Small modular reactors: a chicken-and-egg situation

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NM800.4452 According to James Conca, a nuclear enthusiast who writes for *Forbes*, the nuclear industry in the US is "abuzz" with the potential of small modular reactors (SMRs).[1]

Conca promotes pseudo-research from the 'Small Modular Reactor Research and Education Consortium', according to which a single SMR has the potential to result in US$892 million (€844m) in "direct economic benefits". In other words, the capital cost estimate is US$892 million. The Consortium estimates that the potential economic benefits from the establishment of an SMR construction business in the US could range from US$34−250 billion (€32.2−236.7b) or more.

Better grounded in reality is a report produced by Nuclear Energy Insider, drawing on interviews with more than 50 "leading specialists and decision makers". The report attempts to put a positive spin on the future development of SMRs, but an air of pessimism is all too apparent, even in the report's title: 'Small Modular Reactors: An industry in terminal decline or on the brink of a comeback?'[2]

Pessimism is also apparent in comments by the report's lead author, Kerr Jeferies: "From the outside it will seem that SMR development has hit a brick wall, but to lump the sector's difficulties together with the death of the so-called nuclear renaissance would be missing the point."[3]

In the US[4]:

- Babcock & Wilcox has greatly reduced its investment in SMR development, despite receiving US$111 million (€105m) from the Department of Energy. B&W CEO Jim Ferland said that he sees the future of SMRS as "still being up in the air."
- Westinghouse abandoned its SMR development program in February 2014.
- Warren Buffet's MidAmerican Energy abandoned plans to build an SMR in Iowa after consumer groups prevailed in a legislative battle over 'construction work in progress' legislation that allows utilities to charge higher rates to cover reactor construction costs, even if the reactor is never built.
- NuScale is the only company in the US with any forward momentum − it is aiming to submit documentation to the Nuclear Regulatory Commission in 2016 for design review.

Glenn George from KPMG recently discussed SMR development in the US with Nuclear Energy Insider: "I think that investors are in a wait-and-see mode regarding development of the SMR market. ... Investors will want to see SMR learning-curve effects, but a chicken-and-egg situation is at work: Decreased cost comes from production of multiple units over time, yet such production requires investment in the first place. So it's not surprising that, in the absence of commercial orders, Westinghouse and Babcock & Wilcox have slowed SMR development."[5]

Outside the US, just a few first-of-a-kind SMR projects are under construction − in Argentina (CAREM-25), Russia (KLT-40S) and China (HTR-PM).

The Nuclear Energy Insider report restates the familiar SMR rationale about mass production and streamlined supply chains bringing down costs. But it also calls into question the underlying logic: "SMR concepts face a real challenge in ensuring cost and energy efficiency. Making a power unit smaller also increases the need to have five, ten or even twelve modular reactors working in unison to create the same level of base load electricity as the large PWR's and fossil fuel plants they will replace. In reducing the size of reactor modules you also reduce the amount of thermal energy produced, if an SMR only has an energy efficiency of 30−40% then you require even further units to make up the shortfall."

The report also qualifies the usual SMR rhetoric about economies derived from mass factory production: "Factory assembly of small reactors is one of the core benefits of SMR's. They can be built off site in 'bulk', easily transported and then plugged into an infrastructure network promising a far quicker and cheaper alternative to large PWR's. However, in order to ensure a smooth transition from the drawing board to the construction site there are key questions to be faced in separating the expertise held in a reactor factory and the expertise required to install an SMR when it arrives on site. For an effective SMR supply chain to be developed it will need to be localized − despite the reactors being built off site, a great amount of the on-site infrastructure and materials will still require precision assembly."

If there was any remaining doubt that SMRs are not the 'game changer' they are so often portrayed to be, the report concludes: "Six decades of nuclear development have shown that nuclear energy can only be progressed if 'long-term' strategies are employed across the industry. In an economic climate where there are alternative energies offering far quicker returns on investment, clear questions need to raised and frank discussions held in order to ensure that SMR's do remain a realistic alternative for energy provision."

The report states that notwithstanding the "pervasive sense of pessimism" resulting from abandoned and scaled-back SMR programs, "we believe a more accurate picture is that 2014 has been a teething year, and that the SMR story hasn't even really begun."

Therein lies the problem − the story hasn't begun: no supply chains, no factories churning out identical

reactors, and precious few customers. And another familiar problem that has long plagued the nuclear industry: a bewildering array of proposed designs.

SMR push in the UK

The UK has been bitten by the SMR bug. The National Nuclear Laboratory (NNL) has produced a feasibility study which argues that SMRs might eventually prove cheaper than large reactors, while also noting unresolved 'detailed technical challenges'. The House of Commons Select Committee on Energy and Climate Change has urged the government to spend public money to develop a demonstration SMR.[6]

Academics Gordon MacKerron and Philip Johnstone from the Sussex Energy Group write: "It [NNL] then suggests a potential UK market of between 7GW and 21GW in 2015, the latter number being frankly not credible under any conceivable circumstances. These hoped-for UK markets are also linked to the idea that the UK could become a major technological player in SMR technology, a view that seems tinged almost with fantasy, given that all significant SMR development to date has been outside the UK."[6]

South Korea's SMART reactor

South Korea may have found a model to unlock the potential of SMRs: collaboration with a repressive Middle Eastern state, extensive technology transfer, and if that fans proliferation risks and tensions in a volatile region, so be it.

On March 3, the Korea Atomic Energy Research Institute (KAERI) signed a memorandum of understanding with Saudi Arabia's King Abdullah City for Atomic and Renewable Energy (KACARE) to carry out a three-year study to assess the feasibility of building two first-of-a-kind 'System Integrated Modular Advanced ReacTor' (SMART) reactors.[7]

SMART is a 100 MWe pressurized water reactor design which could be used for electricity generation and desalinization. The cost of building the first SMART reactor in Saudi Arabia is estimated at US$1 billion (€947m).[7]

Among other obstacles, the development of SMART technology has only lukewarm support from the South Korean government; it is no longer financially backed by Korea Electric Power Co. (Kepco); there is no intention to deploy SMART reactors in South Korea; and plans to build a demonstration plant in South Korea stalled.

South Korea launched 'SMART Power' on January 29 − an organisation tasked with marketing SMART technology overseas, conducting joint feasibility studies with interested customers, and continuing design work to make the reactor technology "more economically feasible".

KACARE says that SMART intellectual property rights will be co-owned and that, in addition to the construction of SMART reactors in Saudi Arabia, the two countries aim to commercialise the technology and to promote it world-wide.[8]

KACARE states: "Undisputedly, human capacity building for the production of nuclear power within the Kingdom of Saudi Arabia is a national pursuit of paramount importance as it will essentially contribute to the sincerely devoted endeavors to devise a sustainable development future for Saudi generations."[8]

Failing that, the joint partnership − and the extensive technology transfer and training it entails − will take Saudi Arabia a long way down the path towards developing a latent nuclear weapons capability. Saudi officials have made no secret of the Kingdom's intention to pursue a weapons program if Iran's nuclear program is not constrained.[9]

Wall Street Journal reporters noted on March 11: "As U.S. and Iranian diplomats inched toward progress on Tehran's nuclear program last week, Saudi Arabia quietly signed its own nuclear-cooperation agreement with South Korea. That agreement, along with recent comments from Saudi officials and royals, is raising concerns on Capitol Hill and among U.S. allies that a deal with Iran, rather than stanching the spread of nuclear technologies, risks fueling it."[10]

A bilateral nuclear trade agreement between the US and Saudi Arabia has stalled because of the Kingdom's refusal to rule out developing enrichment or reprocessing technology. "We've been pressing them to agree not to pursue a civilian fuel cycle, but the Saudis refuse," said Gary Samore, a US government official working on nuclear issues during President Obama's first term.[10]

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Belgium and the END of nuclear power

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NM800.4453 Belgium is a microcosm of the ageing nuclear power industry. The International Energy Agency predicts a "wave of retirements"[1] − almost 200 reactor shut downs by 2040 − and *Oilprice.com* argues that it is unclear whether new build will offset the "tidal wave" of reactor shut downs over the next 20 years.[2] Belgium is at the sharp edge of this new nuclear era: the Era of Nuclear Decommissioning, the END.

Belgium's seven reactors − all pressurized water reactors − are all operated by Electrabel, a GDF Suez subsidiary. Electrabel owns 100% of two reactors, 89.8% of four reactors and 50% of one reactor. EDF and SPE are the other companies with ownership stakes.[3]

When all seven reactors were operating, they supplied about half of Belgium's electricity. All are due to be shut down by the end of 2025. Belgium's nuclear phase-out law mandates the shut down of six reactors when they have operated for 40 years − with the exception of Tihange 1, which is due to be shut down in 2025 when it has operated for 50 years.

All seven reactors have been in the news over the past year:

•Doel 1: Shut down when its 40-year licence expired in February 2015.

- Doel 2: Now operating but due to be shut down in December 2015. GDF Suez / Electrabel is negotiating a possible licence extension for Doel 1 and 2 to operate for another 10 years, and seeking regulatory approval.
- Doel 3 and Tihange 2: Offline since March 2014 due to concerns about the integrity of reactor pressure vessels; future uncertain.
- Doel 4: Offline for more than four months in 2014 due to suspected sabotage of the high-pressure turbine. Now operating.
- Tihange 1: Now in its fortieth year of operation but licensed to operate for another 10 years. Greenpeace has initiated a legal challenge against the licence extension, because of the failure to carry out an Environmental Impact Assessment and cross-boundary consultation in line with Belgium's obligations under the Espoo Convention (the Convention on Environmental Impact Assessment in a Transboundary Context). Court hearings are scheduled for March 24 and the judge is expected to present his verdict soon after.
- Tihange 3: Briefly shut down following a fire in December 2014. Now operating.

Policies and politics

Nuclear power policies and laws have been in flux over the past two decades:[3]

- In 1999, the government announced that reactor lifetimes would be limited to 40 years, and banned further reprocessing.
- In 2003, the Belgian Parliament passed legislation banning the building of new power reactors and limited the operating lives of existing reactors to 40 years.
- In 2009, the government decided to postpone the phase-out by 10 years, so that it would not begin before 2025. This would allow the licensing of reactor life extensions. Reactor operators agreed to pay a special tax of €215−245 million (US$227−259m) per year from 2010−14, and more thereafter. GDF Suez also agreed to subsidise renewables and demand-side management by paying at least €500 million (US$528m) for both, and it maintaining 13,000 jobs in energy efficiency and recycling.

However, an election in April 2010 occurred before the agreed proposals were passed by parliament and thus the nuclear phase-out law remains in place. In July 2012 Belgium's Council of Ministers announced that Doel 1 and 2 were to close in 2015 after 40 years of operation, but Tihange 1 would be permitted to operate to 2025. This was written into law in December 2013. The government said that it had rewritten the 2003 law so that its current stance could not be changed by decree, and therefore the timing of the phase-out "is now final."[3,4]

In December 2014 the Council of Ministers from the new ruling coalition government agreed that Doel 1 and 2 could continue operating for a further 10 years, to 2025. Energy minister Marie-Christine Marghem said that it was an "unconditional prerequisite" that the Belgian nuclear regulator − the Federal Agency for Nuclear Control (FANC) − approve licence extensions for the two reactors. She noted that Belgium's planned nuclear phase-out by the end of 2025 remains in place.[4]

The government decision to allow Doel 1 and 2 to continue to operate for a further 10 years was partly a result of problems with other reactors − in particular the outages of Tihange 2 and Doel 3 and uncertainty about their future. GDF Suez / Electrabel is in negotiation with the Belgian government over the Doel 1 and 2 licence extensions but an agreement has not yet been reached − hence the shut down of Doel 1 in February in accordance with the nuclear phase-out law. Further, the regulator FANC has not yet approved licence extensions for Doel 1 and 2.[4]

GDF Suez / Electrabel is unwilling to invest up to €600−700 million (US$634−740m) in necessary upgrades to Doel 1 and 2 unless the government provides a "clear legal and economic framework" to justify the investment. Negotiations include removal of