Global Listed Infrastructure
Has Net Zero gone nuclear?

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US utilities are breaking ground on Small Modular Reactors in the hunt for carbon-free energy

The tech sector's thirst for energy, driven by AI, is an accelerant for 24/7 clean power – renewable and nuclear

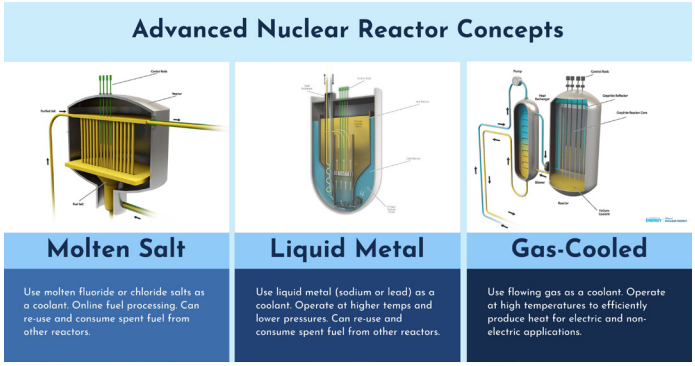
SMRs are carbon-free, dispatchable and enjoy bipartisan support, but development success, standardisation and scale will be required for cost effectiveness

Over the last decade the electricity sector has been at the forefront of decarbonisation, ahead of transport, industry and agriculture. We estimate that the rollout of renewable energy at the expense of older fossil fuel generating units has enabled ~80% of the net zero[1] pathway for utilities to be understood and in progress. The final ~20% requires a carbon-free replacement for gas-fired power generation. US utilities are now seeking to determine whether Small Modular Reactors (SMRs) could serve as this substitute. This technology is now being included in their long-term planning, sites are being selected and we are even seeing the signing of SMR Requests for Proposals (RFPs). In this paper we discuss what an SMR is - the advantages / disadvantages of the technology, developments in progress and how the tech sector is both enabling and de-risking this buildout.

What are SMRs and what are their advantages?

SMRs are defined by the World Nuclear Association as "nuclear reactors generally 300MWe[2] equivalent or less, designed with modular technology using module factory fabrication, pursuing economies of series production and short construction times".

The most current nuclear reactors in operation today are light-water reactors that use water under high pressure as the cooling medium[3]. Advanced nuclear designs can also use other cooling sources such as molten salt, liquid metal or gas.



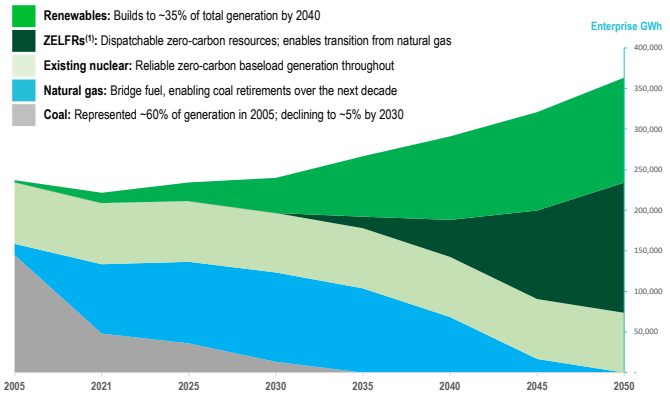
Source: Office of Nuclear Energy as at 5th February 2023.

Gas-fired power generation has supported the rollout of renewables, providing dispatchable[4] energy that compliments the intermittent nature of renewables. Greater use of gas-fired power generation, along with growth in renewables, has allowed coal fired power generation to be taken offline. This has already helped to reduce the electricity sector's carbon intensity since natural gas emits around half as much carbon dioxide as coal, per unit of energy delivered[5]. In order for net zero to be achieved, natural gas will need to be replaced with an even lower carbon option. While batteries can be part of the equation, they don't give us the whole answer. This is where SMRs come in.

The long-term generation mix forecast of Duke Energy, a large, regulated US utility, shows SMRs beginning to contribute in the 2030s and increasingly taking share from gas as we head towards 2050.

1. A target of completely negating the amount of greenhouse gases produced by human activity.
2. MWe: Megawatt electric, defined as one million watts of electric capacity.
3. Source: World Nuclear Association as at 27 August 2024.
4. A dispatchable power source is one that can be adjusted on demand by grid operators to match supply with electricity demand.
5. Source: Center for Climate and Energy Solutions as at 30 September 2024.

Duke Energy generation mix forecast



Source: Duke Energy as at 4th October 2022.

SMRs offer many advantages not provided by renewable energy sources:

1. SMRs will provide dispatchable 24/7 energy that is carbon-free.

2. Construction will take place in factories, allowing for centralised manufacturing that will lower the cost of this technology when scaled up.

3. Being under 300MWe and having centralised manufacturing will allow for shorter construction times, increasing speed to site.

4. SMRs can be housed at the sites of old coal plants with access to water and existing transmission grids, removing one of the largest obstacles cited in further renewable deployment.

5. Nuclear energy is one of the only bipartisan aspects of US energy policy, shielding it from the shifting whims of election cycles.

The main disadvantage of this technology is its lack of development to date. Operational SMRs for power generation do not exist today. There are also multiple types of SMRs. This makes standardisation and cost reduction difficult until further development has been carried out. It is with standardisation, scale and learning that cost reductions will be achieved. The question of safe storage and disposal of radioactive waste will also need to be considered, given the sheer volume of capacity that will be required to meet net zero.

Recent Developments

Two SMRs in development in North America today are:

1. Darlington New Nuclear Project – The Canadian province of Ontario, in conjunction with Ontario Power Generation (OPG), has begun planning and licensing for the deployment of GE Hitachi Nuclear Energy (GEH) BWRX-200 SMRs. The project is scheduled to have four units online equating to 1,200MW by 2029.

   Work has begun on the fabrication and pre-assembly buildings. Site grading for the fabrication shop is complete and the backfill of the building footprint will be finalised soon. OPG has applied to the Canadia Nuclear Safety Commission (CNSC) for a License to Construct. The CNSC has announced a two-part public hearing. The first one took place on 2 October 2024 with the second one scheduled for January 2025.

Darlington New Nuclear Project site

Source: Ontario Power Generation, Summer 2024.

2 Kemmerer, Wyoming - TerraPower, a company founded by Bill Gates in 2008 and PacifiCorp, a utility business owned by Warren Buffett's conglomerate Berkshire Hathaway, are building their first SMR near the site of a retiring coal facility in Kemmerer in partnership with the US Department of Energy's Advanced Reactor Demonstration project.

   The US Nuclear Regulatory Commission (NRC) accepted TerraPower's construction permit application this year. This started the clock on the NRC's review process for the permit application, which will allow construction to begin on the nuclear reactor itself. Preliminary site construction started in June 2024 with the full project expected to come online in 2030.

Bill Gates breaking ground on TerraPower's SMR in Kemmerer, Wyoming

Source: Wyoming Public Media as at 10 June 2024.

Three SMR projects that have reached the site selection stage include:

1. Duke Energy has selected Belews Creek, North Carolina, as the site for their first SMR. Duke plans to build a 600MW SMR by 2035 at this site, which currently houses a large two-unit coal plant. The NRC is currently engaging in pre-application activities with Duke Energy regarding an Early Site Permit. This allows discussions to take place, offering licensing guidance and identifying potential licensing issues early in the process.

2. Dominion Energy has selected North Anna, Virginia as the site for its first SMR. The company has already issued an RFP from leading nuclear technology companies to evaluate the feasibility of developing an SMR at the North Anna site. This news was announced at the site alongside Virginia governor Glenn Youngkin and other local and state leaders.

3. Tennessee Valley Authority have chosen Clinch River, Tennessee as their site for an SMR. They obtained an Early Site Permit for the reactor in 2019 and are partnering with OPG to work together on the design, licensing, construction and operation of the plant.

FSI site visit to Dominion Energy's North Anna SMR site

Source: First Sentier Investors as at 6th September 2024.

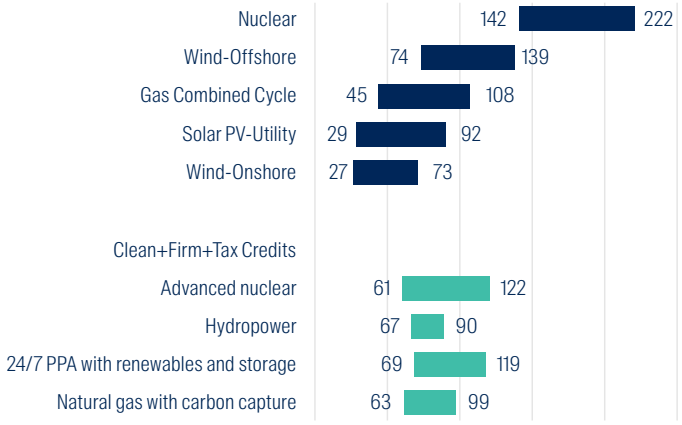
It is also worth noting that TerraPower - in conjunction with Southern Company, another large US utility - has completed the Installation Effects Test of a first-of-its-kind Molten Chloride Fast Reactor at TerraPower's laboratory in Everett, Washington.

Big Tech enabling SMRs

Big Tech (Microsoft, Google, Amazon and Meta) has aggressively moved to secure 24/7 carbon-free energy for their data centres by signing both renewable and nuclear energy power purchase agreements (PPAs). The US Electric Power Research Institute estimates that by 2030, data centres will account for almost 10% of overall US electricity consumption.

With regard to large-scale nuclear PPAs, Microsoft has recently signed a 20-year PPA with Constellation Energy to restart Three Mile Island nuclear power plant in Pennsylvania. The price is estimated to be between US$110 andUS$115 per megawatt hour (MWh), a large premium to PJM[6] forward prices of around US$60 / MWh[7]. This premium is for access to 24/7 dispatchable power. At scale, SMRs' levelized cost of energy is estimated to be between US$61 and US$122 per MWh – a premium to renewable energy but lower than large-scale nuclear.

Illustrative LCOE ranges US$/MWh



Source: Lazard LCOE, First Sentier Investors as at 30 September 2024
LCOE = Levelised Cost of Electricity

Another example is Amazon's AWS subsidiary buying a 950MW data center in Pennsylvania, powered by a nuclear plant that is operated by utility company Talen Energy.

With these examples, it may appear a trend is emerging. However, the number of large-scale nuclear power plants available for commercial contracts is limited. We do not expect to see many of these types of contracts going forward.

6. PJM is a regional transmission organization that coordinates the movement of wholesale electricity in all or parts of 13 eastern US states and the District of Columbia.
7. Source: Bloomberg as at 30 September 2024.

We believe the focus is now moving to SMRs. In May 2024, Duke Energy signed a Memorandum of Understanding with Amazon, Google, Microsoft and steel manufacturer Nucor for a range of new power contracts including both renewables and nuclear. In mid-October 2024, Google ordered six to seven SMRs with a total capacity of 500MW from Kairos Power. They estimate the first commercial reactor will be online in 2030 and additional reactors by 2035. This once again highlights the tech sector's urgent need for power, and its ability to help accelerate the commissioning of such facilities.

The sheer size of these technology companies (their respective market capitalisations are each over 10 times larger than that of Duke Energy – a substantial company in its own right[8]) allows them to accelerate the deployment of SMRs. Their involvement – either by taking direct ownership stakes, or by signing PPAs – de-risks these projects for utilities. While the rollout of renewables will play a role in this equation, utilities cannot build renewables quick enough to satisfy the insatiable demand that we see coming from the tech sector.

Conclusion

SMRs provide 24/7 carbon-free dispatchable energy, significantly replacing gas and enhancing renewable energy in the race to net zero.

US utilities have advanced SMRs more in the past 12 months than over the past 12 years, with Duke Energy and Dominion Energy having selected sites for these plants.

Big Tech's insatiable demand for energy to power new data centers can de-risk the buildout of SMRs through PPAs or potentially via direct equity into these plants. They have both the balance sheet and the urgent need for power to be an accelerant to this technology.

No matter which US political party is in power for the next four years we see this trend as very likely to continue, with SMRs being a rare area of US energy policy that enjoys bipartisan support.

Putting all this together it is very clear that full decarbonisation requires a blend of highly complementary technologies with different attributes. SMRs represent a firm, dispatchable compliment to renewables that has the promise to replace gas and support the achievement of net zero.

GE Hitachi's BWRX-300 reactor

Source: energyfacts.eu as at February 6th 2020.

8. Source: Bloomberg as at 30 September 2024.

Source: Company data, First Sentier Investors, as of 30 September 2024. Companies mentioned herein may or may not be holdings of First Sentier Investors' strategies at the time of writing.

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