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1. NUCLEAR POWER'S ECONOMIC CRISIS

1.1 AN ESCALATING CRISIS

Supporters of nuclear power have issued any number of warnings¹ in recent years about nuclear power's "rapidly accelerating crisis"² and a "crisis that threatens the death of nuclear energy in the West"³, while pondering what if anything might be salvaged from the "ashes of today's dying industry".⁴

Consider the following statements, many of them from nuclear industry insiders:

- "I don't think we're building any more nuclear plants in the United States. I don't think it's ever going to happen. They are too expensive to construct." – William Von Hoene, Senior Vice-President of Exelon, 2018.⁵
- Nuclear power "just isn't economic, and it's not economic within a foreseeable time frame." – John Rowe, recently-retired CEO of Exelon, 2012.⁶
- "It's just hard to justify nuclear, really hard." – Jeffrey Immelt, General Electric's CEO, 2012.⁷
- "I don't think anybody's pretending you can take forward a new nuclear power station without some form of government underwriting or support." – Sir John Armitt, chair of the UK National Infrastructure Commission, 2018.⁸

¹ <https://www.wiseinternational.org/nuclear-monitor/839/nuclear-power-crisis-or-it-merely-end>

² <http://www.environmentalprogress.org/big-news/2017/2/13/why-its-big-bet-on-westinghouse-nuclear-bankrupted-toshiba>

³ <http://www.environmentalprogress.org/big-news/2017/2/16/nuclear-must-change-or-die>

⁴ <https://thebreakthrough.org/index.php/voices/ted-nordhaus/the-end-of-the-nuclear-industry-as-we-know-it>

⁵ <https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/041218-no-new-nuclear-units-will-be-built-in-us-due-to-high-cost-exelon-official>

⁶ <https://www.forbes.com/sites/jeffmcmahon/2012/03/29/exelons-nuclear-guy-no-new-nukes/>

⁷ <https://www.ft.com/content/60189878-d982-11e1-8529-00144feab49a>

⁸ <https://www.theguardian.com/uk-news/2018/jul/10/nuclear-renewables-are-better-bet-ministers-told>

- France's nuclear industry is in its "worst situation ever"⁹, a former EDF director said in November 2016 – and the situation has worsened since then¹⁰.
- Nuclear power is "ridiculously expensive" and "uncompetitive" with solar. – Nobuo Tanaka, former executive director of the International Energy Agency, and former executive board member of the Japan Atomic Industrial Forum, 2018.¹¹
- Compounding problems facing nuclear developers "add up to something of a crisis for the UK's nuclear new-build programme." – Tim Yeo, former Conservative parliamentarian and now a nuclear industry lobbyist, 2017.¹²
- "It sometimes seems like U.S. and European nuclear companies are in competition to see which can heap greater embarrassment on their industry." – *Financial Times*, 2017, 'Red faces become the norm at nuclear power groups'.¹³
- "I don't think a CEO of a utility could in good conscience propose a nuclear-power reactor to his or her board of directors." – Alan Schriesheim, director emeritus of Argonne National Laboratory, 2014.¹⁴
- "New-build nuclear in the West is dead" due to "enormous costs, political and popular opposition, and regulatory uncertainty" – *Morningstar* market analysts Mark Barnett and Travis Miller, 2013¹⁵
- "Nuclear construction on-time and on-budget? It's essentially never happened." – Andrew J. Wittmann, financial analyst with Robert W. Baird & Co., 2017.¹⁶
- "The mooted nuclear renaissance has clearly stalled." – Steve Kidd, former World Nuclear Association executive, 2014.¹⁷
- "Nuclear power and solar photovoltaics both had their first recorded prices in 1956. Since then, the cost of nuclear power has gone up by a factor of three, and the cost of PV has dropped by a factor of 2,500." – J. Doyne Farmer, Oxford University economics professor, 2016.¹⁸

Even the International Atomic Energy Agency (IAEA) – which is tasked with promoting nuclear power – said in a September 2018 report that global nuclear power capacity "risks shrinking in the coming decades as ageing reactors are retired and the industry struggles with reduced competitiveness".¹⁹ The IAEA's low and high estimates for global nuclear power capacity in 2030 are both 36% lower than the same projections in 2010, the year before the Fukushima disaster.²⁰

The nuclear power crisis is most evident in the US and western Europe (discussed below). It is also evident in Japan:

- The Japanese Government's estimate of the cost of Fukushima clean-up activities and compensation has quadrupled and now stands at A\$289 billion (¥21.5 trillion). Indirect costs –

⁹ <http://www.theguardian.com/environment/2016/nov/29/french-nuclear-power-worst-situation-ever-former-edf-director>

¹⁰ <https://climatenewsnetwork.net/frances-nuclear-industry-struggles-on/>

¹¹ <http://www.asahi.com/ajw/articles/AJ201807240045.html>

¹² www.telegraph.co.uk/business/2017/04/01/can-britains-nuclear-ambitions-avoid-meltdown/

¹³ <https://www.ft.com/content/db592ce6-7b4e-11e7-9108-edda0bcb928>

¹⁴ <http://www.forbes.com/sites/jeffmcmahon/2014/12/09/another-giant-declares-nuclear-dead-in-fracking-america/>

¹⁵ <https://www.forbes.com/sites/jeffmcmahon/2013/11/10/new-build-nuclear-is-dead-morningstar/>

¹⁶ <https://www.bloomberg.com/news/articles/2017-02-13/toshiba-s-nuclear-reactor-mess-winds-back-to-a-louisiana-swamp>

¹⁷ <https://www.neimagazine.com/opinion/opinionuranium-enrichment-whats-happening-today-4311115/>

¹⁸ <https://www.popularmechanics.com/science/energy/a18818/can-us-nuclear-power-get-un-stuck/>

¹⁹ <https://www.iaea.org/newscenter/pressreleases/new-iaea-energy-projections-see-possible-shrinking-role-for-nuclear-power>

²⁰ <https://www.wiseinternational.org/nuclear-monitor/866/new-iaea-report-sees-possible-shrinking-role-nuclear-power>

such as replacement power for shuttered reactors – are even larger.²¹ Costs could reach A\$940 billion (¥70 trillion) according to the Japan Center for Economic Research.²²

- 160,000 people were evacuated after the Fukushima disaster. Only 23% of those living in areas that were declared off-limits after the disaster have returned, according to government figures.²³
- Japan's nuclear power industry has been decimated by the Fukushima disaster. Of the pre-Fukushima fleet of 54 reactors, only nine are now operating, at least 20 have been permanently shut down, and the fate of the remaining reactors remains in limbo.

The situation is not so bleak in China, India, South Korea and Russia – but nor is it as positive as nuclear lobbyists sometimes contend.

South Korea has joined a growing list of countries with nuclear power phase-out policies.²⁴ (Other countries phasing out nuclear power include Germany, Switzerland, Belgium and Taiwan.) South Korea's nuclear industry has been rocked by corruption scandals.²⁵ Other than the 2009 contract to supply four reactors to the UAE, South Korea's efforts to establish a nuclear export business have been unsuccessful.

Russia is slowly expanding its reactor fleet, which now comprises 36 reactors and another four under construction (in addition to the recently completed twin-reactor floating nuclear power plant – which is four times over-budget²⁶).

China's nuclear power program has stalled twice over the past decade – after the 2011 Fukushima disaster and again in late 2016.²⁷ The most likely outcome over the next decade is that a small number of new reactor projects will be approved each year, well short of previous projections and not nearly enough to match the decline in the rest of the world. Currently, 46 reactors account for 4.2% of national electricity generation, with another 11 under construction. China's efforts to develop fast-breeder reactor technology have been unsuccessful, with one long-delayed, poorly-performing prototype reactor.²⁸ Former World Nuclear Association executive Steve Kidd noted in August 2018 that the growth of renewables in China "dwarf the nuclear expansion" and that "many of the negative factors which have affected nuclear programmes elsewhere in the world are now also equally applicable in China."²⁹

India's leaders have for decades promised a massive nuclear power expansion – but it never happens. Currently, 22 reactors account for 3.1% of national electricity generation, with another seven reactors under construction.

²¹ <https://www.wiseinternational.org/nuclear-monitor/836/economic-impacts-fukushima-disaster>

²² <https://www.japantimes.co.jp/news/2017/04/01/national/real-cost-fukushima-disaster-will-reach-%C2%A570-trillion-triple-governments-estimate-think-tank/>

²³ <https://www.theguardian.com/world/2019/mar/10/fukushima-eight-years-on- evacuees-come-home>

²⁴ <https://www.wiseinternational.org/nuclear-monitor/844/south-koreas-nuclear-industry-model-others-follow>

²⁵ <https://www.wiseinternational.org/nuclear-monitor/844/south-koreas-nuclear-mafia>

²⁶ <http://bellona.org/news/nuclear-issues/2015-05-new-documents-show-cost-russian-nuclear-power-plant-skyrockets>

²⁷ <https://wiseinternational.org/nuclear-monitor/871/china-rescue>

²⁸ <https://www.wiseinternational.org/nuclear-monitor/831/slow-death-fast-reactors>

²⁹ <http://www.neimagazine.com/opinion/opinionnuclear-in-china-where-is-it-heading-now-6275899/>

1.2 RECENT EXPERIENCE IN NORTH AMERICA AND WESTERN EUROPE: NEW REACTORS COST A\$17–24 BILLION EACH

The V.C. Summer project in South Carolina (two AP1000 reactors) was abandoned after the expenditure of at least A\$12.9 billion.³⁰ The project was initially estimated to cost A\$14.1 billion; when it was abandoned, the estimate was around A\$36 billion.³¹ Largely as a result of the V.C. Summer disaster, Westinghouse filed for bankruptcy and its parent company Toshiba almost went bankrupt as well. Both companies have decided that they will no longer take on the huge risks associated with reactor construction projects.

The cost estimate for the Vogtle project in US state of Georgia (two AP1000 reactors) has doubled to A\$38.8–43.2+ billion and will increase further, and the project only survives because of multi-billion-dollar government bailouts.³² In 2006, Westinghouse said it could build an AP1000 reactor for as little as A\$2.0 billion³³ – 10 times lower than the current estimate for Vogtle.

In the UK, three of six proposed reactor projects have been abandoned (Moorside, Wylfa, Oldbury), two remain in limbo (Sizewell and Bradwell) and Hinkley Point C is at the early stages of construction. The estimated combined cost of the two EPR reactors at Hinkley Point, including finance costs, is A\$48.7 billion (£26.7 billion – the EU's 2014 estimate of £24.5 billion³⁴ plus a £2.2 billion increase announced in July 2017³⁵). A decade ago, the estimated construction cost for one EPR reactor in the UK was almost seven times lower at A\$3.7 billion.³⁶

The UK National Audit Office estimates that taxpayer subsidies for Hinkley Point – primarily in the form of a guaranteed payment of A\$169 / MWh, indexed for inflation, for 35 years – will amount to A\$55 billion³⁷, while other credible estimates put the figure as high as A\$91 billion.³⁸

Hitachi abandoned the Wylfa project in Wales after the estimated cost of the twin-reactor project had risen from A\$26.4 billion to A\$39.7 billion (¥2 trillion to ¥3 trillion).³⁹ Hitachi abandoned the project despite unprecedented offers from the UK government to take a one third equity stake in the project; to consider providing all of the required debt financing; and to consider providing a guarantee of a minimum payment per unit of electricity (expected to be about A\$137 / MWh).⁴⁰

In France, one EPR reactor is under construction at Flamanville. It is seven years behind schedule and the estimated cost of A\$17.7 billion is more than three times the original estimate of A\$5.4 billion.⁴¹ The French Government plans to reduce nuclear power's share of electricity generation from approximately 75% to 50% by 2035.⁴²

³⁰ <https://www.worldnuclearreport.org/Toshiba-Westinghouse-The-End-of-New-build-for-the-Largest-Historic-Nuclear.html>

³¹ <https://www.nytimes.com/2017/07/31/climate/nuclear-power-project-canceled-in-south-carolina.html>

³² <https://www.wiseinternational.org/nuclear-monitor/867/vogtles-reprieve-snatching-defeat-jaws-defeat>

³³ <https://www.nytimes.com/2006/07/16/magazine/16nuclear.html>

³⁴ http://europa.eu/rapid/press-release_IP-14-1093_en.htm

³⁵ <https://www.theguardian.com/uk-news/2017/jul/03/hinkley-point-c-is-22bn-over-budget-and-a-year-behind-schedule-edf-admits>

³⁶ <https://energypost.eu/saga-hinkley-point-c-europes-key-nuclear-decision/>

³⁷ <https://www.theguardian.com/uk-news/2016/jul/13/hinkley-point-c-cost-30bn-top-up-payments-nao-report>

³⁸ <http://www.no2nuclearpower.org.uk/wp/wp-content/uploads/2017/09/Time-to-Cancel-HinkleyFinal.pdf>

³⁹ <https://mainichi.jp/english/articles/20181225/p2a/00m/0na/011000c>

⁴⁰ <https://www.gov.uk/government/speeches/statement-on-suspension-of-work-on-the-wylfa-newydd-nuclear-project>

⁴¹ <http://www.globalconstructionreview.com/news/frances-nuclear-regulator-finally-approves-flamanv/>

⁴² <https://wiseinternational.org/nuclear-monitor/870/french-president-announces-energy-roadmap>

In Finland, one EPR reactor is under construction. It is 10 years behind schedule and the estimated cost of A\$17.5 billion is more than three times the original A\$4.9 billion estimate.⁴³

1.3 SMALL MODULAR REACTORS AND 'GENERATION IV' NUCLEAR POWER CONCEPTS

Generation IV nuclear concepts were considered and rejected by the 2015/16 South Australian Nuclear Fuel Cycle Royal Commission. The Royal Commission said in its final report:⁴⁴

"[A]dvanced fast reactors and other innovative reactor designs are unlikely to be feasible or viable in the foreseeable future. The development of such a first-of-a-kind project in South Australia would have high commercial and technical risk. Although prototype and demonstration reactors are operating, there is no licensed, commercially proven design. Development to that point would require substantial capital investment. Moreover, electricity generated from such reactors has not been demonstrated to be cost competitive with current light water reactor designs."

Small modular reactors (SMRs) are heavily promoted but none are in operation and just a handful of prototypes are under construction.⁴⁵ Experience with SMRs under construction suggests they will be hideously expensive.⁴⁶ For example, Argentina claims to be a world leader in the development of SMRs but the estimated cost of the one SMR under construction in Argentina has ballooned to an absurd A\$31.4 billion / GW (A\$1 billion for a 32-MW prototype).

According to a December 2018 report by the CSIRO and the Australian Energy Market Operator, the cost of power from SMRs would need to more than halve to be competitive with wind and solar PV even with some storage costs included (two hours of battery storage or six hours of pumped hydro storage).⁴⁷

An article by pro-nuclear researchers from Carnegie Mellon University's Department of Engineering and Public Policy, published in 2018 in the *Proceedings of the National Academy of Science*, argues that it is most unlikely that any new large nuclear power plants will be built over the next several decades in the US and is equally pessimistic about the prospects for SMRs.⁴⁸ The researchers conclude that to develop an SMR industry in the US, "several hundred billion dollars of direct and indirect subsidies would be needed to support their development and deployment over the next several decades".

The prevailing scepticism was evident in a February 2017 *Lloyd's Register* report based on "insights and opinions of leaders across the sector" and the views of almost 600 professionals and experts from utilities, distributors, operators and equipment manufacturers.⁴⁹ The report stated that the potential contribution of SMRs "is unclear at this stage, although its impact will most likely apply to smaller grids and isolated markets." Respondents predicted that SMRs have a "low likelihood of eventual take-up, and will have a minimal impact when they do arrive".⁵⁰

⁴³ <https://www.worldnuclearreport.org/World-Nuclear-Industry-Status-Report-2018-HTML.html#lien21>

⁴⁴ http://yoursay.sa.gov.au/system/NFCRC_Final_Report_Web.pdf

⁴⁵ <https://wiseinternational.org/nuclear-monitor/872-873/small-modular-reactors-introduction-and-obituary>

⁴⁶ <https://wiseinternational.org/nuclear-monitor/872-873/smr-cost-estimates-and-costs-smrs-under-construction>

⁴⁷ <https://www.csiro.au/~media/News-releases/2018/renewables-cheapest-new-power/GenCost2018.pdf>

⁴⁸ <https://www.pnas.org/content/115/28/7184>

⁴⁹ <https://www.lr.org/en/latest-news/technology-radar-low-carbon/>

⁵⁰ <http://www.world-nuclear-news.org/EE-Nuclear-more-competitive-than-fossil-fuels-report-09021702.html>

2. IMPLICATIONS FOR AUSTRALIA

The push to repeal Howard-era legislation banning nuclear power is misguided for several reasons and those promoting nuclear power appear to be uniformly ignorant about the crisis that the industry is now facing due to sharply escalating costs.

Even the Australian Nuclear Association acknowledges that nuclear power reactors could not be built without taxpayer subsidies. Thus the proposal to introduce nuclear power fails the test that has been established by Prime Minister Scott Morrison.

Nuclear power is far more expensive than existing energy sources, including renewables, and therefore could not possibly contribute to efforts to reduce power prices. On the contrary, nuclear power would undoubtedly result in higher prices and thus fails the second test that has been established by the Prime Minister.

Dr. Ziggy Switkowski used to be the most prominent public supporter of nuclear power in Australia and he led the Howard government's review of nuclear power in 2006. However Dr. Switkowski said last year that the window for large-scale nuclear power in Australia has closed as renewable energy sources are now cheaper and the cost differential continues to widen.⁵¹

The 2006 Switkowski report estimated the cost of electricity from new reactors at A\$40–65 per megawatt-hour (MWh). That is approximately one-quarter of current estimates. Lazard's November 2018 report on levelized costs of electricity gives these figures⁵²:

- Nuclear power: A\$161–271 / MWh
- Natural-gas combined-cycle: A\$59–106 / MWh
- Wind: A\$42–80 / MWh
- Utility-scale solar: A\$52–66 / MWh

In 2009, Dr Switkowski said that the construction cost of a 1,000 MW power reactor Australia would be A\$4–6 billion.⁵³ Again, that is approximately one-quarter of the current cost estimates for all reactors under construction in western Europe (and Scandinavia) and north America, with cost estimates of those reactors ranging from A\$17–24 billion.

Peter Farley, a fellow of the Australian Institution of Engineers, wrote in early 2019: "As for nuclear the 2,200 MW Plant Vogtle [in the US] is costing US\$25 billion plus financing costs, insurance and long term waste storage. For the full cost of US\$30 billion, we could build 7,000 MW of wind, 7,000 MW of tracking solar, 10,000 MW of rooftop solar, 5,000MW of pumped hydro and 5,000 MW of batteries. That is why nuclear is irrelevant in Australia. It has nothing to do with greenies, it's just about cost and reliability."⁵⁴

⁵¹ <http://www.theage.com.au/business/the-economy/australia-has-missed-the-boat-on-nuclear-power-20180111-p4yyeg.html>

<http://www.smh.com.au/business/the-economy/safety-risks-stall-nuclear-role-in-australia-s-energy-mix-20180125-p4yyvj.html>

⁵² <https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf>

⁵³ <https://www.theaustralian.com.au/opinion/a-clean-and-green-way-to-fuel-the-nation/news-story/92aabe042acb3ef3ffdbdfacc65631bf>

⁵⁴ <https://reneweconomy.com.au/how-did-wind-and-solar-perform-in-the-recent-heat-wave-40479/>

Friends of the Earth Australia believes that the Howard Government's legal prohibition against the construction of nuclear power reactors has served Australia well and should be retained. The ban has saved Australia from the huge costs associated with failed and failing reactor projects in Europe and North America, such as the A\$12.9 billion wasted on the abandoned Westinghouse project in South Carolina. The South Carolina fiasco could so easily have been replicated in South Australia – or any of Australia's states or territories – if not for the Howard Government's wise decision to enact a legal prohibition.

Needless to say, even if nuclear power was economic, several other major obstacles would need to be considered before it could be introduced to Australia, not least the intractable problem of nuclear waste management. Decades-long efforts to establish a repository and store for Australia's nuclear waste continue to flounder and are currently subject to legal and Human Rights Commission complaints and challenges, initiated by Traditional Owners of the affected sites in South Australia.

Globally, no country has a repository for high-level nuclear waste. The United States has a deep underground repository for long-lived intermediate-level waste, called the Waste Isolation Pilot Plant (WIPP). However the repository was closed from 2014–17 following a chemical explosion in an underground waste barrel.⁵⁵ Costs associated with the accident are estimated at over A\$2.9 billion.⁵⁶

Safety standards fell away sharply within the first decade of operation of the WIPP repository – a sobering reminder of the challenge of safely managing nuclear waste for millennia.

⁵⁵ <https://www.wiseinternational.org/nuclear-monitor/794/wipp-waste-accident-horrific-comedy-errors>

⁵⁶ <https://www.latimes.com/nation/la-na-new-mexico-nuclear-dump-20160819-snap-story.html>