Thorium Nuclear Reactors

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Thorium, as a fuel for nuclear reactors, has a potential to advance the quantity and safety of power for the United States. It is safer, more available, and easier to work with than the traditional nuclear fuels such as uranium. While not a complete answer to energy needs, thorium holds great promise as an addition to the full panoply of energy sources in the nation.

According to Marvin Schaffer of the RAND Corporation, most uranium in the United States has to be imported, but thorium can be easily mined from United States soil. Thorium is approximately three to four times more abundant than uranium all over the world, and there is enough thorium in the United States alone to provide sufficient grid power to last us for centuries (2013, p. 4). Other countries may have easier access to thorium instead of uranium. “In India's case, thorium could be particularly attractive, because the country has some of the world's largest thorium reserves but limited access to uranium. Other countries that are working to build civilian nuclear programs, such as the United Arab Emirates, might also find thorium easier to obtain” (Garber, 2009). Unlike uranium, the thorium that is mined out of the ground can be used in a reactor without having to be enriched, as it appears naturally unmixed with isotopes, unlike uranium (Greaves, Furukawa, Sajo-Bohus, & Barros, 2012, p. 454). The abundance, availability and ease of use suggest that this fuel should clearly be considered as an alternative to uranium.

One of the problems with uranium is the need to enrich it, which is a cumbersome and expensive process. Thorium does not need this process because natural thorium has only one isotope, the fertile thorium-232, with only trace amounts of thorium-230 (Greaves, Furukawa, Sajo-Bohus, & Barros, 2012, p. 454). *Fertile* means that thorium-232 by itself will not start the fission process, but if it is bombarded with neutrons, it will be ultimately converted into fissile uranium-233, which can start splitting and generating energy (“Fertile material,” 2014). Because it will not start the fission process without an external source of neutrons, thorium has the advantage of being safer than uranium. Another advantage that thorium has over uranium is that the thorium dioxide fuel is far more stable and has a higher thermal conductivity than uranium dioxide fuel (Kazimi, 2003, p.410). Although there could be questions about how readily conversion to thorium could be made, in fact, existing nuclear reactors can utilize thorium instead of uranium without extensive alteration to the current designs (Garber, 2009). A major benefit of thorium nuclear reactors over uranium nuclear reactors is that thorium has a much higher energy density. According to Dr. Carlo Rubbia, a Nobel-prize winning particle physicist, the amount of thorium required to generate one gigawatt of power for a year is only one ton. To generate the same amount of power using uranium would require two hundred tons of uranium, and using coal would need 3.5 million tons of coal (2006, slide 16). Because of its greater energy density, thorium shows promise as a cleaner and more efficient energy source than either uranium or coal. The efficiency as well as stability and ease of conversion are all compelling reasons to make a switch to thorium.

Thorium reactors come in a variety of different designs, and one reactor design that is in common use is the liquid fuel or molten salt reactor. The concept of liquid fuel/molten salt reactors was developed at the Oak Ridge National Laboratory through the Molten-Salt Reactor Program (MSRP) between 1957 and 1976. Molten salt reactors (MSRs) work by having all the fertile and fissionable material dissolved in a molten salt. The molten salt is circulated through a reaction chamber where a moderator material that creates the conditions for nuclear reaction criticality is located. As the reaction proceeds, heat is generated, and the heated fuel is circulated out of the reaction chamber, where it loses criticality and stops the nuclear reaction. From there, heat exchangers draw out the heat in the molten salt to produce power by turning water into steam to turn turbines. The molten salt is circulated through the reactor and back into a reaction chamber and the process starts all over again (Greaves, Furukawa, Sajo-Bohus, & Barros, 2012, p. 455).

A major advantage of MSRs is that they are actually safer than other reactor designs for a multitude of reasons. An MSR will rarely experience a severe accident such as a meltdown because the fuel is already in a molten state and thus cannot undergo a meltdown (Greaves, Furukawa, Sajo-Bohus,

& Barros, 2012, p.458-459). Furthermore, the internal pressure is very low compared to other reactor designs: "Pressure range contemplated in the MSR is about 0.5 MPa (4.93 Atm or 72,5[sic] PSI) which contrasts to pressures in the range of 15 MPa (148 Atm or 2180 PSI) as are used in PWR´s [pressurized water reactors]" (p. 456). Also, the nuclear waste in an MSR is contained in the molten salt fuel, which remains permanently inside the reactor, thus removing the need to replace and store spent fuel rods. A thorium MSR will not produce as much weapons-grade radioactive material, and any it does produce will be highly radioactive to the point where it is not feasible to make weapons with or even transport the material (p.459). Therefore the concerns about meltdowns and theft of nuclear material by terrorists are greatly alleviated, making this a much safer alternative.

One argument against the use of nuclear reactors is that they are commonly associated with nuclear weapons production. Dr. Rubbia notes that "[i]f we continue to play the game of energy linked with the bomb, problems of mankind would be so complicated that only a few countries will do it, and countries that have little or no energy, they will find themselves in difficulty" (2006, p. 60). However, thorium reactors offer a new possibility for nuclear energy generation without being associated with nuclear weapons. Unlike uranium reactors, thorium reactors do not produce enough uncontaminated weapons-grade radioactive material to be used in making nuclear weapons. Both Dr. Kazimi and Schaffer note that the uranium-233 produced in a thorium reactor will be heavily contaminated with uranium-232, which is useless in a nuclear weapon unless the uranium-233 is extracted via a difficult and expensive enrichment process (Kazimi, 2003, p.413; Schaffer, 2013, p.11). The nuclear energy from thorium can be generated without the fears of proliferating nuclear weapons.

As has been shown, thorium is another means the United States can pursue to reach greater power productivity with fewer problems than traditional nuclear power. Current nuclear facilities can easily be converted to using thorium. It is more readily available, especially in the United States, has more power density, is safer from meltdowns or pressure accidents, and does not lead to the proliferation of atomic weapons. If used in a molten salt reactor, the waste is contained within the reactor, so even the problem of nuclear waste is much less of a problem. Because of its ability to produce a huge amount of power, it is a cleaner source than fossil fuels. In combination with existing power sources, it may offer a positive future to energy needs.

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