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Cleaner Nuclear Power?

Congress pushes for another look at thorium fuel, saying it could reduce the amount of high-level nuclear waste produced by reactors.

By Peter Fairley

Senators representing several Western states, including Utah's Orrin Hatch and Senate Majority leader Harry Reid, of Nevada, are working on legislation to promote thorium. They say it's a cleaner-burning fuel for nuclear-power plants, with the potential to cut high-level nuclear-waste volumes in half.

"They're concerned about the spent fuel from nuclear reactors ending up in their states," says Seth Grae, president of thorium-fuel technology developer Thorium Power (http://www.thoriumpower.com/) , based in McLean, VA.

Nuclear watchdogs say that Thorium Power's technology has real potential. Moreover, they say that the legislation is needed. It would force the Department of Energy (DOE) and the Nuclear Regulatory Commission, which regulates the nuclear industry, to create new offices at the agencies to study thorium-fuel options and promote their use abroad.

"It makes a lot of sense in my view," says Thomas Cochran, director of the nuclear program at the Natural Resources Defense Council (http://www.nrdc.org/) , in Washington. He says that congressional action is needed to overcome resistance within the DOE to exploring thorium.

Using thorium in existing reactors means rethinking the "once through" nuclear fuel cycle employed today in most countries, including the United States. The cycle starts with uranium-oxide fuel enriched in the fissile uranium isotope U235. Fission of the uranium in a reactor generates heat to drive a nuclear power plant's turbines, and it produces a highly radioactive blend of fission breakdown products, including plutonium that can be recovered to make nuclear weapons. Other fission products slow the chain reaction, requiring replacement of fuel every one or two years. The spent fuel is removed and stored on site, awaiting burial.

The DOE is working on a high-level waste repository at Yucca Mountain, in Nevada. But the facility won't open for at least another decade, and there is little political will to build more such sites. Meanwhile, Private Fuel Storage (http://www.privatefuelstorage.com/) , based in Salt Lake City, is proceeding with a controversial interim storage site on Native American land, with a 20-year license and an option to renew. "That's quite a stopover," says Grae.

Thorium Power was launched in 1992 to commercialize a process that reduces the amount of toxic waste produced by traditional reactors. The process was developed by the late nuclear scientist Alvin Radkowsky, a seminal designer of the U.S. Navy's reactors and early commercial nuclear plants. Radkowsky's scheme relies on both thorium and uranium fuels, making it more complex on the front end. But doing so keeps most of the fuel in the reactor longer, and it produces waste that's less toxic.

Each fuel assembly carries a mix of two different fuel rods. The majority are rods containing pellets of thorium oxide. The thorium can't sustain a chain reaction on its own like U235 can, but it can absorb neutrons to form another fissile isotope of uranium that will: U233. In Thorium Power's design, these neutrons are supplied by the remaining rods, which are solid alloys of zirconium and fissile U235-enriched uranium.

Grae says that Thorium Power's hybrid-fuel assemblies are designed to perform as drop-in replacements for uranium-oxide fuel in pressurized water reactors, the most common reactor design worldwide. The reactors require only minimal modifications. The most important adjustment is the use of more-precise cranes to insert and remove fuel assemblies to enable separate extraction of the uranium rods. Grae says that this is key to the waste reduction because most of the thorium stays in the reactor core for nine years. (The uranium rods, like conventional uranium-oxide fuel, are swapped out more frequently.)

Thorium Power plans to test this fuel system within three years, starting in a pressured-water reactor in Russia. The tests will be conducted in partnership with the Kurchatov Institute (http://www.kiae.ru/eng/cont/cont.htm) , a nuclear research center in Moscow. The institute has been testing the endurance of Thorium Power's fuel materials for four years while simultaneously scaling up a uranium-zirconium extrusion process to produce the 3.5-meter rods used in the Russian reactors.

If the rods endure, experts expect that Thorium Power's scheme will succeed because the hybrid thorium-and-uranium fuel concept is already proven. Several early gas-cooled nuclear reactors of the 1950s and '60s used a seed-and-jacket fuel scheme conceptually similar to Thorium Power's. And a few early water-cooled reactors such as the first reactor at Indian Point, NY, operated in the 1960s and '70s with fuel rods filled with a thorium-uranium blend. However, thorium fell out of favor as the nuclear industry standardized around uranium, particularly after uranium fuel slumped to rock-bottom pricing following the accident at Three Mile Island in 1979.

Dumping fuel every two years looks less appealing today, with uranium prices rising rapidly and high-level waste piling up at commercial reactors across the United States. Thorium fuel also responds to growing concern over proliferation of fissile materials that could be used in nuclear weapons. Thorium's byproducts produce intense gamma radiation, making them hard to handle by would-be bomb makers. Thorium Power is focusing its marketing efforts on developing countries in the Middle East, Asia, and Latin America that are looking to build their first reactors; Grae bets that a design that impedes proliferation of nuclear weapons will make reactors easier to finance in such countries. The company is also looking to India, which hopes to exploit its large thorium reserves.

The challenge for thorium proponents is that the DOE already advocates another fuel cycle that promises to cut waste and manage proliferation risks: a so-called closed fuel cycle, whereby chemical reprocessing recovers plutonium from spent uranium fuel for reuse in conventional reactors.

Reprocessing is central to the DOE's Global Nuclear Energy Partnership (http://www.gnep.energy.gov/) (GNEP), whereby major nuclear players such as the United States would guarantee uranium fuel supply to countries that promise to return spent fuel--the plutonium within which could be used to make nuclear weapons.

The GNEP has many critics who argue that the reprocessing of spent fuel will be costly, will increase rather than limit the risk of diversion of fissile materials, and will do little to reduce high-level waste volumes. The DOE's plan is to burn recovered plutonium by blending it with uranium. This produces a hotter and more toxic spent fuel that can only be burned in breeder reactors. Those reactors have, to date, proved infeasible at commercial scale. (See "The Best Nuclear Option (http://www.technologyreview.com/Energy/17059/page1) .")

Grae insists that Thorium Power could benefit, in the long run, from stepped-up reprocessing because its fuel system provides a better outlet for the recovered plutonium: replacing uranium as the neutron source for Thorium Power's thorium-fuel rods. In 2005, nuclear-technology giant Westinghouse evaluated Thorium Power's system as an option for burning surplus military plutonium, and the company predicted that this would be "substantially" cheaper, quicker, and more effective than burning plutonium with uranium.
