.
- was canceled under the Clinton administration due to its proliferation risks, costs, and impracticalities.
- is not in existence anywhere in the world today.

PROLIFERATION

- The IFR must be fueled with plutonium and will produce more plutonium. This plutonium can be used to make nuclear weapons.
- The use of plutonium as fuel breaks down the barrier between the civilian and military use of plutonium and sets up the potential for theft or diversion by outside parties.

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[1] Nuclear Weapons and 'Fourth Generation' Nuclear Power. Friends of the Earth Australia. By Jim Green. January 2009. http://www.foe.org.au/anti-nuclear/issues/nfc/power-weapons/g4nw

[2] ibid.

- Lack of nuclear materials that could be used to make even crude nuclear bombs is generally considered to be the main obstacle to nuclear proliferation. Pyro-processing would lower the proliferation bar considerably. [3]
- The IFR can produce weapons-grade plutonium using a shorter irradiation time.
- The initial load of fissile material in an IFR must come from existing civil or military stockpiles which could provide the rationale for the on-going operation of enrichment and reprocessing plants or even the construction of new ones. [4]
- "*No technical fix can remove the proliferation risks associated with reprocessing and the use of plutonium-based fuel. . . New reprocessing technologies will leave the plutonium in a mixture with other elements, but these are not radioactive enough to provide theft-resistance, and a nation seeking nuclear weapons could readily separate the plutonium from the other elements by chemical means. And some of these other elements are themselves usable in weapons."* [5]

THE RISKS OF SODIUM

- Sodium reacts violently with water and burns if exposed to air. [6]
- Sodium-cooled fast reactors can suffer from sodium leaks and fires, failures of cooling equipment handling liquid sodium, and catastrophic super-criticality accidents. [7]
- Any leak "results in a reaction that can rupture the tubes and lead to a major sodium-water fire." [8]
- The Department of Energy noted in 2002 that *"There have been small sodium leaks (and small fires) at essentially every sodium-cooled reactor plant built; in some cases, several of them."* [9]

SAFETY CHALLENGES

- A fast reactor is vulnerable to a "core disassembly accident". Collapsing the fuel into a reduced volume increases the rate at which the chain reaction occurs. If this were to happen quickly enough, the pressure in the fuel would rise fast enough to lead to an explosion. This could fracture the protective barriers around the core, including the containment building, and release large fractions of the radioactive material in the reactor into the surroundings. Such a

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[3] http://ieer.org/resource/disarmamentpeace/revival-of-pyroprocessing-technology-for-nuclear-fuel-in-bush-administration-energy-plan-poses-serious-proliferation-dangers/ Revival of Pyroprocessing Technology for Nuclear Fuel in Bush Administration Energy Plan Poses Serious Proliferation Dangers. IEER. May 17, 2011.

[4] ibid.

[5] http://www.ucsusa.org/assets/documents/nuclear_power/NPWWch6.pdf *Nuclear Power in a Warming World*, *Chapter 6, Evaluating New Nuclear Reactor Designs*. Union of Concerned Scientists. 2007.

[6] http://www.princeton.edu/sgs/publications/articles/Time-to-give-up-BAS-May_June-2010.pdf *It's time to give up on the breeder reactor. The Bulletin of the Atomic Scientists.* By Thomas B Cochran, Harold A. Feiveson, Zia Mian, M.V. Ramana, Mycle Schneider & Frank N. von Hippel. May/June 2010.

[7] http://ieer.org/wp/wp-content/uploads/2000/05/Annie-statement-transmu.pdf The Nuclear Alchemy Gamble: An Assessment of Transmutation as a Nuclear Waste Management Strategy. Statement of Annie Makhijani, Project Scientist, Institute for Energy and Environmental Research, May 24, 2000.

[8] Ibid. *It's time to give up on the breeder reactor.*

[9] Nuclear Energy Research Advisory Committee and Generation IV international forum, "Generation IV roadmap: Description of candidate liquid-metal-cooled reactor systems report," GIF-017-00, December 2002, p. 34.

"core disassembly accident" has therefore been an important concern among the fast reactor design community ever since the first fast neutron reactors were constructed. **[10]**

- Blanket statements that the IFR is unable to melt down are not credible. How a reactor behaves under accident conditions is extremely complex and the modeling results have to be critically evaluated to check whether the assertions of safety by designer really do hold good. In the case of the Indian fast breeder reactor, this was not the case. [11]
- According to the Union of Concerned Scientists, when looking at so-called Generation IV reactors (which include the IFR, the Small Modular Reactor and the Thorium Fueled Reactor), *"there is no basis for assuming that any of the five designs now under study would be significantly safer than today's nuclear power plants."* [12]
- The IFR has *"little or no operating experience, so detailed computer models would be needed to accurately predict their vulnerability to catastrophic accidents. However, this project is still in its infancy, so developing and extensively validating computer models for each design will be a formidable task."* [13]
- An event that causes the core of an IFR to become more compact—such as a core meltdown — could substantially raise reactivity, resulting in a rapid power increase that could vaporize the fuel and blow the core apart. [14]
- "The necessity of keeping air from coming into contact with the sodium coolant makes refueling and repairing fast reactors much more difficult and time-consuming than for water-cooled reactors." [15]
- Princeton physicist, M.V. Ramana argues against the use of the IFR to address climate change because these types of reactors "have never been built" and because they involve "an associated new type of reprocessing technology called pyro-processing. Both breeders and reprocessing plants have been notoriously problematic." [16]
- Fast reactors have a history of failure. One such, at Dounreay, Scotland, was abandoned two decades ago with the heavily contaminated site now expected to cost more than $5 billion to decommission. [17] On December 8th, 1995, 700 kg of molten sodium leaked from the secondary cooling circuit of the Monju breeder reactor in Japan, resulting in a fire. The sodium spill itself came very close to breaching Monju, a catastrophe which would have spilled plutonium into the environment. [18] France's Superphénix, the world's only commercial-sized breeder reactor, was a financial and production disaster, operating only half of the time that it

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[10] *The Limits of Safety Analysis: Severe Nuclear Accident Possibilities at the PFBR.* Ashwin Kumar, M.V. Ramana. Economic & Political Weekly. October 22, 2011.

[11] *Compromising Safety: Design Choices and Severe Accident Possibilities in India's Prototype Fast Breeder Reactor.* Ashwin Kumar and M.V. Ramana. Science and Global Security. 2008.

[12] ibid. *Nuclear Power in a Warming World*, Chapter 6.

[13] ibid.

[14] E.E. Lewis, *Nuclear power reactor safety* (New York: Wiley, 1977), pp. 245–261.

[15] Ibid. *It's time to give up on the breeder reactor.*

[16] http://amitavghosh.com/blog/?p=4857. M.V. Ramana on the Future of Nuclear Energy in India - Part 2 of 2. By Amitav Gosh, October 22, 2012.

[17] http://www.independent.co.uk/news/science/plans-to-build-a-nuclear-fast-reactor-at-sellafield-come-a-step-closer-7608840.html

[18] http://wikileaks.org/wiki/The_Monju_nuclear_reactor_leak

was connected to the grid and generating less than 7% of its capacity over its abbreviated lifetime due to multiple safety incidents and accidents.

- Fast reactor designs have a stronger coolant void effect. The larger the magnitude of the destabilising (sic) coolant void effect (measured by the "cool-ant void coefficient" – positive quantities implying that the reaction rate increases with the temperature of the coolant), the more likely that an accident that begins via a heating of the coolant can spread to large parts of the core. But fast reactors are not the only type of reactors where a positive coolant void coefficient could play a role in an accident. Indeed, the best known event where the reactor demonstrated such behaviour (sic) was during the 1986 Chernobyl accident. [19]
- As John G. Fuller's famous book title put it, *"We Almost Lost Detroit"* on October 5, 1966, when the Enrico Fermi Unit 1 plutonium breeder reactor – initially proposed to generate plutonium for the U.S. nuclear weapons arsenal – experienced a partial core meltdown. Incredibly, Fermi 1 suffered a sodium fire, as well as a large tritium spill, within the past several years – *more than 35 years after the reactor had been permanently shut down*.

WASTE REDUCTION

- Although the IFR will produce less radioactive waste than a traditional Light Water Reactor, it still produces waste, about 1,700 pounds of waste per year for a plant of about 1,000 megawatts. These wastes will remain dangerous for at least 200 years, still requiring a management plan. [20]
- The notion that the IFR is useful to "consume" radioactive waste is vastly overblown. In 1996, the National Academy of Sciences published a detailed and comprehensive study, *Nuclear Wastes: Technologies for Separations and Transmutation* [21] that concluded that efforts using the IFR to "consume" radioactive waste and reduce the global inventory of transuranic isotopes would "have high costs and marginal benefits that would take hundreds of years." [22]

COSTS

- The construction costs would be high - the costs of traditional Light Water Reactors are already ballooning as high as $12 billion. As Princeton professor Frank von Hippel writes: "The differences between the capital and operating costs of water and sodium-cooled reactors have remained discouragingly large. Many experimental and demonstration breeder reactors have been built around the world but none has been a commercial success." [23]
- "The capital costs per kilowatt of generating capacity of demonstration liquid sodium-cooled fast reactors have typically been more than twice those of water cooled reactors of comparable capacity." [24]

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[19] Ibid. The Limits of Safety Analysis. Kumar & Ramana.

[20] http://web.archive.org/web/20071009064447/www.nuc.berkeley.edu/designs/ifr/anlw.html. An introduction to Argonne National Laboratory's Integral Fast Reactor (IFR) Program.

[21] http://www.nap.edu/openbook.php?isbn=0309052262. Nuclear Wastes: Technologies for Separations and Transmutation. National Academy of Sciences. National Academy Press. 1996.

[22] Ibid. *It's time to give up on the breeder reactor.*

[23] http://fissilematerials.org/library/rr03.pdf. Managing Spent Fuel in the United States: The Illogic of Reprocessing. By Frank von Hippel. January 2007.

[24] Ibid. *It's time to give up on the breeder reactor.*

• "About $100 billion (in 2007 dollars) has been spent worldwide on breeder reactor research and development and on demonstration breeder reactor projects. Yet none of these efforts has produced a reactor that is economically competitive with a conventional light water reactor." [25]

THE PRACTICAL AND POLITICAL

• Integral Fast Reactors, or any kind of nuclear reactor, are not needed for — and not practical to address — climate change. Simply doubling the world's output of nuclear energy would only reduce global greenhouse gas emissions by about 5%. [26]

• A 2003 MIT study concluded that in order to displace a significant amount of carbon-emitting fossil-fuel generation, another 1,000 to 1,500 new reactors would need to come on line worldwide by 2050, more than two new reactors every month, [27] an unrealistic and impracticable proposition. Prioritizing a reactor design that does not already exist would slow the process even more. As Princeton physicist, M.V. Ramana observes, "even if one were to advocate nuclear power, it would be much better to rely on the relatively more proven light water reactors." [28]

• Reactors of any design take too long to build to address climate change in time. The urgency of climate change necessitates the rapid deployment of renewable energy technologies that are ready today and the use of energy efficiency measures. We do not have time to wait for a handful of slow, expensive reactors that would barely make a dent in reducing carbon emissions.

• Besides costing too much, and taking too long, to address the climate crisis, nuclear power still has numerous "insurmountable risks" of its own, such as nuclear weapons proliferation risks, the risk of catastrophic accidental radioactivity releases, and the unsolved radioactive waste problem, not to mention radiological and toxic chemical releases to the environment at various stages of the uranium fuel chain. [29]

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[25] Ibid. *It's time to give up on the breeder reactor.*

[26] http://www.energyscience.org.au/FS03%20Nucl%20Power%20Clmt%20Chng.pdf. Nuclear power and climate change. By Jim Green, Friends of the Earth Australia. November 2006.

[27] http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf. *The Future of Nuclear Power.* 2003. MIT.

[28] Ibid. M.V. Ramana on the Future of Nuclear Energy in India.

[29] *Insurmountable Risks: The Dangers of Using Nuclear Power to Combat Global Climate Change. By Brice Smith.* IEER Press and RDR Books, May 2006.