NUCLEAR ENERGY

Recognition of Small Modular Reactors' Role in the Coming World Is Increasing, But Is that Enough?

by Ramtanu Maitra

April 7—Since *EIR*'s article last November[1] on the developmental prospects of small modular reactors (SMRs), particularly in the United States, at least three major SMR developments have occurred around the globe—in the U.S., China and Canada.

The November 2018 article highlighted NuScale Power based in Tigard, Oregon and its selection of BWX Technologies (BWXT) in Lynchburg, Virginia to refine NuScale's design for manufacturability, assembly and transportability of these modular reactors. This article is an update on the international recognition of SMRs.

Despite the developments reported here, it is evident that SMR development is lacking crucial input from governments—Russia, United States, China, Japan, and India, among others—to work out a functional model, or a couple of models, of SMRs with an eye to expediting SMR deployment in the developing nations.

OSU

NuScale Power, a spinoff of Oregon State University, created a small modular nuclear reactor that does not need outside power to shut down during an emergency.

Developing SMRs quickly and in large numbers is a winning plan to provide a huge population of this world—who have spent their lives with little or no power—an opportunity to access a stable and steady power source and utilize it to develop infrastructure as they need it. This is the prime necessity for SMRs. While SMRs have a significant role to play in the developed nations, where they are in the process of being developed, the goal of the developers should be to get SMRs into the developing nations.

In other words, the success of SMRs depends entirely on their ability to be deployed in large numbers in the developing world. A few, not that many, can be deployed in the developed nations, but SMR technologies will have to contend constantly with the large nuclear reactors which, megawatt-for-megawatt, will remain cheaper than the SMRs. And, of course, in the developed nations, where homes are lit throughout the year and are heated in cold winters, cost will be the supreme determining factor. In those circumstances, the SMRs will lose the contest, and remain a peripheral source of power generation. However, in the developing nations, where the contest will highlight the advantages suitable for them, SMRs will win every time.

1. "Four-Power Priority: Mass Production of Modular Nuclear Reactors to Industrialize Developing Countries: Until Fusion Power Comes Online," by Ramtanu Maitra. *EIR*, Vol. 45, No. 46, Nov.16, 2018. Pp. 11-17. https://larouchepub.com/eiw/public/2018/eirv45n46-20181116/11-17_4546.pdf

New Developments

In the United States, a bill, S.3422, titled the Nuclear Energy Leadership Act (NELA),[2] has been introduced in the Senate "to direct the Secretary of Energy to establish advanced nuclear goals; provide for a versatile, reactor-based fast neutron source; make available high-assay, low-enriched uranium for research, development, and demonstration of advanced nuclear reactor concepts; and for other purposes." In addition to urging the Trump Administration to propel the United States once more into the leadership position in nuclear power development, the bill, among other things, states that "making limited quantities of high-assay, low-enriched uranium (HALEU) available from Department of Energy stockpiles of uranium would allow for initial fuel testing and demonstration of advanced nuclear reactor concepts," accelerating advanced nuclear reactors including the SMRs.

To fuel today's commercial nuclear reactors, the uranium must be enriched so that the Uranium-235 concentration, or "assay," is raised to between 4 and 5 percent. This is called low-enriched uranium (LEU). Many of the reactor designs being prepared for future deployment will need a higher assay uranium fuel to operate. High-assay low-enriched uranium (HALEU) has a U-235 assay above 5 percent but below 20 percent.

The Senate bill also urges the government to extend the term of federal power purchase agreements (PPA) to 40 years from the current 10-year limit. The PPA provisions of the bill would not apply to existing or under-construction nuclear reactors because they are not advanced reactors, but those provisions could apply to a small modular reactor that is under development. In April, the Nuclear Regulatory Commission completed the first phase of design certification—the first step in any nuclear project—for NuScale's small modular reactor, which uses first-of-kind safety measures such as, for example, not requiring emergency backup generators.

Utah Associated Municipal Power Systems (UAMPS) would be NuScale's first customer. In 2016, UAMPS identified a preferred site at the Idaho National Laboratory for a 12-reactor project that NuScale is working on with the public power utility. If S.3422 does become law, it could be "immediately impactful for NuScale," which is looking to deploy its first series of small reactors in 2026, according to the company's chief strategy officer, Chris Colbert.[3]

China and Canada

In China, where nuclear power development is considered an absolute necessity to replace polluting power

2. S.3422, titled, Nuclear Energy Leadership Act (NELA) https://www.congress.gov/bill/115th-congress/senate-bill/3422/text?format=txt

3. "Bipartisan Legislation Aims to Boost Nuclear Power Research," by Peter Maloney. American Public Power Association, Sept. 13, 2018. https://www.publicpower.org/periodical/article/bipartisan-legislation-aims-boost-nuclear-power-research

What Is a Small Modular Reactor?

As nuclear power generation has become established since the 1950s, the size of reactor units has grown from 60 megawatts electric (MWe) to more than 1600 MWe, with corresponding economies of scale in operation. At the same time, there have been many hundreds of smaller power reactors built for naval use (up to 190 MW thermal) and as neutron sources, yielding enormous expertise in the engineering of small power units. The International Atomic Energy Agency (IAEA) defines "small" as under 300 MWe, and up to about 700 MWe as "medium"—including many operational units from the 20th century. Together they are now referred to by the IAEA as small and medium reactors (SMRs). However, "SMR" is used more commonly as an acronym for "small modular reactor," designed for serial construction. Several of them, when installed in a cluster, can form a single, large nuclear power plant.

Today, due partly to the high capital cost of large power reactors generating electricity via the steam cycle and partly to the need to service small electricity grids under about 4 GWe, there is a move to develop smaller units. These may be built independently or as modules in a larger complex, with capacity added incrementally as required.

Small modular reactors (SMRs) are defined as nuclear reactors generally having a capacity to produce 300 MWe equivalent or less, designed with modular technology using module factory fabrication, pursuing economies of series production and short construction times. This definition, from the World Nuclear Association, is closely based on those of the IAEA and the U.S. Nuclear Energy Institute.

CNNC

Concept illustration showing the many application and installation possibilities for the ACP100 multi-purpose modular nuclear reactor.

sources while providing a steady source of high energy flux-density to meet the demand of China's growing industrial and commercial sectors, *Global Construction Review* reported on March 29 that the 125 MW ACP100, designed by China National Nuclear Corporation, will be collocated with the existing Changjiang nuclear plant on Hainan Island on the South China Sea. The construction of the SMR is expected to take a little less than five-and-a-half years, with the first electricity expected to be produced by May 31, 2025.

The ACP100, scheduled to be built underground, based on existing pressurized water reactor (PWR) technology adapting verified passive safety systems, is a third-generation PWR design, intended to supply power to smaller grids and remote areas, as well as offering heat to urban areas—an important application in northern China—and to desalination plants. The almost exclusive use of coal in the colder climes of northern China, is causing serious pollution, particularly by dust, particulates, sulfur, and nitrogen oxides. Not available in the public domain is how and where these ACP100s will be clustered. The NuScale-designed SMRs will be of 50 MW capacity and twelve such modules can be clustered around a single central control station.

In Canada, the nuclear regulator has received the country's first license application to build a small modular nuclear power reactor. The Canadian Nuclear Safety Commission (CNSC) says the application, from Global First Power (GFP), with support from Ontario Power Generation and Ultra Safe Nuclear Corporation, is to deploy its Micro Modular Reactor (MMR) plant at Chalk River in Ontario. According to World Nuclear Association information, the reactor uses fuel in prismatic graphite blocks and has a sealed transportable core. The reactor completed the first phase of the CNSC's pre-licensing vendor design review process in January.

The proposed GFP project's nuclear plant, containing an MMR unit, will provide approximately 15 MW (thermal) of process heat to an adjacent plant, where it can be converted to electrical power (up to 5 MW of electricity) or used as heat for clients. The electrical power could also be supplied to the area grid.[4]

In addition to the developments reported here in the United States, Canada, and China, a number of other countries are also moving ahead with SMRs. Some of them, such as Argentina and the UK are well advanced in this venture. Argentina's CAREM (Central Argentina de Elementos Modulares) project has reached a new milestone in the development of the twelve steam generators for the prototype CAREM-25. *World Nuclear News* reported on this development in May 2018.

Argentina and Britain

CAREM is Argentina's first domestically designed and developed 25 megawatt electric (MWe) nuclear power unit. The prototype of this small pressurized water reactor is being built at a site adjacent to the Atucha nuclear power plant in Lima, 110 kilometers northwest of Buenos Aires. Concrete was first poured for the reactor in February 2014, marking the official start of its construction. At least 70% of the components and related services for CAREM-25 are to be sourced from Argentine companies. The prototype will be ca-

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4. "Canada's Regulator Receives First License Application for Small Modular Reactor." *NucNet*, April 3, 2019. https://www.nucnet.org/all-the-news/2019/04/03/canada-s-regulator-receives-first-licence-application-for-small-modular-reactor

pable of supplying electricity, for example, to a city of 120,000 inhabitants. More powerful units of this design will have a capacity of about 120 MWe. The CAREM project aims to enable Argentina to compete in the global market for small modular reactors, *World Nuclear News* noted.[5]

In Britain, where the power generation future has begun to look bleaker by the day, three proposed, large nuclear reactor projects have faltered recently, representing more than 40% of the country's planned new nuclear capacity. In January, Japan's Hitachi suspended work at the $20.5 billion Wylfa plant in Wales, along with work on its nuclear project at Oldbury-on-Severn in Gloucestershire. This followed the abandonment of the Moorside project in Cumbria late last year, by Toshiba. However, unlike many, if not most, of the European Union countries, UK is not keen to abandon nuclear power and does not want to hang its future entirely on wind, solar, and tidal wave energy sources.

Rolls-Royce leads a consortium that is developing SMRs, but the group said last summer that it needed government support to continue its project. *POWER* magazine reported in January that it was seeking more than £200 million (about $263 million) in government funding. The group already makes components for nuclear submarines that use PWR technology.

The company has said it is developing a 220 MW SMR, a unit that could be doubled for a larger-scale project. In 2016, Paul Stein, the company's Chief Scientific Officer, pegged the cost of a 440 MW plant at about $2.3 billion, saying, "One of the advantages of the SMRs is that they cost a lot less [than large nuclear plants], and it is an easier case to present to private investors."[6]

5. "Argentina Reaches Generator Milestone for CAREM-25." *World Nuclear News*, May 8, 2018. http://www.world-nuclear-news.org/NN-Argentina-reaches-generator-milestone-for-CAREM-25-08051801.html
6. "Consortium Asks UK to Support SMR Nuclear Development," by Darrell Proctor. *POWER* magazine, Jan. 28, 2019. https://www.powermag.com/consortium-asks-uk-to-support-smr-nuclear-development/

CAREM-CNEA

Cutaway of Argentina's CAREM-25 prototype pressurized water modular nuclear reactor.

The Need for Joint Efforts

A prime objective in developing SMRs is to proliferate electric power production in the developing nations that are crying out for it. In the entire continent of Africa, populated by 1.2 billion people, nuclear power has no presence, other than the two nuclear reactors at Koeberg in South Africa, as I pointed out in the cited November 16, 2018 *EIR* article. And yet Africa is desperate for more electrical power to provide a future for today's and tomorrow's population.

Similarly, in Southeast Asia, although in the vicinity of four nuclear power manufacturers—China, Japan, South Korea and India—none of the ten members of the Association of South East Asian Nations (ASEAN)—Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam—has a single nuclear power plant. While nuclear has not played any role whatsoever in these countries, most of them desperately need a much larger electricity generating capacity for their growth. They are damming every stream in sight to generate hydroelectric power.

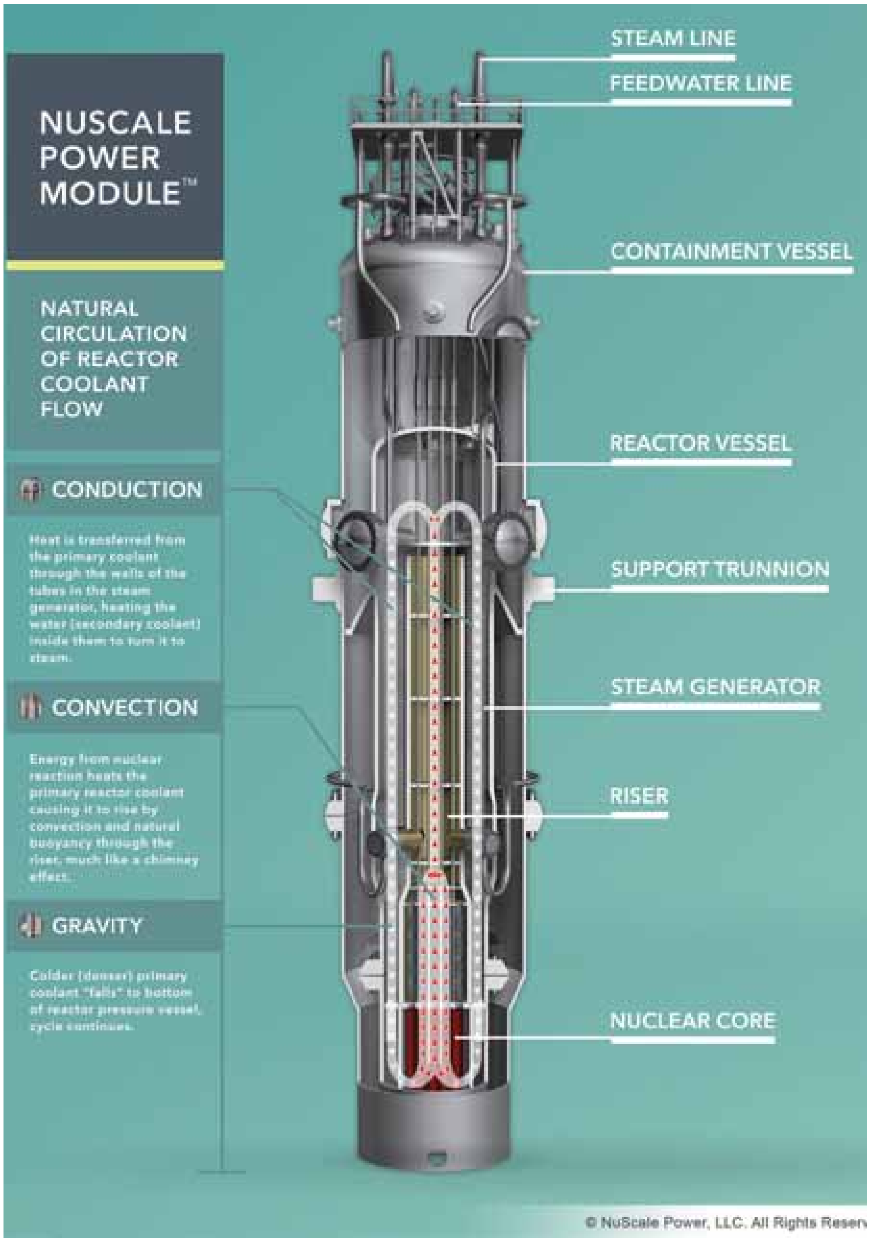
SMRs will also help developed nations by providing power in remote areas with low population density but great mining potential and security needs. SMRs will be a boon for any coastal country facing a fresh water shortfall. China is seriously considering using these plants to provide power for desalination of seawater for domestic and commercial use.

To bring SMRs into the world economy quickly, the developers should seek joint efforts to make one particular model the standard SMR workhorse and install that model as quickly as possible, to provide power-starved nations with a future. There is no doubt that over time, more advanced reactors—such as gas-cooled, fast-neutron, and even pebble-bed varieties of SMRs—will replace the small PWRs now being worked on in the U.S., China and Britain, among other nations.

Canada, on the other hand, is probably spreading its capability too thin. A June 2016 report for the Ontario Ministry of Energy focused on nine designs under 25 MWe for off-grid remote sites. All had a medium level of technology readiness and were expected to be competitive against diesel. Two designs were integral PWRs of 6.4 and 9 MWe, three were High Temperature Reactors (HTRs) of 5, 8 and 16 MWe, two were sodium-cooled fast reactors (SFRs) of 1.5/2.8 and 10 MWe, one was a lead-cooled fast reactor (LFR) of 3-10 MWe, and one was a Molten Salt Reactor (MSR) of 32.5 MWe. Four were under 5 MWe (an SFR, LFR, and two HTRs).

NuScale's Collaborations

There are already some efforts to develop a "standard" SMR. NuScale is involved with the Canadian and British developers and is making some efforts that could help develop similar models of its own. According to the NuScale website, "NuScale Power has been actively involved in the UK Government's Small Modular Reactors Feasibility Study. Following a technical assessment by the UK's National Nuclear Laboratory, it was concluded that the NuScale Power Module is a credible technology, feasible for deployment within a ten year timeframe and, alongside other options, should be investigated further for potential UK involvement."



Cutaway of NuScale Power's small modular nuclear reactor.

Fluor Corporation, NuScale's primary investor, employs more than 1,200 staff in the UK. NuScale has entered into collaborative agreements with other key parts of the UK nuclear sector, including the Nuclear Advanced Manufacturing Research Centre at the University of Sheffield.

In Canada as well, NuScale has made its presence known. On November 27, 2018, NuScale Power announced it had signed a Memorandum of Understanding with Canada's Bruce Power to deploy NuScale's Integral Pressurized Water Reactor (IPWR) small modular reactor technology in Canada. Bruce Power will support evaluation, planning and licensing activities for the NuScale design, including feasibility studies for proposed SMR sites, NuScale said. Bruce Power is Canada's largest private nuclear power generator, operating eight CANDU (Canada Deuterium Uranium) pressurized heavy-water reactors for 6.4 GW of capacity at its Tiverton site, northwest of Toronto.[7]

7 . "NuScale, Bruce Power to develop SMR Business Case." *Nuclear Energy* Insider, Nov. 28, 2018. https://analysis.nuclearenergyinsider.com/france-close-14-reactors-2035-bruce-power-build-nuscale-smr-business-case