Federal Ministry
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Climate Action, Environment,
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Small Modular Reactors? – PowerPoint Reactors!

They are supposed to be small and are creating a major media stir. The wind power giant Ørsted dubbed them “dwarf reactors”.[1] They do not exist, but there is much talk about them. If ever they did exist, in 15 or 20 years, the electricity they generate would be at least as expensive as the electricity generated by their large predecessors. Too late, too costly for our climate.

The promise is decades old but remains alive and kicking: The international nuclear energy industry is making a pitch for small modular reactors of the future – cheap, idiot-proof and therefore ubiquitously deployable, even in areas of high population density. However, they do not really exist. But just like the illusion that concept drawings used to project onto walls back in the 1990s, the virtual spaces on computer screens and in Zoom rooms are being used to conjure up dreams across the continents.

Small modular reactors, SMRs for short, are en vogue again. From old hat to cutting edge.[2] In the 1950s and 1960s, a few of them were actually built, namely in the US.[3] That did not always end well. The small Elk River reactor started operating after a five-year construction period but found itself shut down for good in 1968, just three-and-a-half years later. Fermi-1, an experimental fast breeder reactor located on the banks of Lake Erie, needed 10 years before it was able to supply its first kilowatt-hour of electricity

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[1] Volker Kühn, “Verstrahlte Träume” (Irradiated Dreams), *EnergieWinde*, 27 November 2020, see https://energiewinde.orsted.de/energiepolitik/atomenergie-niedergang-keine-renaissance, accessed on 6 December 2020.

[2] See a summary of the history of SMRs penned by M.V. Ramana, “The Forgotten History of Small Nuclear Reactors”, IEEE Spectrum, 27 April 2015, see https://spectrum.ieee.org/tech-history/heroic-failures/the-forgotten-history-of-small-nuclear-reactors, accessed on 26 November 2020.

[3] 14 reactors with a capacity of less than 100 MW were connected to the grid. Only six reactors with a capacity of between 100 MW and 500 MW began to operate. 113 out of a total of 133 nuclear reactors ever built in the US have a capacity of over 500 MW.

in 1966. Two months later, the reactor's core suffered a partial meltdown. The book "We Almost Lost Detroit" became a bestseller.[4]

Since the 1970s, newly built reactors have been increasing in size, mainly in an attempt to curb costs. However, over the past ten years, it has become crystal clear that large reactors, regardless of their design, are too expensive and—just like the dinosaurs of prehistoric times—too large and too slow to keep pace with their nimble competitors from the renewables sector. Once again, small SMRs are being billed as the panacea. Cheap, easy and quick to build, they are also supposed to be easy to operate.

However, any wine connoisseur will know that a glass of wine served in the restaurant may cost less than a whole bottle, but every single glass of wine added together will be more expensive than the same quantity taken from a purchased bottle. A compelling argument in favour of the entire bottle. This is called "economies of scale" in economics.

Conversely, if I decrease the size of anything I want to build by a factor of 10 or 20, I lose the cost-savings due to economies of scale. The Pebble-Bed Modular Reactor (PBMR), which was originally designed in the Federal Republic of Germany, was considered the SMR champion for decades. In Germany, the concept ultimately failed in 1988 after billions of public money had been invested in two prototype reactors.[5] Initially, the Republic of South Africa started out with the idea of a 110-MW facility, but the plant's capacity was gradually increased to 165 MW in an attempt to make it economically viable. By 2010, this adventure at the Cape had cost the country's taxpayers €800 million. A prototype was never built and the government in Pretoria finally pulled the plug.[6]

Since 2000, the US Department of Energy has resumed generous funding for SMR research. The SMR concept by the name of NuScale was the first of its kind in the world to obtain a generic design approval in the US in summer 2020. But that license is far from a site-specific construction permit. As soon as the first obstacle had been overcome, potentially serious shortcomings were identified in the design. Moreover, the company's financial department had redone the maths.

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[4] John G. Fuller, "We Almost Lost Detroit", *Ballantine Books*, 1976.

[5] Experimental reactors AVR Jülich (15 megawatts) and THTR-300, a Thorium High-Temperature Reactor (THTR) in Hamm-Uentrop (300 megawatts).

[6] David Fig, "Nuclear energy rethink? – The rise and demise of South Africa's Pebble Bed Modular Reactor", Institute for Security Studies, ISS Paper 210, April 2010.

The standard design provides for plants comprising no fewer than 12 modules in order to achieve something close to—theoretical—profitability based on economies of scale. Commissioning of the first module is scheduled for 2029/2030. Good luck!

However, despite the “volume discount”, estimated costs for the NuScale project skyrocketed to levels in no way inferior to the disastrous price tags for the latest generation of European large-scale reactors, the European Pressurized water Reactor or EPR with projects in Finland, France, and the United Kingdom. Now, plans are to increase the capacity of every NuScale module by over one quarter from 60 MW to 77 MW. Ultimately, a standard SMR site would thus have a capacity of 924 MW, which is barely less than the size of today’s conventional large-scale nuclear reactors. The first prospective buyers are already exiting the project.

In Argentina, a 25-MW reactor has been in the making since 2014. In China, two 100-MW modules have been under construction since 2012. Only in Russia, two “floating reactors” with a capacity of 30 MW each began operating in 2019. Construction took nearly 13 years, four times longer than planned. Costs exceed by far those of the most expensive large-scale reactors of the latest generation.[7]

Besides the inveterate SMR proponents, there are people who dream of Generation IV reactor technologies. TerraPower, for example, promises innovation in nuclear technology “to improve the lives of people everywhere and to build the clean energy of tomorrow—today”.[8] The company was founded by Microsoft’s Bill Gates in 2006. Fifteen years later, the reactor only exists on paper, with a vague design that has yet to be approved. Despite having the best access imaginable to the US research elite and virtually unlimited financial means, the company has nothing to show for it except another PowerPoint design. In summer 2020, the company announced “TerraPower has now embarked on engineering”.[9] Stay tuned.

[7] Definite numbers are not known. As of 2015, costs were already estimated to be approx. € 10,000/kW. The most recent cost estimate for EPR construction sites in France (Flamanville-3) and Finland (Olkiluoto-3) is approx. € 7,500/kW.

[8] TerraPower, “About us”, see https://www.terrapower.com/about/, accessed on 25 November 2020.

[9] TerraPower, “TerraPower’s Traveling Wave Technology: Bringing Advanced Nuclear to Market”, Summer 2020, see https://www.terrapower.com/wp-content/uploads/2020/08/TP_2020_TWR_Technology_082020.pdf, accessed on 25 November 2020.