Get Small Nuclear Reactors Off the Starting Blocks—Now!

by Ramtanu Maitra

Dec. 23—Mass production of modular nuclear reactors to industrialize developing countries, until fusion power comes online! That was the title I used when I last wrote about the ongoing efforts to make small modular nuclear reactors (SMRs)—in the *EIR* issue of November 16, 2018. SMRs will be a reliable source of a steady supply of electrical power. Some few positive steps have been taken in a few countries, including in the United States.


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China Enters Global Tech Race For Small Modular Nuclear Reactors

Ariel Cohen Contributor
Energy

NuScale Power SMR design concept

Nearly two years ago China's "Nimble Dragon" (玲龙) project hit headlines when state-owned China National Nuclear Corporation (CNNC) announced

But the funding available to get the SMRs out of the test laboratories and deployed commercially does not match the interest expressed in SMRs exhibited by many concerned individuals around the world who acknowledge the necessity of SMRs for power generation, desalination and other societal benefits. Consequently, the existing funding also does not match the plans for development and production of this revolutionary generation of advanced nuclear reactors.

The capability to manufacture a safe and sound SMR could hardly be the only objective of SMR developers. The more important objective is to develop the capability to fabricate these SMRs in large numbers concurrently. According to one estimate, if the United States wants to secure 25% of the *potential* global SMR market, it must establish an assembly line to produce 28 to 30 NuScale-type SMRs annually. But this estimate, implying the addition of perhaps 10 gigawatts of nuclear power capacity per year around the world through SMRs, is completely insufficient to the demand: Seventy-five countries in the world currently cannot provide 1,000 kilowatt-hours per year per person, which is less than 10% of the American level, and 1.1 billion people still have no access to electricity at all.

If this blight on humanity is to be dramatically and quickly changed, it is SMRs that will do it, for reasons this article will demonstrate.

A new international credit system will have to be established by leading industrial nations, to enable

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them to export capital goods on a large scale to the developing countries, enabling them to grow rapidly and productively and to thereby tackle poverty. SMRs represent a crucial category of such exports during the immediate future. It must begin by the mid-2020s, but it will only happen with such a new, and relatively vast, global generation of credit.

In other words, plans and programs to set up highly-productive "assembly lines" to manufacture these SMRs are an integral part of an overall SMR development. That process has yet to take off due to lack of adequate appreciation of their potential by those who should know better, and behind the scenes blocking by green malthusians. This is manifest in the lack of funding to jump start the many projects. SMRs will be considered a success when deployed in large numbers in energy-hungry nations, most of which are located in Africa, Asia and Latin America.

Except for a few small, but oil- and gas-rich nations in the Middle East, these power-starved nations have neither the capital resources nor the infrastructure for large nuclear power plants on the order of 1,000 MW per reactor, although such large reactors are more efficient and cost-effective when finally on line. The solution for these countries lies squarely in the speedy and abundant deployment of scalable, small modular reactors.

Developing the Modern Labor Force

To usher in an SMR-based nuclear power revolution requires generous participation of the countries where these SMRs are being developed, and wide-ranging collaboration among the countries such as the United States, Russia, China, Japan, France, among others, who have mastered the peaceful use of nuclear technology for power generation.

As for the power-short nations, necessarily only a few of the smaller nations have been able to show financial interest so far. Romania, which is well on its way to adding two new 700 MW CANDU-type units to its fleet, is nevertheless talking to at least one SMR developer. Ukraine is committing to building an SMR component factory for exports. And South Africa, which ditched the plan to buy eight 1200 MW units from Russia, is rethinking its plans for producing electrical power from nuclear energy, and smaller, more affordable units are clearly one of the possibilities it has in mind. Except for Saudi Arabia and Jordan, which have expressed their keenness to buy SMRs, very little movement has been noticed elsewhere.

It is no longer just hearsay that many of these power-deprived nations clearly recognize that the setting up of nuclear power generation plants is of absolute necessity for developing a workforce that for the first time will be backed by a hundred-percent reliable power source—the very essence for developing the foundation of any economy. A power-strong infrastructure enables the setting up of viable industrial and commercial sectors, urgently needed by the people of those countries.

The reason that those countries will be in the market for purchasing SMRs is not only that the capital cost for SMRs is manageable and installation time is short, but also that they do not demand a strong power transmission infrastructure. Most importantly, these reactors will come completely fabricated and tested in the factory. All that will be required is transportation, by land and sea, and setting them up. Added advantage? These SMRs are scalable. Fabricated modules can be added over a period of time to increase power generation as needed to meet growing economic requirements.

Nonetheless, the success of SMRs will depend on how much and how quickly nations such as the United States, Canada, Russia and China finance the entire gamut of SMR *development*. Russia is developing small reactors mainly for export. "Russia's energy system is more suited to large nuclear plants," Anton Moskvin, Vice President of Rusatom Overseas responsible for marketing and business development, told *Nuclear Engineering International* on October 3, 2018. Floating plants could be of interest to nations needing to supply power and water to isolated territories, or facing seasonal power shortages, or having underdeveloped power systems, he said. Russians admit that floating plants have limitations and cannot be set inland.

Why SMRs

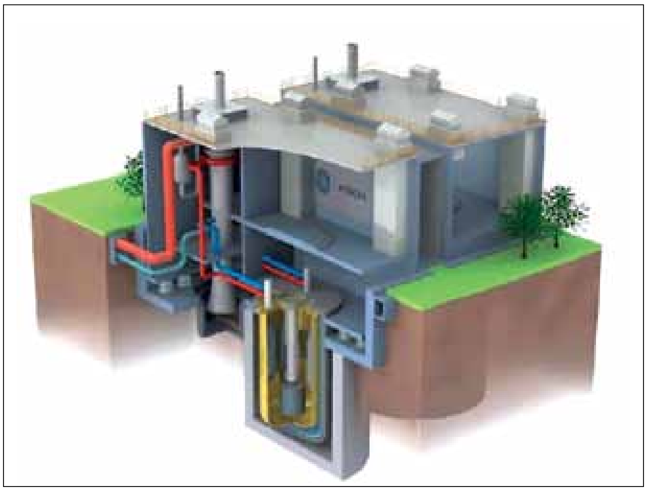
A few points as to why the SMRs are attractive for developing and developed nations are reiterated here. For instance:

• As major components can be manufactured off-site and shipped to the point of use, SMRs allow for the centralization of manufacturing expertise.

• Limited on-site construction is required, as work is concentrated in the manufacturing stage.

• Individual factories could fabricate components for multiple SMRs, increasing fleet-wide design consistency and standardization.

• Modularity and standardized designs can also increase the safety and efficiency of plant operations, as



USNRC

GE Hitachi Nuclear Energy's PRISM nuclear power plant design locates the reactor modules below grade, making them less vulnerable.

they eliminate idiosyncratic design features between plants and streamline operating and maintenance procedures.

- The cost of an SMR has been estimated to be between $800 million and $3 billion per unit, whereas a large reactor typically costs between $10 billion and $12 billion per unit.
- The smaller size of SMRs should translate to each reactor being less capital intensive; costs associated with manufacturing and construction are reduced as less material is required. Factory fabrication can mean quicker construction on site, which reduces the cost of labor and shortens the interval between construction of the reactor and when the reactor begins to generate electricity.
- Transportation of fuel may be minimized since the reactors can be fueled when built in a factory.
- In developing countries or rural communities that lack the electricity transmission infrastructure to support a large nuclear plant, SMRs provide a way for utilities to still have baseload power on the grid.
- Nuclear plant operators can gradually scale up the number of SMRs at a single plant location as demand grows, distributing cost evenly throughout the lifetime of a nuclear power plant.
- The small size of SMRs may allow them to be sited in places where a large baseload plant is not feasible or not needed. For example, SMRs have been considered as a power source for remote mines in Canada that cannot access the grid. This factor is also of great importance in large, power-short nations, such as Nigeria, Indonesia with 17,000-plus islands, and Brazil.
- SMRs will require significantly less land than do power plants with the same output that use wind, solar, biomass, or hydropower. NuScale, one of the leading SMR developers in the United States, estimates that SMRs require only 1% of the land area required for similar generation by other technologies.
- Because of their small size, SMRs can be located underground. This would make them less vulnerable to natural phenomena and destructive acts by man, either through carelessness or by intention.[1]

Who Needs Small Modular Reactors?

In reality, SMRs will have wide-ranging use, not only in small or middle-sized power-short nations, but also in large countries with freshwater shortage but long coastlines. Take the case of India, for instance.

According to a report by India's government planners,

> currently, 600 million Indians face high to extreme water stress and about 200,000 people die every year due to inadequate access to safe water. The crisis is only going to get worse. By 2030, the country's water demand is projected to be twice the available supply, implying severe water scarcity for hundreds of millions of people and an eventual ~6% loss in the country's GDP.
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> As per a report of the National Commission for Integrated Water Resource Development of MoWR [Ministry of Water Resources], India's water requirement by 2050 in a high use scenario is likely to be a milder 1,180 BCM (billion cubic-meter), whereas present-day availability is 695 BCM. The total availability of water possible in country is still lower than this projected demand, at 1,137 BCM.

For more on this see a discussion of the national *Composite Water Management Index* (NITI Aayog, Government of India: June 14, 2018).

Over the years, India's indiscriminate use of groundwater has been squarely blamed for this growing crisis. India has ambitious river-diversion plans to meet the demands of water-short areas. That plan has been hanging fire for decades. However, the river-diversion plan has

1. *Small Modular Reactors: Adding to Resilience at Federal Facilities*, by Seth Kirshenberg, Hilary Jackler, and Jane Eun (at Kutak Rock LLP); and Brian Oakley and Wil Goldenberg (at Scully Capital Services, Inc.), December 2017.

its limitations, since India depends heavily on annual monsoon for replenishing its rivers and groundwater. Monsoon often fails to deliver the water Indians expect and need, to make the rivers run full. Such failures lead to widespread drought in large parts of the country.

On the other hand, India has a coastline of about 6100 km. It touches nine states. Desalination using the SMRs will provide India with a reliable amount of usable water, and over a period of time, will reduce its dependence on drawing out the groundwater and making the land fallow.

SMRs can bring similar benefits to developed nations, such as the United States. California, the most populous state in the Union, is water short. Under present circumstances, the fresh-water shortage in California will be permanent. Today, 75 percent of California's fresh water supply originates in the northern third of the state, above Sacramento, while 80 percent of water users live in the southern two-thirds of the state.

In an average year, California gets about 240 BCM of fresh water from rain, snow and imports from other states. Roughly half of that is absorbed by native plants, evaporates, or flows into the sea. However, the actual amount varies widely from year to year because of nature's uncertainties. California also has about 1350 km of coastline running from north to south. A well-designed deployment of SMRs along the coast would provide a reliable, steady flow of usable fresh water to Californians forever.

USAF/Nicholas Dutton

Extensive damage after Hurricane Maria in Puerto Rico, September 2017.

Puerto Rico

There are also other reasons why SMRs could be of great benefit to the developed nations. Take the case of Puerto Rico, an unincorporated territory of the United States, located about 1850 km southeast of Florida. In essence, however, Puerto Rico is more like a colony of the United States. Puerto Ricans are U.S. citizens, but they have no elected representative serving in the U.S. Congress. Yet they are bound by its decisions, and those of the executive branch.

In 2017, Puerto Rico was battered by two strong hurricanes, Hurricane Irma in September 2017 and two weeks later, by Hurricane Maria. After these back-to-back storms, massive landslides and downed trees blocked mountain roads, cutting towns off from the rest of the island for weeks. Two years later, Puerto Rico's infrastructure remains in shambles, partly because Washington has disbursed very little for the island's rebuilding. While the failure to rebuild Puerto Rico is rooted in politics, what cannot be denied is that the island lies in the path of major hurricanes and the conventional development of infrastructure, such as the island's power grid, in particular, will keep the island vulnerable forever. Puerto Rico's power sector needs a total change, and SMRs would enormously help to usher in that change.

While the energy policy makers in the United States and elsewhere have fallen under the influence of advocates promoting wind, solar, tidal wave basins, and other such so-called renewables, the truth is that Puerto Rico is an ideal location for setting up SMRs. During a panel discussion at a National Clean Energy Week event in Washington in September 2017, former Energy Secretary Rick Perry addressed the issue squarely:

> Wouldn't it make abundant good sense if we had small modular reactors that literally you could put in the back of a C-17 [military cargo] aircraft, transport it to an area like Puerto Rico, push it out the back end, crank it up and plug it in? That could serve tens of thousands if not hundreds of thousands of people very quickly. That's the type of innovation that's going on at our national labs.

Hopefully, we can expedite that.

Gage Skidmore

Rick Perry, Secretary of Energy (2017-2019). "Puerto Rico's power sector needs a total change, and small nuclear reactors would enormously help to usher in that change."

For a fuller discussion of the opportunities for SMRs in Puerto Rico, see "Puerto Rico Group Seeks SMRs for Island Electric Power," in *Neutron Bytes*, October 26, 2018.

Secretary Perry was not the only one who recognized how SMRs would provide a real, and not a cheap and ineffective thumb-tack solution, to the millions living in Puerto Rico who hate the miserable powerless condition in that island. Paul Murphy, managing director of Murphy Energy & Infrastructure Consulting LLC, is part of a project team funded by the U.S. Department of Energy to conduct a feasibility study as to whether advanced nuclear reactors could be a good solution to the island's power problems. Murphy also sits on the advisory board of the Nuclear Alternative Project (NAP), a volunteer-based organization composed of University of Puerto Rico alumni, in partnership with the United Nuclear Industry Alliance (UNIA), based in Mayagüez, Puerto Rico.

Murphy has pointed out that advanced nuclear reactors could be a viable, long-term solution to meet Puerto Rico's needs in an island environment, which poses unique issues of suitability, durability and grid size.

An Oct. 1, 2019 article, "Nuclear Advocates Receive DOE Funding for Exploratory Study on Puerto Rico," posted on the website of Morning Consult, a global technology company that collects, organizes, and shares survey research data to inform decision-making, quotes Murphy: "Windmills and solar panels don't do well in hurricanes. Nuclear plants actually do." For a territory with a vital tourism sector, he said, blanketing the island with wind and solar is untenable. He added that nuclear energy could help reduce Puerto Rico's dependence on fossil fuels.

On March 15, 2018, the Civil Nuclear Trade Advisory Committee (CINTAC) of the U.S. Department of Commerce published a position paper, "Puerto Rico and the Case for Small Modular Reactors," outlining the economic and export potential of SMRs for Puerto Rico. In its cover letter to Commerce Secretary Wilbur Ross, the group wrote:

> The aftermath of Hurricanes Irma and Maria has launched a movement to transform the island's energy infrastructure into a more reliable, environmentally friendly and sustainable one. Today's SMR designs present the technological advances specially tailored for energy challenges of island-type territories like Puerto Rico. For instance, some SMR designs are built underground which could also potentially increase the island's energy security in future hurricane situations.

For more discussion of this topic, see "Puerto Rico Group Seeks SMRs for Island Electric Power," cited above.

France

It is evident from media reporting that more and more countries are now "seriously" thinking of investing time and money in developing SMRs. A September 17, 2019 article in *World Nuclear News* carries the announcement by a French consortium—composed of the Alternative Energies and Atomic Energy Commission (CEA), EDF, Naval Group, and TechnicAtome—of its plans to build a small modular reactor they are calling the Nuward, in the 300-400 MW range, based on French pressurized water reactor (PWR) technology and an SMR design by Westinghouse. The consortium aims to complete the basic design between 2022 and 2025, with a demonstration unit by 2030. In other words, as of now, the announcement is more of a statement of intent but may bear fruit in another decade.

Russia and Its Customers

Russia, a leader in the large, economy-of-scale nuclear power plants, possesses a small nuclear power plant manufacturing capability, but has not revealed its intentions concerning SMRs. From what can be


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French-developed SMR design unveiled

17 September 2019

A new small modular reactor (SMR) design has been announced by the French Alternative Energies and Atomic Energy Commission (CEA), EDF, Naval Group and TechnicAtome. The Nuward - with a capacity of 300-400 MWe - has been jointly developed using France's experience in pressurised water reactors (PWRs).

A design concept for the Nuward SMR (Image: TechnicAtome)

In a joint statement, the organisations said the Nuward design has been developed to meet "growing world demand for decarbonised, safe and competitive electricity generation". The design will "benefit from best in class French technologies from more than 50 years of experience in PWR design, development, construction and more than 2000 reactor years of PWR operating experience".

gleaned, however, Russia will soon opt for developing SMRs of its own design.

Following Jordan's decision to abandon the plan, signed in 2015, to get two 1,000 MW nuclear power plants from Russia at $10 billion each and to opt for an SMR, the Jordan Atomic Energy Commission (JAEC) and Russia's state-owned Rusatom Overseas signed a deal to conduct a joint feasibility study for building a Russian-designed SMR in Jordan. In a joint statement with the JAEC, Evgeny Pakermanov, president of Rusatom Overseas, stated: "The SMR technologies will certainly become one of our top priorities on the way to develop the world energy market." His statement and more about the deal were covered by the *Jordan Times*.

It is not surprising that Russia is planning to give the SMRs a real go. In recent years, Russia has met with setbacks selling their large Water-Water Energetic Reactors (VVERs) since these pressurized water reactors require large amounts of capital. In November 2016, Vietnam abandoned plans to build two multi-billion-dollar nuclear power plants with Russia, as did Japan, after officials cited lower demand forecasts, rising costs and safety concerns.

In Turkey, where Russia has begun construction of the first of four VVER-1200 reactor-based power plants at $20 billion each (estimated), which had been in limbo for years, funding is in short supply. Sberbank, Russia's state-owned banking and financial services company, has recently come up with a $400 million loan to keep the project going, albeit at a slower pace.

China and Argentina

On the other hand, China has reportedly started building its first small modular reactor project on the southern island province of Hainan, the state-owned China National Nuclear Corporation (CNNC) said last July, as part of the country's efforts to diversify its nuclear sector. The project was originally scheduled to go into construction in 2017. The company did not say when the project was likely to be completed.

A setback has been reported from Argentina, where the construction of a prototype of the 25 MW CAREM (Central Argentina de Elementos Modulares), an SMR that has excellent export potential, has been suspended, reports said last August. NBN.media, a Cyprus-based outlet, had reported that Techint Engineering & Construction informed the workers from the CAREM project that they would halt the civil engineering work of the experimental reactor. The primary reason cited by Techint was the unwillingness of the Argentinian Government to reconsider the budget for civil work, after the devaluation of the currency. At the same time, China National Nuclear Corp., which is owned by the state, has signed to finance and build Argentina's fourth and fifth conventional nuclear power plants, in a deal estimated to be valued at nearly $15 billion.

Since most of the reports of SMRs across the world are not transparent, in this article we will focus on the developments in three countries—United States, Canada and South Korea.

Canada

World Nuclear News (*WNN*) reported on November 18, 2019 that Canadian Nuclear Laboratories (CNL), Canada's premier nuclear science and technology organization, had announced the first recipients of support under an initiative launched earlier this year to accelerate the acquisition and deployment of SMRs in Canada, selecting Kairos Power, Moltex Canada, Terrestrial Energy Inc. and UltraSafe Nuclear Corporation (USNC).

According to *WNN:*

> The four projects that have been selected are: Moltex Canada and the University of New Brunswick's test apparatus to explore the potential of converting used CANDU reactor fuel to power their stable salt reactor design; Kairos Power's tritium management strategy for its high-temperature fluoride salt-cooled reactor; USNC's resolution of technical issues for its Micro Modular Reactor (MMR), including fuel processing, reactor safety, and fuel and graphite irradiation; and Terrestrial Energy's evaluation of nuclear safety, security and non-proliferation technologies for its integrated molten salt reactor (IMSR400) and other SMR designs. The Terrestrial Energy project will also look at opportunities to use CNL's existing facilities, notably the ZED-2 reactor, as well as develop new experimental capabilities related to molten salt reactors.

In 2018, Canadian Nuclear Laboratories (CNL) set a goal of siting an SMR on its Chalk River site by 2026, and co-hosted an SMR Vendor Roundtable as part of the G4SR (Generation 4 Small Reactor) conference.

It is evident that the Canadian program is at an early stage and the whole cycle of SMR development has not been laid out yet. At the same time, a connection has developed between the leading American SMR developer, NuScale Power, headquartered in Portland, Oregon, and Ontario Power Generation, Inc. (OPG), Ontario, Canada's public electricity generator.

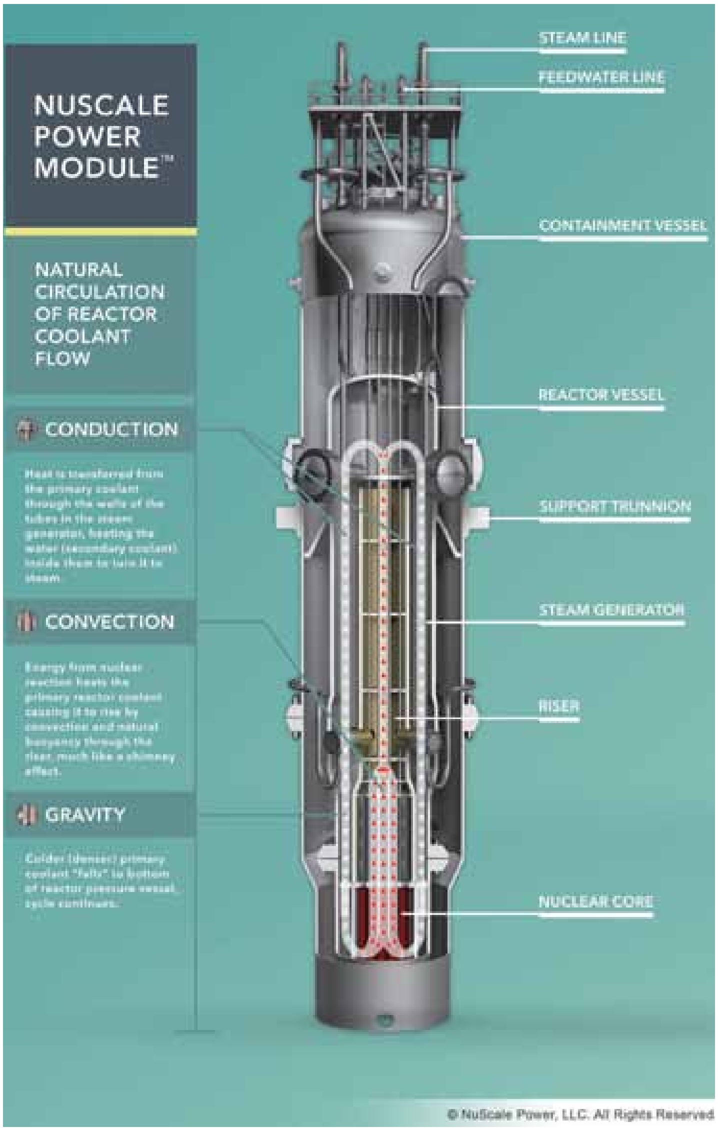
According to a press release by NuScale in the *Financial Post* on November 7, 2018, NuScale and OPG have signed a Memorandum of Understanding, in which OPG has agreed to support NuScale in its SMR vendor design review (VDR) with the Canadian Nuclear Safety Commission. The agreement, according to NuScale Chairman and CEO John Hopkins, was an "important milestone" in the company's efforts to bring its reactor to Canada.

The United States

In the United States, the leading SMR developer, NuScale, announced in a December 12, 2019 press release on its website, titled "NuScale's SMR Design Clears Phase 4 of Nuclear Regulatory Commission's Review Process," that,

> The U.S. Nuclear Regulatory Commission (NRC) has completed the fourth phase of review of the Design Certification Application (DCA) for the company's small modular reactor. NuScale reached this milestone on schedule, marking yet another significant achievement along its path to commercialization. The entire review of NuScale's SMR design is now in Phases 5 and 6.

Phases 5 and 6 of the NRC review remain. Phase 5 entails a review by the NRC's Advisory Committee on



Reactor Safeguards (ACRS). The ACRS is an independent advisor to the NRC that reviews and reports on safety studies and reactor facility license applications and renewals.

Phase 5 "will be completed on or ahead of the original schedule in June 2020," according to NuScale Vice President of Regulatory Affairs Tom Bergman. "Phase 6 is preparation of the Final Safety Evaluation Report (SER), which will incorporate confirmatory items from the Phase 4 advanced SER, and comments raised by ACRS in Phase 5."

In a September 26, 2019 press release, NuScale Power announced that it had signed a Memorandum of Understanding (MoU) with ČEZ Group, a leading Czech utility conglomerate, "to explore applications for NuScale's small modular reactor (SMR) as a long-term energy solution in the Czech Republic. The agreement calls for a sharing of nuclear and technical expertise between the two companies as they examine applications for NuScale's SMR. Specifically, NuScale and ČEZ will exchange information relating to nuclear supply chain development, construction, and operation and maintenance.

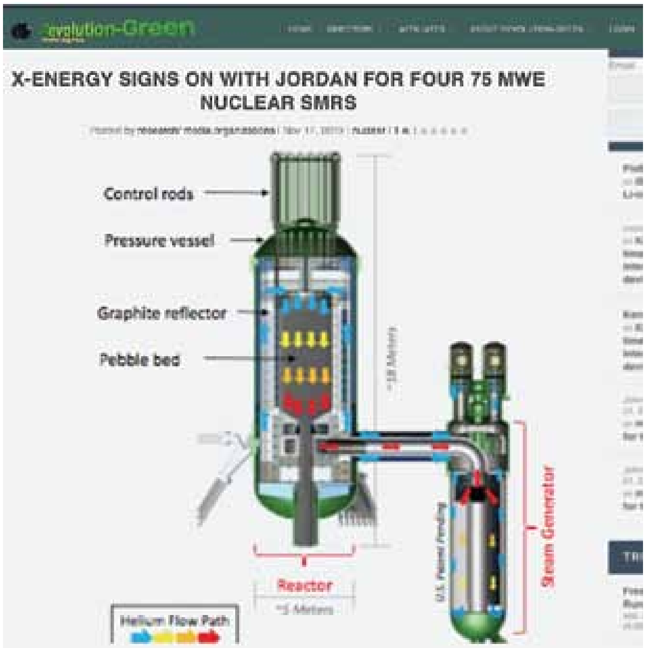
Another American firm, X-energy, a private nuclear reactor and fuel design engineering company based in Rockville, Maryland, entered into an MoU with the Jordan Atomic Energy Commission (JAEC) to assess X-energy's SMR—the Xe-100 high temperature helium-cooled pebble bed modular reactor—and its potential for deployment in Jordan.

NuScale

Artist's rendering of a cross-section of a NuScale SMR power plant, showing five reactor modules installed in a below-grade pool of cooling water. NuScale's 60 MW reactor modules are designed to be installed individually or in arrays of up to 12 units in a single plant.

The Xe-100 is a 200 MW thermal (MWt), 75 MW electric (MWe) reactor, which X-energy envisages being built in a standard "four-pack" plant generating about 300 MWe. All of the components for the Xe-100 are intended to be road-transportable, and will be installed—rather than constructed—at the project site, to streamline construction.

The reactor will use "pebbles" of fuel containing TRISO (TRistructural ISOtropic) coated fuel particles. Each TRISO particle has a kernel of uranium oxycarbide (also known as UCO) enriched to 10% uranium-235, encased in carbon and ceramic layers



which prevent the release of radioactivity. The layers provide each particle with its own independent containment system, while the graphite surrounding the particles moderates the nuclear reaction. Such fuel cannot melt down. X-energy sent its updated design and licensing submittal information to the U.S. Nuclear Regulatory Commission on January 16, 2018.

Reportedly, X-energy is working to design, finance, and license its TRISO-X Commercial Fuel Fabrication Facility, scheduled to begin commercial-scale fuel production in the 2023-2024 timeframe.

On December 2, 2017, the *Jordan Times* had reported that work on selecting a site for an SMR was proceeding in the Qusayer region near Azraq, about 60 km east of Amman. X-energy has an advantage in desert areas such as Jordan, since a helium-cooled reactor would not need the supplies of water required by a PWR (pressurized water reactor), but would need water only for the steam cycle. Jordan has a tiny, 4 GW electrical grid, which can support at most 40 MW of power input from a single source.

On November 15, 2019, according to a statement released by X-energy, JAEC and X-energy have moved on to the second stage of their relationship by signing a letter of intent (LOI) to build four 75 MWe high-temperature gas-cooled reactors that burn TRISO fuel. See also "X-Energy Signs on with Jordan for Four 75 MWe HTGR," in *Neutron Bytes*, November 15, 2019.

South Korea

In South Korea, Mun Mi-ock, first vice minister of Korea's Ministry of Science, and Khalid bin Saleh Al-Sultan, president of Saudi Arabia's King Abdullah City for Atomic and Renewable Energy, signed an MoU on Sept 17, 2019 during the International Atomic Energy Agency conference in Vienna, to work on developing an SMR in Saudi Arabia using technology developed by the Korea Atomic Energy Research Institute.

South Korea brands its SMR technology "SMART," an acronym for System-integrated Modular Advanced Reactor Technology. Korean scientists have been developing it for 22 years. The pressurized water design is able to generate 100 MW, or enough energy to supply a city with a population of 100,000 with 90 MW of electricity and 40,000 tons of fresh water a day. The unit has a 60-year design life and a three-year refueling cycle. ("South Korea signs deal to develop small modular reactor in Saudi Arabia," *Global Construction Review*, Sept. 23, 2019)

Although the SMART does not contain any U.S. technology, concerns have been expressed in the United States about allowing Saudi Arabia to own a 100 MW plant that could violate the NRC rules on export licensing of fuel element fabrication plant equipment. In order to enable such a transfer, some non-proliferation experts claim, Saudi Arabia will have to sign the 123 Agreement with the United States.

Departed Brethren

While many experts have consistently promoted SMRs in industry conferences, lack of capital has already killed off a number of SMR development projects, leaving NuScale Power virtually the sole survivor. Babcock & Wilcox (B&W), which once partnered with the Tennessee Valley Authority (TVA) to design and license two 180 MW mPower SMRs at TVA's Clinch River site in Tennessee, initially received about $111 million from the Department of Energy (DoE), but DoE reduced subsequent payments until finally halting all payments at the end of 2014. The B&W project is as good as dead now. B&W (now BWXT) claims it lacks a customer and is unwilling to invest any more of its own money in SMRs without one.

Westinghouse's 25 MW SMR, in partnership with the St. Louis-based Ameren Corp, a holding company for several power and energy companies, did not fare any better. Failing to qualify for DoE funding, Ameren, now owned by Toshiba, exited the SMR field in early

2014. Efforts by Warren Buffet's MidAmerican Energy to pursue an SMR in Iowa met a similar fate in 2012 when Buffet pulled the plug on that one.

A Future in Flux

According to a March 1, 2015 article, "Be Careful About Rose Colored Glasses When Viewing the Future of SMRs," posted on *Neutron Bytes*, the problem could lie with the political leaders, such as then President Barack Obama, who had little interest in "rebooting" the nuclear industry via SMRs:

> It [the Obama Administration] is continuing its politically driven infatuation with solar, wind, and other so-called "renewable" energy technologies. The "green" wing of the Democratic Party, whose support is needed to elect Hillary Clinton to be President in 2016, continues its hard over-opposition to nuclear energy despite the work of such pro-nuclear green groups as the Breakthrough Institute. Clinton has said little of any significance about nuclear energy other than some plain vanilla campaign rhetoric in 2008.

Terrestrial Energy

Artist's depiction of Canada-based Terrestrial Energy's Integral Molten Salt Reactor, employing Generation IV molten-salt technology, with a power output of 195 MW. Multiple reactor modules can be stacked in its nuclear island.

Policy makers in Washington must realize that development of SMRs could create a large employment base and a vast, new manufacturing industry, employing thousands as a skilled and semi-skilled workforce. According to a NuScale official, NuScale's technology-based SMRs could potentially support 13,500 jobs across the country (based on manufacturing just three 12-module SMR plants per year).

The funding picture is no brighter in Canada, where thoughts of exporting SMRs are yet to develop. In a July 7, 2019 posting, "No-One Wants to Pay for SMRs: U.S. and UK Case Studies," *Nuclear Monitor* Editor Jim Green writes:

> Canadian Nuclear Laboratories has set the goal of siting a new demonstration SMR at its Chalk River site [180 miles north of Ottawa in Ontario] by 2026. But serious discussions about paying for a demonstration SMR—let alone a fleet of SMRs—have not yet begun. . . . The CEO of Terrestrial Energy said in early 2019 that the Canadian government "must … provide financial products which minimize commercial risks," with options including loan guarantees, production tax credits, grants and offtake agreements.

U.S., Canadian Governments Not Interested

Despite the progress pointed out above, there is no indication as of now that the governments in the United States and Canada have really committed to make SMRs a success. NuScale Power has received about $275 million from the U.S. DoE, ($217 million in 2014, and $40 million in 2018), while spending $800 million of its own. However, that kind of funding to develop a new power generation system will simply not do.

As Jim Green rightly pointed out in the cited article:

> No company, utility, consortium or national government is seriously considering building the massive supply chain that is at the very essence of the concept of SMRs—mass, modular construction. Yet without that supply chain, SMRs will be expensive curiosities. [In the United States,] government SMR funding of several hundred million dollars is an order of magnitude lower than subsidies for large reactors (several billion dollars for the AP1000 projects).