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SMALL MODULAR REACTORS: THE NEXT CHAPTER OF THE ENERGY REVOLUTION

The global appetite for energy, in particular electricity, is insatiable. Our demand for electrification is driven to a significant extent by our digital lives, underpinned by the rapid roll-out of data centres, new technologies such as artificial intelligence (**AI**), as well as the electrification of mobility (**EVs**) and increased demand for heat and cooling. In a February 2025 report, the International Energy Agency's (**IEA**) director, Keisuke Sadamori stated:

> "The acceleration of global electricity demand highlights the significant changes taking place in energy systems around the world and the approach of a new Age of Electricity. But it also presents evolving challenges for governments in ensuring secure, affordable and sustainable electricity supply, ... While emerging and developing economies are set to drive the large majority of the growth in global electricity demand in the coming years, consumption is also expected to increase in many advanced economies after a period of relative stagnation."

As the world is looking beyond traditional fossil-fuel based energy sources, nuclear is emerging as the source of long term, low carbon and efficient electricity supply. When people think of nuclear power, they likely think of the huge nuclear power plants in Europe, Asia, and North America. These grid scale plants typically start at 1 GW and up, take many years to plan, permit and build and come at significant cost, generally in the billions. However, small modular reactors (**SMRs**) (typically reactors that produce 300MW or less though some designs are closer to 500MW) are emerging as a more efficient and cost-effective alternative.

Many countries are developing SMRs with over 120 different designs under active development. Such countries include the US, UK, France, Canada, Korea, Czech Republic, Poland, Finland, UAE, Switzerland, Netherlands, and South Africa. With such interest and investment, SMRs are expected to play an important role in future energy markets.

In July 2025, the Nuclear Energy Agency – a part of the OECD – published its third edition of the Small Modular Reactor Dashboard (the **Dashboard**)[1] which sets out the current state of play of SMRs across the globe. It identifies a surge in designs, financing, and regulatory engagement relating to SMRs. This article will look at some of the findings of the Dashboard including the key benefits of SMRs and considerations around their licensing in addition to other key issues, including financing, security and the need for public engagement.

[1] https://www.oecd-nea.org/jcms/pl_108268/new-nea-small-modular-reactor-dashboard-edition-reveals-global-expansion-of-smr-deployment

SMRS - A CATCH-ALL SOLUTION TO THE ENERGY CRISIS?

The IEA predicts that global energy demand will grow 4% per year between now and 2027. Current energy grids and traditional fuel sources will struggle by themselves to meet this demand. Renewables alone cannot supply this level of demand without significant and costly investment in energy storage solutions and grid enhancement. Also, renewables typically take up significant land resources. As a result, many countries are looking to SMRs as a possible solution to provide base load, low carbon power within a geographically small area (essentially providing high density power compared to renewables' low density). The Dashboard shows that over 30 countries are now in various stages of developing their first commercial nuclear power project – many of these will be SMRs.

SMALL AND MODULAR DESIGN

SMR designs look to utilise factory manufacturing and a modular construction process, where quality assurance and testing can take place during the manufacturing stage, with construction timescales reduced and transportation to the customer site simplified.

The 120 (and counting) SMR designs being developed around the world, target varied outputs and different applications, such as electricity, hybrid energy systems, heating, water desalinisation and steam for industrial applications.

There is no single "standard" SMR design, but rather a category of nuclear reactors defined by their output and modular, factory-fabricated construction. While designs vary, prevalent technologies include pressurized water reactors (**PWRs**). These are essentially scaled down versions of the grid scale plants. Other types of SMR are also being developed including high-temperature gas reactors, pebble-bed, thorium and molten salt reactors.

Advanced SMR refers to SMRs that incorporate innovative technologies and designs to enhance safety, flexibility, and affordability compared to conventional nuclear power plants. These reactor designs are often smaller again than SMRs, factory-built for modular installation, and can leverage passive safety features and various technologies beyond traditional light-water designs, offering new applications for electricity, heat, and clean fuels. In addition to SMRs, there is a renewed interest in micro-reactors which have a capacity of 1 – 20MW, as opposed to the 200 – 500MW for SMRs. The Dashboard helpfully provides a collection of leading examples of SMRs under design, as well as some micro-reactors.

USE CASES

SMRs offer a new universe of opportunity for nuclear, with multiple potential use cases. For example, BIG TECH are increasingly turning to nuclear sources of energy to supply the electricity used by the huge hyperscale data centres that drive AI (and intended to accommodate the planned growth in quantum-computing), resulting in Amazon, Meta, Microsoft and Apple all having now made significant investments into the nuclear sector. This is because AI data centres need large amounts of electricity to both power them and keep equipment cool, and access to power has become a critical factor in driving new data centre builds. Importantly, nuclear power, which can provide firm baseload low carbon power 24 hours a day, has become increasingly attractive to the tech industry as it attempts to cut emissions even as they use more energy.

Another potential SMR use case is nuclear maritime, as around 90% of global trade transported by sea, shipping accounts for nearly 3% of worldwide emissions. The IMO is in the process of establishing a new greenhouse gas strategy aiming for zero emissions by 2050, which includes a target for sustainable fuels to represent 10% of energy usage in maritime transport by 2030. Nuclear energy (*with naval nuclear propulsion successfully deployed for decades, with 160 ships being powered by small nuclear reactors – essentially pre-cursers to the modern civil SMRs being planned today*) is increasingly gaining traction in the energy transition, as a potential solution for lowering emissions from international maritime shipping. Regulatory challenges remain with respect to maritime nuclear, with a lack of IMO or other regulation. Land base uses of SMR will take priority in the medium term.

LICENSING

While the nuclear industry across jurisdictions is heavily regulated, this regulation has been focused on medium and large 'traditional' nuclear power plants. Applying the same regulatory approach to

SMRs would unnecessarily constrain and delay their deployment. Given their modularity, technical design (including inherent safety features) and scalability, the regulation of SMRs will require a different approach to traditional nuclear power plants. Crucially, while traditional nuclear power plants are bespoke, often taking many decades to transition through the design phase, to the regulatory approval stage, to construction and completion, given the relative size of SMRs, they will be able to be constructed quickly by comparison once initial design approval is given to the particular SMR model and the industry is tooled accordingly.

While approving the *first* SMR in a given country will be the largest hurdle - that is other than China and Russia, which collectively already have three domestic designed SMRs in operation, once the first SMR is completed (the first-of-a-kind), obtaining approval for the following SMRs (the 'Nth-of-a-kind') should be much more straightforward. Given their small size and modularity, regulators can approve standard designs for each module, which will improve efficiency. In theory, a design for a module only needs to be approved once, following which compliant designs can be rolled out without the need for additional certification.

One option could be to foster international collaboration between national nuclear regulators, so that 'badge of origins' can be utilised with regulators having the ability to passport designs into their own regulatory framework based on this badge of origin from another regulator. There are now encouraging signs that international collaboration between nuclear regulators is indeed increasing, driven by new nuclear technologies (primarily SMRs and advanced micro-reactor SMRs) and the need for more aligned regulatory approaches to ensure global safety and facilitate deployment. In September 2025 the UK and the USA announced the Atlantic Partnership for Advanced Nuclear Energy. The partnership will fast-track reactor design reviews, meaning that if a reactor design passed rigorous safety checks in one country, this work can be used by the other to supports its assessment, avoiding duplication of work. This is expected to speed up the licensing process.

In addition to the UK-USA partnership other initiatives include the International Atomic Energy Agency's (IAEA) Regulatory Cooperation Forum, formal Information Exchange Arrangements for bilateral agreements, and trilateral Memoranda of Cooperation on specific technologies like AI. This collaboration aims to share knowledge, align standards, and streamline regulatory processes, creating efficiency and ensuring consistently high safety levels across different countries.

When dealing with any nuclear substance, safety is paramount. Regulators need to be sure that what they are approving is safe to operate, particularly given SMRs are likely to be situated much closer to and within business districts and even residential areas. Given their compact size, there will be much less reliance on active safety systems (like pumps and valves) and instead more reliance on passive safety systems (such as natural circulation and the use of gravity to assist draining and water movement). However, the whole safety apparatus around SMRs will be on a much-reduced scale from traditional nuclear power plants.

SITE APPROVALS

While regulatory approval of design may be passported from one country to another, approval of the installation of a particular SMR design to a specific site will remain the concern of the national nuclear regulator. Regulators will need to take into consideration the unique factors of each site, which will vary greatly between, for example, those in rural areas vis-à-vis those located in a central business district. Much like the ownership of SMRs themselves, siting is going to involve a mix of public and private entities. The Dashboard highlights that while the majority of potential SMR sites are associated with utilities and government owned entities, a significant minority are linked to laboratories and private industrial players.

SMR site approvals are likely to be simpler than for large scale plants. Due to the smaller size and passive safety features, the area required for an SMR and its associated Emergency Planning Zone (**EPZ**) is likely to be significantly smaller. The EPZ for a grid scale plant can extend up to 60 miles (made up of the 10-mile Plume Exposure Pathway EPZ (**PEPZ**) and 50-mile Ingestion Exposure Pathway EPZ (**IEPZ**)). The Sizewell nuclear power plant in the UK has a 15km and 30km EPZ. The EPZs for SMRs are being developed with flexibility, as SMRs' design allows for smaller EPZs. Regulatory bodies like the U.S. Nuclear Regulatory

Commission are establishing performance-based programs that recognise SMR design advances and offer alternative emergency preparedness requirements to reduce the need for exemptions. Some SMR designs are being planned with site-boundary EPZs.

Of the SMRs covered by the Dashboard, three are licensed to operate, seven have been granted a licence to construct, seven have submitted a licence application, and 33 SMR designs are in pre-licensing activities. This is a sign of a healthy SMR pipeline. While three are operating, many dozens are currently undergoing the regulatory process.

FINANCING

Traditionally, the nuclear industry was financed by governments, with a small amount of private financing. However, private investment in nuclear is surging. In 2023, there were USD15.4bn of funding announcements for SMRs (outside of Russia and China), around one third of which was private funding. Notably, three SMR companies are publicly traded: NuScale, Oklo, and NANO Nuclear Energy. While public funding will remain critical, more investment through public-private partnerships is needed to assure that SMRs are a viable option into the future. The role of large power users (likely the hyperscaler data centre providers) in providing this private funding is becoming more prevalent. Amazon announced last year that it was going to invest more than half a billion dollars in companies developing nuclear power and SMRs. Google has also invested in nuclear and has ordered several SMRs from Kairos Power, with the first due to be completed by 2030. Similarly, Microsoft and Meta have recently announced plans to invest in SMRs.

SECURITY

The relatively small size of SMRs is both a security strength and weakness. It is a strength as there is no need for a vast EPZ security perimeter around an SMR. Additionally, SMRs can be deployed underground, even below water, which offers protection from external threats. SMRs also offer a form of 'energy security' in that once installed, their upkeep is not dependent on consistent imports of fuel etc., with some SMR designs requiring refurling every three to seven years, and others aiming for up to 30 years. However, the smaller size and geographic footprint may also limit the usual layered protection made possible by the EPZs of grid scale plants. In addition, increased digitisation of control systems opens the possibility of cybersecurity threats. Remote maintenance and monitoring systems that are included in some SMR designs also increases this cyber risk potential. Current legal and regulatory frameworks need to be reviewed in the light of this different security threat environment. Aspects of this different approach to security are considered in the Dashboard with a number of SMR design incorporating 'security by design' into the SMR design. This process includes underground siting, robust containment structures and passive safety systems that reduce vulnerabilities and mitigate the consequences of sabotage.

PUBLIC ENGAGEMENT

While this issue is covered last, it is vital to the success of SMRs and the energy transition. SMR projects will not advance far unless a strong relationship is built between those developing SMRs and local communities. Particularly in countries like the UK, where planning laws mean public buy-in is often required for building projects, educating local communities about the benefits of SMRs is important. The Dashboard shows that SMR developers are contributing to a broader public understanding and acceptance of nuclear technologies including through town hall meetings. Educating the public on the benefits of SMRs not just to their local community (although such benefits are sizeable) but to the wider energy transition and global carbon reduction efforts is a crucial part of generating public acceptance of nuclear.

SMRS ARE COMING

With 120 designs and counting and over 30 countries looking to deploy SMRs to meet rapidly increasing energy demand, we can expect to see two or three SMR designs move from first of a kind to nth of a kind over the next decade.

The September 2025 announcement of commercial deals of new SMR deployments in the UK (in addition to the Rolls Royce SMRs previously announced) as well as the first micro reactor demonstrate the speed of developments.

The benefits of the modular design as well as the potential for an element of passporting of designs through a badge of origin approach are expected to increase the number of SMRs being deployed and reduce costs of nuclear power. With a more streamlined design approval process, passive safety features and a smaller overall profile, it is possible that site approvals will also become simpler for SMRs when compared to grid scale plants.

Financing will remain an issue. However, the demand from hyperscalers does provide a new potential source of financing in some use cases. Moreover, public engagement (and education) will be critical to the deployment of SMRs and continued engagement from developers, governments and regulators is required.

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