Time for Norway To Go Nuclear

by Ramtanu Maitra

After an interlude of more than five decades, Norway is finally waking up to the requirements of developing its nuclear power generation capability. Norway was the sixth country in the world to build a nuclear research reactor, which went critical in 1951. But, international nuclear politics mixed with anti-nuclear activism, perhaps more than anything else, kept Norway from developing its nuclear power generation program.

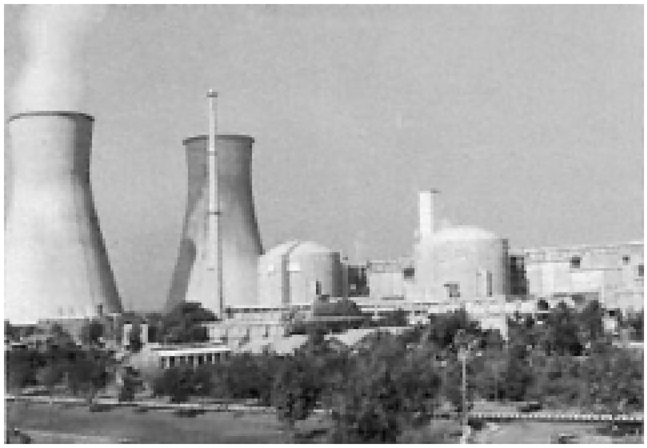
Now a discernible shift has occurred in Norway's energy outlook. As an opener, the Norwegian energy broker, Bergen Energi, has sent an application to the Norwegian authorities for a nuclear license. The two-page letter to the Norwegian Prime Minister, which called for an increased focus on cost-effective energy sources and the need for a "new and independent market player," mentions the nation's large thorium reserves, and refers to a more constructive and more predictable energy policy to be researched, and to developments in thorium-based reactor technologies in the United States and Asia.

Request for a Thorium Cycle

Perhaps the most important aspect touched upon in the Bergen Energi letter is that it urges the authorities to pursue "a more constructive research and development in thorium-based reactor technologies. . . ." Indeed, Norway has the third-largest reserves of thorium, weighing in with an estimated 170,000 tons. However, like most of the world, Norway had done next to nothing to develop this power source.

Worldwide, the use of thorium-based fuel cycles has been studied for about 30 years, but on a much smaller scale than uranium or uranium/plutonium cycles. Basic research and development has been conducted in Germany, India, Japan, Russia, the U.K., and the U.S.A. Test reactor irradiation of thorium fuel to high burn-ups has also been conducted, and several test reactors have either been partially or completely loaded with thorium-based fuel. Much experience has been gained in thorium-based fuel in power reactors, some using highly enriched uranium (HEU) as the main fuel.

The 300-MW Thorium High Temperature reactor (THTR) in Germany was developed out of the experimental pebble-bed high-temperature reactor at Jülich, Germany, the AVR, and operated between 1983 and 1989 with 674,000 fuel pebbles. More than half of these contained a mixture of thorium and HEU fuel; the rest was made up of a graphite moderator and some neutron absorbers.



Department of Atomic Energy, Government of India

India's Kakrapar Atomic Power Station, two units of 220 megawatts each, came on line in 1993 and 1995. Both make use of thorium fuel; four other Indian reactors, now under construction, plan to use thorium.

The Fort St. Vrain reactor, near Platteville, Colorado, in the United States, was the only commercial thorium-fueled nuclear plant in the U.S.A. This was also developed from the AVR in Germany, and operated from 1976-1989. It was a high-temperature (700°C), graphite-moderated, helium-cooled reactor with a thorium/HEU fuel designed to operate at 842 megawatts-thermal (330 megawatts-electric). The fuel was in microspheres of thorium carbide and Th/U-235 carbide, coated with silicon oxide and pyrolytic carbon to completely "contain" the fission products. Instead of tennis-ball size pebbles, the fuel was stacked in hexagonal columns.

Why Thorium?

India has about six times more thorium than uranium, and it is onlty there, as of now, that nuclear power authorities have made a full-fledged commitment to use thorium as nuclear fuel. Both Kakrapar-1 and Kakrapar-2 atomic power plant units are loaded with 500 kg of thorium fuel in order to improve their operation when newly started. Kakrapar-1 was the first reactor in the world to use thorium, rather than depleted uranium, to achieve power flattening across the reactor core. The use of thorium-based fuel is planned in Kaiga-1 and -2 and Rajasthan-3 and -4 reactors, which are under construction.

Concepts for advanced reactors based on thorium-fuel cycles include:

- Light Water Reactors: With fuel based on plutonium oxide (PuO-2), thorium oxide (ThO-2), and/or uranium oxide (UO-2) particles arranged in fuel rods.
- High-Temperature Gas-cooled Reactors (HTGR) of two kinds: pebble bed and with prismatic fuel elements.
- Gas Turbine-Modular Helium Reactor (GT-MHR):

Research on HTGRs in the U.S.A. led to a concept using a prismatic fuel.

• Pebble-Bed Modular reactor (PBMR): Derived from the German design of Dr. Rudolf Schulten, the PBMR was conceived in South Africa, and is now being developed by a multinational consortium. It can potentially use thorium in its fuel pebbles.

• Molten salt reactors: In this advanced breeder concept, the fuel is circulated in molten salt, without any external coolant in the core.

• Advanced Heavy Water Reactor (AHWR): India is on the verge of developing this for its future commercial reactors. The main part of the core is sub-critical with Th/U-233 oxide, mixed so that the system is self-sustaining in U-233.

There are several reasons why the world is finally turning its attention to thorium as nuclear fuel. To begin with, a world, fixated on proliferation of nuclear weapons, has noticed that the weapons-grade fissionable material (uranium-233) is harder to retrieve safely and clandestinely from a thorium reactor than weapons-grade plutonium is from the uranium breeder-reactor.

Secondly, thorium produces 10 to 10,000 times less long-lived radioactive waste than uranium or plutonium reactors. It comes out of the ground as a 100% pure, usable isotope, which does not require enrichment, whereas natural uranium is almost all non-fissionable U-238 with only 0.7% of fissionable U-235.

Finally, thorium does not sustain a chain reaction on its own; fission stops by default if we stop priming it, and a runaway chain reaction accident is improbable.

Although Norway has had little experience with the thorium fuel cycle, it does have a long association with nuclear science. Norwegian nuclear history is particularly interesting because it illuminates France's position in the first decade after World War II, as pointed out by Astrid Forland, an expert from the University of Bergen. It was Norway's export of heavy water to the French nuclear program which helped France develop nuclear weapons sooner than would otherwise have been possible.

Courtesy of General Atomics

The AVR experimental pebble bed reactor in Jülich, Germany, came on line in 1967 and operated successfully for 22 years. It pioneered the use of thorium fuel, using a mixture of thorium and highly enriched uranium in its fuel pebbles.

Checkered Nuclear History

It is also said that the nuclear ambitions of Yugoslavia's Cold War strongman, Joseph Broz Tito, led to Yugoslavia's close collaboration with Norway. The leader of the Norwegian nuclear research program, Gunnar Randers, visited the Vinca Institute of Nuclear Science, in a suburb of Belgrade, Yugoslavia, in 1952; that year, the Yugoslav scientist Dragoslav Popovic began a two-year residence at Randers's Institute for Nuclear Energy Research in Kjeller, Norway.

Correspondence in 1953 between Randers and other Norwegian nuclear scientists and Stevan Dedijer (by then the director of Vinca) indicates that Yugoslavia was especially interested in the chemical extraction of plutonium from irradiated fuel. Several scientists from Vinca spent years at Kjeller researching the process. By mid-1953, Dedijer had a draft agreement with the Norwegian firm Norsk Hydro-Elektrisk Kvaelstofaktieselskab to purchase 10 tons of heavy water.

Forland claims that Norwegian heavy water was also used in the Israeli program. Nonetheless, Norway's inability to make its nuclear industry profitable and competitive in the international market, caused the Norwegian nuclear venture to falter in the mid-1960s. The nadir was reached when the rise of the environmental movement in the 1970s halted all plans for the construction of nuclear power plants in Norway.

How much the environmentalists have slackened off, or the funds to keep the environmentalists feisty have tapered off, is difficult to say. But it is evident that while the Norwegian power market has been deregulated for the past 15 years, very little new power generation capacity has been built during this period. Consequently, power prices have risen in line with increasing demand. Plans for construction of gas-fired power plants have been put on hold due to high costs, because of environmental penalties, and so it is no surprise that Bergen Energi has now asked Oslo to open up the debate for nuclear power generation in Norway.

It is important to note that Nordpool, the pan-Nordic electricity market, already has nuclear power generation capacity through Finland and Sweden. Finland is currently constructing a new 1,600-MW reactor, and Sweden has plans to upgrade its nuclear generation as well.