INL researchers develop strategies to keep today's nuclear power fleet profitable

By Cory Hatch

In the 1960s, nuclear energy established itself as a mainstay of the electrical grid for its ability to produce carbon-free, safe, and reliable power. Indeed, nuclear energy currently provides about 50 percent of carbon-free electricity in the United States, but a major challenge is its cost.

Since the advent of hydraulic fracturing, low-cost fossil fuels have put pressure on the nuclear power industry to remain competitive. As a result, some nuclear plants have struggled to remain profitable, because the wholesale price of electricity does not cover maintenance and operation costs.

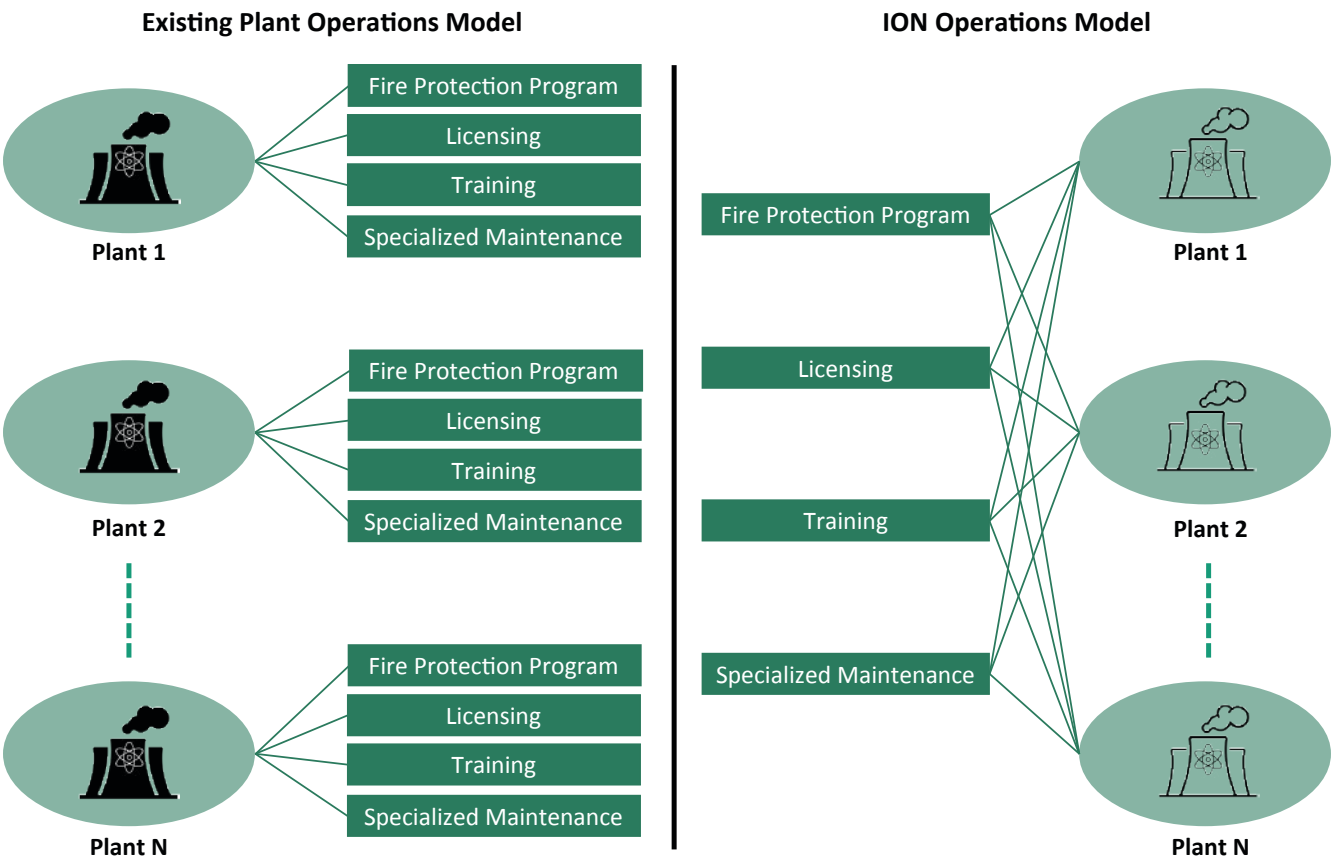
Staying afloat

Experts say that the U.S. nuclear fleet could shrink by 40 percent in the next 5 to 10 years—a major blow to the nation's efforts to curb carbon emissions and reduce the impacts of climate change.

To help the industry remain

The Human Systems Simulation Laboratory at INL allows researchers to simulate industrial control rooms to improve performance. (Photo: INL)

Continued



Comparison of existing nuclear power plant operating model with ION. (Source: INL)

competitive, researchers at Idaho National Laboratory have developed Integrated Operations for Nuclear (ION), a methodology that uses technology innovation and common-sense business practices to lower maintenance and operation expenses of U.S. nuclear plants.

ION's goal is to reduce the expenses of existing nuclear power plants by 30 percent by deploying first-generation technologies within three to five years. This cost reduction will help nuclear plants compete with electricity generated by other sources—especially the relatively inexpensive electricity produced by gas power plants. Beyond that, the hope is to apply ION's principles to advanced reactors and small modular reactors, ensuring that the next generation of nuclear reactors is profitable, safe, and cost-effective.

Researchers at INL calculated the levelized cost of electricity (LCOE)—the average revenue per unit of electricity generated necessary to meet the costs of building and operating a generating plant—for today's nuclear and gas power plants and found that the LCOE of nuclear plants is between $25 and $32 per megawatt-hour, compared with roughly $18 to $58 per megawatt-hour for a gas power plant, depending on the price of fuel. If utility owners and operators implement ION, researchers estimate that the LCOE of nuclear power plants could be reduced to roughly $18 to $22 per megawatt-hour.

"ION answers the question, How do you strategically innovate?" said Craig Primer, plant modernization pathway lead for INL's Light Water Reactor Sustainability Program. "How do you prioritize your modernization projects to ensure a winning combination that keeps your plant cost-competitive? ION lays the groundwork necessary to both identify target operating costs and the process to develop that winning strategy."

Borrowing ideas

The business world is littered with industries—think video chains and mega bookstores—that failed to adapt to changes in culture or technology and paid the price, according to Jason Remer, lead researcher and industry liaison for ION at INL. "The nature of business changes," he said. "If a new technology comes along, are you going to adopt this technology or are you going to become stagnant?"

To develop ION, Remer and his colleagues looked to outside examples of organizations that drastically reduced operation and maintenance costs. Specifically, they modeled their strategy on an oil and gas company that operates an oil platform off the coast of Norway. The Norwegian company worked with a team from the Institute for Energy Technology in Halden to help

address declining revenue. The team took a systematic look at the operation and instituted four types of changes: technology, process, governance, and people.

As it turns out, the company was paying for personnel who didn't necessarily need to be on the platform—and the hotel, food service, and transportation costs for these employees were expensive.

"They moved everything off the platform that didn't need to be there," Remer said. "Then they laid high-speed fiber-optic cable so that some personnel could perform some of their duties from shore. Instead of hiring full-time staff for services and maintenance, the oil rig contracted out some of these jobs, which resulted in more experienced people servicing multiple platforms."

"Production platforms that had a staff were now monitored remotely, and maintenance crews would fly out when needed," Remer continued. By applying simple, mature technologies and sensible business practices, the organization was able to transform its operations and significantly reduce costs.

Working with utilities

Instituting a similar philosophy to nuclear power plants could mean the difference between a profitable business and a plant closure.

Since 2019, Remer and his colleagues have worked with nuclear plant operators such as Xcel Energy to implement ION concepts. "We're trying to help our utilities drop their operation and maintenance costs by about a third," Remer said. Xcel Energy has begun implementing ION at two of its nuclear power plants—Monticello and Prairie Island, both in Minnesota—according to Gene Foote, Xcel Energy's director of nuclear strategy and performance. "We had gone through a phase where our performance was not up to standards," Foote said. "We had to improve performance and cut costs. We had to do something dramatic."

Prompted by Tim O'Connor, who is now Xcel Energy's executive vice president and chief generation officer, Foote and his colleagues began working to implement ION at the two plants. "In addition to reorganization and centralization of our operations, we began going down the path of integrated operations," Foote said. "That's where we began to see some real improvement in our performance."

One example of a change at the Xcel plants is the implementation of "electronic work packages." Instead of manually performing and documenting a procedure, electronic work packages allow a worker to perform a maintenance procedure using a tablet device that coordinates and tracks the work.

"If the electronic work package sees a value that is outside the criteria, it will alert you and sometimes write a corrective action report," said Foote. "It also allows a manager to automatically spot where the workers are in the procedure. A lot of the administrative burden is relieved from the worker and supervisor, and you don't have that administration at the back end to get these things closed."

Within the first three years of implementing changes through ION, Xcel Energy substantially reduced its operations and maintenance costs and has become one of the top-rated nuclear corporations in the United States. ION was so helpful that O'Connor has taken some pieces of the ION process to the rest of the company, specifically, streamlining and centralizing training programs.

In the future, Xcel hopes to take ION even further. Foote noted that "we haven't gone after things like digital architecture or digital control rooms because we're waiting on an extension that will allow our nuclear plants to keep operating for another 10 years. Then we'll certainly explore some of those longer-term technologies."

Digital and nondigital innovations

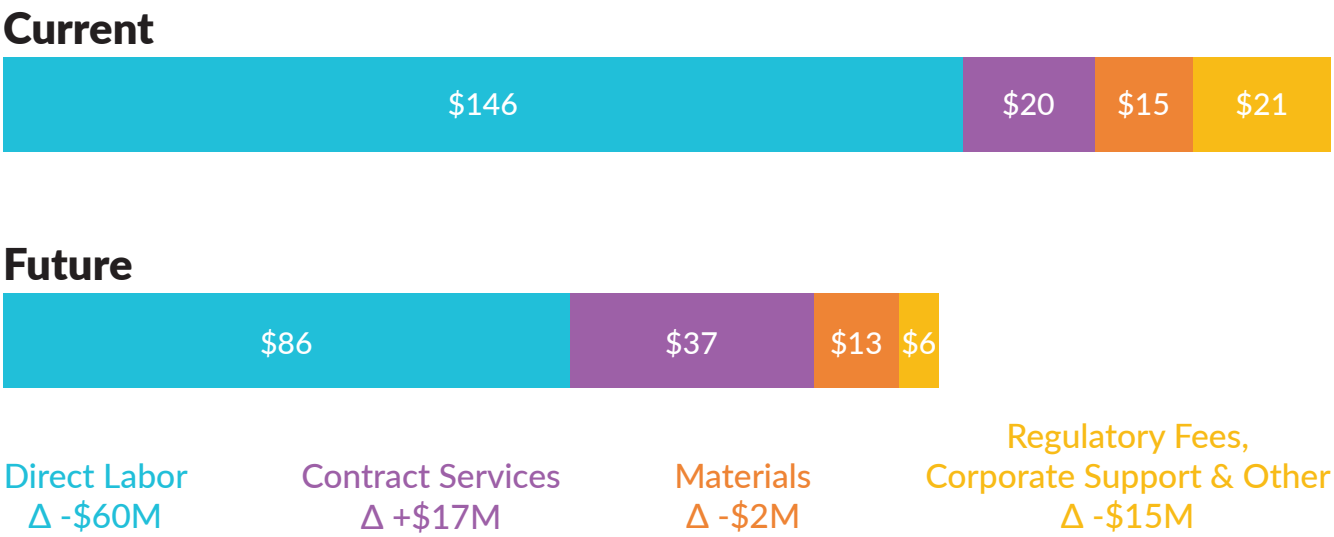
Today's nuclear energy industry has done a good job adopting some new technologies—advances in materials and fuels have helped nuclear plants drastically reduce downtime while increasing safety, for instance. But industry has been slow to embrace other technologies, such as digital control systems, which can save on staffing and increase safety.

"Analog systems are technologies from the 1960s or 1970s," according to Remer. "They're very reliable and safe, but they're not being made anymore, so it's difficult and expensive to get parts. They take a lot of maintenance."

Digital systems, on the other hand, have monitoring and self-reporting systems that reduce the need for the intensive testing that analog systems require. These systems can also help attract new talent, as universities for the most part train nuclear engineers on state-of-the-art digital systems. "We're having trouble, however, hiring engineers out of school because they're trained on digital, but they're being asked to work with analog," Remer said. "With digital control systems, you can give them an environment at the nuclear plant that is similar to what they understand and eliminate tasks."

Some nuclear plants have clung to operational

Continued



Current and future operations and maintenance cost structure. (Source: INL)

procedures that certain digital technologies can render redundant or obsolete. This leads to another technology-based solution—a combination of artificial intelligence and advanced sensors—that can help plant operators monitor equipment remotely and repair equipment only when needed instead of on a set schedule.

Like many of the innovations implemented at Xcel Energy, streamlining unnecessary or redundant regulatory activities can result in big savings. Tasks such as manually filling out reports can often be reduced or eliminated. Remer and his team are striving to find the best ways to meet requirements while still ensuring safety.

For example, a digital control system might allow a nuclear plant to automate chemistry sampling. "An employee might require personal protective equipment—such as safety goggles—to perform this task," Remer said. "Then there's data entry needed after the sampling is complete. If you have an electronic sampling system, those procedures go away completely."

For all its benefits, the latest technology isn't always the answer. Plants are unique and need to be assessed on a case-by-case basis to maximize cost savings and profitability. "If you don't look at it holistically, you can add costs when you add digital equipment," noted Remer. "We have to start with each utility at a different place. It's not one-size-fits-all."

One such low-tech solution is personnel changes, which can result in big savings. Like the moves implemented for the oil rig, some jobs at a nuclear plant can be accomplished remotely or by subcontracted experts. For example, to maintain the diesel generators that a nuclear plant uses for backup power, the plant might hire full-time staff. "We would only work on the generators once every five years, and yet we would have to keep maintenance staff on for years and years because they knew how to rebuild it," Remer said. "Is there a company that is an expert in maintaining diesel generators?" He continued, "ION asks the question, What are you in business to do? We're in business to make power out of neutrons. What kinds of things are not part of our primary mission anymore?"

Meeting costs

In the end, it's all about meeting the cost of electricity that's needed for a plant to stay in business. "What are all the things that we are doing and what can we eliminate, automate, or modify?" Remer said. The ION team at INL can help answer those questions and find solutions that work for a utility's specific needs. As Remer said, "It's just a different way of doing business. It's not an unusual business process, but for nuclear, it's revolutionary."

Cory Hatch is a science and medical writer under contract with Idaho National Laboratory.

About Idaho National Laboratory

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development and also performs research in each of DOE's strategic goal areas: energy, national security, science, and the environment. For more information, visit www.inl.gov. Follow us on social media: Twitter, Facebook, Instagram, and LinkedIn.