The Moscow Times
30 YEARS
INDEPENDENT NEWS FROM RUSSIA

Aiming to Capitalize On Fast Reactors

By Anatoly Medetsky

August 23, 2010

Workers in white uniforms carrying out maintenance work in the Beloyarsk nuclear power plant in the Sverdlovsk region. **Valery Bushukhin**

Editor's note: This is the fifth and last in a series of articles about President Medvedev's efforts to modernize the economy.

The idea to build more efficient and environmentally friendly nuclear reactors, which Rudolf Baklushin helped test in the Soviet Union decades ago, has had its ups and downs.

As deputy chief engineer, he oversaw the construction and — in 1973 — the opening of the first Soviet fast breeder reactor, which produces more fuel than it burns and yields less dangerous waste.

"I volunteered because it promised new, interesting work and new prospects for the industry," said Baklushin, who is now a nuclear scientist at an institute near Moscow.

But costs of building such reactors were high, and when geologists discovered new, extensive

deposits of uranium, the development of the technology was no longer considered a priority.

But despite being at least half a century old, the idea has assumed a fresh urgency recently since President Dmitry Medvedev made it part of his modernization agenda.

Should further tests of the technology succeed, Russia will by 2020 start to commercially produce the reactors — capitalizing on an impressive worldwide lead in the research.

"I would say Russia is certainly the leader in fast reactor technology," said Michael Driscoll, professor emeritus of nuclear engineering at Massachusetts Institute of Technology. "Second, I would say, is France."

Some of the 26 reactors that Rosatom, the state nuclear corporation, plans to build before 2030 will use the new technology, corporation spokesman Sergei Novikov said. According to the corporation's outlook, it will completely phase out the current, third-generation equipment by the start of next century.

Medvedev's prioritization of the technology last year assured the project a guarantee of receiving sufficient federal spending amid Russia's uneasy recovery from the global economic crisis. The government has allocated 110.4 billion rubles ($3.6 billion) for research in this and other nuclear energy areas until 2020 under the New Generation Nuclear Technologies program adopted in February.

Gaining More Fuel

It was the fear that uranium supplies would dry up very soon that pushed the creation of the first fast breeder reactors in the middle of last century. The technology received only lukewarm attention after a great deal of uranium discoveries made the ore widely available worldwide.

Now the concerns have resurfaced.

Rosatom is making an effort to commercialize the fast breeder reactor because, Novikov said, the world is set to run out of affordable uranium in at least 12 years, given the plans by Russia, China, India and other countries to build more reactors.

"If all the plans ... are implemented — and they are getting to it so far — the market will have a shortage both of uranium and the facilities for its enrichment," he said.

Uranium already shot up in price from at least $7 a pound in 2005 to $60 a pound as of June 30 for long-term contracts, Novikov said.

The world may run out of uranium resources completely by the turn of the next century if there's no replacement for the current technology, said Andrei Mikshes, an industry analyst at the Natural Monopolies Institute, a think tank.

The fast breeder reactor achieves what industry insiders call a closed fuel cycle, the ability to use byproducts from one nuclear reaction as fuel for another, allowing for a spectacular expansion of fuel reserves. It usually uses mixed oxide fuel made up of about 20 percent

plutonium and 80 percent plain, unenriched uranium that transmutes into more plutonium as it burns.

The uranium's fast neutrons hit a so-called blanket of uranium-filled tubes around the reactor core, and the interaction converts the uranium in the tubes into plutonium, thus breeding more fuel. Also, such reactors use specific kinds of uranium atoms — or isotopes — that exist in abundance in uranium ore, a change that increases the resource base for energy generation.

Typical fission reactors use uranium-235, a fuel that constitutes less than 1 percent of uranium ore, which must be enriched in order to be used in existing reactors.

Traditionally, uranium-238, which constitutes much of the uranium ore, has been unusable, but the fast breeder reactor would allow for its conversion to plutonium, thus making it reusable as a nuclear fuel.

"At some point, you won't want to throw away the uranium ... down a hole or into a permanent storage site because it's still useful fuel," said Francis Slakey, a professor of physics at Georgetown University. "And it's the fast reactors that allow you to use the fuel."

Nevertheless, not everyone is convinced of a coming uranium shortage. MIT's Driscoll said the prospect that uranium would remain available at a "reasonable" cost for the rest of the century looked very good, citing a recent study by the International Atomic Energy Agency. Other countries will not be in a hurry to embrace the new technology immediately, he said.

"There'll be a few of them, but I don't think it'll be displacing a lot of light water reactors," he said about the next generation reactors. "I think it's an insurance policy."

But he conceded, "In the long term, we definitely should have these machines available because uranium will be perhaps like oil and, in that, it is not going to be low cost forever."

In addition to a better fuel situation, the fast breeder reactor produces waste that is much safer to store because half of its radioactivity dissipates over 30 to 40 years. In contrast, waste from current nuclear reactors can take more than 25,000 years to decay.

On the other hand, Alexander Nikitin, Russia director of Norwegian environmental group Bellona, said too little information was available to the public about the operational safety of these machines.

Tapping the Foreign Market

In pursuing the technology's development, Russia may hope to market the design internationally before everyone else does, Slakey said.

"They may see that there's an inevitable market for the fast reactor, and they want to get ahead of where the other competitors are," he said. "So it may be a business decision on the part of Russia."

International sales of such reactors, however, would come under the regulations of the

Nuclear Nonproliferation Treaty because of the weapons-grade plutonium that they generate, said Mikhail Kovalchuk, director of the Kurchatov Institute, the country's leading nuclear research establishment.

"Taking into account nonproliferation issues, fast reactors can't go on sale for all countries," Kovalchuk, a member of the presidential working group on developing nuclear technologies, said through his press service. "The market for them is limited."

And France, one of the potential buyers, has already mastered the technology of the closed fuel cycle, according to the Kurchatov Institute. The country has a commitment to build a small reactor unit — in addition to its existing one — come 2020, Kovalchuk and Driscoll said.

India will start putting a series of fast breeder reactors into operation next year, while China is developing the technology at a very rapid pace, Kovalchuk said. Japan and South Korea have a longer way to go, and they move slower, he said.

Lower Costs

Fast breeder reactors were initially at least 1 1/2 times as expensive to construct as the conventional equipment. But the costs have been reduced as the design gets simpler, said Baklushin, a researcher at the state-run Alexander Leipunsky Physics and Energy Institute. He estimated their cost at $1,600 per kilowatt of capacity at most.

India offered the same amount of money to Russia to build pressurized water reactors, or PWRs, at Koodankulam, India, where work is ongoing. The reactors, also known by their Russian acronym VVER, have developed an increasingly complicated design over time, which has pushed up costs, Baklushin said.

It was a VVER reactor that Russia launched on Saturday in Bushehr, Iran. The government has plans to build them also in countries such as Turkey, the Czech Republic, Vietnam, Bangladesh and Argentina.

They may become a notch more expensive as Russia — under Medvedev's modernization plan — is going to upgrade them by the end of 2012 to use more digital technology and become more competitive on the U.S. and European markets.

"Everyone is thinking of small improvements to sell their reactors," said Driscoll, adding that VVERs were quite good in their present condition. "Upgrading everything to digital control is something that all of the vendors are very aggressively engaged in."

Other possible upgrades don't involve nuclear science either, he said.

Russia has already tested the next generation of nuclear rectors at two sites. Baklushin's demonstration reactor, called BN-350 and located near the city of Aktau on the Caspian Sea in Kazakhstan, shut down in 1999, but Russia has been operating its successor, BN-600, at the Beloyarsk Power Plant near Yekaterinburg since 1980. Rosatom is now building an improved and more powerful BN-800 at Beloyarsk to continue studies.

Reactors like those at Beloyarsk typically use sodium as a coolant. Rosatom also plans to build

two other types of reactors that will use lead or a lead-bismuth combination as coolants, Novikov said. It plans to choose the best of the three options by 2017, he said.

An Enticing Target

Another concern has been that the reactors produce weapons-grade plutonium, which could wind up in the wrong hands. The United States, which built the world's first fast breeder reactor in 1963, put the brakes on the program a few years later because then-President Jimmy Carter said the plutonium presented an enticing target for terrorists.

Baklushin rejected the idea that thieves could haul away weapons-grade plutonium from a fast breeder reactor.

"If a person tries to steal it, he will die of radiation exposure," he said. "Plutonium removal would require special technology. It's impossible for terrorists to pull that off."

Jacopo Buongiorno, an associate professor of nuclear science and engineering at MIT, said plutonium reserves have been historically managed "very securely" both in the United States and Russia.

To avoid shipping plutonium across long distances, Rosatom could arrange to recycle it on site at the reactors, Driscoll said, adding that the most a terrorist organization could do with the radioactive substance would be to make a dirty bomb.

"If they took a fuel assembly to downtown in New York or Moscow and blew it up with conventional explosives, it would make a very expensive cleanup problem and, of course, cause panic," he said. "So from that point of view, yes, you should guard shipments to avoid that sort of thing."

A More Distant Future

Russia is researching thermonuclear fusion as well — a technology that does not require a mineral fuel like uranium and may eventually replace fast breeder reactors. The country is sharing that research with the European Union, the United States, Japan, China, India and South Korea, with the goal to jointly build a test reactor in France.

Despite repeated delays in the work and its swelling budget, Russia will continue to participate in the project called the International Thermonuclear Experimental Reactor, or ITER, Medvedev said in his state-of-the-nation address in November.

"It is this technology that is the future," he said. "In cooperation with foreign partners, we will open access to a practically inexhaustible source of energy."

While scientifically plausible, the project still presents a lot of challenges in terms of making these reactors a profitable business, said Driscoll, of MIT.

"I am, at this point, very skeptical," he said, adding that the ITER's budget had already run over by a factor of three. "It's possible that it can be done from the scientific point of view, but

I think the economics are going to be quite troublesome."The radiation damage inside the thermonuclear reactor — a machine that is also known as a "tokamak" — would be so huge it would require replacing the expensive surrounding first wall, which faces the high-temperature plasma, every few years, Driscoll said. Another problem is material for high-temperature-resistant superconducting wires to make magnets for the ITER, he said.

"We need to break through to much better metallurgy. ... Nobody can tell us yet whether those two things are possible," Driscoll said. "It's almost an unpredictable thing."

Medvedev's commission on modernization and technological development, which oversees the nuclear research, said on its web site that mankind should plan on mastering the technology by the middle of this century.

In addition to severing reliance on fossil fuels, thermonuclear fusion would save the environment from more greenhouse gases as humanity burns larger amounts of coal, gas and oil to satisfy its growing energy appetite, which could triple by the end of the century.

Conceived in 1985, the ITER project became the subject of a formal agreement in 2005. Preparatory work for the construction of a 500 megawatt tokamak in Cadarache, France, began in 2007, and fusion experiments will begin in 2019, according to the schedule on the ITER web site.

Participating countries, which represent half of the world's population, make their contributions in kind. In one of the latest contracts, the Kurchatov Institute, representing Russia in the ITER effort, agreed in October to supply the so-called cable-in-conduit conductor for the reactor's poloidal field coils.

Rosatom's Chepetsky Mechanical Plant will produce 50 metric tons of niobium-titanium strands for about 13 kilometers of conductors as part of the project.

The effort shows that some on-the-ground work is in progress, no matter how futuristic the whole idea of thermonuclear fusion might seem.

Find all of the previous articles in this modernization series in the "Related articles" box at the top right of this page. Also, visit our Topic page on President Medvedev's innovation push.