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The 'Game-Changing' Technology The Nuclear Industry Is Betting On For A Revival

Small modular reactors could deliver carbon-free energy to a warming world -- unless they're actually a distraction from better approaches.

By Alexander C. Kaufman

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774 COMMENTS



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CAMDEN, N.J. — On a bright, humid afternoon last September, Allen Hickman made the rounds on the floor of a factory that embodies the past, present and future of the nation's atomic energy industry perhaps more than any other site in the United States.

Founded the same year as the Soviet Union's Chernobyl catastrophe — the only major nuclear energy accident in history with an

established death toll — Hickman's employer, Holtec International, built a business helping utilities from New York to Ukraine to Japan manage nuclear waste.

Inside the cavernous, warehouse-like facility on the eastern bank of the Delaware River, sparks flew as welders turned sheets of steel into cylindrical containers designed to seal and store spent fuel from nuclear reactors until the radioactive material can be recycled or buried. In fact, Holtec recently became a customer for its own storage casks as the company bought up four shuttered nuclear power plants, taking over the decommissioning process.

The market for managing and disassembling defunct nuclear plants is growing; the U.S. has closed 13 reactors in just the past decade.



Allen Hickman, vice president of manufacturing at Holtec International, describes the company's systems for the dry storage of used nuclear fuel at the Holtec facility in Camden, New Jersey, on Sept. 13, 2022.

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But so, too, is demand for the zero-carbon electricity that nuclear reactors generate. Outside the factory that hot day nine months ago, the ground was squirming. Everywhere you looked were spotted lanternflies, an invasive species whose arrival last year exacted such a devastating toll on [vital crops and native trees](#) that scientists compared the Southeast Asian insect to a [plague](#).

The bugs swarmed the parking lot, giving the appearance from one story up that the asphalt was moving. Their colonization of the [newly subtropical](#) Northeastern U.S. was just one palpable sign of climate change, along with the sweltering weather persisting well into September.

Rising temperatures were a big part of the reason a portion of the factory was undergoing renovations last fall, with workers raising the ceiling and rerouting part of the tracks that connect to a national rail line. Hickman was preparing for his plant to expand into a new product line: Holtec's very own brand of nuclear reactor.

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It is what some have called the “grave to cradle” model. The company plans to level the decommissioned nuclear plants it owns, including New York's Indian Point and Massachusetts' Pilgrim

Nuclear Power Station, and revive energy production at those sites with its own machines.

Holtec's bid to produce the "[phoenix of nuclear reactors](#)" is unique. But it's hardly the only party competing for a piece of what many in the industry predict is a dawning "nuclear renaissance."

Nearly a dozen companies are rolling out versions of what the industry calls small modular reactors, or SMRs — shrunk-down, less powerful machines that, through assembly-line repetition and bulk orders, investors believe will prove cheaper and faster to build than the large light-water reactors that make up the entire U.S. fleet of 92 reactors today. Should it hit the market in the next few years as many analysts expect, the technology would be, as the Biden administration's nuclear energy chief Kathryn Huff put it, "game-changing."

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While solar and wind energy, both cheap and easily deployed, are expected to remain the fastest-growing sources of electricity in the coming years, those weather-dependent renewables require backup generation that has overwhelmingly come from natural gas — a fossil fuel whose main component, methane, is a super-potent greenhouse gas that threatens to accelerate global warming.

With electric vehicles eating into the limited supply of batteries to store solar and wind power for when the sky is dark and the air is still, few experts believe decarbonization is possible without more of nuclear energy's 24/7 output of carbon-free electricity.



Systems for the dry storage of used nuclear fuel are created in the manufacturing facility at Holtec International headquarters in Camden.

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Unlike natural gas plants, which on average spend only half their working lives producing electricity, or solar panels that produce electrons less than 25% of the time, nuclear reactors pump out huge volumes of electricity [over 90%](#) of the time they're in operation.

Contrary to popular misconceptions about the risks associated with spent fuel, nuclear plants generate relatively small amounts of radioactive waste, which can be safely stored and even recycled. Reactors can go years without refueling, and they require only [minimal amounts](#) of land and mined metals, particularly compared to solar and wind.

Rich democracies may have soured on nuclear power in the wake of accidents like Chernobyl in 1986 and Fukushima in 2011. But the United Arab Emirates is set to complete construction on the fourth reactor of its debut Barakah Nuclear Power Plant this year, capable of supplying a quarter of domestic electricity needs in the country with the [fourth-highest rate](#) of energy consumption per capita. China is building dozens of reactors of all sizes. And in addition to building its own reactors at home, Russia — the world's no. 1 exporter of nuclear technology — is constructing atomic stations in Egypt, Turkey, Bangladesh, India and more. Virtually all of them are large light-water reactors.

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Workers are seen at the Holtec headquarters in Camden.

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For Western countries looking to get back into the nuclear game, the trick for SMRs will be to prove that the reactors can be built closer to the original deadline — or the original budget — than traditional large reactors. Not everyone is convinced the concept is anything more than an exercise in new branding for the same fission energy.

“SMRs are a technical solution to a nontechnical problem,” said James Krellenstein, a physicist and director of GHS Climate, a think tank that advocates for nuclear energy.

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“For most of the SMR designs that are being seriously contemplated, the same factors that contributed to cost and schedule overruns at Vogtle and elsewhere could also pose immense challenges to SMR builds,” he added. “Given the fact that we likely need to build gigawatts of new nuclear in the United States alone, the case favoring SMRs over large light-water reactors is less clear.”

How The U.S. Jump-Started The Nuclear Age – And Then Stalled Out

On Aug. 1, 1946 — just five days shy of a year since the atomic bombing of Hiroshima, Japan — President Harry Truman signed the Atomic Energy Act, transferring control over the peacetime development of nuclear energy from the military to a new civilian-run Atomic Energy Commission. In 1949, the year the Soviet Union became the second country to develop a nuclear bomb, J. Robert Oppenheimer, the American physicist who’d led the Manhattan Project, appeared on the cover of Life magazine to tout the potential

benefits of generating electricity from the awesome power released when uranium atoms split.

In 1953, the newly elected President Dwight Eisenhower, an Army general during World War II, delivered his famous [“Atoms for Peace” speech](#) before the nascent United Nations, vowing to unite the world with abundant nuclear energy. Soon after, the U.S. Navy launched its first nuclear-powered submarine. Having successfully designed the new warship’s reactor, the Westinghouse Electric Company won the federal contract to build the world’s first full-scale nuclear plant on the Pennsylvania shores of the Ohio River in 1958. The U.S. would soon begin constructing dozens of reactors.

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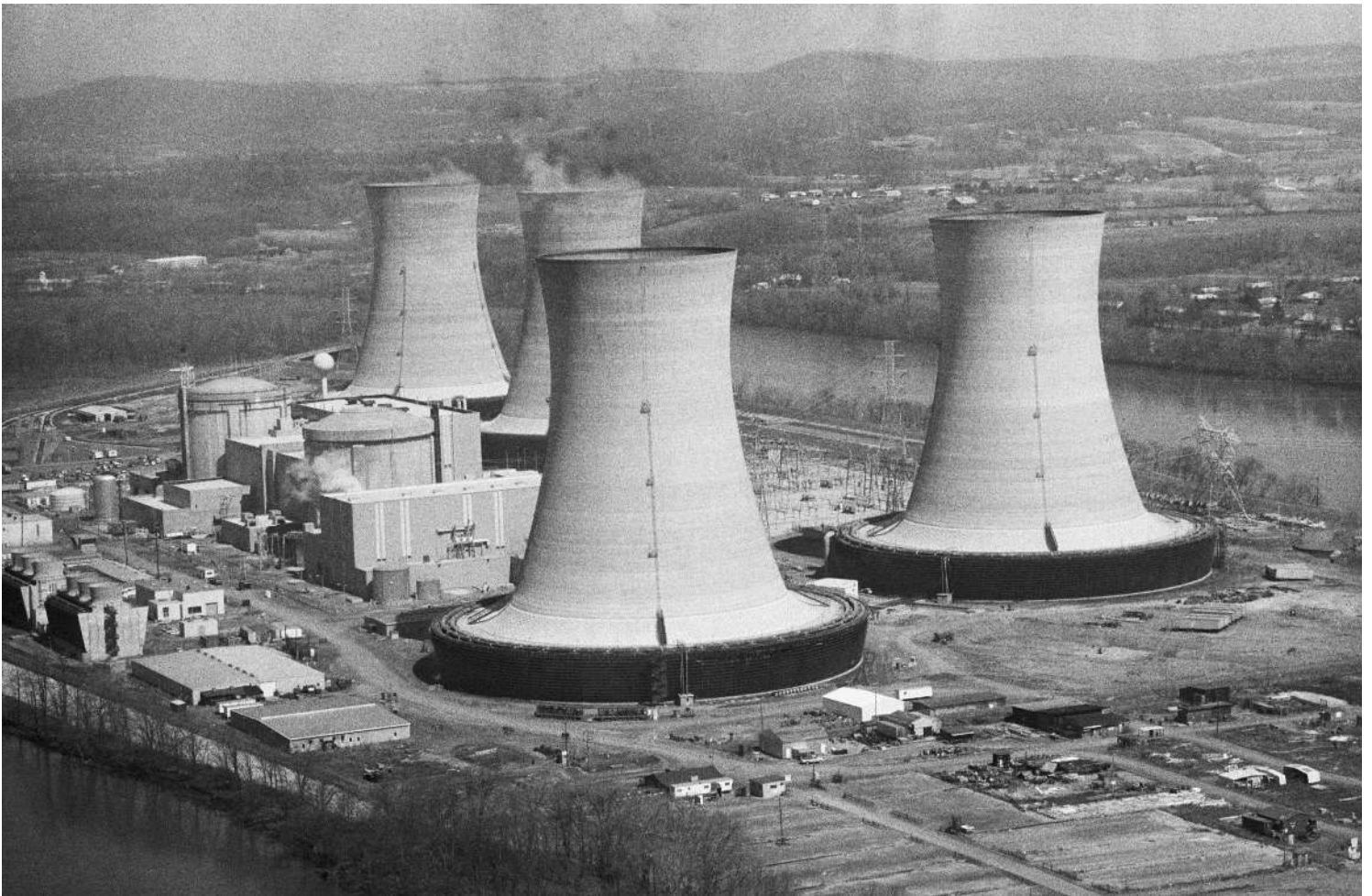
By 1970, Westinghouse was taking out full-spread advertisements pitching itself as the face of American modernity: a gleeful woman loading a Westinghouse-made dishwasher on one page, and “reliable, low-cost electricity” from “the odorless, neat, clean and safe” Westinghouse reactors powering a cheerful beachside nuclear plant on the other. Before long, the United States would make plans for 1,000 reactors.

At the time, the U.S. electricity market was far less complex. Utilities owned the generating plants and power lines, and sold electricity

directly to households at rates set by public commissioners who were elected by voters.

If construction delays on a new reactor drove up costs, it wasn't a big deal. Demand for electricity was going nowhere but up, and these vertically integrated utilities could float losses in one division with the profits of others. Moreover, utilities could pass the construction cost off to ratepayers, then charge a profit based on a percentage on top of the total price, giving companies an incentive to build ever larger projects.

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An aerial view of the Three Mile Island nuclear plant in 1978.

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As with any new technology — particularly one built as infrastructure that could last a century — construction costs regularly exceeded initial estimates. The 75 reactors built between 1966 and 1977 overran budgets by an average of 207%. Regulatory hurdles raised after the Three Mile Island accident “may partly account for even greater cost overruns for the 50 plants constructed after 1979, which averaged 250%,” according to a [report](#) from the Federation of American Scientists, a nonprofit founded in 1946 by researchers who worked on the Manhattan Project.

Another factor driving up costs was the “stagflation” of the 1970s, which triggered a general decline in construction productivity.

Adding to that were the passage of the 1970 National Environmental Policy Act and a 1971 D.C. Circuit Court of Appeals case [that found](#) federal nuclear regulators violated the law by failing to carry out the fullest and most aggressive environmental impact studies possible.

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No one died during the partial meltdown in Pennsylvania in March 1979, and [repeated studies](#) by federal and state scientists found no evidence of an uptick in diseases from the minor dose of radiation released in the accident — an amount markedly less than what the average person is exposed to from natural sources over the course of a year.

But the specter of radiation was already haunting the public imagination. By coincidence, “The China Syndrome,” a movie starring Jane Fonda as a reporter who learns of a disaster cover-up at a nuclear plant, opened in theaters just 12 days before the Three Mile Island accident. Nuclear power had been a pop-culture preoccupation for years by that point: Journalist John Hersey had vividly introduced readers of The New Yorker in 1946 to the new horror of mass radiation sickness, describing the afflictions — pus-oozing wounds, constant vomiting — of survivors of the Hiroshima bombing.

In the months after the “Atoms for Peace” speech, the Rockefeller Foundation [asked the](#) National Academy of Sciences to study the health effects of radiation. The government research body, whose president served on the board of the oil tycoon family’s foundation, put out a dire report a few years later claiming that exposure to any radiation was harmful. The New York Times, whose publisher also served on the Rockefeller Foundation’s board, reported the findings on its front page under the headline “Scientists Term Radiation A Peril To Future Of Man.”

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The report was [later discredited](#), triggering a [furious](#) and [ongoing debate](#) among geneticists. Federal researchers have since turned to a [more comprehensive and technical approach](#) for assessing the cancer risk associated with radiation. But the damage was already done.

A ‘Nuclear Renaissance,’ Buried In Budget Overruns And Drowned By Tsunami

In the years after Three Mile Island, the U.S. canceled more than 100 reactors. And with them, the financing model that had sustained the initial nuclear buildout began to implode.

After issuing billions of dollars in municipal bonds to fund construction of a series of nuclear plants in the Pacific Northwest using three different reactor designs, the Washington Public Power Supply System abandoned all but one of the projects. Unable to earn revenue to pay the money back, the utility in 1983 triggered one of the largest municipal bond defaults in U.S. history, earning WPPSS the nickname “[Whoops](#)” in the national press.

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Despite completing one of two reactors at the Seabrook Station Nuclear Power Plant in southeast New Hampshire after 15 years and billions of dollars, the owner could not resolve a dispute with locals over the size of the emergency evacuation zone. Struggling to get permits to operate the facility, the Public Service Company of New Hampshire canceled its second reactor and [filed for Chapter 11](#) protection in January 1988, becoming the first investor-owned utility since the Great Depression to go bankrupt.



The cylindrical reactor core for the Shoreham Nuclear Plant in Brookhaven, New York, sits in the foreground as construction work continues on it, Jan. 17, 1977.

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Fearing that a traffic bottleneck through New York City would leave them trapped if a major accident unfolded, suburbanites on Long Island successfully fought through the 1980s to keep the completed Shoreham Nuclear Power Plant — meant to provide much of the densely populated region's electricity — from ever opening. After years of charging some of the nation's highest electricity rates to pay off a megaproject that cost 15 times the initial budget yet never had the chance to make money, the Long Island Lighting Company [folded in 1998](#), with much of its assets sold to the state government.

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“The biggest obstacle to new nuclear in the U.S. is our industry’s inability to complete projects on time and on budget,” Krellenstein said. “Given the way new nuclear plants are currently financed in the US, a utility company ordering a large light-water reactor would be betting the entire company on the success of that build. And given our industry’s history, that is hardly a safe bet. ”

Many utilities simply stopped gambling on nuclear. But the whims of investors weren’t a problem for utilities owned by governments, like the Tokyo Electric Power Company.

In Japan — where the lack of fossil fuel reserves and limited space for solar panels and turbines enhanced nuclear power’s appeal — the U.S.-Japanese joint venture between General Electric, Hitachi and Toshiba built the world’s first [advanced boiling water reactor](#), or ABWR, at the Kashiwazaki-Kariwa Nuclear Power Plant on the west coast of the archipelago’s main island. The design, considered the most cutting-edge reactor on the market in the late 1990s, was completed on time and on budget.

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The U.S. planned to build its own ABWR in Texas, and helped partially construct two of the reactors at an unfinished nuclear plant in northern Taiwan. The NRC certified the ABWR reactor for construction in the U.S., giving it a new permitting pathway that would allow any plant that stuck to the initial design to build and operate the facility without jumping through additional regulatory hoops.

But as concern over fossil fuel emissions grew in the early 2000s and the U.S. looked to start building nuclear reactors at home again, a new design hit the market.

Billed as the legendary American company's most advanced reactor yet, Westinghouse equipped its AP-1000 with new safety features and standardized parts that were supposed to make the next generation of atomic energy stations immune to both a Three Mile Island-type accident and the cost overruns that new regulations had made more routine.

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In the final days of December 2005, the U.S. Nuclear Regulatory Commission [greenlighted](#) the AP-1000. Soon after, utilities started placing orders for the new reactor. Meanwhile, the federal government was working on the world's first permanent repository for spent nuclear waste, a facility in Nevada's Yucca Mountain. It was looking like the start of a new atomic golden age.

But the ABWR's achievements in Japan failed to impress American investors. Of the 28 proposed reactors for which utilities applied for NRC licenses, just two were ABWR designs.

"Given the historical challenges of the industry in building projects on time and on budget, it is very, very, very bizarre to me that, with the remarkable and unprecedented success of the ABWR build, the industry itself wasn't more supportive of building more advanced boiling water reactors," Krellenstein said. "It is a historical failing of the industry to be distracted by the next new thing rather than what is tried and true."

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Then came Fukushima. In March 2011, a record earthquake triggered a tsunami that crashed on Japan's northeast coast, killing thousands

of people. Four of the five nuclear plants directly hit in the disaster were unharmed. But the Fukushima Daiichi Nuclear Power Plant had failed to follow modern safety regulations requiring taller seawalls and backup generators on higher ground. As a result, water flooded the diesel generators that provided electricity to keep the plant's reactors cool, initiating the worst nuclear energy accident since Chernobyl.

No one died from radiation exposure. More than 700 residents living near the plant, most of whom were elderly, died from stress related to the hasty evacuation, according to a [survey](#) by the newspaper Mainichi Shimbun. A man in his 50s who was employed measuring radiation levels after the disaster [died in 2018](#) of lung cancer, and the Japanese government reflexively linked the death to the accident as part of an official policy to compensate the families of emergency workers. But [recent research](#) on cattle left alive in the Fukushima exclusion zone found no signs of cancer spikes, leading some scientists to conclude that radiation exposure posed far less of a health risk than previously believed.

Still, old fears of possible nuclear annihilation once again took hold, eclipsing the nascent horror at the hotter, more violent world that fossil fuel emissions were actively bringing into existence.

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Japan halted its other nuclear power plants. Taiwan and Germany adopted plans to swiftly and permanently shutter their atomic stations.

In the U.S., the NRC, unlike after Three Mile Island, resisted ratcheting up regulations on new reactors, and ended up issuing licenses for 14 new reactors using three different designs around the time Fukushima occurred. But the country, now flush with cheap natural gas thanks to the fracking boom, still abandoned all but a handful of new reactors.

One of them, an addition to the federally owned Watts Bar Nuclear Power Plant in eastern Tennessee, had begun construction in the early 1970s. After decades of stops and starts, it finally came online in 2017.

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Atomic plant Vogtle is a two-unit nuclear plant near Waynesboro, Georgia.

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But the two most important projects were in South Carolina and Georgia, where Westinghouse planned to debut the AP-1000 to the world.

The first was the Virgil C. Summer Nuclear Power Station, which already had an older reactor at its facility on the shores of South Carolina's Monticello Reservoir. Adding two AP-1000s would have more than tripled the plant's size.

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With the NRC's new permitting rules, the reactors could have been built and operated under existing licenses as long as the machines were constructed to the exact specifications outlined from the start. The problem was that the design of the AP-1000 wasn't finished by the time construction began. Each tweak Westinghouse made required going back to the NRC for approval.

After spending \$9 billion to dig a hole in the ground, costs mounted, and the South Carolina-based SCANA Corporation was caught lying to state regulators about the project's viability. The state ended up canceling the project, SCANA collapsed and was sold at a fire-sale price, and the utility's [two top](#) executives were [sentenced](#) to prison.

The second project was the buildout of two AP-1000s as Unit 3 and Unit 4 of Southern Company's Alvin W. Vogtle Electric Generating Plant in eastern Georgia. There, too, building first-of-their-kind machines proved challenging. The utility asked the NRC to amend its license at least 160 times. Complicating the project further, Westinghouse [clashed](#) with [multiple](#) construction contractors before ultimately settling in 2017 on the Bechtel Corporation, which had to redo much of the initial building work.

The price tag soared past \$30 billion, and Westinghouse declared bankruptcy in 2017.

The problems building big new reactors on time and budget wasn't unique to the U.S. In the United Kingdom, delays and cost overruns on the Hinkley Point C nuclear plant sent the project's price to [nearly \\$40 billion](#) earlier this year. In France, which famously generates most of its electricity from nuclear power, a new reactor at the Flamanville plant — originally planned to come online in 2012 and cost what would be roughly \$3.2 billion in today's money — pushed back its launch to next year as the price [soared beyond](#) \$13 billion. The expansion of Finland's nuclear plant on Olkiluoto Island came out to nearly \$12 billion.

At the Vogtle plant, Unit 3 finally [hooked up to the grid](#) in April, and is expected to be fully operational later this year, with Unit 4 following close behind. In the meantime, however, China built four AP-1000s, bringing the first [into operation in 2018](#).

Even in a country where nuclear plants take under a decade to build, the first AP-1000 ended up being the longest atomic energy construction in Chinese history. Rather than shy away from the technology, however, China sought to apply the lessons learned from the first few builds. Beijing recently approved plans to build as many as six more AP-1000s.

The Rise Of Small Modular Reactors

China didn't just want more nuclear power — it wanted a greater variety of reactors, doing more than just generating electricity. It wasn't alone.

In 2019, Russia [launched](#) the Akademik Lomonosov, a nearly 500-foot barge with two atomic reactors to serve as the world's first floating nuclear power plant. The ship ultimately docked in Siberia, where its reactors have been used for the last few years to generate steam for a district heating system that keeps warm the Arctic port town of Pevek without gas or oil-fired furnaces.

In 2021, China [broke ground](#) on a similar-sized reactor, called Linglong-1, on the island province of Hainan.

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Compared to traditional large reactors like the AP-1000, these more compact designs were anywhere from 5% to 20% as powerful. But SMRs were meant to fill niches for which 1,000-megawatt goliaths were not as well suited. Among them: competing in market economies where cheap gas plants, solar panels and wind turbines dominated.

SMRs can't resolve many of the issues that nuclear skeptics might have with reactors. The same fission process produces radioactive waste, regardless of reactor size. The same regulations make it risky to finance technology like this — not to mention prohibitively expensive to all but the most deep-pocketed investors.

But a new generation of nuclear entrepreneurs bet that buying SMRs in bundles would significantly increase the number of reactors built over time, as a power plant that may have once built a single 1,200-megawatt reactor instead orders six 200-megawatt machines or opts for dozens of even smaller ones. The first reactor would cost more than the second, which would be more expensive than the third — and so on, until costs for building nuclear power came down to levels that could compete in states like New York, Louisiana and Oregon, where, unlike Georgia, liberalized electricity markets pit power-plant owners against each other to see who can sell the cheapest electrons to the grid.

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“The smaller something is, the faster the cost declines,” said Jessica Lovering, executive director of the Good Energy Collective, a pro-nuclear advocacy group with a progressive political bent. “All evidence points to costs declining if you do serial production in a factory. We see that in batteries, gas turbines, cars, engines. It just makes sense. But we have to get those up and running.”

Based on that logic, it’s easier for utility executives and public service commissioners to get behind the construction of a handful of small modular reactors than a series of large reactors, said Jigar Shah, director of the Department of Energy’s Loan Programs Office.

“There’s a belief — it’s not yet been proven, but certainly there’s a lot of momentum — that this smaller format is one that will be more acceptable to decision makers,” Shah said. “When you look at Vogtle, Unit 4 was about 30% cheaper than Unit 3. So there really is this learning curve that occurs even at one site.”

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The cost of building an SMR plant in the U.S. could be 1.4 to 1.75 times the cost of building another AP-1000 on a per-megawatt basis. The design of the AP-1000 stands to benefit from existing supply chains and a relatively compact form that uses far less concrete and metal than other nuclear or coal facilities, according to an MIT [study](#) published last year.

“Getting down a learning curve means necessarily that after a first difficult build, you have to build another one,” Krellenstein said. “If we’re really convinced there should be a learning curve, then the correct move for the industry is to build another AP-1000. It doesn’t make any sense to learn all the lessons we learned at Vogtle, then throw them away to start a new design on which we’ve learned none of those lessons.”

But not every market is well suited to even one large AP-1000, much less a series of the machines, Shah said.

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“If you’re going to build four AP-1000s, that’d be 4,100 megawatts,” he said. “Transmission systems may not be able to handle it. You can imagine a number of sites that may not qualify for that size, even if you could get the benefits of building four at one site.”

Yet some in the SMR sector believe a nuclear revival will come from not just abandoning large reactors, but eschewing the very technology that underpins those time-tested machines.

In a departure from nearly all the 439 reactors in operation today across 31 countries, companies such as California-based Oklo, Maryland-headquartered X-energy and and the Bill Gates-backed TerraPower are betting on novel reactor technologies that use molten salt or high-temperature gas as coolants instead of water.

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An artist's rendering of NuScale Power's small modular nuclear reactor plant.

NUSCALE

These so-called “advanced” reactors face steep hurdles to reaching the market.

One is fuel. Unlike traditional light-water reactors, which use uranium enriched to about 2%, most of these advanced reactors would use a type of fuel called high-assay low-enriched uranium, or HALEU, which is enriched to just under 20%. Currently, the only commercial vendor of HALEU in the world is Rosatom, Russia's state-owned nuclear company. U.S. efforts to restart a domestic supply chain are only just now beginning, and at least one Danish SMR startup [announced plans](#) this week to rework its product so as not to use HALEU.

Another obstacle is simple inertia. It's been hard enough for regulators to approve any new SMR designs. As investors and

utilities look for potential shovel-ready projects, companies selling novel reactor designs have to overcome not just the fear of doing something new, with few if any established supply chains, but also the challenge of doing something better than the last failed attempt.

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Reactors cooled with substances other than water have existed before in the U.S. Throughout the 1960s, commercial nuclear plants in Colorado, Michigan and Nebraska operated sodium- or gas-cooled reactors. All of them ultimately went out of business. Similar attempts at commercializing these technologies in the U.K., France and Russia failed to follow the light-water reactor's trajectory.

In 2011, a pair of Massachusetts Institute of Technology students proposed building a new type of reactor that would control the fission process with the metal zirconium hydride and cool the reaction with molten salt. They launched the Cambridge, Massachusetts-based Transatomic to bring the technology to market. In 2014, the company claimed in a white paper that its design could “generate up to 75 times more electricity per ton of mined uranium than a light-water reactor” by running on recycled fuel.

Billionaire tech investor Peter Thiel backed the company, which attracted [glowing](#) media [profiles](#) in [glossy magazines](#). In 2016,

however, a panel of MIT professors found errors in the founders' calculations, forcing Transatomic to downgrade its claim from "75 times" to "more than twice," according to an [investigation published](#) the following year in the editorially independent MIT Technology Review magazine. Transatomic [shut down](#) in 2018.

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This April, the National Academy of Sciences published [a lengthy report](#) detailing the promise of advanced reactors, and the perils of licensing one under the NRC's existing regulations. The study concluded that Congress should change the laws to give the NRC more flexibility to assess and approve new advanced technologies, for which existing rules for large, water-cooled reactors are less relevant.

But that hasn't kept startups from moving forward with plans for debut reactors. Oklo, which aims to own and operate its own power plants, [announced a deal](#) last month to open two such facilities in southern Ohio. X-energy [inked an agreement](#) with Dow Chemical last August to build its first reactors at one of the industrial giant's facilities on the Gulf Coast. TerraPower has been [laying the groundwork](#) to convert a coal plant in Kemmerer, Wyoming, into its first demonstration site since November 2021.

The U.S. military is also getting involved. In addition to [making deals](#) with reactor startups, like Virginia-based BWX Technologies, to build low-power “microreactors” that could essentially function like generators on remote bases, the Pentagon is working on [its own microreactor](#), called the MARVEL design.

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In what may be another sign of the technology’s commercial potential, the Nuclear Innovation Alliance, an industry-aligned nonprofit advocating for advanced reactors, in May [added](#) the Ford Motor Company’s top executive in charge of lobbying to its board of directors.

That kind of help navigating Washington’s bureaucracy could be vital as the technology seeks the NRC’s elusive blessing to actually go from deals on paper to shovels in the ground.

In that sense, the other route — building SMRs based on traditional light-water designs — is showing earlier signs of progress.

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In December, the government-owned Ontario Power Generation [agreed to build](#) the first light-water reactor of GE-Hitachi's design as part of an effort by U.S. and Canadian regulators to speed up deployment of SMRs. Three months later, the Tennessee Valley Authority [announced plans](#) to construct the second set of GE-Hitachi's BWRX-300 SMRs.

In January, the NRC [certified](#) Oregon-based NuScale Power's light-water reactor as the nation's first SMR design, adding momentum to that company's plan to build the first six reactors at an Idaho National Laboratory site and sell the power to the government-owned Utah Associated Municipal Power Systems. But the project's costs [are already ballooning](#) with rising interest rates and inflation that has hiked the cost of raw materials.

That could be a boon to Westinghouse's latest reactor, the AP-300 SMR. Although nearly four times smaller and less powerful, the AP-300, unveiled at a press conference in May, is generally "quite identical" to the AP-1000, said Rita Baranwal, Westinghouse's chief technology officer.

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That means it could benefit from the same supply chains that MIT researchers expected would make building an AP-1000 cheaper than constructing the first NuScale reactor.

On June 7, Westinghouse [announced a deal](#) with Finland's state-owned electrical utility Fortum to explore building both sizes of reactor there and in neighboring Sweden. The company's [plan to build Poland's first](#) nuclear plant with AP-1000s suggests the [fast-growing](#) Central European nation could be another potential buyer of its SMR.

"We do not yet have that first customer" for the AP-300, Baranwal said. "That could be someplace outside the United States."

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Westinghouse is hardly the only company eyeing markets overseas.

Shortly after unveiling its own 160-megawatt design for a light-water reactor, Holtec [announced](#) a deal in April to sell as many as 20 of the

as-yet-unbuilt machines to Ukraine's state-owned nuclear energy company while the U.S. firm seeks government support at home for restoring the decommissioned power plants it already owns.

In May, NuScale [said it would](#) build South Korea's first SMR, in a move the company suggested could bring down construction costs worldwide by establishing a global supply chain.

Washington, D.C.-based Last Energy, a reactor startup backed by the same investors behind billionaire Elon Musk's rocket company SpaceX, opted to skip the U.S. market entirely. Instead, CEO Bret Kugelmass — who devised his business plan after years of interviewing industry experts about the hurdles for new reactors for his podcast ["Titans of Nuclear"](#) — set sights on Europe, where regulatory agencies charge licensing fees up front rather than hourly like the NRC. As a result, he said, Last Energy expects to pay tens of millions of dollars to get its technology approved, as opposed to the [more than \\$500 million](#) that NuScale said it ended up paying to the NRC. (Full disclosure: I've been a [guest](#) on Kugelmass' podcast.)

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"We didn't want to fight against NIMBYs on our first plant. We wanted a country that was desperate for a nuclear solution to help with their

energy security and climate goals, a place that would love us and want us,” Kugelmass said. “That’s what led us to focus on Europe.”

The company designed its 20-megawatt water-cooled reactor to use parts that are widely available. It also streamlined the construction process so the entire machine can be shipped from a factory in Texas to industrial buyers in Poland and the U.K. without hiring expensive pipefitters and construction crews.

In March, Last Energy signed a series of deals worth nearly \$19 billion to build 34 reactors in Europe.

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“We needed a reasonable cost — tens of millions, not billions — and a reasonable timeline, a few years, not 10 years ... That ruled out the U.S. for now,” Kugelmass said. “Once they prove it can be done, we’ll come back to the U.S.”

A Bumpy Road Ahead

Back in New Jersey, I drove two hours to one of the oldest reactor facilities in the nation, Oyster Creek Nuclear Generating Station. Or, at least, what remains of it.

The morning I visited, the security building out front was in a state of disrepair, as longtime workers waxed nostalgic about the days when no one could pass through the checkpoint without thoroughly scanning their bodies for radiation. Aside from the gated-off area where spent fuel sat cooling in Holtec storage casks, much of the facility's grounds was a demolition zone, with workers slowly disassembling the concrete structures that once contained the plant's lone nuclear reactor.

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It was here that Holtec wanted to build its first SMR-160. The company bought the decommissioning site in 2019, and a year later received \$116 million from the Department of Energy to research how to repower the facility with SMRs.

But the company's attempt to get New Jersey lawmakers to provide new subsidies for the SMR buildout foundered last year — the [latest development in a tense saga](#) with the government in Trenton over tax incentive payouts and the [alleged bribery](#) of a federal official.

At least one former Holtec employee, who spoke on condition of anonymity because they were not authorized to speak publicly, said the company is far behind its rivals on preparing its license application for the NRC. The more likely pathway to repowering

facilities like Oyster Creek, the employee said, runs through Holtec buying another company's reactors.

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"NuScale is at the front of the line right now," the employee said. "It's more realistic to bet your horses on that."

Still, the leadership of Lacey Township said the Jersey Shore municipality where the Oyster Creek station is located has had a positive experience working with Holtec, despite the NRC [fining the company](#) multiple times for security lapses at the facility. Sitting at the town hall beneath the official Lacey crest, which features [an atomic energy symbol](#), Mark Dykoff — a member of the local government committee and a former mayor — said in September that Holtec "responded admirably" to "any hiccups that have happened."

"We're excited, and we're optimistic," he said. "Holtec is at the forefront with its patents as it relates to spent fuel casks and processes to decommission. The next step is to redevelop the properties that they are decommissioning."

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Bringing Oyster Creek back into operation, Dykoff said, would make Lacey Township a symbol to the rest of the country. Holtec hasn't had as warm a reception in other places where it owns nuclear plants. In New York and Massachusetts, locals are protesting against Holtec's plans to release low levels of a short-lived radioactive isotope into waterways — characterizing what amounts to a [routine practice](#), which scientists say [poses no risk](#) to human health, as wanton dumping of nuclear waste into public rivers and bays.

But political will is only the first step toward building reactors. At a House of Representatives hearing on nuclear energy in April, Republican lawmakers from Virginia — where Gov. Glenn Youngkin (R) has made SMRs a cornerstone of his administration's energy plans — sought answers about how to accelerate the construction of new reactors.

One thing, said Regis Repko, vice president of generation at the utility giant Duke Energy, would be for the federal government to reduce the risk of building first-of-their-kind reactors by providing federally backed insurance.

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“We anticipate that these programs would only be needed for the first several projects,” Repko testified at the hearing. “But their availability to support the decisions by utilities to commit to new projects is vital.”

Another possibility would be for federal agencies to go beyond insurance and sign contracts that promise to pay the difference when the construction costs inevitably exceed early estimates, said Armond Cohen, executive director of the nonprofit Clean Air Task Force.

It’s not just about funding nuclear projects at home. [Legislation](#) introduced in June by Sens. Joe Manchin (D-W.Va.) and James Risch (R-Idaho), and passed out of committee with support from Democrats and Republicans alike, would make it easier for the U.S. government to help finance building reactors overseas, where the nuclear market could see its biggest growth.

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U.S. largesse in financing might help efforts by U.S. companies to capture a bigger share of this market once SMRs are commercialized. In March, the U.S. Embassy in Indonesia [announced \\$1 billion](#) in loans to help Asia's fifth-largest economy build its first SMRs. The U.S. Export-Import Bank, a federal lending agency, [said in April](#) it would provide \$3 billion to fund Poland's reactors.

"For small, newcomer countries, this technology offers stability and security in the face of climate change," said Charlyne Smith, a nuclear engineer and senior analyst at the California-based Breakthrough Institute who is trying to get a nuclear program started in Jamaica, where she is from. "A country like mine is never going to go for a giant, 1000-megawatt reactor. SMRs are the best option."

But the U.S. still lacks key services that Russia does provide, including programs to retrieve and recycle nuclear waste once spent fuel comes out of reactors. This could soon change, as the federal government funds research at its national laboratories toward [novel ways to reuse](#) nuclear fuel. But the process remains slow, and the market need for expensive recycled fuel is limited in a country like the U.S., which has vast uranium reserves that could more cheaply be turned into fresh fuel.

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For now, even as the U.S. cuts off other flows of money from its companies to the Kremlin, sanctions against Rosatom, [mulled since the start](#) of the Ukraine war, have yet to come to fruition — leaving American companies paying upward of [\\$1 billion per year](#) to the same firm supplying the governments of Vladimir Putin and China's Xi Jinping with materials for new nuclear missiles.



A section of the Berlin Wall on the grounds of Holtec International's headquarters in Camden, Sept. 13, 2022.

RACHEL WISNIEWSKI FOR HUFFPOST

Countries building nuclear plants for the first time have few options to turn to for help other than Russia or China. As the U.S.'s own muscles for building and operating nuclear plants atrophy, the future of this technology may lie in the hands of Washington's rivals.

There's a certain irony to it.

When I arrived at Holtec's manufacturing facility just off Interstate 676 last year, I entered through a security gate and steered my Honda down a winding driveway until the road split by the water's edge, overlooking Philadelphia's silvery skyline. Turn right, and you'd end up at the office building where spotted lanternflies had infested the front walkway. Turn left, and you'd be at the factory.

At that fork in the road stood what looked like a missing piece of Stonehenge, 13 feet tall and about four feet wide. Like England's ancient rock marvel, this giant gray monolith originated in Europe. But this concrete slab dated back just a few decades, to a time when the United States was the only superpower, liberal democracy looked ascendent worldwide, and history itself seemed, to some, to have reached its natural final chapter.

It was a chunk of the Berlin Wall. A bronze plaque affixed to the side trumpeted the monument as "an abiding symbol of the triumph of democracy over authoritarianism."

The half-life of that statement may be shorter than it initially seemed.

CORRECTION: *This story previously misstated which court delivered the decision in the 1971 case of Calvert Cliffs' Coordinating Committee Inc. v. U.S. Atomic Energy Commission.*

In a separate clarification, this article has been updated with additional information about the debate over the National Academy of Sciences' 1956 report on the health effects of radiation.

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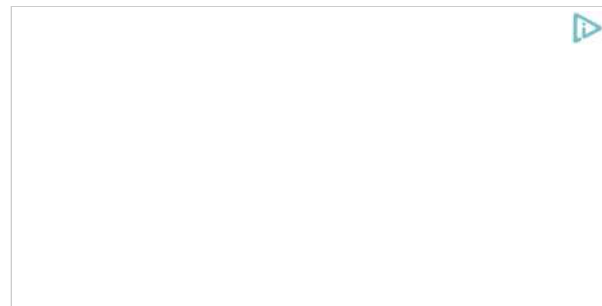


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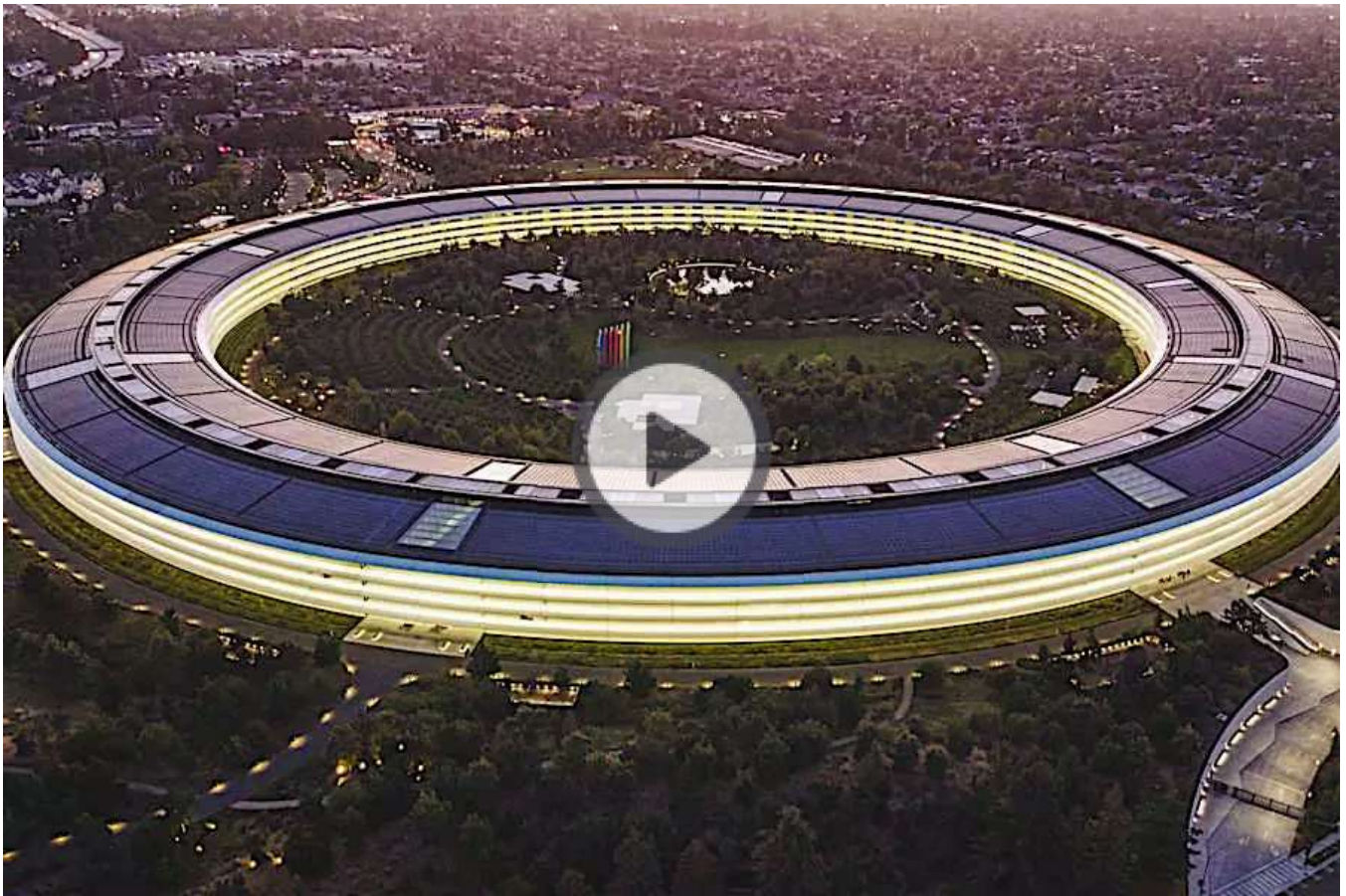
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