Chapter 5

Expert Views on Small Modular Reactors

July 2021

This chapter should be cited as

Study team (2021), 'Expert Views on Small Modular Reactors', in Murakami, T. and V. Anbumozhi (eds.), *Global Situation of Small Modular Reactor Development and Deployment.* ERIA Research Project Report FY2021 No. 07, Jakarta: ERIA, pp.63-67.

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Expert Views on Small Modular Reactors

In the last chapter, the Institute of Energy Economics, Japan (IEEJ) gathered expert views on small modular reactors (SMRs) by participating in and summarising the webinars and published reports. In addition to such information, Ann MacLachlan, a freelance journalist who has detailed knowledge of the global nuclear energy market, kindly wrote her views on SMRs. Here is her review.

1.SMRs: A Review of Market Prospects

The multitude of SMR designs being promoted by both large traditional vendors and start-ups recalls the line-up of nuclear technology contenders in the United States (US) in the 1950s and 1960s. Common sense tells us that, as happened then, only a handful of designs will survive to the commercialisation phase.

Undeniably, SMRs have caught on as a fashion trend in the nuclear world. But this may be due not to their intrinsic value but rather to the market failure of large light water reactors (LWRs). Faced with the reality that no utility company will order a large reactor in the foreseeable future, the US government has poured money into SMRs to support the nuclear sector. Thanks to their image as being safer than large LWRs, SMRs may also win greater public acceptance. In addition, SMRs equate with innovation – a way to keep the nuclear research community afloat and to attract young people to a sector seen as future-oriented. For some activists, they represent a way to allow nuclear energy to play an important role in decarbonising the planet.

However, **technological hurdles** remain for SMR designs, even those based on mainstream PWR technology like NuScale or France's Nuward. More innovative models like fast reactors or those based on molten salt fuel/coolant will reboot the fuel cycle, requiring regulatory adjustments (higher-enrichment fuel, use of thorium) and the adaptation of fuel cycle installations or construction of new ones. These modifications will take years.

Cost is also a major consideration. Current cost projections for power from SMRs are highly hypothetical, since experience is lacking, and are likely to be low, given the track record of cost

projections for nuclear projects in the past.

Even the UAMPS NuScale demonstration project in Utah, which has US$1.36 billion in US federal financial support, upfront power purchase agreements, and a reserved site on federal land, has seen its start-up schedule slip 4 years to 2030, and several customer utilities withdrew when the projected cost rose by almost 50% to US$6.1 billion (Utility Dive, 2020).

[With cheap natural gas, no carbon tax, and high risk premiums on nuclear project financing, further US SMR projects will need significant government support.]

The capital costs, and therefore the market potential, of SMRs are highly dependent on the existence of **long series** of identical or nearly identical units. Whilst this series effect is in theory easier to achieve for SMRs (it takes more units to generate the same amount of power as a large reactor), it will not kick in until production is centralised in a small number of facilities, which may not be soon given the number of players in the field.

In addition, the series effect will not necessarily apply to balance-of-plant and conventional power systems. Site-related costs and civil works will be unique at each site.[1] NuScale is promising up to 80% local supply content to partners in its international agreements, which could dilute the standardisation effect.

It is too early to predict whether these factors – the dispersal of production plants and the time needed to reach the 'nth-of-a-kind' unit with stabilised cost and construction schedule – will be offset by lower unit costs stemming from design simplification and modular construction.

A major determinant in the feasibility and timing of SMR commercialisation is **licensing**. The US Nuclear Regulatory Commission (NRC) approved the design for a NuScale plant with 12 50-MWe modules in 2020 after working on the issue for 12 years (NRC, 2020). A planned new NRC regulatory framework for 'advanced reactors' is still 3 years away, and several key licensing issues are still open. No other SMR design is so far along in licensing at the NRC. NuScale, meanwhile, uprated its reactor module to 60, then 77 MWe, which will require fresh review by the NRC (NuScale Power, 2020).

Meanwhile, the NRC is working with regulators in Canada and the UK to 'harmonise' SMR regulation. As with commercial aircraft, the adoption of a **single regulatory framework for SMRs worldwide** is a key to develop worldwide markets. Experience suggests that will not happen easily, despite the huge international influence of the NRC. Whilst smaller countries with less

[1] Joël Guidez (2020), *French Nuclear Energy Society (SFEN) Webinar on SMRs*. 3 December.

nuclear power experience may adopt the NRC standard, traditional nuclear power countries like France, Russia, and China may be reluctant, not the least because licensing is an element of national industrial sovereignty as well as market power. The potential for resistance to US–Canadian–UK 'global leadership' in harmonising regulation based on US standards should not be underestimated.

2.Market Analysis

According to Xavier Ursat of Électricité de France (EDF) in late 2020,[2] the world market for SMRs could be 'well over' 25 GW by 2035–2040. That is still less than half the potential market projected for 2030 in a 2014 study by the UK NNL (65–85 GW). That gap suggests that the commercialisation of SMRs is receding in time, raising the possibility that SMRs will arrive in too few numbers, too late to revive the nuclear industry or contribute significantly to CO_2 emissions reduction.

A construction-operation licence for the NuScale 'reference plant' in Utah is not expected until 2025 at the earliest, and future financing remains to be worked out. Ed Merrow, a US-based project analyst, considers that whilst SMR projects may be less risky for financiers than larger plants, there will be no large-scale deployment in the short term because 'it will take years' for the designs on the table today to work through the technology hurdles, regulatory channels, and supply chain issues.[3]

Although SMRs are proposed as a replacement for coal-fired power plants in the US and China, with a potentially large market, significant deployment for **power applications** will not happen before demonstration units have provided construction and operating experience to lower the risk profile and reduce costs and construction times.

More potential could be seen in specific situations: isolated sites (military bases, remote communities such as in Canada and Russia) as well as countries or territories with small grids that cannot support large reactors. These seem however not to be a single market but rather several specific markets with different requirements that might require several reactor models, reducing the series effect.

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[2] French Nuclear Energy Society (SFEN) webinar on SMRs, 3 December 2020.

[3] IFNEC-OECD Nuclear Energy Agency workshop, 'Issues in the Financing of Nuclear New Build', 14–15 January 2021.

The existence of a large, interconnected grid on the European continent reduces the potential market for power SMRs in that region.

The potential appears greater, in Europe and elsewhere, for **non-power applications** such as industrial heat, seawater desalination, and hydrogen production by electrolysis. The economics of such projects remains to be demonstrated and project and financing schemes designed.

Traditional nuclear vendor companies are not financially strong enough to sponsor construction, with the possible exception of integrated state-owned companies like Rosatom and its Chinese counterparts. Worldwide, the engineering, project, and construction industry has little equity and 'will not be in the market to take multi-billion-dollar risks' as it used to do, according to Merrow.[4]

Because Canada is already quite far in the evaluation process and ready to licence SMRs, I believe the chances are good for the **SMR market to develop first in Canada**, in partnership with US-based companies. Who will the customers be? Dedicated project companies would be logical, but it will be difficult to finance this kind of project without corporate backing. Perhaps large mining and/or engineering companies in a consortium would work.

It is broadly accepted that government support will be necessary for the first projects. How long must or could that support last? Will it even be allowed in Europe under state aid rules?

Even if SMRs can breach the obstacles of technology, cost, licensing, and financing, there are **other issues**, specific to nuclear projects, that could cause problems. The first, rooted in nuclear weapons proliferation concerns, is the treatment of spent fuel from SMRs, notably in emerging countries like Egypt, Kenya, or Indonesia: Are the countries whose vendors are selling these reactors prepared to take back spent fuel from the world, and will their public accept that? Will small countries buy SMRs if they have to manage spent fuel or the resulting final waste?

Another issue that has proved sticky in the past is nuclear third-party liability. Vendors will be unwilling to sell reactors to countries that have not enacted strict nuclear liability legislation and joined international liability conventions. In India, debate about shielding foreign vendors from liability has lasted for almost a decade without full resolution.

Because of the need to fulfil so many conditions, I do not think the commercialisation of SMRs will happen before the 2040 timeframe. Their success will depend on the concentration of market power in a few hands – to ensure series effects – and the harmonisation of regulatory

[4] Merrow, IFNEC-OECD NEA workshop, see above.

frameworks across many countries.

Potential customers could be any kind of industrial company that needs process heat or dedicated dependable power. Such a configuration would represent a sea of change compared to the nuclear power world we have known since the 1960s.