India Needs Thorium Breeder Reactors

by Ramtanu Maitra

An effort is afoot in India and Russia to initiate research on developing small, sealed thorium breeder reactors for a wide range of uses throughout the world. The most interested party in this development is India, the most obvious reason being that India is a power-starved nation that has developed the entire nuclear-fuel cycle, including the thorium-fuel cycle, and while India is low in uranium reserves, it probably has the largest thorium reserves in the world.

But the plan to develop these reactors is not simply developing nuclear-based power sources. Large nuclear power plants are available all over the world, and even the Indian nuclear industry, under pressure from the industrial and urban sectors, is in the process of developing nuclear reactors with capacity upwards of 500MW.

Small Reactors in Clusters

But, 80% of India's population lives in rural areas, and almost 60% of the workforce depends on agriculture. A vast majority of India's water consumption is in the agricultural sector, and the entire population depends very heavily on annual monsoon rains, which can be extremely irregular, causing devastating droughts, which threaten India's food security. At the same time, India's coastline stretches about 3,570 miles on the mainland, from the border of Bangladesh in the Northeast to Gujarat in the Northwest. More than 600 million people live, bounded by an ocean on one side or the other. And, yet the vast majority of them lack safe, clean water.

The lack of power, massive shortfall of water, and the potential to pull millions out of poverty within the span of a generation, are the primary motivations behind the research on thorium reactors. These small thorium-fueled reactors, which would breed uranium-233 to generate power, can be placed all across power-short and water-short nations, and bring about a surge in economic development not seen before. The power from these small reactors will provide the power requirement for agriculture, small and medium-size industries, desalination of seawater and brackish water to make clean potable water, and also to meet the requirement of all commercial and domestic uses. The beauty of these reactors is that when power demands would grow, another one of these reactors can be placed to form a cluster.

The list of benefits of developing these small reactors by no means ends here. There are other benefits of significant

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The Bhabha Atomic Research Center (BARC) in Trombay, India. Small, sealed thorium breeder reactors would be ideal for power-starved India, and would allow its population of over 1 billion, to overcome its vulnerability to the whims of nature. These small reactors can provide the power needed for agriculture, small and medium-size industries, and desalination of seawater.

dimensions. For instance, to set up these small reactors would require a reasonably small infrastructure, and since the power output will be commensurate with the local population and their activities, power generated from these reactors would be consumed locally. This would eliminate the 12-15% line losses that occur regularly when power is put on large and long grids, and prevent the instability produced in a crucial national electrical power grid, that results when a huge amount of power is dumped, or withdrawn, from that grid. Equally important is the fact that since these reactors are small, their construction and operation would not disrupt people's lives the way large infrastructure-based power plants do. The population living in the rural areas would be able to maintain their way of life, traditions, and environment, and at the same time, have a quality of life they could not have because of endemic shortfall of power and water.

Sealed Safe

But these reactors, now in the concept stage, are even more interesting. Since these reactors would be sealed "for life," removal of fissile material from the reactor core, enclosed within a tamper-proof cask, will not be possible. The whole system would be protected by a network of security alarms. These reactors generate power without requiring either refueling or maintenance. In contrast, conventional nuclear reactors are under constant attack of the anti-nuclear groupies who point at the potential threat of proliferation because these reactors must be charged periodically with new fuel, which later has to be removed for replenishment: both steps allow an opportunity for fissile material to be diverted to weapons programs.

The basic objective of the research is to develop a sealed reactor which will have a lifespan of about 30 years. At the end of this life span, the reactor would be buried in the same sealed condition. For these reactors to generate power without any outside intervention, the sealed reactor would need to be of the fast-breeder type. Thorium-232, a non-fissile material breeds fissile uranium-233, which is the desired breeder-fuel.

It is not clear at this early stage what exactly the overall configuration of these reactors would be. It is expected that the reactors would be small, about 10-15 feet in girth and about 45-50 feet in height. The weight could be as little as 200 tons. These reactors, once they become operational, would produce power uninterrupted for a generation. There will be no down time, since there will be no refueling involved. At Lawrence Livermore National Laboratory in Northern California, a similar project, using uranium-238 as fuel, is in progress. Known as the small, sealed, transportable, autonomous reactor (SSTAR), the machine will generate power without needing refueling or maintenance. To extend the reactor's life, the cylindrical core of the SSTAR will be engineered to sustain fission only when surrounded by a metal cylinder that reflects neutrons back into the fuel. This metal mirror will start at one end of the core, and over the course of the reactor's lifetime, move slowly along to the opposite end, consuming the fuel as it goes.

Clearly, the challenge in developing the thorium-fueled reactors would lie in getting the breeder to breed fissile uranium-233 continuously in such a way that it meets the power demand for three decades or so. The added challenge, of course, will be to compartmentalize the fuel so that uranium-233 becomes always available. To produce uranium-233, atoms of thorium-232 are exposed to neutrons. Thorium-233 forms when thorium-232 absorbs a neutron. Thorium-233 has a half-life of about 22 minutes and decays into protactinium-233 through beta decay. Protactinium-233 has a half-life of about 27 days and decays into uranium-233, also through beta decay. If completely burnt up through fission, one pound (0.45 kilograms) of uranium-233 will provide the same amount of energy as burning 1,500 tons (1,350,000 kilograms) of coal.