2017 in Review: Nuclear Power

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2017 was supposed to be a good year for nuclear power – the peak of a mini-renaissance resulting from a large number of reactor construction starts in the years before the Fukushima disaster (38 construction starts from 2008–2010).

The World Nuclear Association (WNA) anticipated 19 reactor grid connections (start-ups) in 2017.[1] But there were only four start-ups (Chasnupp-4, Pakistan, 315 MW; Fuqing-4, China, 1000 MW; Yangjiang-4, China, 1000 MW; Tianwan-3, China, 990 MW).

Most of the expected start-ups were delayed while the V.C. Summer 2 and 3 reactors in the US were abandoned after at least US$9 billion was spent on the project.

The four start-ups in 2017 were outnumbered by five permanent reactor shut-downs (Kori-1, South Korea, 576 MW; Oskashamn-1, Sweden, 473 MW; Gundremmingen-B, Germany, 1284 MW, Ohi 1 and 2, Japan, 2 x 1120 MW).

The four start-ups in 2017 fell well short of the 10 start-ups in both 2015 and 2016.

The WNA's estimate for reactor start-ups in 2017 was hopelessly wrong but, for what it's worth, here are the Association's projections for start-ups in the coming years:[2]

2018 – 14
2019 – 16
2020 – 7
2021 – 5
2022 – 5
2023 – 4
2024 – 1
2025 – 1

Thus – notwithstanding the low number of start-ups in 2017 – the mini-renaissance that gathered steam in the three years before the Fukushima disaster probably has two or three years to run. Beyond that, it's near-impossible to see start-ups outpacing closures.

New nuclear capacity of 3.3 gigawatts (GW) in 2017 was outweighed by lost capacity of 4.6 GW. Over the past 20 years, there has been modest growth (12.6%, 44 GW) in global nuclear power capacity if reactors currently in long-term outage are included. However, including those reactors – in particular idle reactors in Japan – in the count of 'operable' or 'operational' or 'operating' reactors is, as former WNA executive Steve Kidd states, "misleading" and "clearly ridiculous".[3]

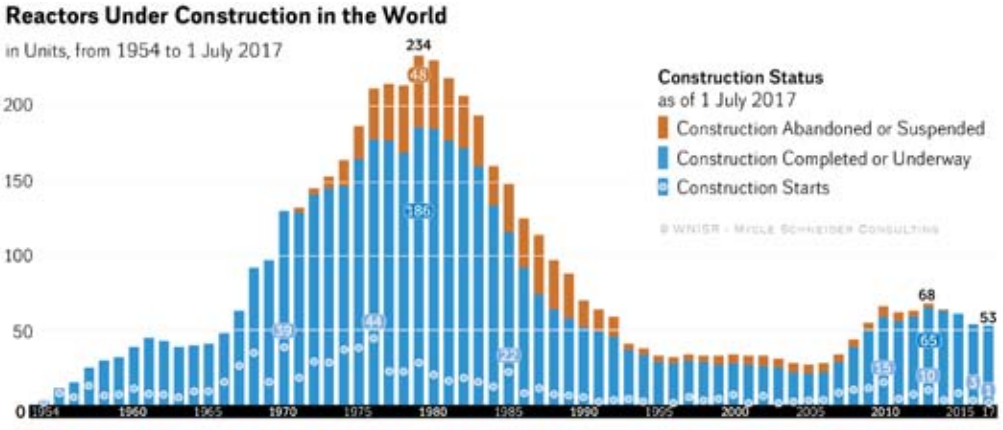
The World Nuclear Industry Status Report (WNISR) excludes reactors in long-term outage – defined as reactors that produced zero power in the previous calendar year and in the first half of the current calendar year – from its count of operating reactors. Thirty-six reactors are currently in long-term outage, 31 of them in Japan.[4]

Excluding reactors in long-term outage, the number of reactors has declined by 29 over the past 20 years, while capacity has grown by a negligible 1.4% (5 GW). Over the past decade, the reactor count is down by 34 and capacity is down by 9.5% (19 GW).

YEAR	GLOBAL NUCLEAR POWER CAPACITY	NUMBER OF REACTORS
31 Dec. 1997[5]	*348 GW*	*434*
31 Dec. 2007[5]	*372 GW*	*439*
31 Dec. 2017		
WNA *(including reactors*	*392 GW*	*447*
in long-term outage)[6]	*353 GW*	*405*
WNISR *(excluding reactors*		
in long-term outage)[7]		

The above figures suggest that the nuclear industry might at least maintain its 20-year pattern of stagnation over the next 20 years or so. But the industry faces severe problems. One is the aging of the global reactor fleet. The average age of the reactor fleet continues to rise, and by mid-2017 stood at 29.3 years; over half have operated for 31 years or more.[8]

The International Energy Agency expects a "wave of retirements of ageing nuclear reactors" and an "unprecedented rate of decommissioning" – almost 200 reactor shut-downs between 2014 and 2040.[9] The International Atomic Energy Agency anticipates 320 GW of retirements by 2050[10] – in other words, there would need to be an average of 10 reactor start-ups (10 GW) per year just to maintain current capacity. The industry will have to run hard just to stand still.



WNISR – Mycle Schneider Consulting.

2008–2017 grid connections, construction starts and permanent reactor closures:[11]

YEAR	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Reactor grid connections	0	2	5	7	3	4	5	10	10	4
Construction starts	10	12	16	4	7	10	3	8	3	4
Permanent shutdowns	2	3	1	13	5	6	1	7	3	5

Assuming the mini-renaissance doesn't continue to flop (as it did in 2017), an average of 10 or so start-ups from 2015–2020 is possible (there were 24 start-ups from 2015–17). But to maintain that level, the number of construction starts would need to increase sharply and there is no likelihood of that eventuating – there have only been seven construction starts in the past two years combined.

The number of reactors under construction is slowly dropping. Using WNA figures, 71 reactors were under construction in January 2014 compared to 58 in January 2018.[6] According to WNISR figures, the number is down from 67 to 52 over the same period.[4] That trend seems certain to continue because of a sharp drop in reactor construction starts: 38 from 2008–2010 compared to 39 in the seven years from 2011–2017.[12]

Nuclear power accounted for 10.5% of global electricity generation in 2016 (presumably a little less now), well down from the historic peak of 17.5% in 1996.[8]

Renewables (24.5% of global generation[13]) generate more than twice as much electricity as nuclear power (<10.5%) and the gap is growing rapidly. The International Energy Agency's (IEA) five-year forecast for renewables predicts capacity growth of 43% (920 GW) from 2017 to 2022.[14,15] The forecast is a "significant upwards revision" from the 2016 forecast, the IEA states, largely driven by solar power growth in China and India. Overall, the share of renewables in power generation will reach 30% in 2022 (over 8,000 TWh) according to the IEA. By 2022, nuclear's share will be around 10% and renewables will be out-generating nuclear by a factor of three.

Non-hydro renewable electricity generation has grown rapidly over the past decade and will probably surpass nuclear power by 2022, or shortly thereafter, then leave nuclear in its wake as renewables expand and the aging reactor fleet atrophies.

A disastrous year for the nuclear industry

Last year was "all in all a disastrous year" for the nuclear power industry according to *Energy Post Weekly* editor Karel Beckman.[16] Lobbyists issued any number of warnings about nuclear power's "rapidly accelerating crisis" while others noted that "the industry is on life support in the United States and other developed economies".[17,18]

Lobbyists engaged each other in heated arguments over possible solutions to nuclear power's crisis – in a nutshell, some favor industry consolidation while others think innovation is essential, all of them think that taxpayer subsidies need to be massively increased, and none of them are interested in the tedious work of building public support by strengthening nuclear safety and regulatory standards, strengthening the safeguards system, etc.[19]

One indication of the industry's desperation has been the recent willingness of industry bodies (such as the US Nuclear Energy Institute) and supporters (such as former US energy secretary Ernest Moniz) to openly acknowledge the connections between nuclear power and weapons, and using those connections as an argument for increased taxpayer subsidies for nuclear power and the broader 'civil' nuclear fuel cycle.[20] The power/weapons connections are also evident with Saudi Arabia's plan to introduce nuclear power and the regime's pursuit of a weapons capability.[21]

The biggest disaster for the nuclear industry in 2017 was the bankruptcy filing of Westinghouse – which also came close to bankrupting its parent company Toshiba – and the decision to abandon two partially built reactors in South Carolina.[22,23] As of January 2018, both Westinghouse and Toshiba are still undergoing slow and painful restructuring processes, and both companies are firmly committed to exiting the reactor construction business (but not the nuclear industry altogether).

Another alarming development for the nuclear industry was the slow-down in China.[24,25] China Nuclear Engineering Corp, the country's leading nuclear construction firm, noted in early 2017 that the "Chinese nuclear industry has stepped into a declining cycle" because the "State Council approved very few new-build projects in the past years".[26]

There were no commercial reactor construction starts in China in 2017 (though work began on one demonstration fast neutron reactor) and only two in 2016. The pace will pick up but it seems less and less likely that growth in China will make up for the decline in the rest of the world.

The legislated plan to reduce France's reliance on nuclear from 75% of electricity generation to 50% by 2025 seems unlikely to be realized[27] but the government is resolved to steadily reduce reliance on nuclear in favor of renewables. French environment minister Nicolas Hulot said in November 2017 that the 50% figure will be reached between 2030 and 2035.[28]

France's nuclear industry is in its "worst situation ever", a former EDF director said in November 2016[29], and the situation has worsened since then. The World Nuclear Industry Status Report summarized recent developments in a January 9 post:[4]

"The French state-owned nuclear builder and service company AREVA was bailed out by the government with a US$5.3 billion cash injection and subsequently broken up. AREVA's reactor building and servicing branch AREVA NP was taken over by state utility EDF, effective from the end of 2017, and relaunched in a "back to the future" initiative as Framatome (EDF

75.5%, Mitsubishi Heavy Industry 19.5%, Assystem 5%). After a loss of over 90 percent of its stock value since 2007, AREVA was delisted in August 2017. The year has also seen the French Nuclear Safety Authority ASN granting exceptional permission to EDF to use a sub-standard reactor pressure vessel at the Flamanville EPR, which is still under construction. The pressure vessel has been found with a level of carbon significantly exceeding technical specifications and is part of an ongoing quality-control scandal pointing to decades of irregularities and forged documents, impacting tens of thousands of pieces in dozens of nuclear plants around the world."

There were plenty of other serious problems for nuclear power around the world in 2017:[30]

- Swiss voters supported a nuclear phase-out referendum.[31]
- South Korea's new government will halt plans to build new nuclear power plants (though construction of two partially-built reactors will proceed, and South Korea will still bid for reactor projects overseas).[32]
- Taiwan's Cabinet reiterated the government's resolve to phase out nuclear power by 2025[33] though a long battle looms.[34]
- Japan's nuclear industry has been decimated – just five reactors are operating (less than one-tenth of the pre-Fukushima fleet) and 14 reactors have been permanently shut-down since the Fukushima disaster (including the six Fukushima Daiichi reactors).
- India's nuclear industry keeps promising the world and delivering very little – nuclear capacity is just 6.2 GW. In May 2017, India's Cabinet approved a plan to build 10 indigenous pressurized heavy water reactors (PHWR). That decision can be read as an acknowledgement that plans for six Westinghouse AP1000 reactors and six French EPR reactors are unlikely to proceed. Most of the 10 PHWRs have been in the pipeline for years and it's anyone's guess how many (if any) will actually be built.[35]
- The UK's nuclear power program faces "something of a crisis" according to an industry lobbyist.[36] In November 2017, the UK Parliament's Public Accounts Committee said the only current reactor construction project, Hinkley Point, amounts to a "bad hand" and "the poorest consumers will be hit hardest".[37] In June 2017, the UK National Audit Office said Hinkley Point is "a risky and expensive project with uncertain strategic and economic benefits."[38]
- All of Germany's reactors will be closed by the end of 2022 and all of Belgium's will be closed by the end of 2025.
- Russia's Rosatom began construction of the first nuclear power reactor in Bangladesh[39], signed agreements to build Egypt's first power reactors[40], and is set to begin work on Turkey's first reactors[41] – but Rosatom deputy general director Vyacheslav Pershukov said in June 2017 that the world market for the construction of new nuclear power plants is shrinking, and the possibilities for building new large reactors abroad are almost exhausted.[42] He said Rosatom expects to be able to find customers for new reactors until 2020–2025 but "it will be hard to continue."[42]
- A High Court judgement in South Africa in April 2017 ruled that much of the country's nuclear new-build program is without legal foundation, and there is little likelihood that the program will be revived given that it is shrouded in corruption scandals and President Jacob Zuma's hold on power is weakening.[43]

The only nuclear industry that is booming is decommissioning – the World Nuclear Association anticipates US$111 billion worth of decommissioning projects to 2035.[44]

The Era of Nuclear Decommissioning

The aging of the global reactor fleet isn't yet a crisis for the industry, but it is heading that way. In many countries with nuclear power, the prospects for new reactors are dim and rear-guard battles are being fought to extend the lifespans of aging reactors that are approaching or past their design date. Perhaps the best characterization of the global nuclear industry is that a new era is approaching – the Era of Nuclear Decommissioning – following on from its growth spurt then 20 years of stagnation.

The Era of Nuclear Decommissioning will entail:

- A slow decline in the number of operating reactors.
- An increasingly unreliable and accident-prone reactor fleet as aging sets in.[45]
- Countless battles over lifespan extensions for aging reactors.
- An internationalization of anti-nuclear opposition as neighboring countries object to the continued operation of aging reactors (international opposition to Belgium's aging reactors is a case in point[46] – and there are numerous other examples).
- Battles over and problems with decommissioning projects (e.g. the UK government's £100+ million settlement over a botched decommissioning tendering process[47]).
- Battles over taxpayer bailout proposals for companies and utilities that haven't set aside adequate funds for decommissioning and nuclear waste management and disposal. (According to *Nuclear Energy Insider*, European nuclear utilities face "significant and urgent challenges" with over a third of the continent's nuclear plants to be shut down by 2025, and utilities facing a €118 billion shortfall in decommissioning and waste management funds.[48])
- Battles over proposals to impose nuclear waste repositories and stores on unwilling or divided communities.

The Era of Nuclear Decommissioning will be characterized by escalating battles (and escalating sticker shock) over lifespan extensions, decommissioning and nuclear waste management. In those circumstances, it will become even more difficult than it currently is for the industry to pursue new reactor projects. A feedback loop could take hold and then the nuclear industry will be well and truly in crisis, if it isn't already.

That said, the situation is fluid – there are ferocious debates over the future of nuclear power in South Korea, Taiwan, Japan, the UK, the US ... everywhere!

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