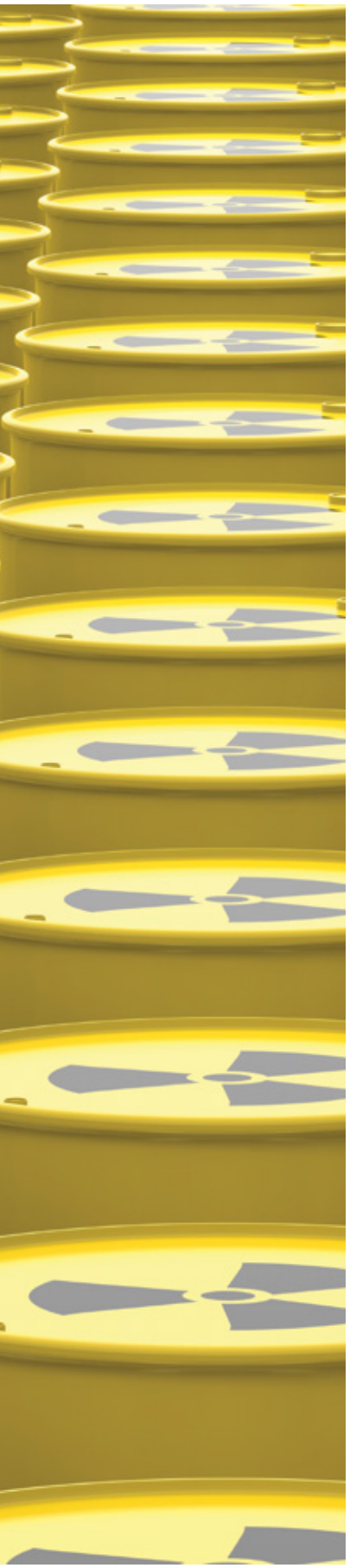

Nuclear meltdown

The industry in the West is facing a crisis, writes William Freebairn—while China and Russia take aggressively to the world stage

Standing on a street corner in Madrid on July 31, Jose Gutierrez's phone rang. It was disappointing news for the acting CEO of nuclear energy company Westinghouse: one of the owners of its high-profile nuclear plant construction project in South Carolina was pulling the plug, abandoning a two-unit expansion effort in mid-stream.

The company could not accept the risk of completing the units without the financial support of Westinghouse, which had filed for bankruptcy reorganization four months earlier in order to end its responsibilities under a construction contract for the units.

Westinghouse is a name synonymous with nuclear energy. Its technology is the basis for about half of the world's 490 operating reactors. Today it is in bankruptcy reorganization, fighting for its corporate life as a result of two US nuclear plant projects that hit construction and financial obstacles. One of those projects will likely never be finished, and the half-built reactors there could join the legacy of never-completed nuclear plants around the world.

The brand-new reactor design, the 1,150 MW AP1000, was selected by utilities in China and the US for construction because of its attractive safety features and claims it could be built quickly. The US units would be the first to break ground in decades in that country, and the selection of the design in China was said to be a harbinger of dozens of such plants spreading across the world.

But instead, at two sites in the US, a combination of first-of-a-kind regulatory, procurement and construction issues produced mounting delays and gradually rising costs.

'The US supply chain had lain dormant for too long—the costs ran away from us'

Crucially, Westinghouse's decision to provide the units to US utilities in Georgia and South Carolina under an effectively fixed-price contract meant that as costs approached $20 billion for each two-unit project, Westinghouse was on the hook for billions of dollars. The demands of funding the construction of four reactors with no potential end in sight triggered a liquidity crisis that threatened not just its US new reactor business, but profitable plant services and nuclear fuel supply businesses in Asia and Europe, Westinghouse said in the bankruptcy documents.

Reorganization would allow it to shed the onerous contracts for the US nuclear plants and keep its other businesses, Westinghouse said.

But the decision also triggered a crisis for the owners of the projects in mid-construction. With four reactors about two thirds complete overall, two groups of power companies led by Georgia Power and South Carolina Electric & Gas had to face completing the units without a main contractor and without price guarantees.

Georgia Power, part of one of the largest US power companies, Southern Company, concluded it would try to press ahead, as long as regulators in Georgia allowed it to collect costs from ratepayers.

But SCE&G, smaller by an order of magnitude in the number of power customers it serves, concluded it did not have the capacity to finish both units. As it was considering a plan to mothball one unit while finishing the other, its partner, the public power company Santee Cooper, decided the risk was too great, and declined to go forward, ending the project for both owners.

After spending about $9 billion, SCE&G and Santee Cooper would pull the plug on one of the most closely watched new nuclear plant construction efforts of the past 20 years. A site that had featured about 3,000 workers in mid-summer now sits silent and empty.

"They had no business being a constructor of nuclear plants," one former Westinghouse executive said in an interview. The company's core business was always the design and supply of the nuclear portions of the plant, the so-called nuclear steam supply system comprising the reactor itself, associated piping and instrumentation and controls, this executive said.

Westinghouse as a brand retains value, and its plant services business and fuel design and fabrication segments are valuable continuing operations, the executive said.

But the result of the restructuring of Westinghouse will have an impact on its reputation as a reactor vendor and even that of the US role in the nuclear industry.

"The US as a supplier of NSSS [nuclear steam supply systems] is going to be in some doubt for some while," he said. "There are others who have leap-frogged us in this area."

The story of how four next-generation nuclear reactors being built in the US experienced such problems is on the one hand mundane. Few $15 billion infrastructure projects avoid delays and cost overruns, and nuclear reactors are among the most complex and highly-regulated machines ever built.

Westinghouse's AP1000 design, ironically, was touted as way to speed construction by being designed in modules, using experience learned from the shipbuilding industry. Proponents said the design was far simpler than other reactors on the market, with a third less piping as the result of simplified safety systems.

However, problems arose almost immediately in the new licensing process used to gain approval for the Vogtle and Summer plant expansions. A one-step licensing process, which combined construction permit with operating license, required the plant to be built to the exact specifications approved by the US Nuclear Regulatory Commission in order to be allowed to operate.

This proved difficult because some details changed between the regulatory approval and start of construction, and because designs are often

altered in the field based on real-world factors, the companies said.

Separately, suppliers of innovative pumps and explosively-operated valves experienced materials and quality control problems that required remanufacturing and additional testing, delaying component deliveries. And exacting nuclear-grade quality control standards proved beyond the abilities of some suppliers.

"The US supply chain had lain dormant for too long," Santee Cooper CEO Lonnie Carter told South Carolina legislators during an investigative hearing into the project's demise August 22. "What's brought us here today is the costs ran away from us," he said.

The collapse of the Summer project has resulted in fierce criticism from state officials, angry that the state's electricity ratepayers will be saddled for billions in costs for units that will not generate power. Separate investigations are under way in the upper and lower chambers of the state legislature, the state attorney general's office, the US Attorney and the US Securities and Exchange Commission.

The pitfalls faced by Westinghouse have been shared by one of the world's other large nuclear companies. France's Areva required a capital injection from the French government of Eur4.5 billion (about $5.23 billion at current rates) following a similarly fraught nuclear plant construction project in Finland. The Olkiluoto-3 reactor is more than nine years behind schedule and the budget has doubled for it.

Like Westinghouse, Areva had guaranteed the price of the first of a new generation of nuclear plant designs, its 1,600 MW EPR, the largest commercial reactor that can be purchased today. And like Westinghouse it experienced a series of delays related to licensing, designing and building that reactor.

Areva and Finnish utility TVO are disputing responsibility for the added costs.

Next-generation designs

The new reactor designs experiencing problems are referred to as Generation III-plus to differentiate them from the earlier units of Generation I and II that dominate the global nuclear fleet. They incorporate additional layers of protection—backups for backups—in the case of Areva's EPR, and simplified so-called passive safety systems that rely on laws of physics like convection and gravity—for Westinghouse's AP1000 and GE Hitachi Nuclear Energy's never-built ESBWR—to increase safety.

However, nuclear regulators have raised many questions about the new systems, as well as for new digital control systems used in the designs. At the sites of EPRs being built in Finland and France and at AP1000s in China and the US, components were found to have manufacturing issues, welding was found to be substandard and poorly documented, and painstaking nuclear-grade quality control procedures not upheld.

China has seen nuclear output surge since the mid-1990s, as it embarked on an ambitious plan to leapfrog Western countries in the area of nuclear power

Countries like Russia and China have aggressively taken to the world stage as reactor builders, with the potential to displace Western rivals, said William Magwood, director general of the OECD's Nuclear Energy Agency.

"They have good products on the market, they know how to market... and they are willing to provide financing on a very large scale" he said.

Even when financing is available in the West, the projects have stumbled on fundamentals of nuclear-grade construction he said.

"In many countries we have not exercised our supply chain, we don't have the project management talent, we just don't have the expertise and the experience to build these large complicated facilities," he said. "As a result of that, we're not very good at it in a lot of places in western Europe and the United States."

China, Russia and South Korea have been building nuclear plants continuously and have not experienced those types of issues, Magwood said.

Of the 53 reactors listed as under construction in this year's World Nuclear Industry Status Report, released in September, the average construction time so far is 6.8 years, with two-thirds being on schedule.

China construction surges

"In the past three decades, we have been building plants continually," Ligang Gao, president of CGN Power, an affiliate of China's largest nuclear power operator by capacity, said during a conference appearance September 14 in London. That experience has allowed it to bring new units of varying designs online in more predictable timeframes, he said. Many of the plants built or under construction in China are of older designs, and advanced domestic designs are untested there.

The first units of the company's newest reactor design, the Hualong One, are under construction at Fangchenggang in southern China, with everything going "smoothly," Gao said. Future Hualong One units are to be exported to Pakistan and potentially the UK.

CGN Power's parent company, China General Nuclear, has 32 subsidiaries and 38,000 employees. With 21.47 GW of nuclear capacity in operation and 10.27 GW more under construction, CGN will soon become the world's second-largest nuclear plant operator, eclipsing Russia's Rosenergoatom, with 27 GW of installed nuclear capacity, and South Korea's Korea Electric Power Co., with 24.4 GW. France's state-owned utility EDF, with 65.9 GW of nuclear capacity, is the largest operator.

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The first Westinghouse AP1000 reactor in the world will not start up in the US or Japan, but will do so in China

sometime in the coming months, officials say. The first Areva EPR to operate will be either Tianwan-1 in China or Olkiluoto-3 in Finland, while domestically-developed units of advanced design, such as a gas-cooled high-temperature design originating in Germany, will operate in China.

China has experienced fewer delays in construction of even those next-generation units, in part because it has relied on the support of western regulators in approving the designs, and because the projects are national priorities that do not face financial questions.

"China has become a pilot for the world" in nuclear reactor construction, said Nesimi Kilic a nuclear engineer at the IAEA, in a statement October 24. The nuclear industry is closely watching China as it deploys first-of-a-kind units such as the Westinghouse AP1000 units, he said.

Of the 53 reactors being built globally, 20 of them are in China.

The country's nuclear power plan calls for it to have 58 GW in installed nuclear capacity by 2020, with an additional 30 GW under construction. If those targets are met, China's nuclear fleet could be similar in size with that of the US by the late 2020s, if as expected 10 or more nuclear units are retired in the US in coming years because of financial challenges.

However, China has 31 GW of nuclear capacity today and is building 20 GW more, so its ability to reach the 50 GW target is uncertain, the authors of the World Nuclear Industry Status Report said.

The share price of CGN has declined since 2015, however, as the company has faced concerns about slowing electricity demand in China, as well as increased pressure from renewable sources and overcapacity in some parts of the country. Potential power price reforms could also have a negative impact on the country, the World Nuclear Industry Status Report said.

The report is produced for environmental organizations including the Natural Resources Defense Council and the Greens group in the European Parliament annually.

Electricity production in China from wind power has eclipsed that from nuclear power since 2011, and in 2016 wind and solar together generated 307 TWh while nuclear power produced 198 TWh, the report said.

Despite growth in China and interest by countries such as the Saudi Arabia, Turkey and the United Arab Emirates to launch nuclear energy programs, global prospects for nuclear energy may be slowing.

The International Atomic Energy Agency adjusted its forecasts for nuclear energy lower this year, noting that the impact of the 2011 Fukushima I nuclear accident is continuing to reduce potential nuclear generation in the future as some countries phase out reactors. In 2030 global nuclear capacity could be in the range of 345 GW to 554 GW, about 45 GW lower than in the 2016 estimate, it said.

Shrinking in the West

Nuclear energy appears to be growing in Asia and shrinking elsewhere.

"Nuclear power is far from dead but it is in decline and renewable energy is growing by leaps and bounds," said S. David Freeman, a former chairman of the Tennessee Valley Authority, one of the largest operators of US nuclear units, in an introduction to the World Nuclear Industry Status Report.

Competitive markets have been very bad news for nuclear power around the world, Freeman wrote. Where markets have been liberalized and competition is introduced, new reactors have not been built without significant government support, he said.

Renewable sources of power, which usually benefit from grid priority, subsidized tariffs or other incentives, have grown faster than nuclear energy, he said.

Of the 53 reactors being built globally, 20 of them are in China

Market rules are the biggest problem facing nuclear energy, NEA's Magwood said.

Unless something changes, the US could face a diminished role in the global nuclear market, he added. Low prices of natural gas, if they last for an extended period, a lack of policies to price carbon and overall power market designs that favor other fuel sources are factors working against nuclear power, he said.

One possible window for the return of US vendors to the global market is the development of small modular reactors, units of less than 300 MW that can be deployed singly or in groups of up to 12, Magwood said. These reactors can serve smaller grids, are typically built offsite and assembled where needed, and are much less challenging to finance, supporters have said.

Unless something changes, the US could face a diminished role in the global nuclear market

Some such designs are built to embrace flexible operations, meaning they can operate in a manner to follow power loads, making them a better match for the growing amount of intermittent renewable energy on the grid, he said.

"If small modular reactors perform at levels even close to what vendors are saying in terms of safety performance, cost, ease of construction, flexibility of operation, you could see the whole conversation switch around," he said.

But those designs are still mostly on the drawing board, although vendors such as NuScale Power in the US are in the process of getting design approval from regulators and hope to have demonstration units online in the mid-2020s.

As for Westinghouse, it is set to emerge from bankruptcy next year with its nuclear plant services and nuclear fuel businesses intact, and hopes to continue to provide the engineering and procurement services related to new nuclear plants, Gutierrez, who has been named permanent CEO, told reporters October 14.

The company is convinced there will be a fleet of AP1000s built in China, Gutierrez said, although that country gained rights to do so without Westinghouse involvement as part of its deal to buy the first four units. Additional AP1000s are possible in India and the UK as well, he noted.

"We are taking a realistic approach," and the company will not be involved in the construction portion of future projects, Gutierrez said.

The company is likely to be sold through the bankruptcy process; potential bidders have access to financial information on the company and several interested groups have approached Westinghouse, he said. Any purchase is subject to a variety of approvals by nuclear regulators and by the US Committee on Foreign Investment in the United States, which reviews purchases for potential national security implications. This is seen by many nuclear industry officials are reducing the likelihood that Westinghouse could end up in Chinese or Russian hands.

The company's travails are difficult for some in the nuclear sector. "It gives me heartache," said the former Westinghouse executive. "Once you work that long for a company, you've always got that 'W' tattooed on your body somewhere." ■