The future of nuclear energy will be decided in Idaho

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The global resurgence for nuclear energy starts in the barren, high desert of Idaho.

Almost every nuclear plant in the world today can trace its lineage back to Idaho National Laboratory's sprawling 890-square-mile complex. Researchers there were the first to generate electricity from splitting the atom back in 1951, and countless scientists have since visited the remote site to test reactor designs.

But while it's been a crucial stop on the path from drawing board to deploying systems in the field, it's been 50 years since the last reactor was switched on there. The lengthy gap speaks to the challenges of harnessing a fission reaction. The lab stands poised to shepherd a new wave of nuclear technologies to market, but the recent cancellation of a major project at the site shows INL's research prowess alone isn't enough to ensure the industry will play a major role in combating climate change in the coming decades.

Dozens of companies are developing advanced reactor designs, which are typically smaller than the mammoth power plants widely used today. That approach has been touted as a faster, cheaper way to build reactors. Many companies are planning pilgrimages to INL, which is home to a vast array of facilities to evaluate reactor cores, fuels, coolant materials and other critical components.

These new designs will need rigorous testing to ensure safety and reliability before they can go into service, and research this decade will have a major influence on the shape of the nuclear industry over the rest of the century. Scientists at the lab are eager to get going.

"This is the hard part, but also the fun part," said Ron Crone, associate lab director for INL's Materials & Fuels Complex. "This is Disneyland for nuclear energy."

Research groups, including the International Energy Agency, have called for an aggressive expansion of carbon-free nuclear technology to help rein in climate change. But startups have had to contend with rising costs and the glacially slow regulatory approval process. The industry got a hard reality check in November, when NuScale Power Corp. canceled plans to build a commercial power plant at the INL site that would've been the first in the U.S. to use several so-called small modular reactors (SMR) instead of a single large one.

Rising prices for steel and other key materials, as well as higher interest rates all drove up the cost at which the company could deliver electricity by more than 50%. That made it very challenging for the company to line up enough customers to justify the project.

NuScale is the only company with approval from the US Nuclear Regulatory Commission for an SMR design and the Idaho project was its flagship effort. Pulling the plug is a big setback for the industry's revival, said Chris Gadomski, lead nuclear analyst at BloombergNEF.

"INL is trying to position itself at the forefront of advanced reactor development," he said. "But commercializing advanced reactors in the US is not so easy."

INL calls itself America's nuclear energy laboratory, and its core missions include keeping the existing fleet of reactors in service and developing the next generation of fission power plants. A total of 52 reactors were built and operated at the facility as the technology became a mainstream source of electricity. The last new one to go into service there was in 1973, though.

"We've been stalled at 52," said Brady Orchard, projects director at the Materials & Fuels Complex. "As a country, we have stepped away from nuclear energy."

The past few decades have been fallow for the industry. Some facilities at the national lab were mothballed; the reactor used in that key 1951 effort to harness a fission reaction was converted into a museum; and a massive containment dome was weeks away from demolition when Energy Department officials decided in 2018 that it might still be useful. That move could well prove prescient.

The facility is about 80 feet high, with a shiny coat of silver paint on the exterior. The walls are 12 inches of concrete and an inch of steel, designed to contain radiation once scientists start testing new reactors inside. Contractors are in the process of expanding the loading doors to make it easier to move large equipment in and out of the dome.

Rather than forcing visitors to use their imagination, the lab has a set of augmented reality goggles that provide a glimpse of what the facility will look like when it's up and running. Put them on and you can see virtual versions of complex machinery installed all around the cavernous interior, even though it may be a while until there's an actual reactor in the building.

The virtual view reflects the palpable sense of optimism at INL. Reactor number 53 is on track for completion in 2025, and there are at least three more lined up behind it. INL has a timeline plotting out more reactors in development there and at other US sites, including a sister national lab in Oak Ridge, Tennessee, and commercial projects planned in Texas, Wyoming and elsewhere.

These various projects use different types of uranium fuels and feature new cooling materials. Some are for research and there's a tiny, microreactor aimed at powering remote military bases, while others are bigger and expected to go into commercial service to power the grid. Together, they tell a story of an industry reinvigorated with new ideas.

Still, it's also an industry facing challenges. The much-anticipated fifty-third reactor will most likely be Marvel, an Energy Department microreactor project aimed at showcasing ways fission can be tapped for heat to power, for example, industrial processes as well as generating electricity.

Once it's tested and in service, INL staff expect the data gathered at the site will help develop subsequent designs. They've already got a space ready for the reactor inside another facility used to test the impact of very short but intense bursts of energy unleashed by nuclear reactions. But getting Marvel ready is also taking longer than expected; it was initially scheduled to be ready in 2024.

In an industry that's well-known for projects that blow through budgets and schedules, delays like these aren't surprising. Yet they do add a dose of reality to temper the enthusiasm at INL.

"Are all of these going to work? No," said Crone. "But are some of them going to work? Absolutely."

There are also broader questions about the resurgence of the nuclear industry, not just about whether the companies can deliver new reactors, but whether they should do so at all. Prominent environmental groups such as Greenpeace are strongly opposed to promoting nuclear energy because it produces dangerous waste that will remain deadly for centuries. Instead, those groups are calling for countries to deploy more wind and solar power.

Doing so could also get clean electrons on the grid faster. A number of governments also see an easier course for deploying renewables and have called for tripling the world's renewable capacity by 2030.

"We're diverting money from truly renewable resources," said Leigh

Ford, executive director of the Snake River Alliance, an Idaho-based watchdog group that is critical of INL's mission. "I'm very concerned we're going to go the route of creating more nuclear waste."

But for supporters, INL's research is critical. The facility played a major role as companies built a world-spanning fleet of reactors that now supplies about 10% of the planet's electricity. Nuclear power is the second-biggest source of carbon-free energy after hydropower, and it could well be key to curbing emissions. Aside from the renewables advocacy at COP28, the US is spearheading a push to triple atomic capacity globally by 2050.

Validating new designs at INL will be an important step toward deploying more reactors globally, said John Kotek, senior vice president for policy development and public affairs at the Nuclear Energy Institute trade group.

"There's probably not a reactor design out there that doesn't have ties to work done there," said Kotek. "There were a lot of firsts out there."

The emergence of new reactor designs, with different sizes and capabilities, will likely help the industry's expansion. The conventional nuclear plants in service now typically have about 1 gigawatt of capacity—roughly enough energy to power for 876,000 homes—and building them is a major undertaking. The Vogtle nuclear project in Georgia aims to be complete next year, more than seven years behind schedule and at least $16 billion over budget.

Many of the new reactor designs are much smaller—including some potentially as small as 1 megawatt—and are expected to be built in factories and assembled on-site. That approach may make it easier and faster to deploy the systems, and may also open the door to nuclear power entering new markets around the world. However, that also means that validating the technology will be critical, said INL's Crone.

"The things we're working on today are going to have a major impact on the world," said Crone.

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