Key to India-Russia Relations: Development of Thorium Reactors

by Ramtanu Maitra

In early December, Indian Prime Minister Manmohan Singh, fresh from his recent trip to Washington, will be in Moscow for a two-day visit to hold talks with Russian President Dmitri Medvedev and Prime Minister Vladimir Putin, among others, to strengthen India-Russia cooperation. The key area of discussion should be a bilateral effort to accelerate commercialization of thorium-fuelled reactors—an area of scientific and technological work where both countries have invested wisely and have met with substantial success.

The India-Russia talks take place in the context of the emerging alliance among the three great Eurasian powers—India, Russia, and China—and follow breakthrough agreements between China and Russia to develop Russia's Far East (see last week's *EIR*). The developments are in line with Lyndon LaRouche's proposal for a Four-Power combination, including the United States, to bring the world out of the current crisis.

When the Indian Prime Minister began his second term this year, he announced that he will focus on development of rural India, with special emphasis on building a strong physical infrastructure. India has a massive shortage of both power and water. The prime challenge of the Manmohan Singh government will be to develop both of these, along with quality education and health care for all Indians. In meeting the challenge of water and power shortages, India will have to lean heavily on nuclear power reactors of small and medium size. Power generated by these reactors can be consumed locally, by a village, or a cluster of villages, improving the living condition of the rural people.

Nuclear for Power and Water

In addition, the heat generated by these small reactors can be utilized efficiently by producing potable water through flash desalination. The technology has already been developed by the Indian nuclear scientists based in the Bhabha Atomic Research Center (BARC) in Trombay. India's vast peninsular coast is desperately short of water, and installing hundreds of small thermal reactors generating 50 MW, or less, of electrical power could desalinate billions of gallons of seawater and make it potable. There is no doubt that, with the help of Russian and Indian scientific and technological capabilities that have been developed over recent decades, this goal can be reached within a few years.

Prime Minister Singh has recognized this potential of nuclear reactors. Last September, he told the International Conference on Peaceful Uses of Atomic Energy in New Delhi, "We have built a nuclear desalination plant at Kalpakkam and are working on the use of isotope hydrology techniques for rejuvenation of springs, which is an important source of drinking water. I see a growing role for nuclear energy in these areas in the coming decades."

India-Russia cooperation in science and technology has, so far, remained centered around high-tech armaments and the Russian contribution to India's space program. For instance, since 1991, Russia was supplying the cryogenic engines to power India's Geosynchronous Satellite Launch Vehicles (GSLVs) that have placed satellites in geostationary transfer orbit. Although Russia could not transfer critical cryogenic technologies to India due to international opposition, the Russia-supplied engines helped the Indian Space Research Organization (ISRO) to put a number of satellites in orbit. Now, however, India has developed the technology. Last December, ISRO had successfully conducted the flight acceptance hot test of the indigenous cryogenic engine at its Liquid Propulsion Systems Centre at Mahendragiri. The first indigenous cryogenic engine will be used in the GSLV rocket that is slated to

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Russia and India have worked to enhance scientific and technological collaboration over the years. In early November, Russian Deputy Prime Minister Sergei Sobyanin visited India, where he met with Prime Minister Manmohan Singh in advance of the Indian Premier's upcoming visit to Russia. The two are shown here in New Delhi on Nov. 9.

put the experimental communication satellite GSAT-4 in the orbit. The launch will take place in December 2009.

India-Russia Technological Cooperation

In addition, New Delhi and Moscow have jointly developed the BrahMos cruise missile. The supersonic missile—which derives its name from India's Brahmaputra and Russia's Moscow rivers—has a range of almost 300 km, and is designed for use with land, sea, and aerial platforms. BrahMos is based on the earlier Russian design for the SS-N-26 (3M55 Oniks) cruise missile. The Indian Air Force is reportedly considering the possibility of fitting the BrahMos on its Su-30 combat jets. The BrahMos missile is a two-stage vehicle that has a solid propellant booster and a liquid propellant ram-jet system. The missile can fly at 2.8 times the speed of sound, and is capable of being launched from multiple platforms based on land, sea, sub-sea, and air.

In September 2009, a memorandum of understanding (MoU) was signed by India and Russia to develop and induct a new hypersonic version of their joint venture 290-km-range BrahMos cruise missile by 2015. The new missile, they said, will be known as "BrahMos-2," and will have a speed of over 6 Mach (around 6,000 km per hour) with a striking-range of 290 km. While this scientific and technological cooperation is of immense benefit, particularly for India, which has been under international sanctions (for its refusal to sign the Non-Proliferation Treaty, and for testing nuclear devices) from obtaining a large number of high-tech materials, the key to the India-Russia scientific and technological collaboration lies in the development of the next generation of nuclear reactors fired by thorium fuel.

Both Russia and India have done a significant amount of groundwork to enhance bilateral scientific and technological collaboration over the years. In early November, Russian Deputy Prime Minister Sergei Sobyanin, who also co-chairs the Russian-Indian Commission on Trade, Scientific and Cultural Cooperation, visited India as part of preparation for the Indian Premier's upcoming visit to Russia. During his Nov. 9-12 visit, in addition to meeting Monmohan Singh and External Affairs Minister S.M. Krishna, Sobyanin reviewed the two 1,000 MW Pressurized Light Water nuclear power units (VVERs) now being built at Koodankulam near Chennai.

Russian Nuclear Reactors

The two 1,000 MW Russian reactors are in the later stages of construction, with the first unit expected to go on line sometime early next year, and the second, around eight months later. Four more reactors for Koodankulam have already been ordered. Russia will also supply fuel for these reactors for their entire lifespan. In August, dummy fuel—akin to the real one in terms of weight and other features, but without uranium—for the first reactor was received. Previously, the project received the first shipment of uranium from Russia for the second 1,000 MW unit at Koodankulam. The first shipment was received in early 2008.

In addition, Russia has offered a 30% discount on the $2 billion price tag for each of its new nuclear reactors under discussion for sale to India. Moreover, the Russians are open to authorizing the nuclear fuel firm TVEL Corporation to deliver uranium not just for the Russian-built nuclear power stations, but for existing heavy-water-based power reactors in the country as well, including the Tarapur station, according to Indian Government sources. On the other hand, India has promised the Russians an increased role in the nuclear sector. Over and above the agreement signed for four reactors at Koodankulam, where two reactors are already under construction, talks have been initiated for building the seventh and eighth reactor units with Russian assistance at the same site. The Russians are also lobbying hard for earmarking at least one more new site, other than Koodankulam, for setting up Russian-designed reactors.

From these developments, and taking into account India's desperate need to enhance its power generation capacity through nuclear energy, it is a foregone conclusion that India will procure more large Russian reactors in the coming years. However, it is now time for these two nations, which have invested over the years in developing a thorium fuel cycle, to bring to fruition small and medium-size commercial thorium reactors at the earliest possible time.

India decided on long-term nuclear power generation based on a three-stage program back in the 1950s. In the first stage, natural uranium (U-238) was used in pressurized heavy water reactors (PHWRs). In the second stage, the plutonium extracted from the spent fuel of the PHWRs was scheduled to be used to run fast breeder reactors. The fast breeders would burn a 70% mixed oxide (MOX) fuel to breed fissile uranium-233 (U-233) in a thorium-232 (Th-232) blanket around the core. In the final stage, the fast breeders would use Th-232 and produce U-233 for use in the third-stage reactors.

One advantage of using a combination of thorium and uranium is related to the proliferation question: There is a significant reduction in the plutonium content of the spent fuel, compared with what comes out of a conventional uranium-fueled reactor. Just how much less plutonium is made? The answer depends on exactly how the uranium and thorium are combined. For example, uranium and thorium can be mixed homogeneously within each fuel rod, and, in this case, the amount of plutonium produced is roughly halved. But mixing them uniformly is not the only way to combine the two elements, and the mix determines the plutonium production.

Indian Initiatives

To a certain extent, India has completed the first stage of its nuclear program, putting on line more than a dozen nuclear power plants so far, with a few more plants now in the construction process. The second stage is as yet realized only by a small experimental fast breeder reactor (13 MW), at Kalpakkam, in the state of Tamil Nadu. Meanwhile, the Indian authorities have approved the Department of Atomic Energy's proposal to set up a 500 MW prototype of the next-generation fast breeder nuclear power reactor at Kalpakkam, thereby setting the stage for the commercial exploitation of thorium as a fuel source. India's commitment to switch over to thorium stems, in part, from its large indigenous thorium supply. Thorium has no isotopes and is a non-fissile element. However, it has a thirst for capturing a neutron to convert itself into U-233, a fissile material, and can be used as fuel in the reactors.

India began the construction on the facility for reactor physics of the Advanced Heavy Water Reactor (AHWR) in 2007. The AHWR will use Th-232, the "fuel of the future," to generate 300 MW of electricity, up from its original design output of 235 MW. The reactor will have a lifetime of 100 years, and is scheduled to be built on the campus of India's main nuclear research and development center, the Bhabha Atomic Research Center. The construction of the AHWR will mark the beginning of the third phase of India's nuclear electricity-generation program. The fuel for the AHWR will be a hybrid core, partly Th-232/U-233, and partly thorium-plutonium. The reactor will be a technology demonstrator for thorium utilization.

India-Russia cooperation in the area of Th-232 as reactor fuel has been progressing for some time. In 2000, India and Russia signed a protocol in Moscow for cooperation in developing thorium-based nuclear fuel for use in the pressurized light water reactors being sup-

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On his visit to India, Russian Deputy Prime Minister Sobyanin reviewed the two 1,000 MW pressurized light water nuclear power units (VVERs) now being built at Koodankulam near Chennai (shown here). At present, the VVERs are designed for use with enriched uranium (about 6% of fissile U-235, and the rest, non-fissile U-238) as fuel.

plied by the Russians for Koodankulam. At present, the VVERs are designed for use with enriched uranium (about 6% of fissile U-235, and the rest, non-fissile U-238) as fuel.

The protocol signed in 2000 concretized the "Proposal on R&D on Thorium Utilization in Russian VVER-1000," signed on April 29, 1999, in Moscow, at a meeting of specialists of the Bhabha Atomic Research Center and the Nuclear Power Corporation of India, on the Indian side, and the Kurchatov Institute on the Russian side. That document also envisaged development of a fuel that can be used without altering the design of the reactors that Russia would supply. According to D.N. Moorty, an Indian nuclear chronicler, the Moscow proposal has two interesting aspects. The "proposal" recognized that "an agreement between [the Russian Federation] and India on the construction in India of a series of reactors of VVER-1000 does exist."

Russian Expertise vis-à-vis Thorium

The second interesting aspect of the proposal records that the Kurchatov Institute had developed "a safe, low-cost, nuclear fuel design with thorium utilization for Russian VVER reactors that offers a nuclear fuel," which has five features: It is 20% less expensive than traditional fuel (enriched uranium); it can be inserted in Russian VVERs without modification to the reactors; it reduces nuclear waste by half in volume when compared to traditional fuel; it reduces risk of fission material proliferation; and it allows for effective thorium utilization without reprocessing.

Moorty points out that, about two months before the 2000 protocol for joint R&D on thorium utilization was signed, scientists at the Indira Gandhi Centre of Atomic Research (IGCAR) at Kalpakkam confirmed that India was already so highly advanced in thorium utilization in the form of a blanket, along with a certain amount of enriched uranium in the fast breeder test reactor (FBTR), that a prototype fast breeder reactor was already under construction at Kalpakkam using the same technology.

The Russian expertise in thorium fuel is no secret; its development began almost two decades ago. In 1992, the eminent nuclear engineer Alvin Radkowsky, architect of the naval nuclear program that had spawned the civilian nuclear energy industry, on the advice of his former teacher and pioneering nuclear physicist, Edward Teller, embarked on the project to design a new nuclear fuel made out of non-fissionable mineral thorium. He realized that thorium, though non-fissionable, could be made to sustain a nuclear reaction in the presence of fissile U-235 or plutonium 239.

By the mid-1990s, Radkowky's outfit, Thorium Power, Inc., with the support of the U.S. Department of Energy, began a project involving, reportedly, 500 Russian scientists and engineers at the Kurchatov Institute and other Russian research institutions, in fabricating and testing a thorium fuel, to burn plutonium in Russian VVER-1000 reactors.

According to Nancy Roth, editor of the U.S.-based *Fuel Cycle Week*, following Radkowsky's untimely death, a new thorium fuel underwent ampoule irradiation testing at the Kurchatov IR-8 research reactor for several years, and full-scale lead test assemblies were expected to be tested in a VVER-1000 reactor at the Kalininskaya nuclear power plant, by the first quarter of 2008.