NUCLEAR SPENT FUEL RECYCLING

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Over the past few years, recycling nuclear power spent fuel has received growing attention. Fears of global warming due to fossil fuel burning have given nuclear energy a boost with dozens of new power reactors planned world-wide over the next 15 years. To expand nuclear energy growth the Bush administration is seeking to establish international spent nuclear fuel recycling centers that are supposed to recycle uranium, and convert nuclear explosive materials, such as plutonium to less troublesome elements in advanced power reactors.

Advocates, such the Heritage Foundation, a conservative think-tank, argue that used fuel at U.S. power plants contain enough energy “to power every U.S. household for 12 years.” Heritage points out that nuclear recycling “can be affordable and is technologically feasible. The French are proving that on a daily basis. The question is: Why can't oui?”

As is common with nuclear technologies, the answer, like the devil, is in the details.

The “Once through” and “Closed” Nuclear Fuel Cycles

Nuclear recycling advocates are seeking to overturn a 30 year U.S. nuclear nonproliferation policy that discouraged nuclear reprocessing, also known as the “once through” nuclear fuel cycle. It was adopted by President Carter in 1977 three years after India exploded a nuclear weapon using plutonium separated from reactor spent fuel. When separated by reprocessing, plutonium does not have a significant radiation barrier to prevent diversion, theft and bomb making, especially by terrorists.

Under the “once through” policy intact spent fuel rods are to be sent directly to a repository. Radioactive materials in spent fuel are bound up in ceramic pellets and are encased in durable metal cladding, planned for disposal deep underground in thick shielded casks.

Carter's decision reversed some 20 years of aggressive promotion by DOE's predecessor, the U.S. Atomic Energy Commission (AEC), of the "closed" nuclear fuel cycle, in which spent fuel would be reprocessed to fuel plutonium "fast" reactors. "Fast" reactors generate more subatomic particles, known as neutrons, which split uranium atoms to produce energy. Because of their potential abundance of neutrons, proponents claim that fast reactors would not only produce electricity but would generate up to 30 percent more plutonium than they consumed.

With design changes, fast reactors now are, ironically, being touted as a means to get rid of plutonium, rather than making more. In theory this is correct, but recycling advocates conveniently ignore the fact that the experience with fast reactors is marked with failure. Over the past 50 years, at least 15 "fast" reactors have been closed due to costs and accidents in the U.S., France, Germany, England, and Japan. There have been two fast reactor fuel meltdowns in the United States including a mishap near Detroit in the 1960's. Russia operates the remaining fast reactor, but it has experienced 15 serious fires in 23 years[1]

Plutonium, which makes up about 1 percent of spent fuel, is currently used in a limited fashion plants by blending it with uranium. Known as mixed oxide fuel (MOX), it can only be recycled once or twice in a commercial nuclear power plant because of the buildup of radioactive contaminants. According to a report to the French government in 2000 the use of plutonium in existing reactors doubles the cost of disposal. [2]

The quest to close the nuclear fuel cycle has created a plutonium legacy of major proportions. Of the 370 metric tons of plutonium extracted from power reactor spent fuel over the past several decades, about one third has been used. Currently, about 200 tons of plutonium sits at reprocessing plants around the world – equivalent to the amount in some 30,000 nuclear weapons in global arsenals.[3]

Recycled Uranium

In 2007 the International Atomic Energy Agency concluded that "reprocessed uranium currently plays a very minor role in satisfying world uranium requirements for power reactors." [4] In 2004, about 2 percent of uranium reactor fuel in France came from recycling,[5] and it appears now to have dwindled to zero. [6] There are several reasons for this.

Uranium which makes up about 95 percent of spent fuel cannot be reused in the great majority of reactors without increasing levels of a key source of energy, uranium 235, from 1 to 4 percent, through a complex and expensive enrichment process.

Reprocessed uranium also contains undesirable elements that make it highly radioactive and reduces efficiency of the fuel. For instance the build up of uranium 232 and uranium 234 creates a radiation hazard requiring extraordinary measures to protect workers. Levels of uranium-236 impede atom splitting; and to compensate for this "poison, recycled uranium has to undergo costly "over-enrichment." Contaminants in reprocessed uranium also foul up enrichment and processing facilities, as well as new fuel. Once it is recycled in a reactor larger amounts of undesirable elements build up – increasing the expense of reuse, storage and disposal. Given these costly problems, it's no surprise that DOE planning includes disposal of future reprocessed uranium in landfills.

Nuclear Recycling and the Environment

In order to recycle uranium and plutonium in power plants, spent fuel has to undergo treatment to chemically separate these elements from other highly radioactive byproducts. As it chops and dissolves used fuel rods, a reprocessing plant releases on the average about 15 thousand times more radioactivity into the environment than nuclear power reactors[7] and generates several dangerous waste streams. If placed in a crowded area, a few grams of waste would deliver lethal radiation doses in a matter of seconds. They also pose threats to the human environment for tens of-of-thousands of years.

In Europe reprocessing has created higher risks and has spread radioactive wastes across international borders. Radiation doses to people living near the Sellefield reprocessing facility in England were found to be 10 times higher than for the general population.[8] Denmark, Norway, and Ireland have sought to close the French and

English plants because of their radiological impacts. [9] For instance, discharges of Iodine 129, a very long-lived carcinogen, have contaminated the shores of Denmark and Norway at levels 1000 times higher than nuclear weapons fallout.[10] Health studies indicate that significant excess childhood cancers have occurred near French and English reprocessing plants[11] [12] [13] [14] Despite a firestorm of criticisms from the nuclear industry, experts have not ruled out radiation as a possible cause.[15]

Nuclear recycling in the U.S. has created in one of the largest environmental legacies in the world. Between the 1940's and the late 1980's, the Department of Energy (DOE) and its predecessors reprocessed tens of thousands of tons of spent fuel in order to reuse uranium and make plutonium for nuclear weapons. [16]

By the end the Cold War about 100 million gallons of high-level radioactive wastes were left in aging tanks that are larger than most state capitol domes. More than a third of some 200 tanks have leaked and threaten water supplies such as the Columbia River.[17] The nation's experience with this mess should serve as a cautionary warning. According to DOE, treatment and disposal will cost more than $100 billion;[18] and after 26 years of trying, Energy has processed less than one percent of the radioactivity in these wastes for disposal. [19] By comparison, the amount of wastes from spent power reactor fuel recycling in the U.S. would dwarf that of the nuclear weapons program -- generating about 25 times more radioactivity. [20]

Costs

As a senior energy adviser in the Clinton administration, I recall attending a briefing by the National Academy of Sciences in 1996 on the feasibility of recycling nuclear fuel. I'd been intrigued by the idea because of its promise to eliminate weapons-usable plutonium and to reduce the amount of waste that had to be buried, where it could conceivably seep into drinking water at some point in its multimillion-year-long half-lives.

But then came the Academy's unequivocal conclusion: the idea was supremely impractical. It would cost up to $500 billion in 1996 dollars and take 150 years to accomplish the transmutation of plutonium and other dangerous long-lived radioactive toxins. [21] Ten years later the idea remains as costly and technologically unfeasible as it was in the 1990s. In 2007 the Academy once again tossed cold water on the Bush administration's effort to jump start nuclear recycling by concluding that “there is no economic justification for going forward with this program at anything approaching a commercial scale.”[22]

Meanwhile, the client base for Areva the French nuclear recycling company has shrunk to one new contract for a relatively small amount of spent fuel from the Netherlands. Most revealing is that its main customer, the French utility, Electricité de France, is balking at doing further business unless the price goes down--something that Areva says it can’t do.[23] It appears that even the French may be starting to say no instead of oui.

The key to recycling is being able to reuse materials while saving money, reducing pollution, and making the earth a safer place. On all accounts, nuclear recycling fails the test.

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[1] Ibid.

[2] Von Hippel, F., Managing Spent Fuel in the United States: The Illogic of Reprocessing, A research report of the International Panel on Fissile Materials, January 2007, www.fissilematerials.org

[3] Ibid.

[4] International Atomic Energy Agency, Management of Reprocessed Uranium: Current Status and Future Prospects, IAEA-TECDOC-1529, February 2007. http://www pub.iaea.org/MTCD/publications/PDF/te_1529_web.pdf

[5] Organization for Economic Cooperation and Development (OECD) and the International Energy Agency (IEA), Uranium 2005: Resources, Production and Demand, (2006)NEA-6098. http://www.nea.fr/html/ndd/reports/2006/uranium2005-english.pdf

[6] Mary Byrd Davis, Nuclear France: Materials and Sites, CRUAS-MEYSSE, http://www.francenuc.org/en_sites/rhone_cru_e.htm, “Cruas is the first, and up until now, the only French power plant to use PWR fuel made of enriched, reprocessed uranium (URE). At the end of 2000, 210 t of URE in total had been loaded into Cruas reactors 3 and 4. The loading of URE began in 1994 in reactor 4, with an enrichment of 3.5% (equivalent to 3.25% for a classic U02 fuel) and a burnup of 40 GWd/t. Since 1999, reactors 3 and 4 have been loaded with URE at 3.95% (equivalent to 3.7% for a classic fuel) with a burnup of 45 GWd/t. A load URE in reactor 3 or 4 of Cruas corresponds to 20 t of fuel [Coeytaux 01]. The reactors are also adapted to Mox at the technical level, but the use of Mox would require going through a new authorization procedure.”

[7] Schneider, M., Coeytaux, X., Faïd, Y.B., Marignac, Y., Rouy, E., Thompson, G., and Fairlie, I, Directorate for General Research, European Parliament , Possible Toxic Effects from the Nuclear Reprocessing Plants at Sellefield (UK) and Cap La Hague (France), Scientific and Technological Options Assessment, EP/IV/A/STOA, January 17, 2001. HUhttp://www.europarl.europa.eu/stoa/publications/studies/20001701_en.pdfUH (Hereafter known as STOA 2001)

[8] Ibid

[9] STOA 2001.

[10] X. L. Hou, H. Dahlgaard and S. P. Nielsen, Iodine-129 Time Series in Danish, Norwegian and Northwest Greenland Coast and the Baltic Sea by Seaweed ,Estuarine and Coastal Shelf Science, Vol 1, No.5, November 2000, http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6WDV-45F54VV-K&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=8100df10ae8e8b58c1e0a8ede2be6e61

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[12] Craft A.W., Parker L., Openshaw S., Charlton M., Newell J., Birch J.M. & Blair V. (1993), "Cancer In Young People In The North Of England, 1968-85 Analysis By Census Wards", Epidemiol. Commun. Health 47, 109-115 http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pubmed&pubmedid=8326267

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[15] STOA 2001

[16] U.S. Department of Energy, A Preliminary Review of the Flow and Characteristics of Recycled Uranium Throughout the DOE Complex, 1952 – 1999,F-001-001, March 2001, Washington, D.C.

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[19] Alvarez, R., Radioactive and the Global Nuclear Energy Partnership, Institute for Policy Studies, April 2007, HUhttp://www.whistleblower.org/doc/2007/gnepFINAL.pdfUH

[20] Ibid.

[21] National Research Council, Committee on Separations Technology and Transmutation Systems Board on Radioactive Waste Management, Nuclear Wastes: Technologies for Separation and Transmutation Systems, 1996, National Academy Press, Washington, .D.C. HUhttp://www.nap.edu/catalog.php?record_id=4912#tocUH

[22] National Research Council, Committee on Review of DOE's Nuclear Energy Research and Development Program Board on Energy and Environmental Systems, Review of DOE's Nuclear Energy Research and Development Program.2007, National Academy Press, Washington, D.C. **http://www.nap.edu/catalog.php?record_id=11998#toc**

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