NUCLEAR POWER’S GLOBAL STAGNATION AND DECLINE

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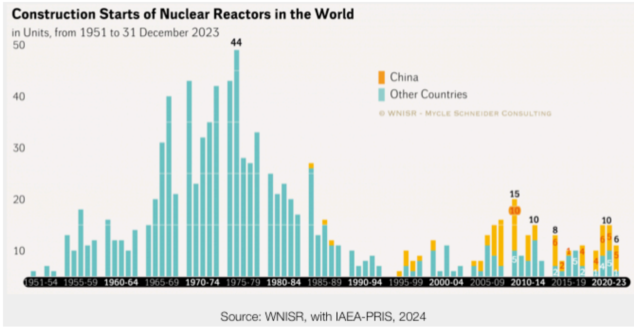

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INTRODUCTION

Over the last 50 years nuclear power has been shaped within dramatically over-estimated claims for its future prospects, versus the reality of its actual performance. The long history of plummeting expectations goes back as far as 1972 when 3450 gigawatts (GW) of global capacity was predicted for the year 2000, dropping to the prediction in 1978 of 728 GW. That was just before the industry suffered the crippling Three Mile Island Accident with declines in projections continuing on towards the more sober reality of 371 GW of nuclear capacity operating across the world in 2000. The current push in Australia to deploy nuclear reactors over the next several decades again contrasts an excessive optimism for nuclear proponents against the continuing stagnant situation of nuclear programs worldwide.

The latest nuclear proposals are built on three speculations.

First, projected AI-related energy demand where – as with nuclear power proponents in the 1970’s who projected huge demand for nuclear power that never eventuated – there are already signs likely demand from this source is overstated: for example, the new leading AI entrant, DeepSeek, requires just 10% of the energy of competitors.

Second, speculative techno-optimism that new technologies such as small modular reactors will resolve industry project management issues. Yet these small reactors are underwhelming where they do exist and unproven otherwise.

Third, prospective wish-fulfilment, where dozens of nuclear ‘newcomer’ countries are offered as saviours, despite not having approvals and funding in place in a large majority of cases.

This paper presents evidence leading to the following conclusions:

- The global nuclear power industry is stagnating rather than growing, so claims that 'Australia is being left behind' have no basis.
- Where there is growth, it is primarily in authoritarian countries such as China and Russia.
- Small modular reactors are offered as ‘magic bullets’ but they do not exist and available evidence suggests they would be uneconomic.
- The number of countries operating nuclear power reactors is the same as it was in the late 1990s.

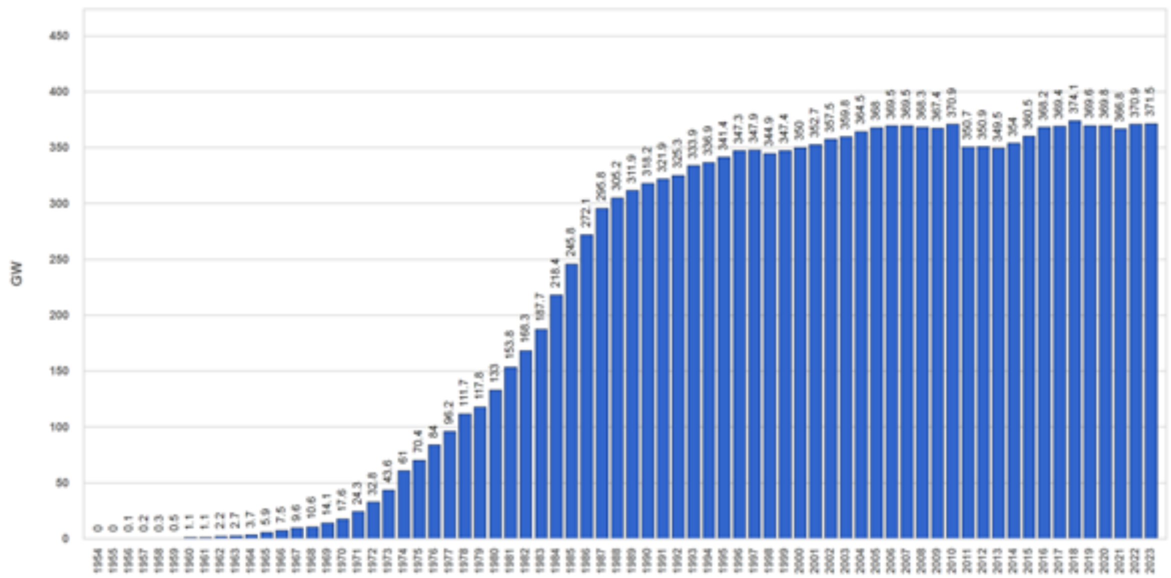
- The number of potential nuclear power newcomer countries with approvals and funding in place, or construction underway, is just three and all those projects are funded heavily by the Russian state.
- Renewables growth dwarfs nuclear growth, by a factor of 155 last year. The same applies to China: a ratio of 100:1 last year.
- Western democracies building new reactors have all experienced extraordinary cost overruns and construction blowouts.

The current state of nuclear power

So what is the state of nuclear power? The World Nuclear Industry Status Report presents these details regarding developments in 2024:

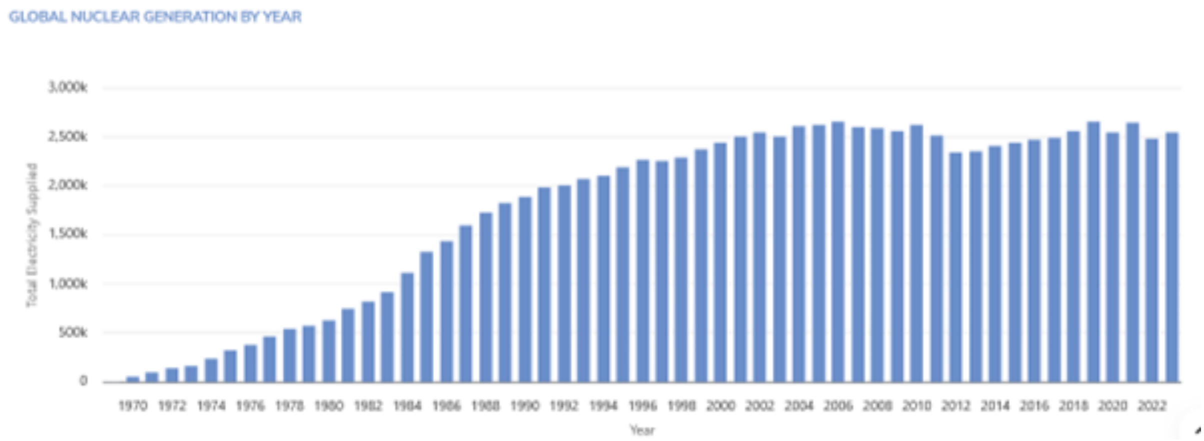
- The number of operating reactors fell from 413 to 411, which is 27 fewer than the peak of 438 reactors in 2002.
- Global nuclear power capacity was stagnant at 371 GW. Indeed, there has been no growth over the past 20 years and very little growth in the decade before that (less than one percent per year).

Figure 9. Historical evolution of the worldwide nuclear power (as of 31 Dec. 2023)



Source, IAEA, Nuclear Power Reactors in the World 2024

Likewise, nuclear power generation (typically measured in terawatt-hours) has been stagnant for 20 years with very little growth in the decade before that.



Source: World Nuclear Association.

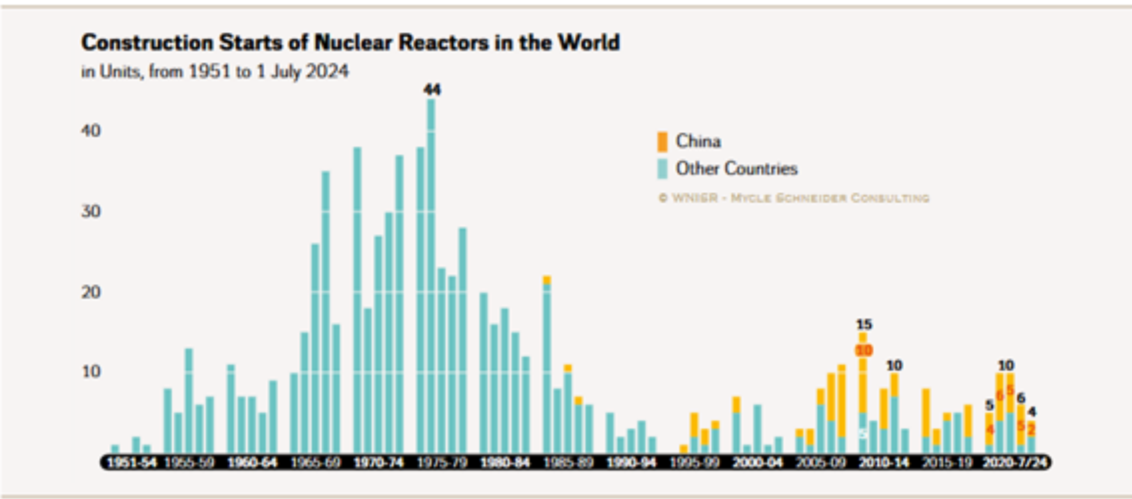
As of 1 January 2025, nuclear power accounted for 9.15 percent of global electricity production, down from 9.2 percent a year earlier and barely half of its peak of 17.5 percent in 1996. The drop in nuclear power's share of global electricity generation is certain to continue. In one improbable scenario, the International Atomic Energy Agency anticipates 60 percent nuclear power growth by 2050 but says that the nuclear share of global electricity generation will still fall in that scenario, by 2.3 percent.

As of 1 January 2025, the mean age of the global power reactor fleet was 32.1 years. In 1990, the mean age was just 11.3 years. As the rate of closure of ageing reactors increases, it will become increasingly difficult for the industry to maintain its long-term pattern of stagnation let alone achieving any growth. The International Atomic Energy Agency projects 325 GW of nuclear closures from 2018 to 2050 or 10 GW per year on average. Average construction starts and reactor startups over the past decade have fallen well short of 10 GW per year so a higher build rate will be required just to maintain the pattern of stagnation.

Construction starts and numbers of reactors under construction

- The picture of nuclear reactor starts and numbers under construction was reported to be similarly constrained:
- There were nine power reactor construction starts in 2024: six in China; one in Pakistan implemented by Chinese companies; one domestic reactor in Russia and one in Egypt being built by Russian agencies. In the decade from 2015-24, the average has been 6.5 construction starts per year. The historic one-year peak was 44 in 1976.
- In the five years from 2020–24, there were a total of 40 reactor construction starts, of which 26 (62 percent) were in China, one in Pakistan carried out by Chinese companies, and the other 13 implemented by the Russian nuclear industry in Egypt, India, Turkiye, and at home. Russia also began building four reactors in China.
- In the five years from 2020–24, Chinese and Russian companies have been the only builders with reactor construction starts worldwide.

Figure 14 · Construction Starts in the World/China



Sources: WNISR, with IAEA-PRIS, 2024

Source: World Nuclear Industry Status Report 2024

The World Nuclear Industry Status Report notes that:

- As of 1 January 2025, there were 61 power reactors under construction, two more than a year earlier but eight less than in 2013 (and 173 fewer than the 1979 peak of 234).
- Almost half of the 61 reactors are under construction in China (29), including four implemented by the Russian industry which is also building in Bangladesh (2), Egypt (4), India (4), Iran (1), Turkiye (4), and at home (6), thus a total of 25 reactors.
- The only country besides Russia and China building abroad is France with two reactors under construction in the UK.
- Almost all constructions (over 93 percent) are implemented either in nuclear weapon states or by entities controlled by nuclear weapons states in other countries.
- Of the 807 reactor construction starts since 1951, at least 93 reactors had been abandoned or suspended as of 1 July 2024, in 19 countries. That is 11.5 percent, or one in nine.

Small modular reactors

Given the actual experience of attempts to develop and deploy small modular reactors it is not surprising that the optimism of those pressing for renewed nuclear activity has dwindled in relation to them. There were no small modular reactor (SMR) startups in 2024.

Indeed there has never been a single SMR startup unless you count so-called SMRs not built using factory ‘modular’ construction techniques, in which case there is one each in China and Russia. Cheap, quick mass-production of SMRs is nowhere in sight. The so-called SMRs in China and Russia and China took 9 and 12 years to build, respectively, and in both countries planning plus construction took 20 years or more.

A few more so-called SMRs are under construction worldwide (in China, Russia and Argentina) but none of these projects are using modular construction techniques. A 2024 report by the Australian Academy of Technological Sciences and Engineering notes that no small modular reactors exist in any OECD countries and the technology has not been proven technically or financially.

French utility EDF's decision to suspend its Nuward SMR project was another setback in 2024 (following the previous abandonment of four other SMR projects: Flexblue, Antares, NP-300, ASTRID). So was the bankruptcy filing of US company Ultra Safe Nuclear – the company's assets were sold for a song (US$8.5 million) through an auction process conducted pursuant to Section 363 of the US Bankruptcy Code.

Those failures followed the decision of US company NuScale to abandon its flagship project in Idaho in 2023 after cost estimates rose to a staggering A$31 billion per GW, more than double the 2015 estimate. The levelised cost estimate rose to US$119 (A$189) per megawatt-hour (MWh). The Minerals Council of Australia states that SMRs won't find a market in Australia unless they can produce power at a cost of A$60-80 / MWh. That is well under half the NuScale estimate of A$189 / MWh.

A December 2024 CSIRO *GenCost* report provides these levelised cost estimates for Australia:

	2024	**2030**
Nuclear – small modular	A$400-663 / MWh	A$285-487 / MWh
90% solar PV + wind including storage costs	A$106-150 / MWh	A$94-137 / MWh

Another (failed) nuclear renaissance?

Claims that 40–50 countries are actively considering or planning to introduce nuclear power, in addition to the 32 countries currently operating reactors, do not withstand scrutiny. Current promotional claims lack substance and there is no credible reason to believe that the current claims of a nuclear 'renaissance' are likely to prove to have any more reality than the essentially never arriving 'renaissance' of the late 2000s.

Less than one third of the countries currently operating reactors have active reactor construction programs: 10 out of 32.

As of 1 January 2025, reactors were under construction in just 13 countries, two less than a year earlier. Seven percent of the world's countries are build reactors; 93 percent are not.

Of the 13 countries building reactors, only three are potential nuclear 'newcomer' countries building their first nuclear plant: Egypt, Bangladesh and Turkiye. In those three countries, the nuclear projects are led by Russian nuclear agencies with significant up-front funding from the Russian state.

The World Nuclear Association (WNA) observes that apart from those three countries, no countries meet its criteria of 'planned' reactors, i.e. "approvals, funding or commitment in place, mostly expected to be in operation within the next 15 years". The WNA lists six countries in its 'proposed' category, "specific programme or site proposals; timing very uncertain". And the WNA lists 17 countries with "provisional plans, commitment pending or deferred".

The number of potential newcomer countries with approvals and funding in place, or construction underway, is just three and all those projects are funded heavily by the Russian state.

The number of potential newcomer countries with approvals and funding in place, or construction underway, without substantial Russian state funding, is zero. That is the underwhelming reality underlying highly exaggerated claims about 40-50 countries pursuing nuclear power.

Over the past five years, there have been no reactor construction starts worldwide other than Russian and Chinese projects at home and abroad. Apart from China's construction project in Pakistan, and France's twin-reactor project in the UK, only Russia is building reactors abroad (in China, Bangladesh, Egypt, India, Iran and Turkiye). But Russia's capacity to fund such projects is diminishing, and the political fallout over Russia's invasion of Ukraine puts further constraints on potential future projects abroad (as well as compromising and complicating existing nuclear export projects).

There is no evidence of a forthcoming wave of nuclear newcomer countries in the coming years and decades. At most in prospect is a trickle. That has been the historical pattern with just seven newcomer countries building and operating reactors over the past 40 years and just three this century: the Czech Republic (1985), Mexico (1990), China (1991) Romania (1996), Iran (2011), the UAE (2020) and Belarus (2020).

The number of countries operating power reactors in 1996–1997 reached 32. Since then, nuclear newcomer countries have been matched by completed phase-outs and thus the number is stuck at 32. That is the underwhelming reality underlying exaggerated claims about 40-50 countries pursuing nuclear power.

Four countries have phased out nuclear power: Italy (1990), Kazakhstan (1999), Lithuania (2009) and Germany (2023). Five countries have begun reactor construction projects but abandoned those projects and never completed any power reactors: Austria, Cuba, Philippines, Poland and North Korea.

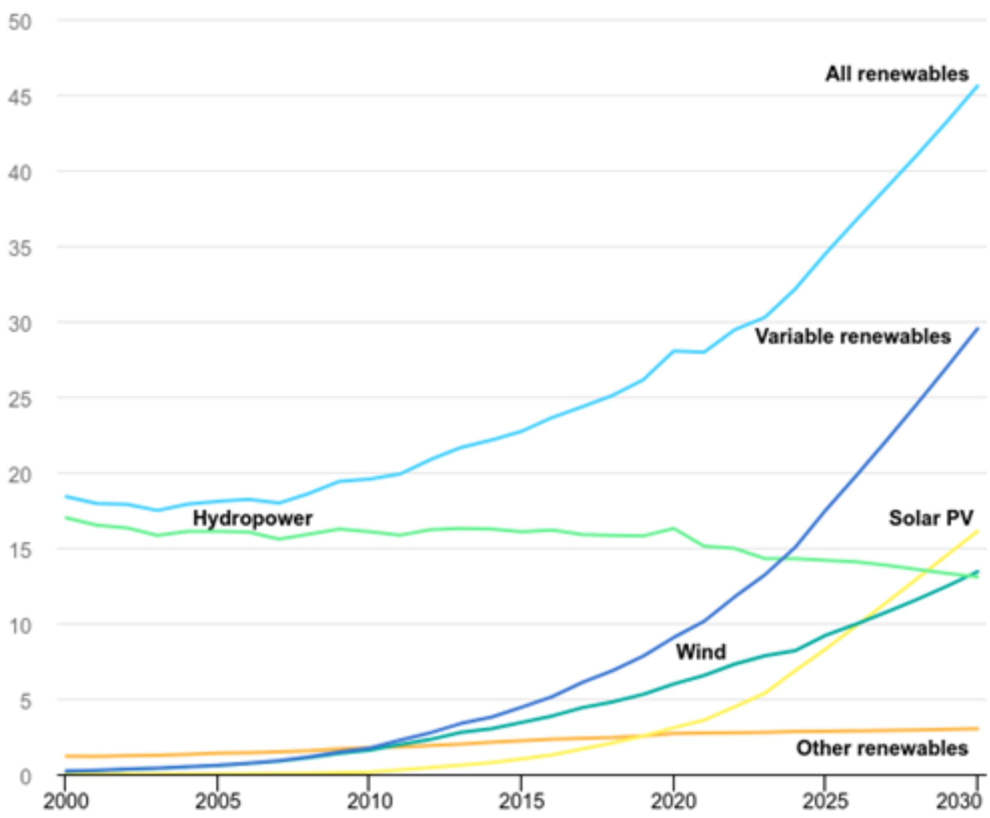
Countries now planning to phase-out nuclear power include Spain, Switzerland and Taiwan. An 'organic' nuclear phase out is underway in many other countries: existing reactors are ageing and the prospects for new reactors are slim or nil.

It is doubtful whether the number of nuclear newcomer countries over the next 20–30 years will match the number of countries completing phase-outs.

Nuclear growth dwarfed by renewables

In striking contrast to nuclear power's net gain of 4.3 GW in 2024, the International Energy Agency's (IEA) October 2024 'Renewables 2024' report estimates 666 GW of global renewable capacity additions in 2024. Based on the IEA's estimate, renewables capacity growth was 155 times greater than that of nuclear power.

The IEA expects global renewable capacity to increase by more than 5,520 GW from 2024-2030 and the Agency expects renewables to jump from 30 percent of global electricity generation in 2023 to 46 percent in 2030.



Source: International Energy Agency

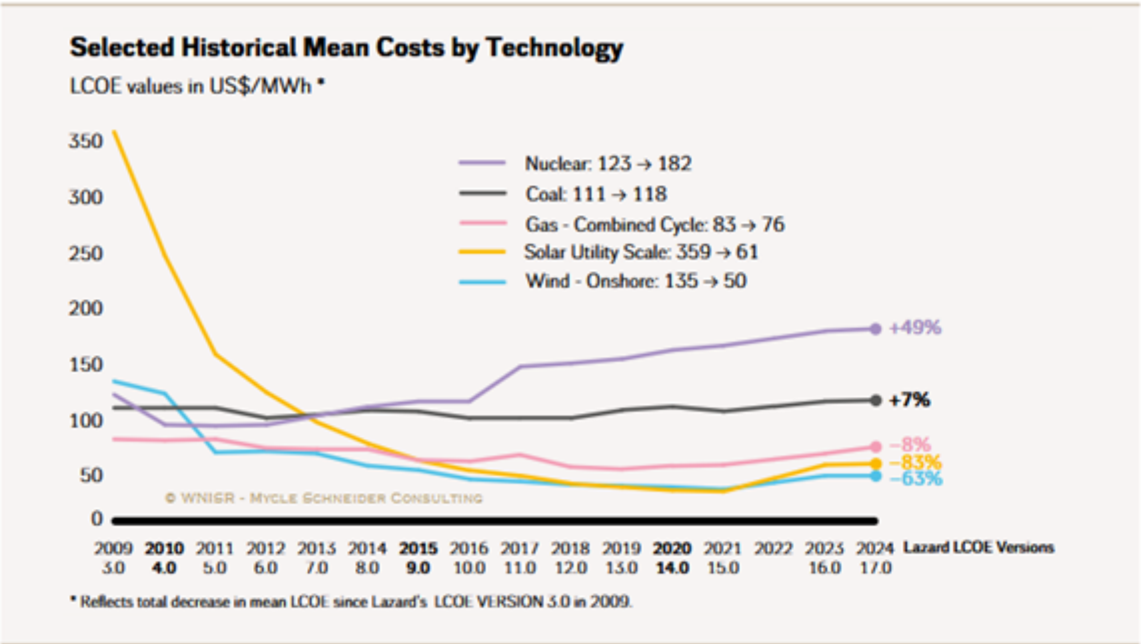
The IEA states:

- In 2025, renewable electricity generation is set to overtake coal-fired generation.
- In 2026, wind and solar power generation are each poised to surpass power generation from nuclear.
- In 2029, electricity generation from solar PV is set to surpass hydropower, becoming the largest renewable power source globally, with wind-based generation expected to surpass hydropower in 2030.

A *BloombergNEF* analysis finds that renewable energy investments reached $US728 billion (A$1.16 trillion) in 2024, up 8 percent on the previous year, whereas nuclear investment was flat at US$34.2 billion (A$54.4 billion). Thus renewable investments were 21 times greater than nuclear investments.

In striking contrast to massive cost overruns with nuclear projects, renewable costs have fallen sharply. Lazard investment firm data shows that utility-scale solar and onshore wind became cheaper than nuclear power from 2010–2015. From 2009–2024, the cost of utility-scale solar fell 83 percent; the cost of onshore wind fell 63 percent; while nuclear costs increased 49 percent.

Figure 58 · The Declining Costs of Renewables vs. Traditional Power Sources



Source: Lazard Estimates, 2024

Sources: World Nuclear Industry Status Report 2024, Lazard 2024.

China to the rescue?

In the 20 years from 2005 to 2024, there were 109 power reactor startups and 108 permanent closures worldwide. Of these, 51 startups were in China with no closures. Outside China, there has been a net decline of 50 reactors over the same period with 58 startups and 108 closures.

Thus worldwide nuclear power can only be said to be stagnating because of growth in China, outside of which there has been significant decline.

In China, nuclear growth is dwarfed by the growth of renewables. In 2024 there were three reactor startups with a combined capacity of 3.5 GW. That is 100 times less than the 356 GW of solar (277 GW) and wind (79 GW) capacity installed in China in 2024.

In 2020, China aimed to install at least 1,200 GW of solar and wind capacity by 2030. The target was surpassed in 2024. The International Energy Agency expects China to install 3,207 GW of new renewable electricity capacity from 2024–30. That expected growth in China alone is 8.5 times greater than current *worldwide* nuclear power capacity of 377 GW. And it is 40 times greater than the 80 GW of installed (50 GW) and under-construction (30 GW) nuclear capacity in China.

Lessons for Australia

Alongside the risk of Fukushima-scale disasters, the weapons proliferation risks, the risk of attacks on nuclear plants (and the reality of attacks on nuclear plants in Ukraine), and the intractable nuclear waste legacy, the reality is that nuclear power just can't compete economically.

The industry's greatest problem at the moment is a recognition of this by investors, resulting in a capital strike. Even with generous government/taxpayer subsidies, it is becoming difficult or impossible to fund new reactors – especially outside the sphere of China and Russia's projects at home and abroad.

Who would bet tens of billions of dollars on nuclear power projects when the recent history in countries with vast expertise and experience has been disastrous:

- In France, the latest cost estimate for the only recent reactor construction project, at Flamanville, increased seven-fold from €3.3 billion to €23.7 billion (A$39.4 billion) for just one reactor. Construction took 17 years. No reactors are currently under construction in France.
- In the US, one project in South Carolina, comprising two Westinghouse AP1000 reactors, was abandoned in 2017 after A$14.3 billion was wasted on it. Westinghouse declared bankruptcy and almost forced its parent company Toshiba to do the same. All that remains is the nukegate scandal: an avalanche of legal action including criminal cases.
- The only other reactor construction project in the US – the twin-reactor Vogtle project in the state of Georgia – reached completion at a cost 12 times higher than early estimates. The final cost was at least US$17 billion (A$27 billion) per reactor. Completion was 6–7 years behind schedule. No power reactors are currently under construction in the US.
- In the UK, the 3.2 GW Hinkley Point twin-reactor project was meant to be complete in 2017 but construction didn't even begin until 2018 and the estimated completion date has been pushed back to 2030-31. The latest cost estimate – £23 billion (A$46.3 billion) per reactor – is 11.5 times higher than early estimates. The UK National Audit Office estimates that taxpayer subsidies for the Hinkley Point project could amount to £30 billion (A$60.4 billion).
- No other reactors are under construction in the UK. The last power reactor startup in the UK was 30 years ago, in 1995, since when there have been 24 permanent reactor shut-downs.
- The estimated cost of the planned 3.2 GW twin-reactor Sizewell C project in the UK has jumped to nearly £40 billion (A$80.5 billion) or A$40.2 billion per reactor, twice the cost estimate in 2020. Securing funding to allow construction to begin is proving to be difficult and protracted despite a new 'Regulated Asset Base' funding model which foists the enormous risk of enormous cost overruns onto taxpayers and electricity ratepayers.

Those three countries – France, the US and the UK – have vast nuclear expertise and experience. They all enjoy synergies between civil and military nuclear programs. All of the above-mentioned construction projects were (or are) on existing nuclear sites. All projects were (or are) long-delayed and tens of billions of dollars over-budget.

Claims that potential nuclear 'newcomer' countries such as Australia, without any of those advantages, could build reactors quickly and cheaply strain credulity. Whether renaissance or perhaps baroque, pro-nuclear claims seem based more on the emotion and passion than the practical realities of technical, economic and political rationality.

About the authors:

Dr. Darrin Durant is Associate Professor in Science and Technology Studies at the University of Melbourne. He has published widely on environmental controversies including climate politics and debates about nuclear power and nuclear waste disposal, as well as on the relation between experts and citizens in democratic decision-making, disinformation and democracy, and climate denialism. His most recent book is Experts and the Will of the People: Society, Populism and Science (Palgrave, 2020). Of relevance to nuclear matters is

Nuclear Waste Management in Canada: Critical Issues, Critical Perspectives (UBC Press, 2009), and he is currently completing a book on Australian debates about nuclear power 1998-2025.

Professor Jim Falk is a Professorial Fellow in the School of Geography, Earth and Atmospheric Sciences at the University of Melbourne; Senior Fellow in Melbourne Climate Futures; and Emeritus Professor at the University of Wollongong. Over some fifty years he has been the author of many books and papers dealing with climate change and energy issues with a continuing focus on issues associated with nuclear technology.

Dr. Jim Green is the national nuclear campaigner with Friends of the Earth Australia, a member of the Nuclear Consulting Group, and a former editor of the 'Nuclear Monitor' newsletter produced by the World Information Service on Energy.