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Monitored this issue:

2019 in review: Nuclear power down for the count

Jim Green – Nuclear Monitor editor

Nuclear power went backwards last year with the permanent shutdown of nine power reactors (totaling 6.0 gigawatts) and the grid connection of six (5.2 GW).[1] Grid connections were concentrated in Russia (three, including two very small 'floating' reactors on the Akademik Lomonosov barge) and China (two) with one in South Korea. The shutdowns were spread across eight countries.

Worse still for the industry – much worse – is the paucity of reactor construction starts. There were just three construction starts in 2019 (totaling 3.2 GW): one each in China and Russia, and Bushehr-2 in Iran which faces an uncertain future. No countries entered the nuclear power club in 2019 (construction starts or grid connections).

The mean age of the global power reactor fleet is 30.3 years as of Jan. 2020 and the average age passed 30 years in 2019.[2] That's an old fleet, increasingly prone to accidents, large and small; increasingly prone to extended outages and thus increasingly uncompetitive in electricity markets.

The International Atomic Energy Agency (IAEA) anticipates the closure of up to 139 GW from 2018–2030[3] – more than one-third of current global capacity of 395 GW (including idle reactors in Japan). And the IAEA anticipates 325 GW of retirements from 2018 to 2050 – 82% of current global capacity.[3] Based on IAEA figures (and others, including those from the International Energy Agency), the industry will need about 10 new reactors (10 GW) each year just to match retirements. The industry did indeed average nearly 10 construction starts from 2008–13 (a total of 59). But the number has sharply declined in the aftermath of the Fukushima disaster and catastrophic cost overruns, with just 26 construction starts over the past six years at an average of 4.3. There were more construction starts in 2010 (16) than in 2016–19 combined (15).[4]

This table captures the birth and death of the nuclear power mini-renaissance:[4]

6-year period	2002-07	2008–13	2014–19
Construction starts	24	59	26
Average	4.0	9.8	4.3

Diana Ürge-Vorsatz, Vice-Chair of an Intergovernmental Panel on Climate Change Working Group, notes in the foreword to the World Nuclear Industry Status Report 2019:[5]

"Trend indicators in the report suggest that the nuclear industry may have reached its historic maxima: nuclear power generation peaked in 2006, the number of reactors in operation in 2002, the share of nuclear power in the electricity mix in 1996, the number of reactors under construction in 1979, construction starts in 1976. As of mid-2019, there is one unit less in operation than in 1989."

The number of power reactors under construction has been falling slowly but steadily in recent years, from 68 in 2013[5] to 46 as of Jan. 2020[6] (52 according to the IAEA[7]).

Here are the World Nuclear Association's (WNA) figures on anticipated dates for commercial reactor startups (grid connections):[8]

2020	2021	2022	2023	2024	2025	2026
14	9	9	7	4	2	2

If those figures prove to be more-or-less accurate, nuclear power will enjoy a few relatively good years before the rot sets in. But the WNA figures are never accurate (the WNA anticipated 15 reactor starts-ups in 2019 but the true figure was just six). Further delays in reactor startups will result in some smoothing out in the above table.

Currently, nuclear power reflects two contradictory dynamics. The earlier mini-renaissance is evident but will subside by the mid-2020s. The Era of Nuclear Decommissioning (END) is in its infancy (with nine reactor closures, historians may mark 2019 as the beginning of this qualitatively new era) and will be in ever-sharper focus by the mid-2020s. The END will be characterized by a decline in the number of operating reactors; an increasingly unreliable and accident-prone reactor fleet as aging sets in; 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; and escalating battles over and problems with decommissioning and waste disposal.[9]

Until such time as the rot sets in, the nuclear industry can console itself with these figures indicating stagnation in the reactor count and near-zero growth in capacity:

a marginal increase or decrease in the reactor count depending on whether reactors in long-term outage (most of them in Japan) are included or excluded.

a 5.5% increase in nuclear capacity over the past 20 years (excluding reactors in long-term outage) – a compound annual growth rate of 0.27% per year.

Year	**Number of operable reactors**	**Capacity (GW)**
31 Dec. 1999[10]	432	347
31 Dec. 2009[10]	437	371
31 Dec. 2019		
• Including reactors in long-term outage[11]	442	392
• Excluding reactors in long-term outage	415[12]	~366[13]

Pro-nuclear spin

So how are the nuclear industry and its supporters responding to the industry's miserable state? Mostly with denial and delusion.

Here are the 'top 6 nuclear power achievements' of 2019 according to the executive editor of *POWER* magazine.[14]

1. *World's first EPR nuclear power plant enters commercial operation with the Sept. 2019 commencement of commercial operation of the second of two EPR reactors in Taishan, China.*

The original 2013/14 startup dates for Taishan 1 and 2 were missed by five years due to construction problems and safety concerns (including the extraordinary Creusot Forge scandal in France[15]). Excavation work for the Taishan reactors began in 2008 and construction of the two reactors formally began in 2009 and 2010. China General Nuclear Power Corporation acknowledged a cost increase of 40% for the two Taishan reactors to US$11 billion.[16] As a result of delays and cost overruns, the market for EPRs in China has all but evaporated.[5]

The EPR reactor under construction at Flamanville, France, is 10 years behind schedule: construction began in Dec. 2007, the planned startup date was 2012, and EDF now says that commercial operation cannot be expected before the end of 2022.[17] The current cost estimate of €12.4 billion (US$13.7 billion) is 3.8 times greater than the original estimate of €3.3 billion (US$3.6 billion).[18]

The EPR reactor under construction at Olkiluoto, Finland, is 10 years behind schedule: construction began in April 2005, startup was anticipated in 2010, and startup is now scheduled in 2020. The current cost estimate of about €11 billion (US$12.2 billion) is 3.7 times greater than the original €3 billion (US$3.3 billion) price tag.[19]

The estimated combined cost of the two EPR reactors under construction at Hinkley Point, UK, including finance costs, is £26.7 billion (US$35.0 billion) (the EU's 2014 estimate of £24.5 billion[20] plus a £2.2 billion increase announced in July 2017[21]). A decade ago, the estimated construction cost for one EPR reactor in the UK was almost seven times lower at £2 billion.[22] The UK National Audit Office estimates that taxpayer subsidies for Hinkley Point will amount to £30 billion[23] (US$39.4 billion), while other credible estimates put the figure as high as £50 billion (US$65.6 billion).[24]

Undeterred, *POWER* magazine claims that a 6-unit EPR project in India will be the world's largest nuclear power plant "if completed as planned".[14] It would be a miracle if the project is completed as planned; indeed it would be a minor miracle if it even begins given funding constraints.

2. *World's first ACPR-1000 nuclear power plant begins commercial operation in China*

Grid connections of ACPR-1000 reactors in China in 2018 and 2019 mark a significant achievement. But the broader picture is highly uncertain. There has only been one reactor construction start in China in the past three years. The number of reactors under construction has fallen sharply from 20 in 2017 to 10 currently.[26] No-one knows whether or not the Chinese nuclear program will regain momentum. Wind and solar combined generated nearly double the amount of electricity as nuclear in 2018.[27]

3. *Akademik Lomonosov connects to grid*

Estimated construction costs for Russia's floating nuclear power plant (with two 32-MW ice-breaker-type reactors) increased more than four-fold and eventually amounted to well over US$10 million / megawatt (US$740 million / 64 MW).[28] A 2016 OECD Nuclear Energy Agency report said that electricity produced by the plant is expected to cost about US$200 / MWh, with the high cost due to large staffing requirements, high fuel costs, and resources required to maintain the barge and coastal infrastructure.[29]

The primary purpose of Russia's floating nuclear power plant is to help exploit fossil fuel reserves in the Arctic[30] – fossil fuel reserves that are more accessible because of climate change. That isn't anything to celebrate; it is disturbing and dystopian.

4. *Vogtle nuclear expansion progresses*

Yes, the Vogtle twin-AP1000 project in the US state of Georgia continues, for better or worse. Construction began in 2013 and the planned startup dates were April 2016 and April 2017. The project is 5.5 years behind schedule and it is unlikely that the revised completion dates of Nov. 2021 and Nov. 2022 will be met.[31]

In 2006, Westinghouse claimed it could build one AP1000 reactor for as little as US$1.4 billion.[32] The current cost estimate for the two Vogtle reactors – US$27–30+ billion[33] – is 10 times higher.

The Vogtle project only survives because of mind-boggling, multi-billion dollar taxpayer subsidies including US$12+ billion in loan guarantees, tax credits and much else besides. Westinghouse declared bankruptcy in 2017, largely as a result of its failed AP1000 projects in South Carolina (abandoned after the expenditure of at least US$9 billion) and Georgia, and Westinghouse's parent company Toshiba was almost forced into bankruptcy and survives as a shadow of its former self.

5. *NRC approves Clinch River nuclear site for SMRs*

6. *NuScale's SMR design clears Phase 4 of NRC review process*

But who will pay for small modular reactors (SMRs)? Industry won't budge without massive taxpayer subsidies. A 2018 US Department of Energy report states that to make a "meaningful" impact, about US$10 billion of government subsidies would be needed to deploy 6 gigawatts of SMR capacity by 2035.[34] And the pro-nuclear authors of a 2018 article in the *Proceedings of the National Academy of Science* argue that for SMRs to make a significant contribution to US energy supply, "several hundred billion dollars of direct and indirect subsidies would be needed to support their development and deployment over the next several decades".[35]

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Gulf nuclear ambition

Dr. Paul Dorfman

Four nuclear reactors are under construction in United Arab Emirates, called Barakah – Arabic for *Divine Blessing*. Why have the Emirates invested in new nuclear, will they destabilise the volatile Gulf region, and what are the safety, security, and environmental risks?

The South Korean Korea Electric Power Corporation's (KEPCO) winning bid for the construction of the UAE reactors was spectacularly low, about 30% lower than the next cheapest bid. Although nuclear reactor design has evolved, the cost of key improved safety design features would have made their APR1400 reactor design uncompetitive, so they chose not to include them. Having done so, KEPCO was able to dramatically undercut its competition for the UAE bid, with the Chief Executive of a French nuclear corporation comparing the Korean reactor to 'a car without airbags and seat belts'.

And KEPCO acknowledge their reactor design doesn't contain essential features such as either secondary reactor containment or a 'core-catcher' – both of which are design features expected in all new nuclear reactors in Europe. This is important, because these are safety features designed to defend against significant radiation pollution release in the event of an accidental or deliberate large airplane crash, or military attack. Particularly worrying is the lack of a core-catcher which, in the event of a failure of the emergency reactor core cooling system, would catch the core if it breached the reactor pressure vessel.

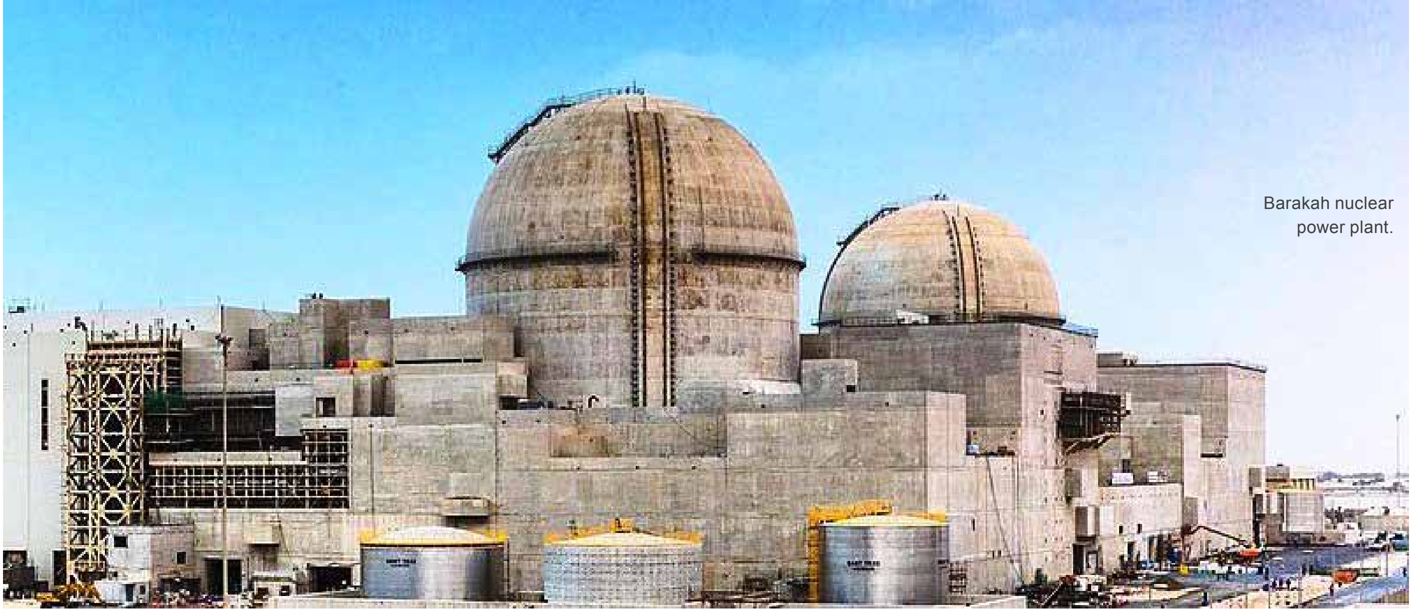
And then there's the cracks in the reactor containment buildings. Christer Viktorsson, Director General of the UAE's Federal Authority for Nuclear Regulation admitted that cracks in the reactor containment building for No. 3 reactor were discovered at Barakah in 2017. In October 2018, Abu Dhabi's Emirates Nuclear Energy Corporation (ENEC) acknowledged concrete cracking in the containment buildings of two of the four reactors at Barakah. Subsequent examination was conducted on the containment buildings for the Nos. 1, 2, and 4 reactors, and cracks were found in all of them. Not only that, but the reactor's Pilot Operated Safety Relief Valve (POSRV) leaks. The POSRV is designed to protect the pressurizer against overpressure – but in the UAE APR1400 reactor, when the valve is opened, cooling water has leaked during start-up. These giant valves should be redesigned and replaced ahead of reactor operation at Barakah – but they haven't.

Back-Draft

The Gulf region faces unique challenges. The tense geopolitical environment makes nuclear an even more controversial issue in the region than elsewhere, because Gulf states are concerned that neighbours might use their civilian nuclear programs for military ends. And they have a point. Unless uranium enrichment and reprocessing technologies are tightly regulated against diversion of civil materials for military purposes, the fact is that new nuclear power plants provide the cover to develop and make nuclear weapons. Whether that capability is turned into actual weapons depends largely on political inclination, and Saudi officials have made it clear on more than one occasion that there is another reason for their interest in nuclear energy technology which was not captured by the royal decree on the Saudi nuclear program – the relationship of the civil program to nuclear weapon production.

There's a very real possibility that the Emirates will follow suit and decide to pursue advanced nuclear fuel cycle capabilities. One issue will be the fate of separated plutonium, and whether overseas reprocessing will encourage the UAE to use plutonium-based fuels at Barakah. These fresh plutonium-bearing mixed oxide (MOX) fuels, pose a more serious proliferation risk than spent fuel or low enriched uranium fuels. Here, it's unsettling to reflect that up to 30% of the Barakah APR1400 reactor cores can be loaded with MOX fuel with minor modifications.

As recent military strikes against Saudi oil refineries confirm, nuclear safety involves the broader issue of security – especially since some armed groups may view UAE military operations as a reason to target their nuclear installations, or intercept enriched uranium fuel or waste transfers. Perhaps disconcertingly, Yemeni rebels have already claimed to have fired a missile at the Barakah nuclear power plant site in 2017. UAE subsequently denied the claim, insisting it had an air defense system capable of dealing with any threat. Yet the protection of the UAE nuclear plant with fighter aircraft or surface-to-air missiles may not be an easy task, and time available to scramble fighter aircraft or fire surface-to-air missiles may prove limited, as recent events in Saudi indicate.



Barakah nuclear power plant.

Marine Ecosystem

The sub-compartments of the Arabian Gulf are widely identified as slow-flushing sea areas. Whilst some Gulf surface waters have a flushing time-scale of more than 3 years, surface waters in the southern sector of the Gulf, including Kuwaiti, Saudi, Qatar and UAE sectors, have a longer flushing time of 5+ years. The highly saline and dense bottom waters of the Gulf have a flushing time of *circa* 6 years. The Gulf is an unusually shallow sea area, and the UAE coastal territorial waters are some of the shallowest areas of the Gulf, with less than 20 metre depth area extending a long way seaward. Thus, both normal operational radioactive discharges and pollution from accidents or incidents at Barakah would remain in the Gulf marine environment for a considerable time period.

Tim Deere-Jones, a marine environment scientist, notes that aqueous radioactive discharges from Barakah nuclear power plant will include a broad cocktail of at least 60 radionuclides, with half-lives ranging from the short to the very long. Liquid discharges won't be steady-state, but will be 'pulsed' with wide fluctuations in intensity and time-scale. Many of the liquid radioactive discharges, including tritium, will be soluble – leading to risk of both radioactive transport and incorporation into mudflats in interstitial water. Since caesium-137 has a half-life of 30 years, radionuclide pollution following any accident or incident would comprise a significant pollution threat, particularly in deep sediment, as would strontium-90, which has a half-life of *circa* 28 years. Plutonium-239, due to its high density and half-life of 24,100 years, would be transported in more complex ways, persisting in deep sediment for millennia.

Deere-Jones points out that the UAE coast is notable for fairly dense areas of both eel grass and mangrove – and coastal lagoon, eel grass and mangrove environments represent a crucial ecosystem, comprising an important nursery and juvenile area for a very large range of Gulf marine life, including those species that support human life. UAE's extensive mangrove habitats grow on and in coastal fine sediments and mudflats. Such sedimentary environments are notable for their ability to sequester a range of pollutants including radioactivity, and it's widely understood that fine sediment deposits act as a 'sink' for the concentrations of such pollutants which increase and concentrate over time.

When suspended in the water column, fine clay organic particles provide material onto which radionuclides can adsorb; leading to both long-range transport through the water column, and eventual re-concentration in deposition and accretion sites distant from the discharge point. During periods of rapid deposition and incorporation, sedimentary adsorbed pollutants may also be sequestered in sedimentary deposits where – isolated from sunlight, oxygen and biological activity – they remain as an un-degraded toxic source to be released if those sediments are disturbed by storm action, tidal surge, and seismic event. Since maritime transport of sea-discharged radionuclides is well understood to extend to many hundreds of miles out from the point-source of the pollution, discharge of radioactive materials from the 4 PWRs at Barakah will inevitably lead to a human dietary dose from sea foods.

Sea-to-land transfer of marine radioactivity – via coastal flooding during storm surges, super tides, and via marine sea spray and aerosols – has been shown to extend at least 10 miles inland from coast lines, and to generate both human inhalation and dietary doses. Therefore any accident involving either a Fukushima type LOCA (loss-of-coolant accident) escape-to-sea of reactor coolant, cooling pond waters or emergency cooling waters; or Chernobyl type wash-out or fall-out of aerial plume material onto sea surface, presents a significant risk – with consequent impact on area-wide fisheries, tourism, and public health.

Drinking Water

And then there's the drinking water. The Gulf region is one of the most water-scarce in the world. With few freshwater resources and low rainfall, many Gulf states rely on desalination. The Middle East has 70% of the world's desalination plants – mostly in Saudi Arabia, the United Arab Emirates, Kuwait, and Bahrain. Saudi Arabia leads the world in the production and consumption of desalinated water, with an estimated SR91bn (US$24.3bn) of expansion plans in the pipeline until 2020.

The 250,000 sq km Gulf is more like a salt-water lake than a sea. It's shallow, just 35 metres deep on average, and almost entirely enclosed. The few rivers that feed the Gulf have been dammed or diverted and the regions hot and dry climate results in high rates of evaporation. With groundwater sources either exhausted or non-existent and climate change bringing higher temperatures and less rainfall, Gulf states plan to nearly double the amount of desalination by 2030. Given the clear and present danger of radioactive sea-water pollution following an accident or incident at Barakah, it follows that all Gulf desalination plants and, hence, all Gulf drinking water will be at significantly increased risk.

Climate Change

The International Panel on Climate Change have just reported that extreme sea level events that used to occur once a century will strike every year on many coasts by 2050, whether climate-heating emissions are curbed or not. This means that coastal nuclear power plants, such as Barakah, are increasingly vulnerable to sea-level rise, storm surge, tidal ingress, flooding of reactor and spent fuel stores, and nuclear islanding, which under many climate change scenarios, may well happen quicker than planned for.

Perhaps alarmingly, the UK Institute of Mechanical Engineers (IME) point out that coastal reactors, together with radioactive waste stores including spent fuel, may need to be relocated. In this sense, adapting coastal nuclear power, such as Barakah, to climate change may well entail significantly increased expense for decommissioning and radioactive waste storage.

The low-lying nature of the UAE coastal zone emphasises the vulnerability of Barakah to climate change induced sea-level rise. Here, it's important to reflect that assessments of climate change sea level rise, storm surge, flooding, sea water temperature rise, thermal expansion, and increasing salinity in the Gulf proximal to Barakah are, as yet, conspicuous by their absence.

The Gulf and, more specifically, the coastal waters of the UAE already have high sea surface and bottom water temperatures and the trend appears ever upwards. UAE waters are even more susceptible, due to shallow draft and slow flushing times. Gulf marine system exhibits severe oceanographic conditions – notably, the world's highest sea temperature with seasonal maxima between 34°C – 36°C, along with abnormal seasonal fluctuations of about 20°C, and hypersaline seawater. Thus, despite the installation of large heat exchangers and condensers, future global heating induced temperature regimes may contribute to increasingly reduced reactor cooling at Barakah.

Hiding in Plain Sight

The case for nuclear power in the Middle East has never been strong, and market investment in new nuclear has proven to be uneconomic – this holds for all plausible ranges of investment costs, weighted average cost of capital, and wholesale electricity prices. So, the question remains: why has UAE cast significant resources at nuclear power, a quintessentially late 20th century technology, when other more efficient, less risky, technically and economically viable options already exist? Since new nuclear makes little sense in the Gulf, which has some of the best solar energy resources in the world, the answer may lie hidden in plain sight.

More information: See Paul Dorfman's Dec. 2019 report, 'Gulf Nuclear Ambition: New Reactors in United Arab Emirates', https://www.nuclearconsult.com/wp/wp-content/uploads/2019/12/Gulf-Nuclear-Ambition-NCG-Dec-2019.pdf

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First Nation votes 'no' to nuclear waste dump near Lake Huron

The Saugeen Ojibway Nation has voted against plans for a deep geological repository (DGR) near Lake Huron in Canada. Industry and government will respect the decision and will no longer target the site.

Collectively, the Chippewas of Nawash Unceded First Nation and the Chippewas of Saugeen First Nation are referred to as the Saugeen Ojibway Nation (SON). A SON statement said:

"We were not consulted when the nuclear industry was established in our Territory. Over the past forty years, nuclear power generation in Anishnaabekiing has had many impacts on our Communities, and our Land and Waters, including the production and accumulation of nuclear waste. In 2013, Ontario Power Generation committed to SON that it would not build the DGR without our support.

"This vote marks a historic exercising of our Aboriginal and Treaty Rights and free, prior and informed consent in our Territory. The Communities have voted against the DGR. The vote results are as follows: 170 yes, 1,058 no, 4 spoiled ballots, 1,232 total votes."

Chief Lester Anoquot – Chippewas of Saugeen First Nation, said:

"This vote was a historic milestone and momentous victory for our People. We worked for many years for our right to exercise jurisdiction in our Territory and the free, prior and informed consent of our People to be recognized. As Anishinaabe, we didn›t ask for this waste to be created and stored in our Territory, but it is here. We have a responsibility to our Mother Earth to protect both her and our Lands and Waters. Today, our People have voted against the DGR; tells us that we must work diligently to find a new solution for the waste."

The Lake Huron DGR was to accept low and intermediate-level waste. A separate process is underway to find a site for disposal of spent nuclear fuel.

Small modular nuclear reactors – a case of wishful thinking at best

Gordon Edwards, Michel Duguay, and Pierre Jasmin

On Friday the 13th, September 2019, the Saint John Telegraph-Journal's front page was dominated by what many readers hoped will be a good luck story for New Brunswick – making the province a booming and prosperous nuclear energy powerhouse for the entire world

After many months of behind-the-scenes meetings throughout New Brunswick with utility company executives, provincial politicians, federal government representatives, township mayors and First Nations, two nuclear entrepreneurial companies laid out a dazzling dream promising thousands of jobs – nay, tens of thousands! – in New Brunswick, achieved by mass-producing and selling components for hitherto untested nuclear reactors called SMNRs (Small Modular Nuclear Reactors) which, it is hoped, will be installed around the world by the hundreds or thousands!

On December 1, the Saskatchewan and Ontario premiers hitched their hopes to the same nuclear dream machine through a dramatic tripartite Sunday press conference in Ottawa featuring the premiers of the provinces. The three amigos announced their desire to promote and deploy some version of SMNRs in their respective provinces. All three claimed it as a strategy to fight climate change, and they want the Canadian government to pledge federal tax money to pay for the R&D.

Perhaps it is a way of paying lip service to the climate crisis without actually achieving anything substantial; prior to the recent election, all three men were opposed to even putting a price on carbon emissions.

Motives other than climate protection may apply. Saskatchewan's uranium is in desperate need of new markets, as some of the province's most productive mines have been mothballed and over a thousand uranium workers have been laid off, due to the global decline in nuclear power.

Meanwhile, Ontario has cancelled all investments in over 800 renewable energy projects – at a financial penalty of over 200 million dollars – while investing tens of billions of dollars to rebuild many of its geriatric nuclear reactors. This, instead of purchasing surplus water-based hydropower from Quebec that is a lot less expensive and more secure.

In a December 2 interview on QUB radio, Gilles Provost, spokesperson for the *Ralliement contre la pollution radioactive* (Movement against radioactive pollution, a Quebec-based group) and former environmental journalist at Le Devoir, criticized the announcement of the three premiers as ill-considered and premature, since none of the conjectural nuclear reactor prototypes exist in reality.

Quite a contrast to the three premiers' declarations, boldly claiming that "SMRs" (they leave out the "N" to minimize public opposition) will help solve climate change, knowing full well that it will take a decade or more before any benefits can possibly be realized – if ever.

These new nuclear reactors are so far perfectly safe, because they exist only on paper and are cooled only by ink. Declaring them a success before they are built is quite a leap of faith, especially in light of the three previous Canadian failures in this field of "small reactors." Two 10-megawatt MAPLE reactors were built at Chalk River and never operated because of insuperable safety concerns, and the 10-megawatt "Mega-Slowpoke" district heating reactor never earned a licence to operate, again because of safety concerns.

The Mega-Slowpoke was offered free of charge to two universities – Sherbrooke and Saskatchewan – both of whom refused the gift. And a good thing too, as the only Mega-Slowpoke ever built (at Pinawa, Manitoba) is now being dismantled without ever producing a single useful megawatt of heat.

"Nuclear renaissance" – clambering out of the dark ages?

This current media hype about modular reactors is very reminiscent of the drumbeat of grandiose expectations that began around 2000, announcing the advent of a Nuclear Renaissance that envisaged thousands of new reactors – huge ones! – being built all over the planet. That initiative turned out to be a complete flop. Only a few large reactors were launched under this banner, and they were plagued with enormous cost-over-runs and extraordinarily long delays, resulting in the bankruptcy or near bankruptcy of some of the largest nuclear companies in the world – such as Areva and Westinghouse – and causing other companies to retire from the nuclear field altogether – such as Siemens.

Speculation about that promised Nuclear Renaissance also led to a massive (and totally unrealistic) spike in uranium prices, spurring uranium exploration activities on an unprecedented scale. It ended in a near-catastrophic collapse of uranium prices when the bubble burst. Cameco was forced to close down several mines. They are still closed. The price of uranium has still not recovered from the plunge.

Large nuclear reactors have essentially priced themselves out of the market. Only Russia, China

Canadian company StarCore Nuclear's image of its proposed high-temperature gas-cooled SMR.

and India have managed to defy those market forces with their monopoly state involvements. Nevertheless, the nuclear contribution to world electricity production has plummeted from 17 percent in 1997 to about 10 percent in 2019. In North America and Western Europe, the prospects for new large reactor projects are virtually nil, and many of the older reactors are shutting down permanently without being replaced.

Climate changes' valid preoccupation

Many people concerned about climate change want to know more about the moral and ethical choices regarding low-carbon technologies: "Don't we have a responsibility to use nuclear?" The short reply is: nuclear is too slow and too expensive. The ranking of options should be based on what is cheapest and fastest – beginning with energy efficiency, then on to off-the-shelf renewables like wind and solar energy.

In Germany, Dr. David Jacobs, founder of International Energy Transition Consulting, is proudly mentioning the green energy sector's contribution in achieving the lowest unemployment rate since reunification of his country in the early 1990s. Post-Fukushima Angela Merkel's decision to close down all of its nuclear reactors by 2022 has pushed the country to purchase photovoltaic solar panels and 30,000 megawatts of wind energy capacity in only 8 years: an impressive achievement – more than twice the total installed nuclear capacity of Canada. It would be impossible to build 30,000 megawatts of nuclear in only 8 years. By building wind generators, Germany obtained some carbon relief in the very first year of construction, then got more benefit in the second year, even more benefit in the third, and so on, building up to a cumulative capacity of 30,000 MWe after 8 years.

With nuclear, even if you could manage to build 30,000 megawatts in 8 years, you would get absolutely no benefit during that entire 8-year construction period. In fact you would be making the problem worse by mining uranium, fabricating fuel, pouring concrete and building the reactor core and components, all adding to greenhouse gas emissions – earning no benefit until (and *if*) everything is finally ready to function. In the meantime (10 to 20 years), you will have starved the efficiency and renewable alternatives of the funds and political will needed to implement technologies that can really make an immediate and substantial difference.

In Saskatchewan, Prof. Jim Harding, who was director of Prairie Justice Research at University of Regina where he headed up the Uranium Inquiries Project, has offered his own reflection. Here is the conclusion of his December 2, 2019 comment: *"In short, small reactors are another distraction from Saskatchewan having the highest levels of GHGs on the planet – nearly 70 metric tonnes per capita. While the rest of Canada has been lowering emissions, those here, along with Alberta with its high-carbon tar sands, have continued to rise. Saskatchewan and Alberta's emissions are now almost equal to all the rest of Canada. Shame on us!"*

In the USA, engineers and even CEOs of some of the leading nuclear companies are admitting that the age of nuclear energy is virtually over in North America. This negative judgment is not coming from people who are opposed to nuclear power, quite the opposite – from people lamenting the decline. See, for example, one major report from the Engineering faculty at Carnegie-Mellon University (https://tinyurl.com/cmu-nukes).

SMR costs and toxicity

That Carnegie-Mellon report includes Small Modular Nuclear Reactors in its analysis, without being any more hopeful than we are. This is mainly because a new generation of smaller reactors, such as those promised for New Brunswick, will necessarily be more expensive per unit of energy produced, if manufactured individually.

The sharply increased price can be partially offset by mass production of prefabricated components; hence the need for selling hundreds or even thousands of these smaller units in order to break even and make a profit. However, the order book is filled with blank pages – there are no customers. This being the case, finding investors is not easy. So entrepreneurs are courting governments to pony up with taxpayers' money, in the hopes that this second attempt at a Nuclear Renaissance will not be the total debacle that the first one turned out to be.

Chances are very slim however. There are over 150 different designs of "Small Modular Reactors." None of them have been built, tested, licensed or deployed. At Chalk River, Ontario, a consortium of private multinational corporations, comprised of SNC-Lavalin and two corporate partners, operating under the name "Canadian Nuclear Laboratories" (CNL), is prepared to host six or seven different designs of Small Modular Nuclear Reactors – none of them being identical to the two proposed for New Brunswick – and all of these designs will be in competition with each other. The Project Description of the first Chalk River prototype Small Modular Reactor has already received over 40 responses that are posted on the CNSC web site, and virtually all of them are negative comments.

The chances that any one design will corner enough of the market to become financially viable in the long run is unlikely. So the second Nuclear Renaissance may carry the seeds of its own destruction right from the outset. Unfortunately, governments are not well equipped to do a serious independent investigation of the validity of the intoxicating claims made by the promoters, who of course conveniently overlook the persistent problem of long-lived nuclear waste and of decommissioning the radioactive structures. These wastes pose a huge ecological and human health problem for countless generations to come.

Finally, in the list of projects being investigated, one finds a scaled-down "breeder reactor" fuelled with plutonium and cooled by liquid sodium metal, a material that reacts violently or explodes on contact with air or water. The breeder reactor is an old project abandoned by Jimmy Carter and discredited by the failure of the ill-fated French SuperPhénix because of its extremely dangerous nature. In the event of a nuclear accident, the Tennessee Clinch River Breeder Reactor was judged capable of poisoning twelve American states and the SuperPhénix half of France.

One suspects that our three premiers are only willing to revisit these bygone reactor designs in order to obtain funding from the federal government while avoiding responsibility for their inaction on more sensible strategies for combatting climate changes – cheaper, faster and safer alternatives, based on investments in energy efficiency and renewable sources.

Gordon Edwards PhD, is President of the Canadian Coalition for Nuclear Responsibility; Michel Duguay, PhD, is professor at Laval University; Pierre Jasmin, UQAM, Quebec Movement for Peace and Artiste pour la Paix.

European campaign against reactor lifetime extensions

Gerard Brinkman – WISE Amsterdam

In the last few years, nuclear energy is more and more often framed as possible solution to climate change. It is receiving positive coverage in the Netherlands as part of a narrative as a potential safe and clean alternative to fossil fuels. This renewed attention for nuclear energy has led some people to think that building new nuclear power plants is the answer to all climate change. A closer look will most often lead to other conclusions, but it is a fact that nuclear energy seems to be back on the agenda.

In the upcoming months we will start a discussion on climate change and nuclear energy. The main goal is to meet with a new and younger audience and talk with them about the issues. Instead of reacting to articles in the media, which frame nuclear energy as positive, we will proactively tell our side. Renewed attention for the arguments is necessary to shift the debate to a more green and sustainable direction. In March and April we will have meet-ups in a number of cities.

We will use Sunday April 26th– the 34th anniversary of the Chernobyl accident – to protest against the lifetime extension of nuclear power plants. The peak of building nuclear power plants was in the seventies and eighties, which means that quite a number of them are now facing their 40th anniversary. In Europe about one-third of the operational nuclear reactors are older than their technical design lifetime. While most of the first generation of reactors have been closed down, the second generation of reactors are largely still operational. And only a few of those reactors are likely to be closed down in the near future.

In the Netherlands, the Borssele nuclear plant almost silently got permission to continue operating until 2033, which would make it a 60-year-old plant. On April 26th, there will be a protest-meeting against this lifetime extension at the site of Borssele.

It is the aim of WISE to broaden the campaign to a European level. It would be a strong signal to politics and the public if there are demonstrations at various nuclear sites on April 26th. Already we asked several groups in Europe to join.

Interested in participating? Please contact WISE Amsterdam, gerard@wisenederland.nl

Transporting nuclear wastes across Australia in the age of bushfires

Noel Wauchope

The Australian government is pushing ahead with plans for a National Radioactive Waste Facility[1] – a repository for low-level waste and indefinite 'interim' above-ground store for long-lived intermediate-level waste – near Kimba on South Australia's Eyre Peninsula (a site in South Australia's Flinders Ranges was recently ruled out).

With bushfires raging across Australia, it might seem insensitive to be worrying now about this nuclear waste site and the transport of wastes to it. But this is relevant and all too serious in the light of Australia's climate crisis.

The U.S. National Academies Press compiled a lengthy and comprehensive report on risks of transporting nuclear wastes – concluding that among various risks, the most serious and significant is fire:[2]

"The radiological risks associated with the transportation of spent fuel and high-level waste are well understood and are generally low, with the possible exception of risks from releases in extreme accidents involving very long duration, fully engulfing fires. While the likelihood of such extreme accidents appears to be very small, their occurrence cannot be ruled out.

"Transportation planners and managers should undertake detailed surveys of transportation routes to identify potential hazards that could lead to or exacerbate extreme accidents involving very long duration, fully engulfing fires."

Current bushfire danger areas include much of New South Wales, including the Lucas Heights area[3]; north and coastal eastern Victoria; and in South Australia, the lower Eyre and Yorke Peninsulas. If nuclear wastes were to be transported across the continent, whether by land or by sea, from the Lucas Heights nuclear research reactor south of Sydney to Kimba in South Australia, they'd be travelling through much of these areas. Today, they'd be confronting very long duration, fully engulfing fires.

Do we know what route the nuclear wastes would be taking to Kimba? Does the Department of Industry Innovation and Science know? Does the Australian Nuclear Science and Technology Organisation (ANSTO) know? Well, they might, but they're not going to tell us.

We can depend on ANSTO's consistent line on this: "In line with standard operational and security requirements, ANSTO will not comment on the port, routes or timing until after the transport is complete."[4]

That line is understandable of course, due to security considerations, including the danger of terrorism.

Spent nuclear fuel rods have been transported several times, from Lucas Heights to ports – mainly Port Kembla – in great secrecy and security. The reprocessed wastes are later returned from France or the UK with similar caution. Those secret late-night operations are worrying enough, but their risks seem almost insignificant when compared with the marathon journey envisaged in what is increasingly looking like a crackpot ANSTO scheme to truck intermediate-level nuclear waste (including spent fuel reprocessing waste) from Lucas Heights to the distant Kimba site for interim above-ground storage. It makes no sense whatsoever and the (interim) solution is simple enough: ongoing above-ground storage at ANSTO's Lucas Heights site. It is accepted that these stores are best located as near as practical to the point of production, as in the case of USA's sites.[5]

Australians, beset by the horror of extreme bushfires, can still perhaps count ourselves as lucky in that, compared with wildfire regions in some countries, we do not yet have the compounding horror of radioactive contamination spread along with the ashes and smoke.

Risks

Fires in Russia have threatened its secret nuclear areas.[6] Several American nuclear analysts have studied fire dangers in Russia's waste transport and temporary storage: "These risks could pose serious security implications not just for Russia but for the U.S. and for the world."

Similarly, Ukraine has had catastrophic wildfires, endangering nuclear waste facilities and transport.[7]

In the USA:

- the Hanford Nuclear Waste Reservation, always a dangerous place, had its dangers magnified by wildfires.[8]
- In 2018, California's Woolsey wildfire[9] spread radioactive particles from the Santa Susana nuclear waste area.[10] Famously, Kim Kardashian, not previously known for environmental activism, took up the struggle to expose this scandal and agitate for a clean-up.[11]
- In Idaho, a nuclear research facility like Lucas Heights aroused much anxiety about its wastes and waste transport as wildfires invaded the area.[12]
- In Missouri, a smouldering underground fire has come perilously close to a radioactive waste dump, the West Lake Landfill.[13,14] The dump was also threatened by an above-ground fire in 2015 and the site operator was admonished by the EPA.[13]
- In Nevada, a fire broke out at a radioactive waste dump in 2015.[13] County officials and law enforcement agencies declared an emergency. Several explosions were recorded on video, spreading debris up to 190 feet and depositing two waste drums outside the fence line. In 1979, Nevada's governor ordered the facility to shut down after a radioactive fire on a truck parked at the facility gate.
- Also in Nevada, a truck hauling salt underground at the Waste Isolation Pilot Plant (WIPP) – a deep underground repository for intermediate-level nuclear waste – in 2014

caught fire.[13] Six workers were treated in hospital for smoke inhalation, another seven were treated at the site, and 86 workers were evacuated. The Accident Investigation Board said the root cause of the fire was Nuclear Waste Partnership's "failure to adequately recognize and mitigate the hazard regarding a fire in the underground."

Many in the US have long been aware of the transport danger. The state of Nevada released a report in 2003 concluding that a steel-lead-steel cask would have failed after about six hours in the fire and a solid steel cask would have failed after about 11 to 12.5 hours.[15] There would have been contamination over 32 square miles of the city and the contamination would have killed up to 28,000 people over 50 years.

Media reporting

Most reporting on Australia's bushfires has been excellent, with the exception of Murdoch media trying to downplay the connection between climate change and worsening fires.[16] However, there has been no mention of the proximity of bushfires to the Lucas Heights nuclear site. As happened with fires in 2018, this seems to be a taboo subject in the media.[17]

While it has never been a good idea to trek the Lucas Heights nuclear waste for thousands of kilometres across the continent, Australia's new climate crisis has made it that much more dangerous. Is the bushfire apocalypse just a one-off? Or, more likely, is this nationwide danger the new normal?

Australia has no choice but to adapt to this globally heating world and to do what we can to stall the heating process by becoming part of a global climate action movement. And fast. In this new and scary scenario, nuclear power has no place. If nuclear power actually were an effective method of combatting climate change, it would still have no place because the reactors would never be up and running in time.

Climate change

It is ludicrous, as well as dangerous, for Australia's nuclear lobby to pretend that nuclear power is any part of a solution to climate change. Ben Heard, in his nuclear front "environmental" site Bright New World, proposes this and actually uses the bushfire risk as an argument for nuclear power.[18] Mark Ho of the Australian Nuclear Association (and ANSTO) uses the bushfire risk as the reason why Australia should remove the ban on nuclear power, though he doesn't explain the connection.[19]

From the point of view of the federal government and the nuclear lobby, the bushfires are probably a timely distraction. The whole bizarre plan for a Kimba nuclear waste dump might just be able to proceed, quietly, as a local matter only.

On the other hand, the Australian public in all states, those "quiet" people who go along with this government's lack of any real policies, is now stirring, waking up to the painful realisation that climate change is upon us. Bushfires are now the national horror. They won't want the horror of nuclear waste transport dangers added to the mix.

Any number of the effects of climate change can adversely impact nuclear facilities … drought and dwindling water resources, extreme heat within nuclear power plants, coastal flooding, severe weather events such as hurricanes and storms … and the increasing frequency and intensity of bushfires.

"I've heard many nuclear proponents say that nuclear power is part of the solution to global warming," says David Lochbaum, a retired nuclear engineer and former director of the Nuclear Safety Project at the Union for Concerned Scientists.[20] "It needs to be reversed: You need to solve global warming for nuclear plants to survive."

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The computer infection of Kudankulam and its implications

M.V. Ramana and Lauren J. Borja

The October 2019 cyberattack on a computer system at the Kudankulam nuclear power plant points to new pathways to severe accidents that can result in widespread radioactive fallout. Attempts to lower this risk would further increase the cost of nuclear power.

On October 28, 2019 a computer security analyst tweeted that computer hackers had gained "Domain controller-level access at Kudankulam Nuclear Power Plant" (KKNPP) in Tamil Nadu.[1] KKNPP has two operational nuclear reactors that had been connected to the electric grid in October 2013 and August 2016.

The tweet was based on an information drop on the Dtrack virus at VirusTotal, which is an online repository of malware code.[2] A version of the Dtrack virus found on the VirusTotal website included credentials specific to KKNPP's internal network, indicating that Dtrack had infected computers inside the nuclear power plant.

Nuclear energy is a unique source of electricity. One of its peculiarities is its capacity to suffer severe accidents that can spread hazardous radioactive contamination across thousands or even tens of thousands of square kilometres requiring evacuation of populations for decades or centuries. To avoid such accidents, the construction of nuclear power plants requires vast quantities of concrete and steel, exacting manufacturing standards, and layers upon layers of control systems at nuclear plants.

Despite such measures, there have been a number of accidents, of both small and large magnitude, since the beginning of the nuclear age. Each accident typically exposes a new vulnerability and often these accidents occur through pathways that were not conceived of by plant designers. The realization that hackers might be able to infect the computers in a nuclear power plant, potentially affecting the physical operation of the nuclear reactors themselves, is another safety vulnerability that had initially not been fathomed.

In addition to the technical aspects of accidents at nuclear power plants, the nature of organizations that operate hazardous technologies can affect both the likelihood and severity of accidents. Scholars who study safety in hazardous technologies have identified three characteristics of organizations that help to mitigate accidents, all of which involve how organizational leaders behave. These include placing a high priority on safety in design and operations; setting and maintaining safety standards and practices; and learning from failures. The little that is known of how the Nuclear Power Corporation of India has responded to the malware infection at KNPP suggests that organizational leaders did not meet these requirements adequately, especially the last one.

What happened

The Dtrack virus was well known in the computer security business. The prominent cybersecurity firm Kaspersky had reported that initial versions, called ATMDtrack, had been used to steal card data from Indian ATMs.[3] Dtrack is the broader variant, which has been used to infiltrate Indian financial institutions and research centres.

The malware uses a remote administration tool that would allow a remote party to gain full control over an infected device.[4] Specifically, the most successful version of Dtrack "is able to list available files and running processes, key logging, browser history and host IP addresses," according to a description provided by Kaspersky. These functions indicate that the primary goal of the Dtrack virus is to spy on or steal information from its victim.

Based on similarities to a previous malware attack in South Korea, Kaspersky attributed Dtrack[5] to the Lazarus hacking group.[6] Lazarus attacks have occurred in many different countries and have included the infamous WannaCry and Sony Breach[8]. Kaspersky has connected activity from Lazarus to IP addresses in North Korea; however, the cybersecurity firm acknowledges that this may be a 'false flag' operation intended to obfuscate the cyber criminal's true location.

In the KKNPP attack, the file dump from the Dtrack virus suggests that the hackers only had access to the internal information technology (IT) network of the plant.[9] This network contains information pertaining to the organizational aspects of the plant corresponding to tasks associated with management or payroll. While valuable information, such as personal information on employees or business practices, still exists on IT networks, they are not considered as critical as operational technology (OT) networks. OT networks control industrial processes; at KKNPP the OT networks would control the management and safety of the plant's nuclear reactors.

More recent coverage[10] and investigation by additional cybersecurity researchers found that the Dtrack variant at KNPP included credentials specific to the KNPP networks coded directly into the virus itself.[11] This indicates that the October 2019 attack was more sophisticated than initially thought, and potentially targeted at retrieving information specifically from KKNPP.

The targeted nature of the malware version found on KKNPP computers suggests that this might actually be a second version of the virus, created from information gathered during an initial infection. By coding in information specific to KNPP networks, hackers might have tried to make the second round of malware more lethal. There is precedent for hackers using a persistent presence on a network to successively unleash more complex and devastating attacks: one example was the devastating cyberattacks in 2015 and 2016 on the Ukraine power grid.[12]

Kudankulam nuclear power plant.

Despite this unsettling revelation, it still does not seem likely that the KKNPP attack was intended to cause direct damage. The hackers might have been just targeting information about the plant. What might motivate such information gathering expeditions? The reason is that if a hacker, either an individual or a group, were to be interested in causing serious damage to some nuclear installation, the biggest challenge might be obtaining the technical information about the design of the facility.

We know that in the case of the Stuxnet attack that was launched by US and Israeli intelligence services to attempt to sabotage Iran's uranium enrichment program, there is reason to think that the espionage component was perhaps the most expensive aspect of the entire operation.[13] (Ralph Langner, the person who gets the most credit for deciphering the Stuxnet attack, has estimated that the development of Stuxnet may have cost "around ten million dollars".[14]) Malware, such as the Dtrack virus, aimed at gathering information, might be a way to reduce the cost of complex cyberattacks.

Three difficult conundrums

Cyber security should be a concern at nuclear power facilities worldwide, and the infection at KKNPP is one more indication that these types of cyberattacks are possible. Many other security researchers have sounded a similar warning. Two recent reports, one from the UK-based Chatham House[15] and one from the US-based Nuclear Threat Initiative[16], have identified multiple computer security concerns specific to nuclear power plants. The Chatham House report identifies the nearsightedness of the plant operators: "nuclear plant personnel may not realize the full extent of this cyber vulnerability," in part due to a "pervading myth that nuclear facilities are 'air-gapped'– or completely isolated from the public internet – and that this protects them from cyberattack.

Yet not only can air-gaps be breached with nothing more than a flash drive (as in the case of Stuxnet), but the commercial benefits of internet connectivity mean that nuclear facilities may now have virtual private networks and other connections installed, sometimes undocumented or forgotten by contractors and other legitimate third-party operators." (A Virtual Private Network or VPN is a connection that uses a public connection, like the Internet, to link two previously disconnected computer networks. The public network used to establish this connection, however, does not have to be the Internet. For a nuclear power plant, it is possible that the IT and OT networks could be connected via VPN, but still remain isolated from the broader Internet. This would allow employees to access control room operations while at their desk inside the facility. The Chatham House report, which was compiled after meeting with many nuclear industry professionals, suggests that the public network used was indeed the internet – especially if "contractors," who are less likely to be on-site than plant employees, set up the VPNs.)

Let us unpack that a little. First, the term commercial benefits refers to the fact that while connecting a computer system to the internet poses risks, it also provides benefits. An obvious one is operational convenience. Someone working on that computer might need to copy some information or download a piece of software that is needed to carry out a task or report to a supervisor. Connecting to a larger network also allows technicians elsewhere, such as maintenance personnel, to work on the system without having to physically come into the nuclear power plant. This is the first conundrum: one cannot even try to avoid cyberattacks without forgoing the benefits that come with network or internet connectivity. For nuclear power plants that require extensive use of computers and similar equipment, the operational cost of not being connected to the larger network could be considerable.

Second, the role of employees is important. The phenomenon where employees who either knowingly or unknowingly threaten the security or safety of the organization they work in is referred to as the "insider" threat. Many of the examples presented in the Chatham House report were either caused by an employee or contractor who was authorized to act on the internal plant control system. For the most part, these contractors or employees might well have had no malicious intentions. But nevertheless their actions do result in adverse consequences. The conundrum here is that nuclear power plants or other infrastructural organizations must have employees, so the risk from insiders cannot be eliminated.

Further, bringing in contractors or third-party operators further increases the number of people with "inside" access to a system. Furthermore, these outside employees, while they may have technical expertise in a subsystem, may have less familiarity with the nuclear plant as a whole. This is illustrated in an example from 2008 at the Hatch nuclear power plant in the United States.[17] In March of that year, the industrial control system failed when a contractor restarted a computer to install an update on the IT network of the plant. The restart of the IT network, which is supposed to be separate from the OT network that controls the nuclear reactors, caused a zero value to be entered into the control system data. A safety system misinterpreted this zero value as an insufficient cooling water and automatically shut down the reactor. The contractor was aware that the computer would need to be restarted, but not that it could potentially shut down the nuclear reactor. The reactor was out of commission for 48 hours and the company had to purchase electricity from another provider to make up its power supply obligations.[18] This cost the company US$5 million. Had the problem occurred at a different period, when the electricity grid is already stretched, there could have been blackouts.

The third conundrum arises from the almost inevitable conflicts between organizational priorities. It is clear that timely updates to plant computer systems is an important priority, but this can negatively impact operations. As everyone with a computer or smart phone should know, installing software updates of different kinds in a timely fashion is generally considered good for avoiding virus attacks and malware and so on. At Hatch, there may well have been some vulnerability that arises from leaving the system unpatched. But installing the update had a detrimental effect on the control system of the plant and thus its operations.

Likewise, there are conflicts between what is good for business and what is better for security. Having access to the internal control network of a nuclear power plant might be important from a business perspective. Creating this connection, however, also creates a security vulnerability. Since 2008, many companies recognized the problems with this connectivity and attempted to build separate networks. But the problem is far from fixed, as the NotPetya malware attack in 2017 revealed.[19] While the virus primarily targeted IT networks, its impact was felt in OT networks around the world, such as in the radiation monitoring systems at the Chernobyl nuclear power plant.[20]

One definition of the word conundrum is that it is a problem with no good solutions. That is definitely the case with cyberattacks on complex facilities like nuclear power plants. In most realistic circumstances, there can be no guarantee that the computer systems at nuclear power facilities can be kept completely safe from attacks.

Inadequate response from plant operators and government

All of these vulnerabilities can be ameliorated or intensified by the organization that controls the hazardous technology under question. One way that organizations can make things worse is to think that there is no danger. The safety theorist James Reason once wrote that one of the many paradoxes about safety is that "if an organization is convinced that it has achieved a safe culture, it almost certainly has not". This has, unfortunately, been the case with the Nuclear Power Corporation of India Limited (NPCIL).

The Chatham House report mentioned earlier described a similar phenomenon in nuclear power plant operators – the false belief that an air-gap was sufficient protection for their computer systems.

Belief in that myth was on full display on October 29, 2019, the same day as the initial tweet, when NPCIL issued a press release on behalf of the KKNPP plant:[21]

"Some false information is being propagated on the social medial platform, electronic and print media with reference to the cyber attack on Kudankulam Nuclear Power Plant. This is to clarify that the Kudankulam Nuclear Power Project (KKNPP) and other Indian Nuclear Power Plants Control Systems are stand alone and not connected to outside cyber network and Internet. Any Cyber attack on the nuclear Power Plant Control System is not possible."

While the press release did not explicitly deny a malware infection, it dismissed public concern over cybersecurity at the plant. Within a day, however, the NPCIL issued a second press release confirming the presence of malware:[22]

"Identification of malware in NPCIL system is correct. The matter was conveyed by CERT-In when it was noticed by them on September 4, 2019. The matter was immediately investigated by DAE specialists. The investigation revealed that the infected PC belonged to a user who was connected in the internet connected network used for administrative purposes. This is isolated from the critical internal network. The networks are being continuously monitored. Investigation also confirms that the plant systems are not affected."

While it is possible that both of the press releases are true, the initial press release is misleading. And while the second press release admits malware infection, it affirms earlier statements that control systems were not affected. Requiring this nuanced reading of the press release, however, makes it seem like NPCIL was not being forthcoming with information about this security threat.

Despite not containing any falsehoods about the infection itself, from what is known publicly now there was one glaring falsehood in the first press release: the claim that it is not possible to carry out a cyberattack on a system that is not connected to outside networks or the Internet.

Why do we say that this claim is false? This is because air-gapped networks can be infected in many ways, most obviously when an employee connects an infected device, such as a PC or USB drive, to the isolated network. This is what appears to have happened at Natanz, the uranium enrichment plant in Iran, where a spy recruited by the Netherlands is reported to have installed the Stuxnet virus.[23] That virus operates by infecting computers that are used to control centrifuges that are used to enrich uranium. The computer does not need to be connected to the internet. If this computer is infected, the virus causes the centrifuges to spin faster than designed, which results in their destruction. Thus, a computer virus can have a physical effect on a system that is not connected to the internet.

Furthermore, as our discussion of security conundrums illustrated, establishing and maintaining this separation is operationally challenging. In some instances, the systems are not separated at all and the “air-gap” may exist only in the minds of plant operators.

Implications

There are two major implications that flow from the attack on Kudankulam’s computer systems. The first has to do with the potential for severe accidents at nuclear power plants. Cyberattacks can create a further pathway for accidents. Even if the attacks themselves might not cause, say, the meltdown of the core, by potentially disabling safety systems or causing other problems, such as loss of electric power at the plant, these attacks could set the stage for a meltdown if it is combined with some other challenge to the plant’s safety systems, for example a severe storm or an earthquake.

The second implication has to do with one other peculiarity of nuclear power, besides its propensity for severe accidents. Unlike most other sources, the cost of building nuclear plants has increased rather than declined with more experience. This is most evident in the US and France, which are the two countries with the most number of nuclear plants. Under very specific conditions and among small subsets of these plants, there have been slight declines, but the overall trend is unambiguously one of cost appreciation. Analysts have termed this a case of negative learning.

The observed increases in cost have to do with the peculiar characteristic that we started with: the potential for severe accidents at nuclear plants. A substantial part of the cost of building nuclear plants comes from the need to avoid such accidents. The inclusion of safety measures, often designed to deal with new vulnerabilities discovered by examining the record at all nuclear plants, does drive up the cost. Of course, these costs might be only a very small fraction of the already astronomical costs of nuclear power plants, but they serve to increase the bill. The cyberattack on Kudankulam is an example of a new vulnerability.

Should NPCIL address it by instituting new safety measures at not just that reactor but also other nuclear power plants, those would typically drive up the cost of building and maintaining these nuclear plants. That, in turn, would make electricity from these plants even more expensive than it already is.

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