The SMR 'hype cycle' hits a hurdle in Australia

Jim Green – Nuclear Monitor editor

Dr. Mark Cooper, senior research fellow for economic analysis at the Institute for Energy and the Environment at Vermont Law School, writes about the small modular reactor (SMR) 'hype cycle' which shares many features with the hype that drove the 'nuclear renaissance' – the short-lived upsurge of interest in large reactors in the late 2000s.[1]

Cooper identifies three stages of the hype cycle:

1. Vendors produce low-cost estimates.
2. Advocates offer theoretical explanations as to why the new nuclear technology will be cost competitive.
3. Government authorities then bless the estimates by funding studies from friendly academics.

But the circular, self-referential SMR hype cycle has been disrupted in Australia by two government agencies, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Energy Market Operator (AEMO). The latest *GenCost* report produced by the two agencies estimates a construction cost of A$16,000 (US$10,700) per kilowatt (kW) for SMRs.[2]

The estimate has been furiously attacked by, amongst others, conservative politicians[3] involved in a federal nuclear inquiry last year, and the Bright New World (BNW) lobby group[3-5] which accepts secret donations from the nuclear industry and has a long history of spreading pro-nuclear misinformation.[6]

BNW objects to CSIRO/AEMO basing their SMR cost estimate on a "hypothetical reactor".[4] But BNW does exactly the same, ignoring real-world cost estimates for SMRs under construction or in operation. BNW starts with the estimate of US company NuScale Power, and adds a 50% 'loading' in recognition of past examples of nuclear reactor cost overruns. Thus BNW's estimate for SMR construction costs is A$9,132 (US$6,090) per kW.[5]

Two big problems: the NuScale cost estimate is bollocks, and BNW's proposed 50% loading doesn't fit the recent pattern of nuclear costs increasing by far greater amounts.

NuScale's construction cost estimate of US$4,200 per kW[7] is implausible. It is far lower than Lazard's latest estimate of US$6,900–12,200 per kW for large reactors[8] and far lower than the lowest estimate (US$12,300 per kW) of the cost of the two Vogtle AP1000 reactors under construction in Georgia (the only reactors under construction in the US).[9] NuScale's estimate (per kW) is just one-third of the cost of the Vogtle plant – despite the unavoidable diseconomies of scale with SMRs and despite the fact that every independent assessment concludes that SMRs will be more expensive to build (per kW) than large reactors.[10] Further, modular factory-line production techniques were trialled with the twin AP1000 Westinghouse reactor project in South Carolina – a project that was abandoned after the expenditure of at least US$9 billion, bankrupting Westinghouse.[11]

Lazard estimates a levelised cost of US$118–192 per megawatt-hour (MWh) for electricity from large nuclear plants.[8] NuScale estimates a cost of US$65 per MWh for power from its first plant.[12] Thus NuScale claims its electricity will be 2–3 times cheaper than that from large nuclear plants, which is implausible. And even if NuScale achieved its cost estimate, it would still be higher than Lazard's figures for wind power (US$28–54) and utility-scale solar (US$32–44).

BNW claims that the CSIRO/AEMO levelised cost estimate of A$251–330 per MWh for SMRs is an "extreme overestimate".[3] But an analysis by WSP / Parsons Brinckerhoff, prepared for the SA Nuclear Fuel Cycle Royal Commission, estimated a cost of A$225 per MWh for a reactor based on the NuScale design.[13] Power from the Russian floating plant – the only operational SMR in the world – costs an estimated US$200 per MWh (A$300 per MWh).[14] Thus the CSIRO/AEMO figure of A$251–$330 per MWh is reasonable while BNW's figure – A$123–128 per MWh with the potential to fall as low as A$60[3] – is an extreme underestimate.

BNW promotes[4] a 2016 study by Lovering, Yip and Nordhouse in support of its claims about nuclear construction costs – but the 2016 study was widely criticized[15] for cherry-picking, with one such critic being a former World Nuclear Association executive.[16] BNW also promotes[4] the US Energy Innovation Reform Project report[17], but the cost figures used in the report are nothing more than the optimistic estimates of companies hoping to get 'advanced' reactor designs off the ground. And BNW promotes the report by the Economic and Finance Working Group of the Canadian government-industry 'SMR Roadmap' initiative.[18] But the first-of-a-kind SMR cost estimates in the Canadian report – the most relevant being an estimated C$163 (A$177) per MWh for a 300-MW on-grid SMR – are all higher than BNW's estimate of A$123–128 per MWh.

Cost overruns

BNW proposes adding a 50% 'loading' to NuScale's cost estimate in recognition of past examples of cost overruns. Here are just some of the recent examples of much greater cost increases:

* The estimated cost of the high-temperature gas-cooled SMR (HTGR) under construction in China has nearly doubled.[19]
* The cost of Russia's floating SMR quadrupled.[20]
* The estimated cost of Argentina's SMR has increased 22–fold above early, speculative estimates.[21] and the cost increased by 66% from 2014, when construction began, to 2017.
* The cost estimate for the Vogtle project in US state of Georgia (two AP1000 reactors) has doubled to more than US$13.5 billion per reactor and will increase further.[9] In 2006, Westinghouse said it could build an AP1000 reactor for as little as US1.4 billion[22] – 10 times lower than the current estimate for Vogtle.
* The estimated cost of about €12.4 billion[23-24] for the only reactor under construction in France is 3.8 times greater than the original €3.3 billion estimate.
* The estimated cost of about €11 billion[25] for the only reactor under construction in Finland is 3.7 times greater than the original €3 billion estimate.
* The estimated combined cost of the two EPR reactors under construction in the UK, including finance costs, is £26.7 billion (the EU's 2014 estimate of £24.5 billion[26] plus a £2.2 billion increase announced in July 2017[27]). In the mid-2000s, the estimated construction cost for one EPR reactor in the UK was £2 billion[28], almost seven times lower than the current estimate.

Timelines

BNW notes that timelines for deployment and construction are "extremely material" in terms of the application of learning rates to capital expenditure.[5] BNW objects to the CSIRO/AEMO estimate of five years for construction of an SMR and proposes a "more probable" three-year estimate as well as an assumption that NuScale's first reactor will begin generating power in 2026 even though construction has not yet begun.[4]

None of the real-world evidence supports BNW's arguments:

* The construction period for the only operational SMR, Russia's floating plant, was 12.5 years.[29]
* Argentina's CAREM SMR was conceived in the 1980s, construction began in 2014, the 2017 start-up date was missed and subsequent start-up dates were missed.[30] If the current schedule for a 2023 start-up[31] is met it will be a nine-year construction project rather than the three years proposed by BNW for construction of an SMR. Last year, work on the CAREM SMR was suspended, with Techint Engineering & Construction asking Argentina's National Atomic Energy Commission to take urgent measures to mitigate the project's serious financial breakdown.[32] In April 2020, Argentina's energy minister announced that work on CAREM would resume.[33]
* Construction of China's HTGR SMR began in 2012[34], the 2017 start-up date was missed[35], and if the targeted late-2020 start-up is met it will be an eight-year construction project.
* NuScale Power has been trying to progress its SMR ambitions for over a decade and hasn't yet begun construction of a single prototype reactor.[36]
* The large reactors under construction in the US are 5.5 years behind schedule and those under construction in France and Finland are 10 years behind schedule.
* In 2007, EDF was boasting that Britons would be using electricity from an EPR reactor at Hinkley Point to cook their Christmas turkeys in December 2017 – but construction didn't even begin until December 2018.[37]

Learning rates

In response to relentless attacks from far-right politicians and lobby groups such as BNW, the latest CSIRO/AEMO *GenCost* report makes the heroic assumption that SMR costs will fall from A$16,000 per kW to A$7,000 per kW in the 2030s. The report states that SMRs were assigned a "higher learning rate (more consistent with an emerging technology) rather than being included in a broad nuclear category, with a low learning rate consistent with more mature large scale nuclear."

But there's no empirical basis, nor any logical basis, for the learning rate assumed in the report. The cost reduction assumes that large numbers of SMRs will be built, and that costs will come down as efficiencies are found, production capacity is scaled up, etc.

Large numbers of SMRs being built? Not according to expert opinion. A 2017 Lloyd's Register report[38] was based on the insights of almost 600 professionals and experts from utilities, distributors, operators and equipment manufacturers, who predicted that SMRs have a "low likelihood of eventual take-up, and will have a minimal impact when they do arrive".[39] A 2014 report produced by *Nuclear Energy Insider*, drawing on interviews with more than 50 "leading specialists and decision makers", noted a "pervasive sense of pessimism" about the future of SMRs.[40] Last year, the North American Project Director for *Nuclear Energy Insider* said that there "is unprecedented growth in companies proposing design alternatives for the future of nuclear, but precious little progress in terms of market-ready solutions."[41]

Will costs come down in the unlikely event that SMRs are built in significant numbers? For large nuclear reactors, the experience has been either a very slow learning rate with modest cost decreases, or a negative learning rate.[42]

Real-world data

Obviously, the starting point for any logical discussion about SMR costs would be the cost of operational SMRs – ignored by CSIRO/AEMO and by lobbyists such as BNW.

There is just one operational SMR plant, Russia's floating plant. Its estimated cost is US$740 million for a 70 MW plant.[20] That equates to A$15,900 per kW – almost identical to the CSIRO/AEMO estimate of A$16,000 per kW. Over the course of construction, the cost quadrupled[20] and a 2016 OECD Nuclear Energy Agency report said that electricity produced by the Russian floating plant is expected to cost about US$200 per MWh with the high cost due to large staffing requirements, high fuel costs, and resources required to maintain the barge and coastal infrastructure.[14]

Figures on costs of SMRs under construction should also be considered – they are far more useful than company estimates, which invariably prove to be highly optimistic.

The World Nuclear Association states that the cost of China's HTGR is US$6,000 per kW.[43] Costs are reported to have nearly doubled, with increases arising from higher material and component costs, increases in labour costs, and increased costs associated with project delays.[19]

The CAREM SMR under construction in Argentina illustrates the gap between SMR rhetoric and reality. In 2004, when the reactor was in the planning stage, Argentina's Bariloche Atomic Center estimated an overnight cost of USS$1,000 per kW for an integrated 300-MW plant (while acknowledging that to achieve such a cost would be a "very difficult task").[44] When construction began in 2014, the cost estimate was US$15,400 per KW[45] By April 2017, the cost estimate had increased US$21,900 per kW.[46]

To the best of my knowledge, no other figures on SMR construction costs are publicly available. So the figures are:

A$15,900 per kW for Russia's light-water floating SMR

A$9,000 per kW for China's HTGR

A$32,800 per kW for Argentina's light-water SMR

The average of those figures is A$19,200 per kW, which is considerably higher than the CSIRO/AEMO figure of A$16,000 per kW and more than double the BNW estimate of A$9,132 per kW.

SMR hype cyclists going around in circles

The hype cycle partly explains the growth of nuclear power a half-century ago, and the short-lived resurgence 10–15 years ago.[1] Currently, SMR hype cyclists are practiced and polished and they have an endless amount of propaganda to recycle and regurgitate. But their economic claims are sharply contradicted by real-world data. And the coordinated propaganda campaign simply isn't working – government funding and private-sector funding is pitiful when measured against the investments required to build SMR prototypes let alone fleets of SMRs and the infrastructure that would allow for mass production of SMR components.

Wherever you look, there's nothing to justify the high hopes and hype of SMR hype cyclists. Argentina's SMR program is a joke. Plans for 18 additional HTGRs at the same site as the demonstration plant in China have been "dropped" according to the World Nuclear Association.[47] Russia planned to have seven floating nuclear power plants by 2015, but only recently began operation of its first plant.[29] South Korea won't build any of its domestically-designed SMART SMRs in South Korea – "this is not practical or economic" according to the World Nuclear Association[48] – and plans to establish an export market for SMART SMRs depend on a wing and a prayer … and on Saudi oil money which is currently in short supply.[49]

Mark Cooper argues that rather than learning from past experience, nuclear hype cyclists are becoming even more deluded:[1]

"Has the nuclear industry been cured of its myopia? Not at all. In fact, there is a sense that the disease is getting worse, not better, since the characteristics that are said to make small modular technologies attractive are precisely the characteristics that make other alternatives more attractive. In the past, the refusal to look at alternatives could be explained by the fact that the advocates were looking at different characteristics – claiming that huge baseload facilities are indispensable. They dismissed the alternatives because they are too small or too variable.

"Today, they emphasize small size and speed to market, characteristics on which the alternatives are vastly superior. At the same time they ignore the innovation that has sharply increased renewable load factors and the dramatic advances in information and control technologies that have improved the ability to forecast and integrate renewables."

Cooper's analysis is reflected in the latest CSIRO/AEMO report, which finds that SMR construction costs per kW are 2–8 times higher than costs for wind or solar.[2] Costs per unit of energy produced are 2–3 times greater for nuclear compared to wind or solar including either two hours of battery storage or six hours of pumped hydro energy storage.

Likewise, the latest Lazard's report on levelized costs of energy shows that nuclear power is more expensive than renewables:[8]

Energy Source	***Cost / MWh***
Nuclear	US$118–192
Wind power	US$28–54
Solar PV utility scale	US$32–44
Solar thermal with storage	US$126–156
Geothermal	US$69–112

References:

1. Mark Cooper, May 2014, 'The Economic Failure of Nuclear Power and the Development of a Low-Carbon Electricity Future: Why Small Modular Reactors Are Part of the Problem, Not the Solution', https://www.nirs.org/wp-content/uploads/reactorwatch/newreactors/cooper-smrsaretheproblemnotthesolution.pdf
2. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/CSIRO-GenCost2019-20_DraftforReview.pdf
3. https://www.brightnewworld.org/media/2020/2/10/the-cost-of-nuclear-in-australia
4. https://static1.squarespace.com/static/58254e216a496325c2d90145/t/5e410a8f5af4111d703967c5/1581320856770/BNW+AEMO+Planning+%26+Forecasting+submission_07022020+FINAL.pdf
5. https://static1.squarespace.com/static/58254e216a496325c2d90145/t/5e6de0f59988a61549c94c99/1584259322959/GenCost_Draft+review_BNW_15032020.pdf
6. https://nuclear.foe.org.au/ben-heard-secret-corporate-donations/
7. https://www.powermag.com/nuscale-boosts-smr-capacity-making-it-cost-competitive-with-other-technologies/?printmode=1
8. Lazard, Nov. 2019, 'Lazard's Levelized Cost of Energy Analysis – Version 13.0', https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf
9. https://www.wiseinternational.org/nuclear-monitor/867/vogtles-reprieve-snatching-defeat-jaws-defeat
10. https://wiseinternational.org/nuclear-monitor/872-873/smr-cost-estimates-and-costs-smrs-under-construction
11. https://wiseinternational.org/nuclear-monitor/872-873/smr-economics-overview
12. https://www.powermag.com/nuscale-boosts-smr-capacity-making-it-cost-competitive-with-other-technologies/?printmode=1
13. http://nuclearrc.sa.gov.au/app/uploads/2016/05/WSP-Parsons-Brinckerhoff-Report.pdf
14. https://www.oecd-nea.org/ndd/pubs/2016/7213-smrs.pdf
15. https://www.wiseinternational.org/nuclear-monitor/840/nuclear-economics-critical-responses-breakthrough-institute-propaganda
16. https://www.neimagazine.com/opinion/opinionachieving-better-nuclear-economics-new-designs-and-industry-structure-4848005/
17. https://www.innovationreform.org/wp-content/uploads/2018/01/Advanced-Nuclear-Reactors-Cost-Study.pdf
18. https://smrroadmap.ca/wp-content/uploads/2018/12/Economics-Finance-WG.pdf
19. http://www.nextbigfuture.com/2016/12/chinas-plans-to-begin-converting-coal.html
20. http://bellona.org/news/nuclear-issues/2015-05-new-documents-show-cost-russian-nuclear-power-plant-skyrockets
21. https://wiseinternational.org/nuclear-monitor/872-873/smr-cost-estimates-and-costs-smrs-under-construction
22. https://www.nytimes.com/2006/07/16/magazine/16nuclear.html
23. https://www.thelocal.fr/20191028/french-nuclear-power-plant-is-seven-years-late-and-costs-have-tripled
24. https://www.bloomberg.com/news/articles/2019-10-09/edf-lifts-cost-of-french-nuclear-reactor-by-14-to-13-6-billion
25. https://www.worldnuclearreport.org/World-Nuclear-Industry-Status-Report-2018-HTML.html#lien21
26. http://europa.eu/rapid/press-release_IP-14-1093_en.htm
27. https://www.theguardian.com/uk-news/2017/jul/03/hinkley-point-c-is-22bn-over-budget-and-a-year-behind-schedule-edf-admits
28. https://energypost.eu/saga-hinkley-point-c-europes-key-nuclear-decision/
29. https://en.wikipedia.org/wiki/Russian_floating_nuclear_power_station
30. https://en.wikipedia.org/wiki/CAREM
31. http://www.smrnuclear.com.au/wp-content/uploads/2020/04/SMR-GLOBAL-STATUS-REPORT-APRIL-2020_v4KP.pdf
32. https://steelguru.com/power/construction-work-stops-at-carem-25-smr-at-atucha-nuclear-power-plant-in-argentina/552591
33. https://world-nuclear-news.org/Articles/Argentinean-projects-to-resume-after-hiatus
34. https://world-nuclear-news.org/Articles/Key-components-of-second-HTR-PM-reactor-connected
35. https://www.world-nuclear-news.org/NN-First-vessel-installed-in-Chinas-HTR-PM-unit-2103164.html
36. https://www.nuclearconsult.com/wp/wp-content/uploads/2019/07/Prospects-for-SMRs-report-2.pdf
37. https://www.theguardian.com/uk-news/2016/sep/15/hinkley-point-c-guide-uk-first-new-nuclear-plant-for-20-years
38. http://info.lr.org/techradarlowcarbon
39. http://www.world-nuclear-news.org/EE-Nuclear-more-competitive-than-fossil-fuels-report-09021702.html
40. http://1.nuclearenergyinsider.com/LP=362
41. Nuclear Energy Insider, 2019, 'The time is now – build the investment case to scale SMR', https://www.nuclearenergyinsider.com/international-smr-advanced-reactor
42. https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_autre_document_travail_service_part1_v10.pdf
43. http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx
44. https://www.researchgate.net/publication/267579277_CAREM_concept_A_competitive_SMR
45. US$446 million / 29 MWe. https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/argentina.aspx#ECSArticleLink4
46. US$700 million with the capacity uprated from to 32 MW. https://www.bnamericas.com/en/news/electricpower/argentine-nuclear-reactor-due-to-start-up-in-2020/
47. http://www.world-nuclear-news.org/NN-First-vessel-installed-in-Chinas-HTR-PM-unit-2103164.html
48. http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/south-korea.aspx
49. Dan Yurman, 12 April 2020, 'How the Oil War between Saudi Arabia and Russia Affects their Plans for Nuclear Energy', https://neutronbytes.com/2020/04/12/how-the-oil-war-between-saudi-arabia-and-russia-affects-their-plans-for-nuclear-energy/