# India Gets an Offer For Thorium Reactor

by Ramtanu Maitra

The Indian Atomic Energy Commission received an offer in September of a novel type of thorium breeder reactor from the California-based Dauvergne Brothers, Inc. This is a significant development, because India has been considered a pariah state since its rejection of the Nuclear Non-Proliferation Treaty (NPT) and testing of nuclear explosives in 1974 and in 1998. Since 1974, India has been prohibited from getting any nuclear-related technologies, or other technologies that the nuclear-weapons states consider can be transformed for utilization in India's nuclear power development.

The proposed Dauvergne reactor is fuelled with a fissile start-up material like uranium only once, when the reactor begins operation. After that, the reactor runs for its full operational life on uranium-233 (U-233) which is bred in the reactor core from thorium.

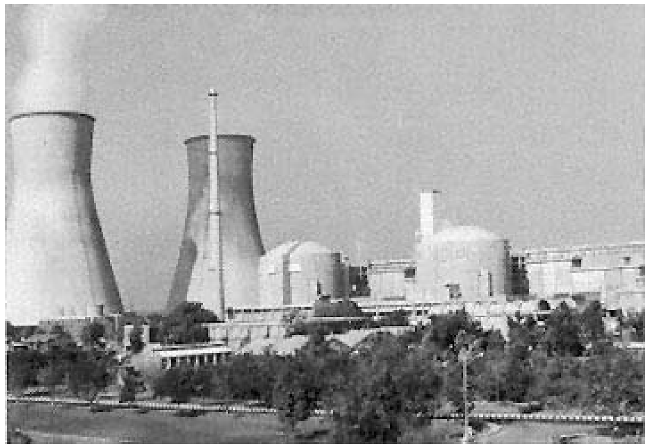
It is likely that New Delhi will ignore the offer, because it would undermine India's already developed plutonium-triggered thorium-reactor program, and it is thought to have been floated primarily to curb India's ongoing plutonium-extraction process. It is also suspected in New Delhi that the offer has the backing of the Bush Administration, which wants India to stop its production of plutonium.

Dauvergne Brothers, Inc. (DBI) was founded in June 1965 by Hector A. D'Auvergne. In 1968, the company initiated research on the packaging of thorium in a nuclear reactor in order to produce hydrogen as an energy carrier, thus creating a new commodity in thorium as an energy source. DBI has continued advancing its thorium program, with ongoing concentration on nuclear vessels and biomass to produce a commodity for the replacement of gasoline.

Sustained research by DBI scientists and engineers resulted in the company's development of a thorium-fuelled reactor, according to its website. DBI claims that its reactor "starts up using conventional uranium-based nuclear fuels, and incrementally converts to an all-thorium fuel cycle over a period of 10 years, using India's abundant supply of thorium ores to maintain energy independence."

Computer simulations of the DBI thorium breeder reactor show that a single load of 25% uranium-oxide fuel and 75% thorium-oxide will keep the reactor running for a decade. "In that time, enough U-233 will be bred in the thorium oxide fuel to increase the output power of the DBI reactor core by 50% adding only fresh thorium oxide as fuel," the DBI website reports. After that, no uranium ores are needed.

DBI claims that after approximately ten years of operation, much of the activated thorium fuel would be transferred, without any reprocessing necessary, into a second-generation DBI reactor core that would have higher power output than the first. "Fresh thorium breeder bundles will be added to perpetuate the cycle." In addition, DBI claims, unlike the zirconium fuel cladding of most breeder reactors, the DBI fuel capsules are derived from an industrially available material that is much less expensive than nuclear-grade zirconium alloys.



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; eight other Indian reactors in the planning stage, will also use thorium.*

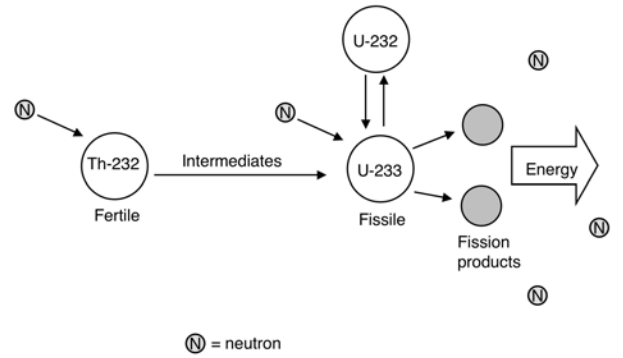
## India's Own Thorium Reactor

From the initial look of things, the offer is laudatory. Thorium, which India has in plenty, cannot be directly burned in a reactor, but has to be converted into fissile U-233. India's own thorium utilization strategy hinges on reprocessing the spent fuel from the thorium reactor—a contentious issue between India and the United States because of the plutonium involved. Thus DBI claims that its reactor design, which eliminates reprocessing, is tailor-made for the Indian situation.

However, in a research program that took India almost three decades, Indian scientists and engineers have designed a thorium-fuelled nuclear reactor which is planned to be India's "bread and butter" in generating nuclear-power-based electricity to deal with the nation's power-starved situation. The design of the indigenous thorium reactor took almost seven years to reach its present level. In contrast, the proposed DBI reactor is still pretty much at the blueprint stage.

In August 2005, Indian nuclear scientists V. Jagannathan and Usha Pal unveiled before the international community the revolutionary design of an Advanced Thorium Breeder Reactor, the ATBR, that can produce 600 megawatts of electricity for two years "with no refueling and practically no control maneuvers." India is presently developing its commercial version of this thorium reactor. Designed at the Mumbai-based Bhabha Atomic Research Centre, the ATBR has been

FIGURE 1
### Simplified Diagram of the Thorium Fuel Cycle




*The neutron trigger to start the thorium cycle can come from the fissioning of conventional nuclear fuels (uranium or plutonium) or an accelerator. When neutrons hit the fertile thorium-232, it decays to the fissile U-233 plus fission fragments (lighter elements) and more neutrons. (Not shown is the short-lived intermediate stage of protactinium-233.)*

acknowledged as far more economical and safe than any other power reactor in the world.

The ATBR does not require natural or enriched uranium, which India is finding difficult to import; the reactor uses thorium. It requires plutonium initially as "seed" to ignite the reactor core. Eventually, the ATBR can run entirely with thorium and fissile uranium-233, which is bred inside the reactor, or obtained externally by converting fertile thorium into fissile uranium-233 by neutron bombardment.

According to Indian scientists, the ATBR will annually consume 880 kg of plutonium for energy production from "seed" rods, while converting 1,100 kg of thorium into fissionable uranium-233. This 230 kg gain in forming fissionable fuel makes the ATBR a kind of thorium breeder.

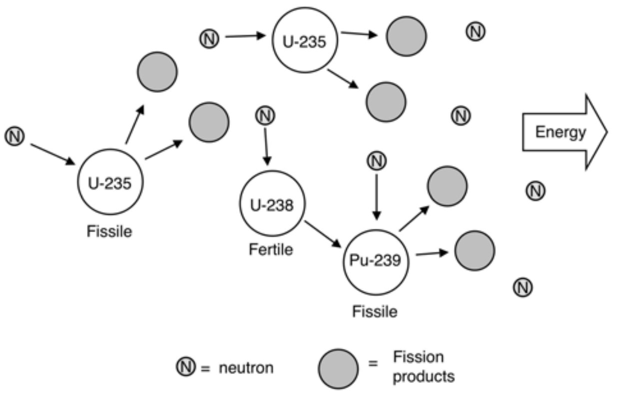
The uniqueness of the ATBR design is that there is almost a perfect "balance" between fissile depletion and production that allows in-bred U-233 to take part in energy generation, thereby extending the core life to two years. This does not happen in the present-day power reactors, because fissile depletion takes place much faster than production of new fissile fuel.

## The Caveat

In the light of recent developments vis-à-vis the ongoing discussions on the U.S.-India nuclear deal, the DBI offer creates problems. To begin with, while India is still debating how to make the nuclear deal work, DBI's offer is considered in India to be that of an anxious party making its bid to enter the Indian market, with the backing of Washington.

In addition, some observers point out that the offer, for all practical purposes, has been made to undermine India's unique thorium-fuelled reactor design. India expects that its thorium-fuelled reactors, which can be built in sizes ranging from very small to large power-generation capacities, will not

FIGURE 2
### Simplified Diagram of the Uranium Fuel Cycle




*In the conventional uranium fuel cycle, the fuel mix contains fissionable U-235 and fertile U-238. A few fast neutrons are released into the reactor core (for example, from a beryllium source), and when a neutron hits a U-235 nucleus, it splits apart, producing two fission fragments (lighter elements) and two or three new neutrons. Once the fission process is initiated, it can continue by itself in a chain reaction, as the neutrons from each fissioned uranium nucleus trigger new fissions in nearby nuclei. Some of the U-238, when hit by a neutron, decays to plutonium-239, which is also fissionable.*

only help India to overcome its electrical power deficiency, but will enable to country to become an exporter of commercial reactors.

DBI, on the other hand, is unlikely to find the production of small reactors "profitable," although small reactors are what India needs for water desalination and rural development uses.

Underlying all this, there is a bigger caveat. It is widely acknowledged that India has nuclear weapon capabilities, and the Indian population is not at all ready to give up this option, considering that no other country that has developed nuclear weapons is ready to do the same.

In this context, India's plan to breed plutonium had always been the cynosure of the nuclear-weapons states alone. In the ongoing discussions of the India-U.S. nuclear deal, the breeding of plutonium is an up-front issue. The form the nuclear deal has taken so far, indicates that India will be allowed to breed plutonium for its commercial power generation.

But DBI makes clear that India no longer has any reason to breed plutonium, based on DBI's version of the thorium-fuelled reactor. In justifying its offer to India, DBI stated: "international agreements between India and uranium-source nations to use proliferation-resistant fuels in the DBI Reactor Program, subject to IAEA [International Atomic Energy Agency] monitoring, could sever the link between civilian and military nuclear programs in India, without adversely affecting India's ability to scale up the DBI Reactor Program using native thorium in future generations."