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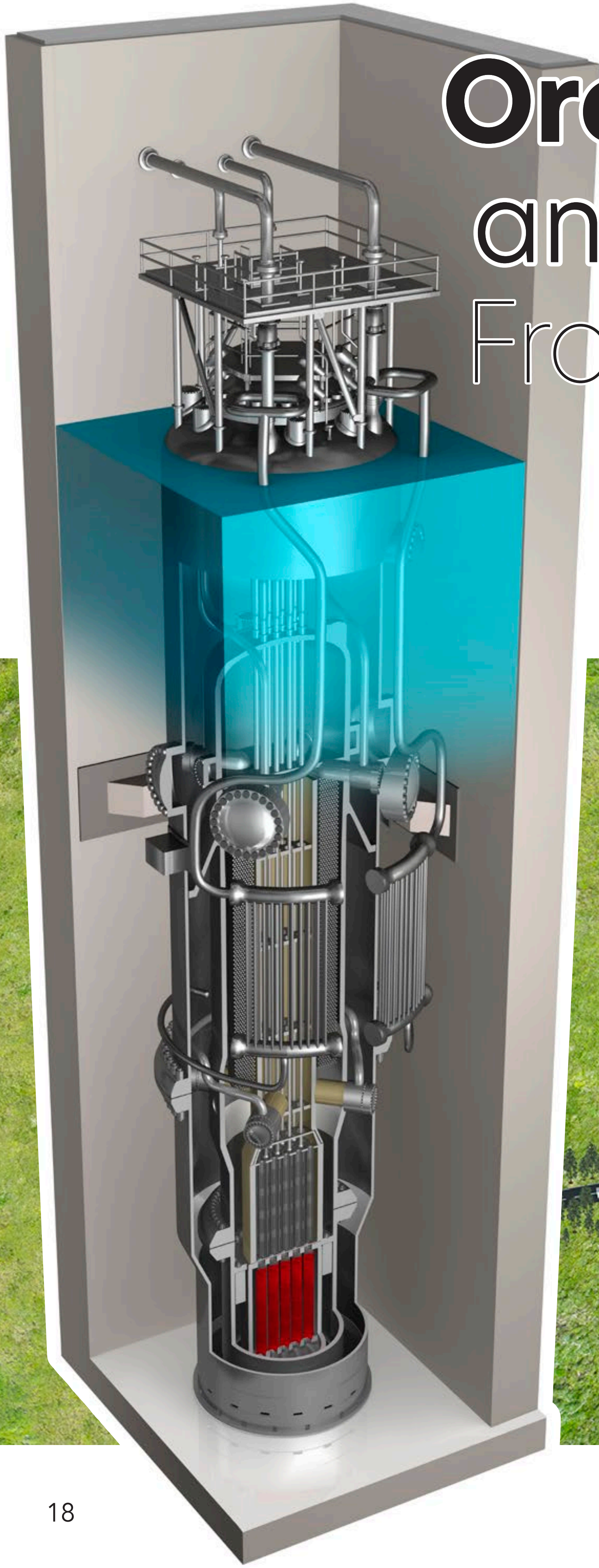
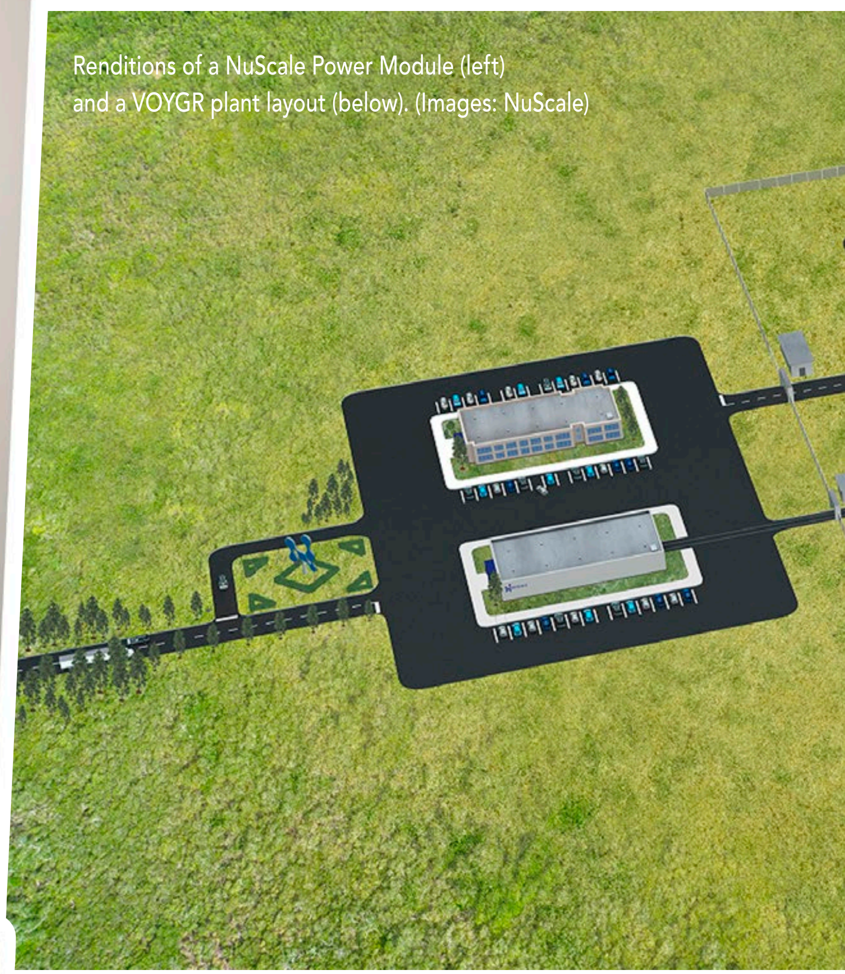
Oregon State and NuScale: From university to start-up





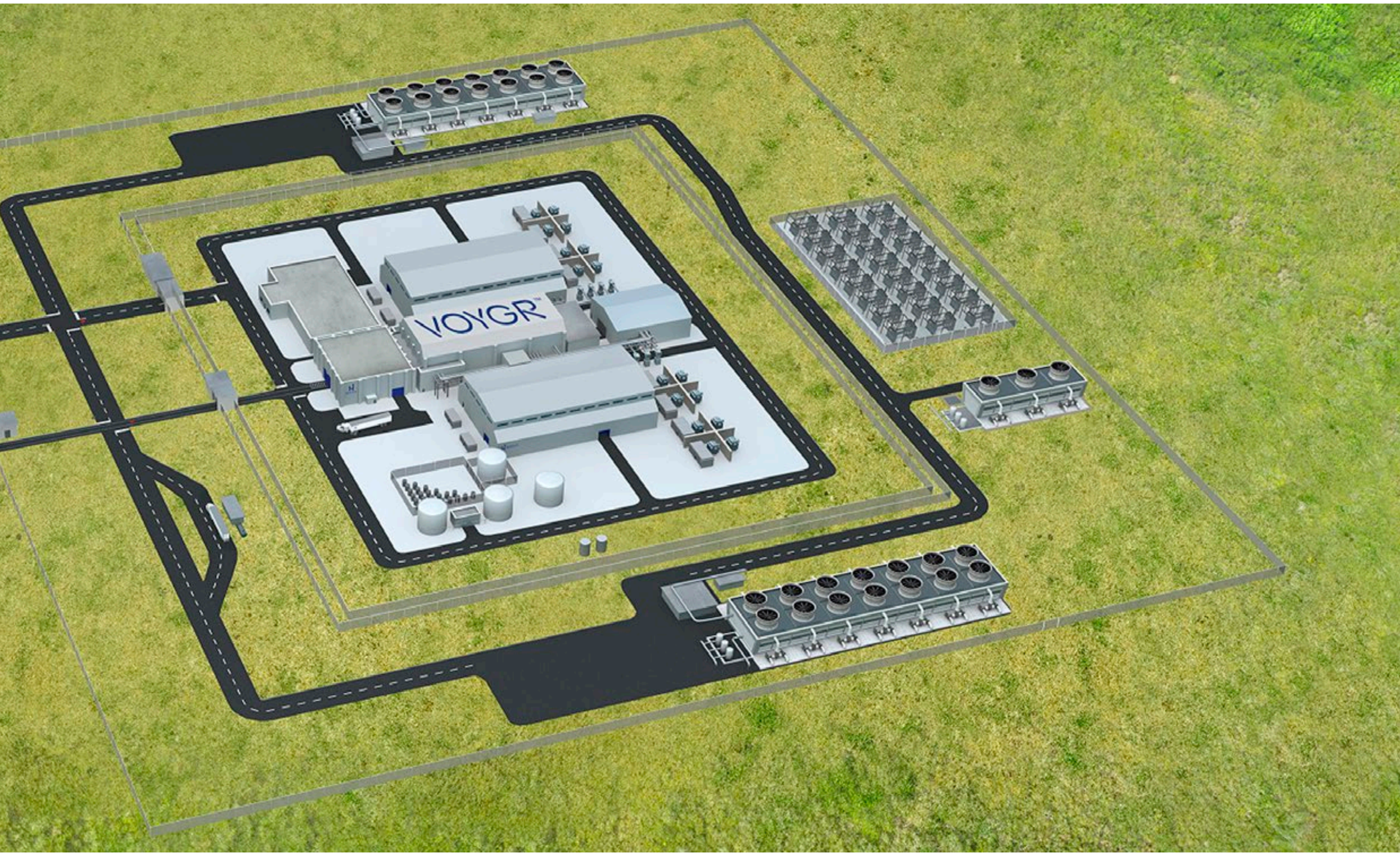
Renditions of a NuScale Power Module (left) and a VOYGR plant layout (below). (Images: NuScale)

By Brian Woods

Universities are places where professionals, experts, and students come together to teach and learn, to conduct and disseminate research, and to dream and explore. Universities have a long history of technological innovation and development. It should therefore come as no surprise that institutes of higher education have been an integral part of the recent explosion of innovation within the advanced nuclear reactor community. Universities have not only powered workforce and technology development, but in a number of cases, they have served as the actual birthplaces of today's advanced reactor designs.

In September 2020, NuScale Power received from the Nuclear Regulatory Commission a standard design approval for its NuScale small modular reactor design. The NuScale design, called the NuScale Power Module, is the first-ever small modular reactor to receive design approval from the NRC. It is a light water design that relies on natural circulation during both normal and off-normal operations. Each NuScale Power Module provides up to 77 megawatts of electricity or 250 megawatts of thermal energy. The company anticipates building plants—dubbed VOYGR—with four, six, or 12 modules, allowing each VOYGR plant to be tailored based on local needs. The first six-module plant is expected to be fully operational by 2030 as part of the Utah Associated Municipal Power Systems Carbon Free Power Project.

The story of NuScale the company, however, began many years ago. In 2005, 40,000 feet in the air, Ron Adams, then dean of Oregon State University's College of Engineering, and José Reyes, then a professor in the Oregon State School of Nuclear Science and Engineering, were chatting during a flight. The subject eventually turned to Reyes's recent sabbatical at the International Atomic Energy Agency (IAEA) and his work promoting natural-circulation small modular reactor concepts. When Reyes mentioned a design that Oregon State had previously developed as part of a Department of Energy grant, Adams encouraged Reyes to pursue commercialization of the concept.



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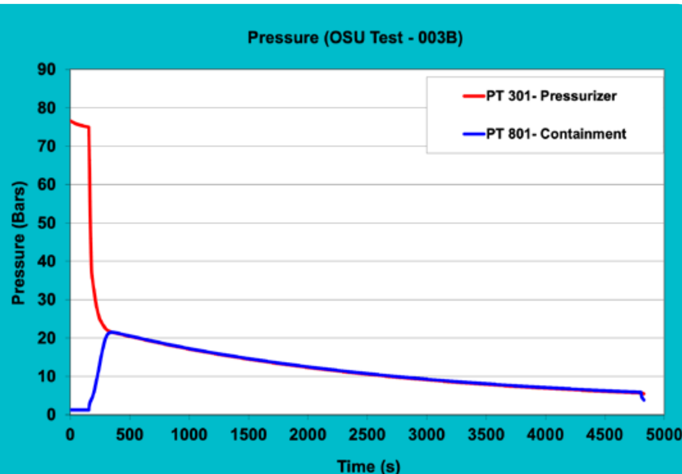
The DOE grant in question was from the Nuclear Energy Research Initiative program. Reyes partnered with the Idaho National Engineering and Environmental Laboratory (now Idaho National Laboratory) and a company called Nexant, which was part of Bechtel. The goal of the research project was to explore nuclear reactor designs using a clean slate—if we had to build nuclear power reactors now, what would they look like?

One of the major issues that the team faced was determining what size next-generation reactors should be. The group at first thought larger designs would be favorable due to their economies of scale. As the project progressed, however, it became clear that small reactor designs might offer unique opportunities for the nuclear power industry. The team followed two guiding principles: make the design as simple as possible and as safe as economically feasible. The principle of simplicity led the designers to a small reactor that operates using natural circulation during normal operations, thus having no need for pumps. The design's simplicity had significant benefits to safety as well, as potential accident types, such as a large-break loss-of-coolant accident, were eliminated by design. It also allowed the design to incorporate a containment that not only serves as a fission product barrier but also serves as an integral part of the passive cooling systems used to mitigate accident scenarios.

From this project, the Multi-Application Small Light Water Reactor (MASLWR) design was born. The general design was developed, and a scaled test facility was built at Oregon State. This test facility was one-quarter scale by height with an electrically heated core of 400 kilowatts. The researchers completed a series of three tests in December 2003, one of which was a loss-of-coolant accident that demonstrated the effectiveness of a coupled containment and reactor vessel to mitigate the progress of such an event. These results added support to the ideas espoused by Reyes.



Results from the first series of tests in the world to demonstrate the effectiveness of using an immersed containment to depressurize and cool a reactor following a loss-of-coolant accident, December 2003. (Graph: Oregon State)

In 2004, Reyes went to the IAEA on sabbatical. While there he had the opportunity to interface with representatives from a variety of countries. Many of these countries lacked a well-developed electrical grid and didn't have the capital available to develop such an infrastructure—or to build the large-scale nuclear generation assets that are common in many developed nations. Reyes realized that these countries represented a potential market for the MASLWR design. Its relatively small size would allow entities without access to large reserves of capital to get into the nuclear power market. The reactor's small size would also allow for the reactor components, including the reactor vessel and its internals, to be transported to remote locations, thus allowing the design to be used without a well-developed electricity grid. Reyes was sure he was onto something—simple and safe, but also with a market that other designs would find hard to satisfy.

This brings us up to that fateful midflight conversation between Reyes and Adams. It is one thing to have an idea—and one that Reyes was sure would have a place in the nuclear industry. However, it is quite another thing to make such an idea a reality: Reyes needed some support.

Adams connected Reyes with Paul Lorenzini, an alumnus of the Oregon State School of Nuclear Science and Engineering, to serve as a business advisor. Oregon State worked with Reyes and his team to develop the intellectual property and patents that would become the foundation for NuScale. Between 2005 and 2007, Reyes worked with Oregon State's Commercialization Program to help the venture line up potential investors. The small team also worked on refining the original MASLWR concept, coming up with more than 20 design modifications over those years.

In 2007, the team signed its first investor to land its first infusion of external funding. The investor negotiated an equity share agreement with Oregon State as well as a teaming agreement for the use of the MASLWR test facility. It was at this time that Oregon State handed direction of the venture off to the team, and NuScale Power, Inc. was born.

Reyes took a leave of absence from the university to become NuScale's cofounder and chief technology officer. The other faculty involved in the original MASLWR concept and patents all opted to stay at the university. However, the Oregon State–NuScale partnership continued to flourish after the founding of the company. The original MASLWR test facility was modified and renamed the NuScale Integral Systems Test (NIST) facility. It has since been modified a second time, and the current version of the facility is named NIST-2. Since 2007, NIST-1 and NIST-2 have been crucial components of NuScale's data collection program. Oregon State has a long history of collecting data for design and licensing applications under a quality assurance program (NQA-1) accredited by the American Society of Mechanical Engineers. However, this was the first time the university was involved in the testing of a design so early in its development.

"The NIST program provided an ideal arena for students to apply their learned knowledge for industry applications," said Qiao Wu, an Oregon State professor who is also one of the original NuScale patent holders. "The program supported four graduate and five undergraduate students annually during the peak years, working with professionals including utility reactor operators and quality assurance officers."

Beyond NIST, Oregon State has supported NuScale in a variety of experimental and computational research projects. In 2020, the NuScale Energy Exploration Center (E2 Center) was commissioned at the university. The E2 Center is a state-of-the-art simulator of a NuScale small modular reactor power plant control room, allowing users to take on the role of a control room operator at a 12-unit plant. The E2 Center offers a hands-on learning opportunity to apply nuclear science and engineering principles through simulated nuclear power plant operation scenarios.

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The NIST facility at Oregon State University. (Photo: Oregon State)

The NIST research team, 2017. (Photo: Oregon State)

Oregon State's relationship with NuScale has changed as the company has grown. One thing that hasn't changed is the personal connection between the two. NuScale now boasts over 460 employees, many located at the NuScale engineering headquarters in Corvallis. Over the years, many Oregon State graduates have found their way over to NuScale and now occupy important positions in the organization. The two entities also partner on a strong internship program. Although the program is open to all, many Oregon State students have gotten their starts as engineers in the NuScale internship program. When speaking with Reyes, he believes that the entrepreneurial spirit that pervades Oregon State has also been brought to NuScale, helping them in their drive to change the nuclear power industry.

"NuScale and Oregon State have been on a remarkable journey," said Reyes. "We share a vision born of innovation, made real by passion and steadfast dedication, and poised to solve the greatest engineering challenges of our times. Not only shall our efforts flourish, they shall create a legacy that will benefit humankind for generations to come."

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The NuScale Energy Exploration Center at Oregon State. (Photo: NuScale/Oregon State)