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TECH TALK:

RISING INTEREST IN SMR TECHNOLOGY

Could emerging "small modular reactors" find use in remote areas or for major projects?

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Tech Talk *is an on-going forward-looking ERIS article series curated to inform environment industry and other professionals about emerging technologies that may find application in their projects. This article explores developments and some pros and cons of small modular reactor (SMR) technology, research projects for which are underway in Canada and the United States (see last page).*

From Russia with love

Tucked into a specially constructed mooring in the Siberian port of Pevek, high above the Arctic Circle, the Akademik Lomonosov is now feeding power to the grid in the isolated Chukotka region in Russia's far-east. It's been doing so since December 19, 2019, shortly after being granted an operating license by Russia's nuclear regulator.

To critics, it's a floating Chernobyl—the first Russian floating nuclear power station. To defenders, it's proof of the value of small modular reactor (SMR) technology.

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Actually, it's neither. It's much smaller and much more sophisticated than the Soviet-era RBMK 1000 reactor that failed at Chernobyl. And though it's small by nuclear standards (two 35 MW reactor units), it's not modular. The reactors are standard Russian nuclear icebreaker power plants, modified to produce electricity or heat.

Despite this, the Akademik Lomonosov is a symbol of the promise and the risks of new SMR technology that's attracted new legislation and investment in the United States, and in which Canada hopes to attain a leadership position. *(See sidebar on US developments.)*

Canada enters the market

In November 2018, 10 months before the Akademik Lomonosov docked in Pevek, Natural Resources Canada released its SMR Roadmap, an elaborate plan to position Canada at the forefront of a technology that it believes may become an important component of the energy mix in a carbon-constrained future.

Despite questions, others follow

Critics say the roadmap embarks Canada on a dubious path. Even if the technology works, the power it generates will be too costly, they say, and the market for SMRs too limited to give it any prospect of commercial success. It will leave behind a mess. Modular components will have to be decommissioned. Sites will have to be decontaminated. And there will remain the intractable problem of nuclear waste.

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Those concerns haven't dissuaded other countries – the United States, China, Argentina, for instance – from joining the race. Things are moving rapidly. In Ontario, Global First Power, in partnership with Ontario Power Generation (OPG) and Ultra Safe Nuclear Corporation,

has begun the environmental assessment of its plan to build a micro modular reactor demonstration plant (15 MW thermal or 5 MW electrical) at the Canadian Nuclear Laboratories site in Chalk River. It has simultaneously filed an application with the Canadian Nuclear Safety Commission (CNSC) to begin site preparation The next step will see shovels in the ground.

Moltex in New Brunswick

In New Brunswick, Moltex Energy is among the leaders in the development of a grid-scale (300+ MW) reactor. The reactor could serve as an alternative to a second CANDU reactor that had originally been envisioned for the Point Lepreau nuclear power plant. Even more intriguing is the possibility that the stable salt technology employed by a Moltex reactor could consume spent fuel from its CANDU neighbour.

All designs incorporate passive safety systems. If the reactor is not operating as expected, it shuts itself down. There's no decision required, no red button that an operator must push.

Until you have a reactor built,
HOW DO YOU KNOW HOW SAFE IT IS?

"Reactors on paper are quite safe," warns Gordon Edwards, President of the Canadian Coalition for Nuclear Responsibility. "But they're only ink-fueled reactors. Until you have a reactor built, how do you know how safe it is?"

Why SMR interest is rising

Two factors are driving interest in SMRs, says Eric McGoey, Engagement and Communications Director for Global First Power. Climate change is one. The world needs non-emitting sources of energy. The other is technology. It is no longer necessary to build gigantic nuclear power plants with massive footprints and multi-billion dollar price tags.

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Edwards says there's another driver: the market for large nuclear plants has been on a steady decline since 1977 and the nuclear industry needs a win. SMRs are its shiny new bauble. With enough razzle dazzle, nuclear peddlers hope prospective clients won't notice that SMRs are not a bauble, but potentially a pig in a poke.

The technology has existed on paper for some time, explains Diane Cameron, Director, Nuclear Energy Division at Natural Resources Canada, but only recently has technology caught up with the design specs.

SMRs are put forward as
THE GOLDILOCKS OF NUCLEAR POWER PLANTS

A Goldilocks technology?

For many applications, SMRs are put forward as the Goldilocks of nuclear power plants. Grid-scale models could serve needs of larger areas. By law, Saskatchewan will have to shutter its coal-fired generating plants by 2030. A grid-scale SMR could fill the gap that wind and solar cannot.

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RELY HEAVILY ON COAL FOR POWER...

Large pockets of the United States still rely heavily on coal for power, and though the current political climate may not support a migration away from it, governments change.

An SMR could be installed on the site of a decommissioned coal-fired plant. "You could take advantage of your existing workforce, do some retraining, take advantage of the existing transmission assets, and then you've got a really interesting business case," says McGoey

Conceivably, a grid-scale plant could support mineral development in Ontario's Ring of Fire. Remote communities, in Canada's north or in other infrastructure-poor pockets of the world, would also be potential candidates.

That's the market that's attractive to proponents like Moltex Energy. The UK-based company has struck a relationship with NB Power and is in the process of having its technology reviewed by the CNSC.

Moltex's plan is to develop the technology in New Brunswick, demonstrate it in North America, and then sell it internationally. There are potential sales in New Brunswick, Ontario, Saskatchewan and in the United States, he says.

"The big market is Asia and the developing world," says Rory O'Sullivan, Moltex's CEO for North America.

Suitability for remote use

Micro modular reactor designs exist that conceivably could be trucked into a remote mining site, dropped onto a pad and power a mine for 20 years – a healthy lifespan for most mines. At decommissioning, the reactor would be shipped back home for refurbishment or disassembly.

For that to happen, SMR technology needs to make business sense and environmental sense, and it's far too early to know if either proposition will hold true, admits François Caron, Chemistry Professor at Laurentian University and Director of the Energy Centre at MIRARCO Mining Innovation in Sudbury. There are many competing designs and several projections of costs, but none that yet meet the rigor that a scientist like Caron demands.

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"The business model that we think is going to be most attractive would be to have an operator like us [OPG] tell you that we can give you X number of megawatts for Y years at Z price," says McGoey. OPG would handle licensing, installation, operation and decommissioning. Caron agrees.

"Mine operations are complicated enough as it is," he says. A mine owner doesn't need the added complication of worrying about an onsite SMR.

That's just magical thinking, Edwards counters. There are roughly 150 SMR designs, all competing for a share of an uncertain market.

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"Unless they can mass produce these things, there's no chance they can make them competitive." And, he believes, the market simply isn't there.

Hurdles and hopes

Any SMR would need a license from the CNSC. In support of Canada's SMR initiative, the CNSC has been working to adapt its regulations to an SMR environment, says Andrew Dusevic, a Saskatchewan student-at-law who recently completed his LLM thesis on SMR regulation. CNSC regulations have evolved to meet the needs of CANDU reactors.

"I think [the CNSC] understands intuitively that it doesn't make sense to license a 5 MW unit the same way you license a 3,000 MW unit," says McGoey.

CNSC regulations are largely performance-based, says Dusevic, and that makes them better suited and more easily adapted to SMRs. Other jurisdictions, notably the United States, rely on prescriptive regulations, which are often poorly suited to new technologies like SMRs. SMR developers also covet the CNSC imprimatur. The CNSC is a globally respected regulator of nuclear facilities. An SMR with a license under CNSC regulations would likely be far better regarded than one licensed in China, for instance.

"Building a project at Chalk River, from a technical perspective, is probably pretty easy," says McGoey. The site has hosted nuclear facilities and the local population knows the industry. But the Chalk River plant is intended only to test the technology and prove its commercial worth. Taking that same project and trying to plunk it down in remote, off-grid communities, likely on the traditional territory of an Indigenous nation, is entirely another matter, he admits. Those communities can be anticipated to raise legitimate concerns.

Public acceptance and the path forward

Probably the biggest hurdle SMRs will have to clear is public acceptance. In countless communities across the country, and around the world, nuclear is a word that raises eyebrows.

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Caron believes that a properly educated public will accept that nuclear power is here to stay, and that it's a good thing. Nuclear scientists understand nuclear energy, says Caron. The public does not, and that's a gap that has to be bridged.

But Edwards says the nuclear industry has shown itself to be unable to deliver on its promises. It has so far failed to revitalize the industry. There's no reason to believe that now, with SMRs, it suddenly will.

In the next few years, testing of new equipment, and enabling legislative (and possible new safety) requirements will determine whether Caron's optimism or Edwards' skepticism will prevail.

United States SMR Developments

New legislative developments in the U.S. Congress and Senate on small modular reactors (SMRs) is bipartisan and suggestive that the US is serious about this "climate-friendly" technology.

Last year the Senate Energy & Natural Resources Committee reintroduced the Nuclear Energy Leadership Act *(S.903) and Congress introduced a companion bill (H.R.3306). As was reported in an article in Neutron Bytes, the legislation compels four main developments:*

- *The Department of Energy (DOE) would be required to complete at least two advanced reactor demonstration projects by the end of 2025 and two to five more additional projects by 2035. The Versatile Test Reactor on which work has started, will be governed by a timeline targeting start of operations in 2026. DOE must devise a 10-year strategic plan.*
- *DOE must increase production of high-assay low-enriched fuel (HALEU), which contains U-235 greater than 5% and less than 20%. Many new SMR designs (sometimes called "advanced reactor designs") will include the use of this fuel, such as TRISO pebbles at 9-10% U-235s.*
- *The U.S. government hopes to develop a workforce qualified to build and operate SMRs; a legislative section is devoted to enhancing DOE's University Nuclear Program, with a $49 million investment.*
- *Included in the new laws are purchase power agreements with Department of Defense (DOD) facilities: these require a new agreement for an advanced reactor by 2023 and special consideration for other advanced designs afterwards (with terms of up to 40 years).*

Interestingly, over 50 small modular reactors companies across North America are evaluating advanced reactor design concepts. The companies are looking at how to make the reactors modular and smaller, such that they could be mass produced. Consideration is being given about how to: utilize coolants other than light water; operated a normal atmospheric pressure; use physics and not just engineering for safe reactors; and, evaluate designed that can recycle nuclear waste as fuel.

Two–to–20-megawatt reactors could power military bases, remote remediation sites, and far-away communities. (Many of these currently use costly and polluting diesel fuel. SMRs could be attractive to off-grid industrial operations, mines, and energy consumers in developing nations.)

The US federal government is focusing attention on the DOE's aforementioned Versatile Test Reactor — a priority project noted in the Nuclear Energy Innovation Capabilities Act of 2017. *The DOE is conducting fast turnaround testing and qualification of advanced fuels and materials. Fuels and materials tests will include: sodium-cooled, lead/LBE, HTGR, and molten salt designs.*

Companies with prominent positions in the SMR space include Westinghouse and Moltex. (See main article.)

In March 2018, the DOE awarded Westinghouse and its team $13 million to prepare for the Nuclear Demonstration Unit (NDU) of the "eVinci" micro reactor. The plan is to work through design, analysis, testing and licensing (to manufacture, site and test the NDU) by 2022.

World Nuclear News reports that Moltex signed an agreement with the New Brunswick Energy Solutions Corporation and NB Power to build a demonstration SSR-W at the Point Lepreau nuclear power plant site in Canada.

To learn more, read the whole Neutron Bytes article here:

https://neutronbytes.com/2019/07/07/congress-moves-ahead-with-legislation-to-promote-development-of-advanced-nuclear-reactors/