NUCLEARENERGY INSIDER

SMR 2015

Small Modular Reactors: An industry in terminal decline or on the brink of a comeback?

Exclusive insight on the critical questions being asked of an industry at a crossroads

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1. Introduction

There is no denying that 2014 has been a challenging year for the Small Modular Reactor (SMR) industry. With the collapse of the Generation mPower joint venture, Westinghouse pulling resources from SMRs and little progress made with licensing, observers could be forgiven for believing that the industry is at a standstill.

However, the ambition and determination of SMR's strongest proponents has not been dampened. Vital questions surrounding the next steps towards first-of-a-kind construction are being asked, and inventive new thinking is being deployed to get SMR's back on the agenda for 2015.

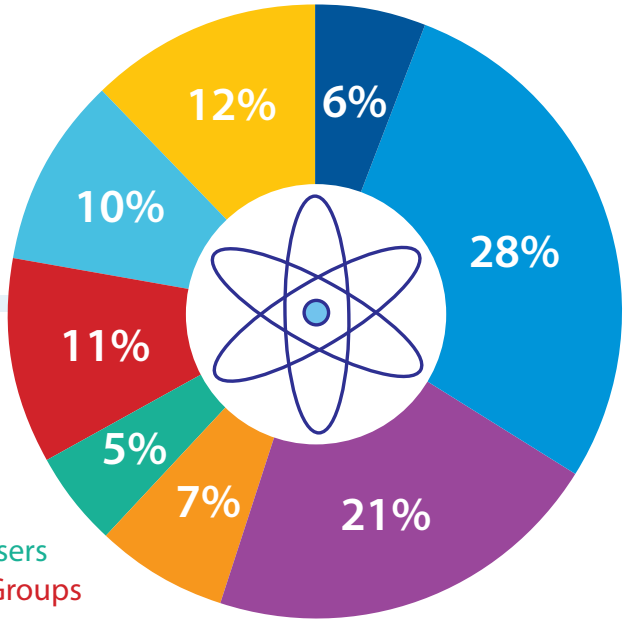
To cut to the heart of critical discussions taking place right now, Nuclear Energy Insider conducted more than 100 hours of primary research with the SMR industry's most influential executives.

Disclaimer: All testimonies and opinions given in this report have been anonymised as part of Nuclear Energy Insiders strict research principles

2. Who we spoke to

Nuclear Energy Insider spoke to more than fifty of the SMR industry's leading specialists and decision makers in order to provide exclusive insight into the crucial challenges that have been faced in the past 6-8 months, and a clear view of the opportunities available to drive modular reactor technology into a successful future.

By speaking to members of the whole community, from SMR vendors, we can provide a robust picture of the current state of the 'nuclear renaissance' and identify the innovative thinking that will enable SMR commercialization to get back on track.



3. Critical questions raised and solutions required

To give you exclusive insight into the key concerns of the SMR industry's most influential executives, Nuclear Energy Insider has summarized the full research findings into the following report and analysis.

Critical challenges detailed include:

- ***Licensing and Design Certification***
- ***Funding and Financing of SMR's***
- ***Creating a Brand New Supply Chain***
- ***Understanding SMR's in the Nuclear Energy Market***

3.1 SMR Licensing and Design Certification

Light Water SMR's are not simply shrunken PWR's

As with any first-of-a-kind licensing process there have been concerns over the ability of regulators to adapt to small nuclear, having spent so many decades assessing mainly large PWR's. Despite some assertions that Light Water SMR's can be licensed as miniature PWR's there have been real difficulties in adapting the regulatory process for one key reason; safety.

The problem is that SMR vendors have enhanced the safety characteristics of their reactors to such a degree that they have subsequently improved their business model. This is because they have improved plant safety to such an extent they can theoretically offer nuclear power to a much wider range of sites and settlements than a large PWR. As a result, vendors have created a situation where SMR's cannot be licensed as simply miniature PWR's as they now offer markedly improved safety systems compared to the large reactors. Consequently, vendor business models are hinged on regulatory backing that would allow them greater opportunities for siting than currently offered to large reactors. The problem is that this is currently outside of what the regulators are currently prepared to license, such as placing an SMR next to a petrochemical plant for instance or in the middle of a settlement.

In order to provide clarity for those preparing designs for licensing, the SMR industry has called for clear direction regarding fundamental safety licensing criteria. Providing clarity in areas such as emergency planning zones and operational staffing is essential to ensuring further investment in SMR's is not wasted. Given the costs involved in submitting design documents to regulators it makes prudent business sense to wait for direction rather than push forwards with designing a reactor that may require costly safety adjustments in future.

Fortunately there have been positive signals in the US that the NRC will at least establish policy on the broad siting and operational safety expectations by the end of 2015.

The NRC as the gold standard

The great appeal of SMR's is that they will one day be globally exportable to all countries regardless of infrastructure development. In practise though each reactor design - whether they be Light Water, High Temperature Gas, or Molten Salt - will have to go through a strict, costly and ultimately time consuming licensing process prior to deployment.

Though few stakeholders would risk advocating the elimination of sovereign regulators, there have been loud calls for key regulators to at least collaborate on broad policy areas. This would undoubtedly serve to ease the financial burden on vendors and ensure that SMR's remain a technology that can be deployed before future energy demands make SMR's unsustainable.

This is not to say that the SMR industry would like all regulators to follow US policy without hesitation. What it does suggest however is that international regulators should respect the NRC's resources for licensing and consider taking the NRC as an example on at least the broadest policy commitments. Establishing early licensing collaboration will not only reduce costs for vendors, but also streamline the export process of SMR technology to previously non-nuclear states.

3.2 Funding & Financing of SMR's

Why should I build the first one?

As with any product, the first always costs more to build than the fifth. This being because the first of anything to be built will always come with an unfinished build manual, and the risk of unexpected construction expenditure.

Unlike designing a new car you cannot simply make a test model and then unveil the finished article in a showroom. Despite the fact that modular reactors will reap the benefits of factory style assembly, the bill to build the first one will incur unexpected teething expenses, whether in material selection, prolonged timeframes or unforeseen logistical challenges in assembling the first modular reactor components.

The risk involved in taking on the first-of-a-kind reactor needs to be weighed against ratepayer and shareholder interests, and in a post-recession economy these risks must be scrutinised even further.

Taking on the first-of-a-kind does not come without the waste expenditure and it becomes difficult for a customer to commit when they might get a cheaper product if they were second or third-of-a-kind.

To provide some insight on the possible path forward, we have summarised the two strongest solutions offered by the SMR industry's leading executives below.

Building a showroom model

One of the more compelling proposals is to build a demonstration SMR, much like in the automotive, aerospace, cell phone or any other customer driven market. A demonstration SMR would however haemorrhage a company's capital stream, destabilizing the platform from which

further models would eventually be made. Outside of the US there are promising first-of-a-kind SMR projects under construction in Argentina (CAREM-25), Russia (KLT-40S) and China (HTR-PM). However, what these projects possess which US companies do not is the majority investment of public money and the full backing of the state. As a result there have been calls in the US market for the federal government to commit to building a demonstration reactor if it is truly committed to using SMR's as means to reboot the US's role as the leading nuclear power. Some even propose that the government uses SMR technology to provide power to a national laboratory as a sensible early adoption of promising technology.

Incentives and support from the public purse

A second and more realistic option is to translate political support for the concept of SMR's into a substantial federal investment covering the excess costs of the first-of-a-kind model. It has been argued by many in the nuclear industry that SMR's will require federal incentives in order to encourage sufficient confidence for shareholders to commit to such a long term investment.

Either through tax incentives or federal backing there has been one clear call to action. In the minds of the potential customers only the injection of public capital can stimulate investors to the point of taking on a first-of-a-kind SMR and the associated financial risk.

Although the actual construction of SMR's is still some years away, the industry will be heading for further uncertainty unless early discussions are held between stakeholders as to where financial support for first-of-a-kind models will come from along with confidence over the strength of that support.

3.3 Understanding SMR's in the Nuclear Energy Market

A vital component to ensuring a diverse yet stable energy portfolio

Current Light Water SMR designs have been developed to take advantage of factory assembly, lower financial risks and shorter construction timeframes. The fundamental economic idea is that if there is enough market demand for SMR's, mass production techniques and streamlined supply chains will bring down the costs of nuclear energy so that they can produce more competitive electrical power.

However, 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.

Whilst SMR's offer a great deal of energy flexibility to energy utilities – having many modules in a single facility allows for greater energy stability should a single module need to be taken out of production – there is a fine line to tread between installing enough modular reactors for base load electricity and ensuring that cost per MWe remains competitive with other sources of energy.

Nuclear Power versus Nuclear Energy Markets for SMR's

The easiest pathway to increased efficiency would ultimately rest on ensuring that as much energy as possible can be harnessed from Modular Reactors, whether it is electrical, thermal or both. Whilst an energy utility may not find thermal energy particularly useful, the high temperature heat market offers an alternative range of potentially interested end customers. The differences in potential end customers steer the discussion away from pure nuclear power provision of base load electricity, to a discussion on who can best utilize nuclear produced energy of both electricity and heat.

Within desalinization, petrochemical and metals manufacturing industries vital thermal energy is currently produced by burning oil or natural gas. With fossil fuel markets liable to immense volatility, nuclear energy offers a stability that fossil fuels and renewables cannot match. The ramifications of expanding a small modular reactor's customer base to include such industries means a much stronger economic model. Increasing energy efficiency can mean interest from wider markets, whilst more orders lead to lower per-unit cost.

Admittedly, the concept of opening up the process heat markets to SMR's is not new, it's as old as the nuclear industry itself and there are no signals that a desalinization facility will order a first reactor. What is clear however is that the discussion on small modular reactors is becoming more customer focussed, and questions on how the end users can support designs closer to certification are being scrutinised. As a result it makes little sense to overlook the perspectives offered by a wider nuclear energy market when discussing the vital next steps of the SMR industry.

3.4 Creating a Brand New Supply Chain

Supply chain localization

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. Previous attempts to localize supply chains will provide invaluable case studies for ensuring that vital infrastructure can be built and local engineering populations managed without a disproportionate waste of resources.

Currently national governments are conducting feasibility studies to ensure not only that the technology is applicable to their infrastructure needs, but also that their supply chain infrastructure could support the requirements of building a nuclear reactor. What is required is a coherent attempt to bring these parties into the stakeholder community early to ensure a mutual assessment of capabilities - well before the first reactors begin assembly.

Energy Efficiency & Materials Selection

By reducing an SMR's size it becomes simpler to build, easier to transport and ultimately cheaper than a large reactor. However a reduction in size means a reduction in energy production. As discussed earlier, addressing energy efficiency is fundamental to improving the business model for SMR's.

The challenge of material selection is borne out of increasing the energy efficiency of a unit so that it is disproportionately greater than that of a large LWR. All materials lose strength at higher temperatures meaning that more efficient reactors will have to employ more advanced materials. Understanding how material selection will impact on the whole supply chain is essential, especially if these materials require forging in an SMR factory for individual reactors, or if the higher operating temperatures will impact the material integrity of the surrounding operating plant.

4. Conclusion and the next steps

The research demonstrates that one of the key challenges being faced by the SMR industry is the lack of a holistic 'long-term' approach to the future of the technology.

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.

Moving beyond a technical discussion of reactor design concepts, Nuclear Energy Insider is excited to announce the return of the ground breaking **5th Annual Small Modular Reactor Summit (April 14-15, Charlotte NC)** with an exciting new direction and expert speaker line-up – serving as a world leading focal point for valuable discussion on the future trajectory of this pioneering industry.

Just some of the new topic areas our agenda will examine:

- *Understand vital public and private project funding initiatives, with insight from DOE, Wall Street and private investment groups, in order to identify key routes available to facilitate first model construction*
- *Intensive discussion of efforts required to streamline design licensing processes in a global SMR marketplace and standardise common licensing principles via international regulatory collaboration*
- *Analyse energy demand projections for nuclear and process heat markets relative to design expectations and encourage confidence in the development of SMR's as a crucial cog in a robust energy portfolio*
- *Engage with critical lessons learned in the localization of large nuclear supply chains to ensure your ability to secure a highly efficient SMR export strategy*

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