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So, What Exactly Are Small Modular Nuclear Reactors?

Does nuclear have a role in a digital, decentralized, renewable energy world? GTM explains the weird and wonderful world of clean energy.

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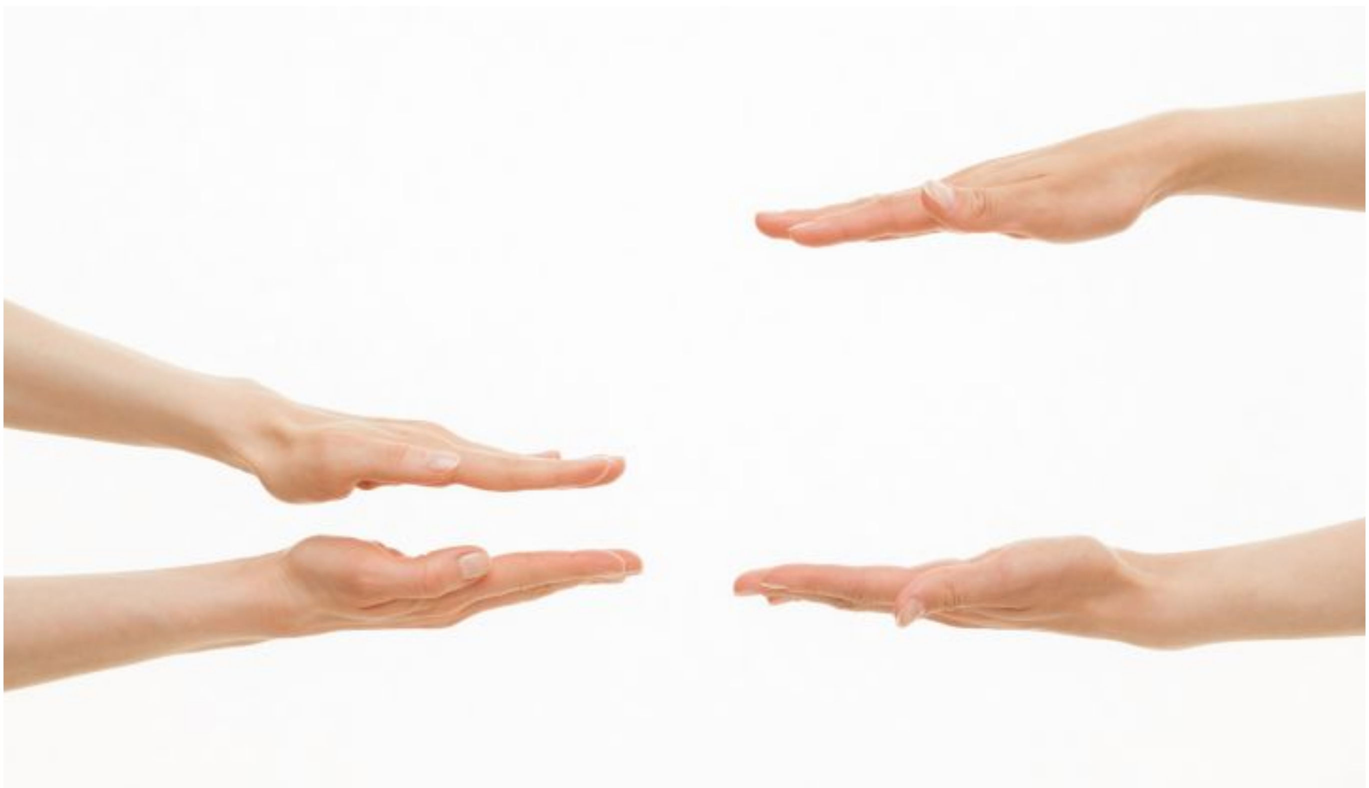

GTM helps explain the weird and wonderful world of clean energy.

What's the problem with nuclear energy? At a time when lawmakers are scratching their heads over how to decarbonize national energy systems, nuclear is a technology that is low-carbon, mature and, despite the odd meltdown, relatively safe (https://www.visualcapitalist.com/worlds-safest-source-energy/).

Yet across North America and Europe, nuclear can't seem to get a foothold. More than half of the 48 new reactors (https://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx) that the World Nuclear Association (WNA) lists as being built worldwide are in just four countries: China, India, the United Arab Emirates and Russia. China alone accounts for a quarter of the total.

Meanwhile, in the U.S., the world's top generator of nuclear power, only two new reactors (https://www.greentechmedia.com/articles/read/covid-19-impacted-productivity-of-vogtle-nuclear-plant-construction) are currently under construction — and Southern Company's Plant Vogtle expansion is massively overdue and over-budget.

It's the same story in France, which has a higher proportion of nuclear energy on the grid than any other country in the world. French developer EDF was hoping for its sole new-build project to go live last year (https://www.greentechmedia.com/articles/read/epr-nuclear-reactor-model-may-finally-go-live-europe-2019), along with another reactor it is building in Finland. It failed to meet both targets.

Nuclear construction cost and schedule overruns are causing the sector to fall from grace in these formerly hospitable markets. And the business case for reactors is increasingly shaky in places where the grid is moving to a more digital, distributed and renewable model.

To stay relevant in regions such as Europe and North America, the nuclear industry knows it needs a new plan. It's betting on a sleeker, more appealing kind of nuclear technology: the small modular reactor, or SMR.

SM... what?

Whereas the world's largest traditional nuclear reactors have topped 1.6 gigawatts of generating capacity per unit, the Vienna-based International Atomic Energy Agency (IAEA) defines the "small" category as anything delivering up to 300 megawatts.

Confusingly, the IAEA has also used SMR as an acronym for "small and medium reactors," which encompasses units of up to 700 megawatts. But today, the term "SMR" is usually reserved for small reactors that are designed for factory-style serial production (hence the term "modular").

To round off the SMR nomenclature class, there are also fun-sized units called "very small modular reactors," or VSMRs, of up to 15 megawatts, and micro modular reactors, or MMRs, of up to 10 megawatts.

The pros and cons of small modular reactors

Teeny reactors have been around for almost as long as the nuclear industry itself and are still found in places such as naval vessel engine rooms and research facilities.

Today's SMR developers are hoping to build on the experience gained with such units to create a new class of nuclear technology that can operate safely in a range of power market environments and be mass-produced to reduce unit costs and installation times. While smaller reactors may miss out on the economies of scale that could theoretically be gained from building big nuclear plants, SMR proponents say that a factory approach to manufacturing could help the sector cut costs and remain competitive as renewables come down in price.

Although the exact level of cost reduction is subject to speculation, one 2017 study (https://www.psi.ch/sites/default/files/import/ta/PublicationTab/MSc_Piotr_Dobrzynski_2017.pdf) suggested a factory-produced pressurized water SMR might be between 15 percent and 40 percent cheaper than a traditional plant scaled to provide the same electrical output.

Oregon-based NuScale Power, one of the front-runners in SMR development, estimates it could build its first plant, with a dozen 50-megawatt reactors totaling a net 684 megawatts of electrical power, for $3 billion.

That's roughly 20 percent cheaper on an installed per-megawatt basis than the $14 billion (https://www.world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx) quoted to the Georgia Public Service Commission in 2014 for the two 1.25-gigawatt units now under construction at the Vogtle plant located near Waynesboro in that state. (Vogtle's costs have now ballooned to around $28 billion (https://www.ajc.com/news/local/georgia-vogtle-nuclear-report-more-delays-extra-costs-flaws/mBxlgXiDcf0SIaTFr0cZXL/).)

Alongside theoretically cheaper construction, the size of SMRs means they could potentially be deployed in many situations where it wouldn't make sense to have a full-scale nuclear plant. They can also in theory be designed to incorporate the latest safety features, allowing them to be placed in brownfield sites or otherwise close to areas of human habitation. Advocates see them being used to power remote towns, desalination plants, mines and other similar sites.

One early possible application, now being pioneered in Russia (https://www.greentechmedia.com/articles/read/confidence-in-russia-floating-nuclear-timeline), is for SMRs to be mounted on vessels for the provision of nuclear power to remote coastal communities.

So what's the catch?

The main problem with the SMR concept is that it has yet to be tested in earnest. There is a handful of sub-300-megawatt reactors in operation across China, India and Russia, but none of them would qualify as SMRs in the modern sense.

The closest thing to an SMR out there in the real world is a Russian floating plant (https://www.greentechmedia.com/articles/read/confidence-in-russia-floating-nuclear-timeline) that uses naval reactors. The plant is estimated to have cost 21.5 billion rubles (a bargain-basement $314 million at today's rates), but it is hard to imagine that model being licensed for use in places such as the U.S.

Indeed, certification is a major stumbling block for SMRs generally. And you can hardly blame bodies such as the U.S. Nuclear Regulatory Commission. Many SMR designs use novel technologies and construction techniques, and regulators have to issue licenses based on developer proposals rather than real-life plants. This means licensing has proceeded slowly in markets such as the U.S. and Canada.

In the U.S., for example, NuScale only passed the fourth of a six-phase Nuclear Regulatory Commission design certification application review last December, almost 12 years after initiating the process. No other SMR maker has undergone the U.S. regulator's design certification review.

Until SMRs are approved and built in bulk, it is impossible to test whether developers' cost claims are true. Not everyone is convinced that they are.

Canadian academic Professor M.V. Ramana, for example, believes scant demand for SMRs (https://www.greentechmedia.com/articles/read/interest-in-small-modular-nuclear-grows) coupled with a massive diversity of designs means no vendor could likely achieve the level of mass production required for low-cost manufacturing.

Has that skepticism put nuclear developers off?

Oh, no. A few years back, the IAEA listed no fewer than 48 potential SMR designs under development. And the WNA lists 19 small reactors (https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx) as currently operating, under construction or close to deployment.

The countries most interested in developing or deploying SMRs can be gleaned from the membership of the IAEA's SMR regulators' forum: Canada, China, Finland, France, Russia, Saudi Arabia, South Korea, the U.K. and the U.S.

SMRs are under development in a range of countries, including the U.S., Canada, South Korea, Argentina and several countries in Europe. "We are likely to see demonstration and first-of-a-kind plants from many of the programs over the coming decade," says WNA Senior Communication Manager Jonathan Cobb.

NuScale's progress with its small modular reactor

It's a fair bet that the first SMR that will enter operation in U.S. soil will be the Utah Associated Municipal Power Systems plant that NuScale expects to have operating by 2027.

NuScale got the NRC's final stamp of approval (https://www.greentechmedia.com/articles/read/nuscales-federal-safety-approval-moves-u.s-modular-reactor-a-step-closer-to-reality) on its SMR design this September, a critical step for the Portland, Oregon-based company's plans to build its first commercial systems. In March, the company said its schedule would not be affected by the coronavirus pandemic.

And NuScale is far from the only U.S. contender in the race to commercialize SMRs. Another one to watch is Bill Gates-backed TerraPower (https://www.greentechmedia.com/articles/read/bill-gates-nuclear-reactor-company-adds-molten-salt-storage-to-its-smr-system), which in August added molten salt storage to its technology mix. It is aiming to have reactors working in the late 2020s.

But won't renewables be even harder to beat by then?

Oh, yes. In 2018, NuScale was predicting its SMRs would have a levelized cost of energy of $65 per megawatt-hour (https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiUrNeq8fnpAhUIkRQKHfIVDK4QFjACegQIARAB&url=https%3A%2F%2Fwww.nuscalepower.com%2F-%2Fmedia%2FNuscale%2FFiles%2FAbout-Us%2Fnuscale-uk-prospectus.ashx%3Fla%3Den%26hash%3D0B3DC6EBCC85E30F61F48AEE219034E68D0DF37D&usg=AOvVaw1tohqqteQQOwL8O17gd9ut). For comparison, the U.S. Energy Information Administration calculates (https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf) that by 2025 solar PV will have an LCOE of $32.80 per megawatt-hour and onshore wind will be at $34.10.

Of course, if NuScale's plant works without problems, then its power supply won't be subject to intermittency. That might be a lot to ask of the first-ever U.S. SMR to roll off the assembly line, however. And a long history of delays and cost overruns in traditional nuclear construction does not exactly bode well for the competitiveness of SMRs in the mid- to late 2020s.

What happens to the nuclear industry if it can't get anywhere with SMRs?

Nuclear faces steep challenges in many of its former strongholds, and if SMRs don't pan out as a concept, then the future for the industry looks bleak in those markets.

However, there is still a strong commitment to nuclear in China, India and Russia, not to mention smaller markets such as Argentina and Turkey.

Russia has already effectively started deploying SMRs with its floating plant, and Cobb said China was likely to commission a 210-megawatt high-temperature gas-cooled reactor at the end of this year. So even if SMRs don't make it in places like Western Europe or North America, they might still become part of the generation mix in some of the world's biggest energy markets.

And if all else fails, there is still the promise of fusion (https://www.greentechmedia.com/articles/read/fusion-still-tantalizingly-far-off-despite-recent-signs-of-momentum).

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