months of work during a sabbatical, Ryan Keisler, a physicist now at KoBold Metals, a mineral exploration company, published a preprint describing a simple model with considerable skill in 6-day forecasts. "Given how much historical data there was to learn from, it just had to work at some level," Keisler says.

A next step will be to produce ensemble results, a forecasting innovation that helps capture uncertainty by running a model multiple times to create a range of possible outcomes. AI researchers could follow the traditional technique of tweaking initial weather conditions just slightly before each model run, or they could adapt the AI generative techniques making waves in text and image generation to create tweaked conditions on the fly. "I'm pretty sure every group is working on that," Rasp says. Such ensemble forecasts could help the AI models better predict extreme events, such as strong hurricanes, that they currently underestimate in intensity.

To improve further, the AI models could be weaned off the reanalysis data, which carry the biases of traditional models. Instead, they could learn directly from the petabytes of raw observation data held by weather agencies, Keisler says. Google's short-term weather model already does so, training itself on data from weather stations, radar, and satellites.

The potential for these models doesn't stop at weather prediction, says Christopher Bretherton, an atmospheric scientist at the Allen Institute for AI. They cannot project climate on their own, because the 40-year training data sets are not long enough to capture global warming trends, which are subject to complex feedbacks from clouds, gases, and aerosols that can accelerate or slow climate change. But they could assist a new generation of high-resolution climate models being developed to run on exascale computers, the latest ultrafast machines. Once those models produce enough output for the AIs to be trained on, the AIs could take over. "We can make emulators of these models and then run them 100 times faster," Bretherton says.

Few expect traditional forecasts to disappear anytime soon, but AI is "rapidly approaching the point where it could be a useful complement," says Matthew Chantry, who coordinates ECMWF's AI work. Adoption might be slowed by unease about the black-box nature of the AI: Researchers often can't say how such systems reach their conclusions. But that concern can be overstated, says Chantry, who notes that traditional models are also so complicated that "there's a degree of opaqueness already built into them."

Ultimately, it will come down to users, Grover says. "If you're a farmer in the field, would you care about the more accurate forecast, or the one you can write down with physical equations?" ■

PHOTO: A. CHO/*SCIENCE*

ENERGY

Deal to build pint-size nuclear reactors is canceled

NuScale Power's small modular reactors promised cheaper nuclear power, but costs soared and utilities balked

By **Adrian Cho**

A plan to build a novel nuclear power plant comprising six small modular reactors (SMRs) fell apart last week when prospective customers for its electricity backed out. Utah Associated Municipal Power Systems (UAMPS), a coalition of community-owned power systems in seven western states, withdrew from a deal to build the plant, designed by NuScale Power, because too few members agreed to buy into it. The project, subsidized by the U.S. Department of Energy (DOE), sought to revive the moribund U.S. nuclear industry, but its cost had more than doubled to $9.3 billion.

"We still see a future for new nuclear," says Mason Baker, CEO and general manager of UAMPS, which planned to build the plant in Idaho. "But in the near term, we're going to focus on … expanding our wind capacity, doing more utility-scale solar, [and] batteries." NuScale, which was spun out of Oregon State University in 2007, declined to make anyone available for an interview. But David Schlissel of the Institute for Energy Economics and Financial Analysis says, "The communities and their ratepayers have avoided a giant financial debacle."

To some observers, the plan's collapse also raises questions about the feasibility of other planned advanced reactors, meant to provide clean energy with fewer drawbacks than existing reactors. NuScale's was the most conventional of the designs, and the closest to construction. "There's plenty of reasons to think [the other projects] are going to be even more difficult and expensive," says Edwin Lyman, a physicist and director of nuclear power safety at the Union of Concerned Scientists.

The U.S. nuclear industry has brought just two new power reactors online in the past quarter-century. In a deregulated power market, developers have struggled with the enormous capital expense of building a power reactor. Two new reactors at Plant Vogtle in Georgia, one of which came online in May, cost more than $30 billion.

To whack down cost, engineers at NuScale decided to think small. Each NuScale SMR would produce just a fraction of the 1.1 gigawatts generated by one of the new Vogtle reactors. As originally conceived in 2014, the plant would contain 12 SMRs, each producing 60 megawatts of electricity, and would cost $4.2 billion.

Small reactors are not an obvious winner. Basic physics dictates that a bigger nuclear reactor will be more fuel efficient than a smaller one. And a big nuclear plant can benefit from economies of scale. However, a small reactor can be simpler. For example, NuScale engineers rely on convection to drive cooling water through the core of each SMR, obviating the need for expensive pumps. SMRs also can be mass-produced in a factory and shipped whole to a site, reducing costs.

A mock-up of part of NuScale's reactor enabled engineers to study what it would be like to work inside.

Size aside, NuScale's SMR is relatively conventional. Whereas other advanced reactor designs rely on exotic coolants, NuScale's sticks to water. It also uses the same low-enriched uranium fuel as existing power reactors. Those features helped the NuScale design win approval from the Nuclear Regulatory Commission (NRC) in September 2020—the only advanced reactor to have done so.

DOE agreed to host the plant at its Idaho National Laboratory, avoiding the state and local permitting processes commercial reactors ordinarily face. Still, by the time NRC

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approved the design, the cost for the project has risen to $6.1 billion. That led DOE to pledge $1.4 billion to the project and developers to scale back to six modules, each pumping out 77 megawatts. In January, an analysis revealed that the cost had increased by another $3 billion and suggested power from the plant would cost $89 per megawatt-hour, roughly three times as much as power from wind or utility-scale solar.

Why the costs sky-rocketed remains unclear. Lyman notes that NuScale's first plant was always going to be expensive, as the company still needed to optimize its production lines. Even so, he says, NuScale designers overestimated how much they could save with a simpler design. "They never demonstrated that you could compensate for that penalty in economies of scale with these other factors."

Jacopo Buongiorno, a nuclear engineer at the Massachusetts Institute of Technology, says the NuScale design has an Achilles' heel. Each reactor's core resides within a double-walled steel cylinder, with a vacuum between the walls to keep heat from leaking out. The reactor modules sit in a big pool of water, which in an emergency can flood into the vacuum space around a reactor to prevent it overheating. Compared with a conventional reactor's building, the pool requires more reinforced concrete, the price of which has soared, Buongiorno says. "In terms of tons of reinforced concrete per megawatt of power, NuScale's design is off the chart."

UAMPS's members balked at the cost of that power. UAMPS had the right to break the deal if by early next year members didn't agree to buy 80% of the plant's 462 megawatt output, Baker says. The agency had commitments for just 26%. On 7 November the 26 of the 50 UAMPS members that had signed up for the project voted to terminate it, Baker says.

Other, more ambitious nuclear projects are in the works. DOE has agreed to help a company called Terrapower develop a reactor that will use molten sodium as a coolant and another company, X-energy, develop an SMR cooled by helium gas. Both plants would use novel fuel enriched to 20% uranium-235. That fuel is not yet commercially available, and it could make those designs even more expensive, Lyman says.

Buongiorno says he wouldn't read NuScale's failure as a verdict on all advanced reactor designs. "I would steer clear of broadstroke comments in terms of cost," he says. Baker says he has no doubt that the country needs new nuclear plants to supplement the fluctuating supply of power from wind and solar. "To achieve the nation's decarbonization goals, it's got to happen." ■

COMMUNITY

Ousted biologist starts over

Fired for sexual misconduct, biologist David Sabatini lands new job in Prague. Reactions are mixed

By **Meredith Wadman**

David Sabatini, the high-flying biologist who lost positions at three prominent U.S. institutions after breaching sexual misconduct policies, began a new job on 1 October as a senior scientist at the prestigious and wealthy Institute of Organic Chemistry and Biochemistry Prague (IOCB), an arm of the Czech Academy of Sciences (CAS). The hire has divided Czech scientists and ignited new debate about second chances for those who commit sexual misconduct.

"I am very honored to join IOCB," Sabatini said by email. He added that he spent much of the past 2 years "of deep sorrow" in reflection. "In my new lab I will be extra vigilant to make sure that all lab members feel welcome. … I will try my best to not cause offense."

> **"We welcome him to our midst."**
> **Zuzana Kečkéšová**, IOCB

Jan Konvalinka, director of the 940-person institute, said in a statement: "We believe that [Sabatini] has been punished enough for his previous actions and that the research community will be served best if this brilliant scientist returns to research."

In 2021, the Howard Hughes Medical Institute fired Sabatini, and the Whitehead Institute for Biomedical Research forced him out after an investigation found he violated the institute's sexual harassment and relationship policies. That investigation found that Sabatini conducted a clandestine sexual relationship with a woman scientist whom he was mentoring while she launched a lab at the Whitehead. The investigation also found, among other behavior, that he created a lab culture that rewarded sexualized banter and created a "pervasive" fear of retaliation.

Although Sabatini has admitted mistakes, he has maintained that the relationship was consensual, the probe was unfair, and his punishment disproportionate. Soon after he lost his Whitehead position, Sabatini sued the institute, its director, and the woman scientist for defamation and workplace discrimination. The woman scientist countersued. The litigation is ongoing.

In 2022, Sabatini resigned a separate, tenured professorship at the Massachusetts Institute of Technology (MIT), which had found he violated its rules on sexual relationships. The same year, he dropped a job offer at New York University after *Science* made the offer public and student protests erupted.

Some of his new colleagues welcomed Sabatini's hiring. Zuzana Kečkéšová, a molecular biologist at IOCB, knew Sabatini when she was a postdoc at the Whitehead from 2008–17. She wrote: "I do not believe that striking Dr. Sabatini from the list of people who can ever hold a job again helps solve the structural problems of women in science. … We welcome him to our midst." (Kečkéšová is also one of two "ethical proxies" at IOCB.)

Several scientists noted that IOCB has been a leader in promoting workplace equity in a country whose proportion of women scientists—27%—is among the lowest in the European Union. Given IOCB's public profile, they expect it to be vigilant.

Other Czech scientists were upset. "He's going to lead people? Oh my goodness," says Vladimíra Petráková, a biophysicist and group leader at CAS's J. Heyrovsky Institute of Physical Chemistry. "An independent [probe] concluded he is a sexual harasser. That sends a very bad message … that we don't want to create a safe space for our employees and students."

Sabatini "is dismissive and filed a defamation suit," added Marcela Linková, a sociologist who heads the National Contact Centre for Gender and Science, part of CAS's Institute of Sociology. "Any person in a position of power over junior colleagues who does not acknowledge the amounts of power they have and how that limits a junior person's maneuvering space—and uses that power against that colleague—is not trustworthy for a supervisory position."

Sabatini began as a senior group leader at IOCB on 1 October. A co-discoverer of mTOR, a protein that regulates growth and aging, Sabatini says he will continue to focus on growth regulation in animals. He will receive startup funds from IOCB and intends to apply for grants from the Czech government and the European Research Council. A $25 million, 5-year pledge from New York City hedge fund manager Bill Ackman and an anonymous donor is not involved in his funding, he said. Sabatini says he expects his lab will "probably" include 12 to 15 people when fully staffed. ■

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