ANS UTILITY WORKING CONFERENCE

A look back, a look ahead

IT'S NOT SURPRISING that at a conference of industry leaders, leadership itself was on many people's minds. Leadership, several speakers contended, will be an especially significant area of the industry in the coming years.

"It is one of the challenges that we have over the next decade—bringing leaders into our industry, developing them through our programs, not only in the industry but in the NRC [Nuclear Regulatory Commission]," said Marvin Fertel, the Nuclear Energy Institute's chief nuclear officer, during the plenary session of the very well-attended ANS Utility Working Conference, held August 3–6 in an idyllic ocean-side resort in Amelia Island, Fla. "We're going to see a tremendous turnover of people and we're going to lose a lot of experience and we're going to lose a lot of leaders. It is a major challenge that we face over the next decade."

The following day, Don Price, who works for Chicago-based Navigant Consulting, noted the differences he has seen emerge in industry leadership over the past two decades. "One of the biggest changes that I've seen over the years in the industry has been the emergence of, the more emphasis on, better leadership. If we think back 20 years, there were plant managers and chief nuclear officers, who aren't here now, who really weren't very good people persons or managers," Price said. "And I've seen [recently] what I think of as the better managers, the ones who have risen to the top over that time. I think that's part of the reason that performance is better, that INPO [Institute of Nuclear Power Operations] index numbers have been getting better."

Almost a year-and-a-half later, however, the industry still remains shaken by the March 2002 Davis-Besse incident, in which boric acid was found to have corroded a softball-sized pit in the reactor vessel head, leading to the kinds of loss of public confidence and extended shutdowns the industry had hoped were in its rearview mirror. Many speakers, one way or another, touched on the experience.

"The question I get asked probably more than anything else is, 'Do we have to worry about other Davis-Besses out there? Are there issues that are going to crop up that are going to lead to extended shutdowns of a unit and the kind of residual credit uncertainty that we've seen for FirstEnergy, based upon the extended outage for Davis-Besse?'" noted onetime NRC commissioner James Asselstine, who now works for the financial firm Lehman Brothers.

An especially significant area of the nuclear industry in the coming years is bringing in and developing new leaders.

But the allure of possible construction of new nuclear power plants in the coming years was foremost on the minds of speakers at the meeting. There was optimism, but it was guarded, cautious optimism.

"You really have to have realistic expectations," Fertel cautioned. "It's a business decision. It's not a religious experience. Companies are going to make business decisions on new plants. What we need to do is make sure that the conditions are right to facilitate those business conditions. We think we're getting there. But they're not going to happen overnight."

In all, there were 25 sessions during the conference. There were specialized tracks for business, engineering, maintenance, operations, regulatory relations, and supply chains. Following are some of the highlights from the three-day conference.

10 years past, beyond

Marvin Fertel's perspective on the past 10 years of the nuclear industry focused on two parts: 1993–1998 and 1998–2003. In those first five years, senior management at utility companies was more experienced than it is now. The CEOs in almost all of the large utilities had come up through the ranks of the nuclear programs, Fertel said. "The chief nuclear officers moving up had a lot of experience and were pretty dynamic guys. We saw a lot of attention at nuclear plants to senior management," Fertel said.

Fertel

There was also a swing toward improved performance at many plants, although there was still much work to be done. Coming into 1993, there were seven plants on the NRC watch list, Fertel said. And the 1993–98 period saw more than a dozen plants shut down for over a year, he noted.

In the electricity business, the industry began moving from government regulation to competition. The 1992 Energy Policy Act resulted in wholesale competition in electricity markets across the country. Led by California and Michigan, states began moving toward retail competition. "It was pretty chaotic. What it did was it started to help nuclear plants, but really almost set up a dysfunctional electricity market for us that we live in today," Fertel said.

But in the mid-1990s, Fertel said he didn't share the rampant concerns about shutdowns because of large stranded costs. On the contrary, plants without large stranded costs were in most danger of shutting down. "From a business standpoint, if I have $5 billion invested in a plant and had to write $4 billion off in order to keep the plant operating competitively, would I then shut the plant down? That doesn't seem to make sense—I just wrote off $4 billion. The company may go bankrupt. If I were the CEO I might get fired. But the plant wouldn't shut down.

"The plants we thought were at risk during that period were the small plants that didn't have a lot of stranded costs, where a CEO may decide, 'I don't need a headache of a nuclear plant. I'd rather get rid of it and shut it down so I don't have to write a lot off. . . .'

"So, we thought the paradigm was a little messed up in the way that people were attacking nuclear at the time. It didn't bother us because they were shooting at the wrong target. We knew the plants with the large stranded costs would survive if not treated fairly. And, ultimately, most of them have been treated pretty fairly."

Continued

In 1998–2003, "things got a lot better," Fertel said. This period has been experiencing a shift to a more more risk-informed, performance-based, safety-focused regulatory process. "It has, in essence, allowed for the consolidation we've seen in the nuclear industry," Fertel said. "I'm not convinced we would have seen companies buying plants . . . if they thought the oversight process was still susceptible to watch-list, troubled-plant behavior. There was just too much uncertainty, too much risk for companies to make those decisions."

There has been an upswing in financial community confidence in the nuclear industry in the past five years, Fertel said, owing chiefly to the safe and reliable operation of nuclear power plants during this period. But that confidence remains fragile, he emphasized. "I can tell you that after the Davis-Besse event, we spent the next two to three weeks in conference calls with the financial community—calls that had 150 people on them—trying to explain to them the significance of that event, its implications for other events, and what we thought happened, what NRC was doing to assess the situation, what the industry was doing to assess the situation," Fertel explained.

As far as the next 10 years, a portion of the industry's efforts should focus on preparing for the next energy bill, which is expected to be passed in a decade or so. It will be important that the leaders in Congress 10 years from now have a good understanding of the value and benefits of nuclear energy, Fertel said.

He said he believes there will be an increased focus on climate change and air pollution mitigation in the coming decade. With more stringent requirements on carbon emissions, the nuclear power industry may be able to reap some rewards. "It's going to actually change for the better for nuclear by either increasing the cost of our competition or allowing us to play in that arena in a way that we can be more constructive," Fertel said.

The most important objective for the industry, however, is to continue safe and reliable operation, Fertel said. "The one thing to keep in mind is that as you reach your plateau of excellence, the only thing you can do is fall off. You have to really focus to stay there. And maybe it's not fair. But in the industry we work in, the environment we live in, any drop-off in our performance has more significant implications for us than maybe it should. . . . So, maintaining focus on safe, reliable operation is absolutely the most important thing we can do."

Creating investor confidence

Nuclear power has a positive role to play in the more volatile, competitive marketplaces that are emerging today, said James Asselstine, director of high-grade credit research at Lehman Brothers, during the plenary session. Although the experiences of the 1980s and 1990s taught investors to be wary of the nuclear industry, more recently investors have come to realize that nuclear units can be attractive and valuable assets as the industry moves toward a more competitive marketplace across the country, he said.

The nuclear industry's restructuring efforts over the last decade or so are among the leading factors affecting why investors perceive the industry in a more positive light. Among the benefits of the transition to competition has been the quieting of concerns over stranded-cost recovery. "I think most of those issues have really been put to rest at this point. The utilities have fared well in their ability to recover stranded costs for the nuclear units," he said. Also, more than one-third of the industry-wide $40–45 billion decommissioning costs have already been collected in the period of regulated operations, and incremental recovery of the remaining decommissioning costs have been passed on to ratepayers, Asselstine noted. And the business realities of a competitive marketplace have driven the extensive consolidation the industry has undergone in recent years, which has led to greater economies of scale and greater ability to capture the operating strengths and strategies of stronger performers within the industry. "We [the financial community] tend to believe that larger organizations may be better equipped and better staffed to cope with individual plant challenges if and when they occur," he said.

Nuclear power enjoys a number of advantages compared to its competitors. Low and stable costs have characterized the industry in recent years. Nuclear is also a relatively clean technology compared to fossil fuels, and so is not subject to uncertainties about new environmental cost requirements. And many nuclear units are in regions where they are needed to maintain reliability of the electricity grid. "My take on the economics for a well-run single nuclear unit is about 2 to 2.2 cents per kilowatt-hour, total," Asselstine said. "And large multiunit sites appear to be able to do better than that. That makes nuclear quite competitive, in terms of the existing assets on a variable cost basis, with other alternatives, including both coal and combined-cycle natural gas."

Nonetheless, there are some serious issues that investors remain concerned about. Foremost, on the heels of the Davis-Besse incident, is the question of material condition. Asselstine stressed that continued vigilance of material condition issues is of "critical importance" to maintaining the positive investor sentiment that the plants have today. Also, spurred by the controversies surrounding Indian Point station in New York, investors have questioned whether emergency preparedness may prove to be a new uncertainty for plants. "We're all watching the events as they've unfolded, both at the state level and more recently at the NRC and FEMA [Federal Emergency Management Agency], to determine whether we are going to see some additional or incremental uncertainty," he said. And continuing plant security concerns have investors wondering whether there may be an unforeseen steep rise in costs at some point in the future, he noted.

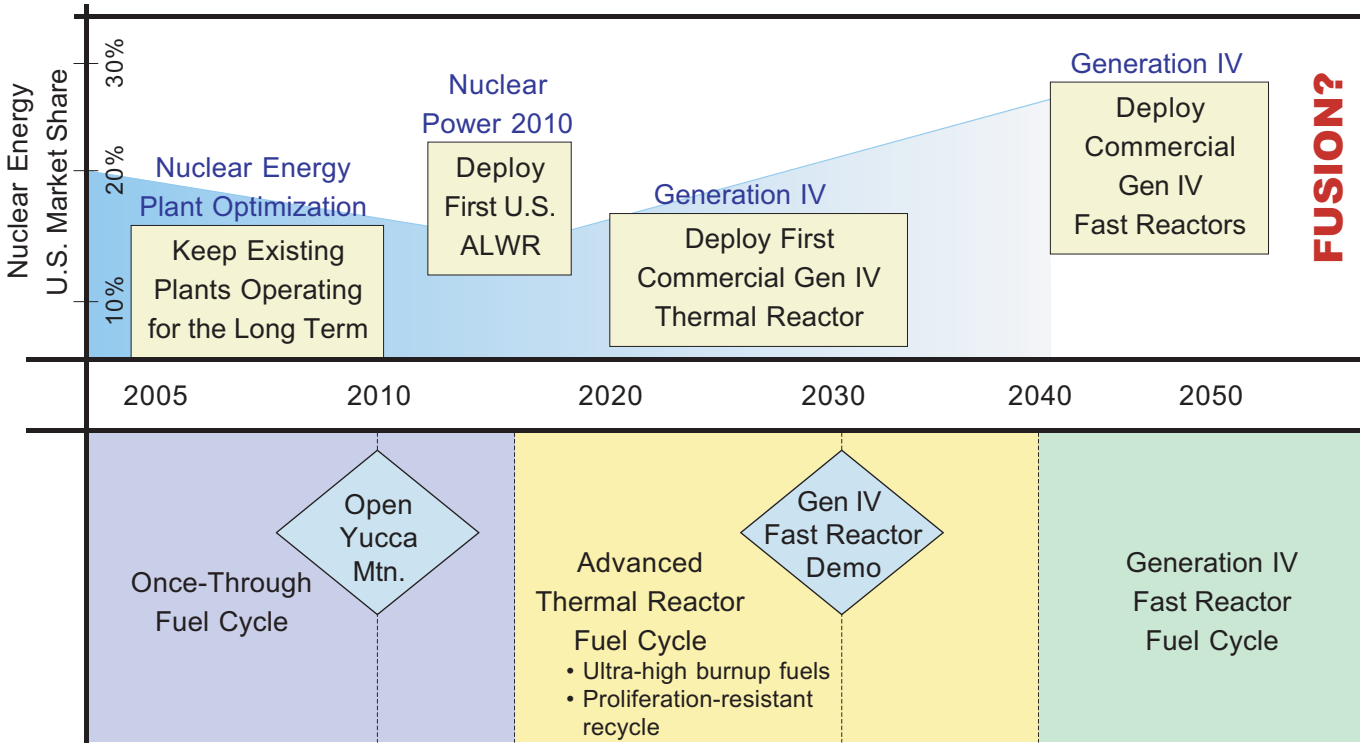
For the financial community to invest in new nuclear power plants, they simply must be competitive with the alternatives. Commitments to new nuclear plants will be "purely and simply" a business decision, Asselstine emphasized, and the plants must make economic sense compared to the alternatives. A new nuclear power plant will have to be delivered at around $1100 per kilowatt if it's going to compete with combined-cycle gas, which typically costs about half as much, he said.

But the industry's ability to provide assurance for a predictable cost and schedule—that at the end of the day, it can deliver a plant at $1100 per kilowatt—is a key issue in turning new plant construction into an attractive investment. And proving that the new, largely unverified licensing process is viable will also add to the attraction of building a new plant. "The big area of residual uncertainty really is the combined operating license. And that's where investors, given the experience of the '80s—and quite frankly the companies as well—have the greatest concern and anxiety: the ability of the licensing process to introduce delays in operation of the plant once construction is completed. And that uncertainty will exist until we work through the first few applications," Asselstine said.

Generation IV technologies

When President Bush and his staff began to formulate what would be the National Energy Policy, nuclear power was not seen as a major portion of the nation's energy mix, noted Bill Magwood, director of nuclear energy for the Department of Energy, during the plenary session. (In a first of sorts, Magwood gave his presentation by telephone, after stormy weather on the East Coast had canceled numerous flights out of Washington, D.C. "It's a pleasure to see so many familiar faces in the audience today," he quipped at the opening of his presentation.) But after noting that most growth by 2025 was scheduled to occur in natural gas and coal industries, and that electricity fuel imports would increase by 75 percent in that time, nuclear power began


Magwood



Generation IV: Magwood outlined the Department of Energy's plan for nuclear power plants through the middle of the century.

to play a greater role in the plan. By the time the report was released in May 2001, it recommended expanding nuclear energy in the United States as a major component of the nation's national energy policy. "It was only after people began to look at the reality of the situation—that we were on a course to import more of our energy, on a course to become more and more dependent on natural gas—that nuclear really became an important element of this," Magwood said.

So it is crucial not only to maintain the existing plants, which have proven to be safe and cost-effective, over the long term, but to begin replacing them with new advanced light-water reactors, Magwood said. The DOE's Nuclear Power 2010 program was undertaken with this objective in mind—to begin building new ALWRs by the turn of the decade.

And looking even further out, Generation IV technologies will reach a stage in the coming decades when they, too, can become a reality. "We believe these can be deployed as early as 2020, but more likely toward 2025," Magwood said. Working with nine other countries, DOE has identified several Generation IV systems that the international community believes hold the greatest promise and that are deployable by 2030.

The Department of Energy has divided Generation IV technologies into two categories. The first, thermal neutron systems, use advanced, high-burnup fuels and should be available by 2020. One of these so-called Gen IV-A systems, called the Next Generation Nuclear Plant, will be based on very high-temperature reactor technologies, with a coolant outlet temperature above 1000 °C. This will provide for highly efficient production of hydrogen using thermochemical water-cracking technology. "We're very, very interested in these technologies, and we expect that this will be the cornerstone of most of our effort over the next decade," Magwood said. There is currently a proposal before the Senate to build a demonstration reactor in Idaho.

Another Gen IV-A system under consideration is the high-temperature, high-pressure Supercritical Water-Cooled Reactor, which is generating more excitement in foreign partners, Magwood said. Although it does not look dissimilar from many water-cooled reactors in use today, the system presents significant materials challenges, he said. "We think this could potentially be a transition to Gen IV technology from existing technology that could be integrated well into the existing fleet of reactors."

The other, Gen IV-B reactors are based on fast neutron systems and use proliferation-resistant, closed fuel cycles that will help minimize the long-term stewardship burden. These systems won't be available until around 2040, Magwood said. One example is the Gas-Cooled Fast Reactor, which could provide a way of both producing hydrogen in high-temperature reactors and retaining the ability to recycle the material in a fast-reactor fuel cycle, Magwood said. "This is one that we in the U.S. don't have a great deal of experience in. But there are some interesting aspects of the Gas-Cooled Fast Reactor that we believe are worth exploring."

The Lead-Cooled Fast Reactor is another Gen IV-B system. It offers the possibility of a very long-term core life, Magwood noted. "Some of the initial estimates indicate we could have core lives of up to 30 years if we design reactors in the right way. So, the proliferation benefits to that are obvious. It's worth some exploration."

For Generation IV technologies to be realized, Magwood believes it is essential for the United States to work with the international community and provide leadership in pulling the countries together.

In the meantime, the DOE is interested in exploring a wide range of nuclear energy production technologies, he concluded. "We think there's a role for both the nearer term technologies, with thermal reactors, particularly light-water reactors. But we also think fast reactors have a role for the future. And we expect to be working with the international community to explore those technologies."

The go/no-go decision

During a session in the regulatory relations track, titled "Future Nuclear Power Plants," NEI senior director of new plant deployment Ron Simard opened his talk on the outlook for new nuclear power plants by outlining some of the business risks of building new plants. A CEO thinking about building a new nuclear power plant is looking at making a large capital investment—$1 billion or $2 billion—that's going to be exposed for a fairly long period of time,

Simard said. In order to get that money back, the company will have to float debt and issue stock, which will dilute the earnings per share.

And, to say nothing of operational risks, the construction risks are as yet undetermined. "The technology is mature, but the business environment is new and uncertain," Simard said. The 103 plants that are running today were built in a cost-of-service environment, where the capital investment was recovered through a rate base. "The rate at which you recover that capital . . . is suitable for that type of environment, but not for the new competitive business environment that we're going into," he said.


Simard

In essence, the perceived risk for constructing the next nuclear power plants needs to be no greater than investing in the alternatives, like combined-cycle plants, Simard said. "As a matter of fact, it probably needs to be better. I've heard one CEO say, 'Well, if they were equal—if my risks, my rate of return and all were the same—on a new gas plant, why would I build nuclear? Why would I want that headache?' So, we need to even beat that bogie."

In order to encourage power companies to build nuclear power plants, there must be consistencies in the cost and construction schedule of plants in order to give confidence that they can be brought to market on a predictable timetable. Several utilities and the Department of Energy are currently studying advanced construction techniques to verify that three-year construction schedules are achievable, Simard said. "The overarching objective that we're trying to achieve here is we're trying to bring new nuclear plants to market in something like six years or less. In other words, that amount of time where you first have to make that significant commitment of capital [up to] the closing of the breakers, it needs to be no worse than six years."

Also, the new 10 CFR Part 52 licensing process—which aims to resolve design safety and site suitability issues before significant amounts of capital are invested—needs to be validated to make construction of a new nuclear power plant attractive to utility CEOs. That process is under way, with the first early site permit applications having been submitted by Entergy, Exelon, and Dominion. Also, three reactor designs have been certified by the NRC, with six more being looked at, Simard said.

He emphasized that the NRC's development of efficient and predictable means of verifying ITAAC (Inspections, Tests, Analyses, and Acceptance Criteria) will go a long way toward reassuring potential investors. Under Part 52, if the NRC has certified the safety of the design and established the suitability of the site in a combined license, then any postconstruction hearings can focus only on whether the inspections, tests, and analyses have been done and the acceptance criteria have been met, Simard explained. "You'll see a heavy emphasis on ITAAC because this is really the key to being able to assure the industry, the financial community, the public that the construction is a process that is not going to raise the kind of fundamental questions that we've run into in the past."

Simard said NEI is working on a standardized guidance document for license applicants. The document will guide applicants on what they need to do to assemble an application, what the NRC is going to need to see, and what resources applicants are going to need to file an application. "The overall objective by the end of next year [is] to have in place revision zero of a standardized COL [combined operating license] application guideline document, along with pretty good cost and schedule estimates that will feed into business decisions," Simard said.

A questioning attitude, in which workers "expect success, but anticipate failure," needs to be instilled.

"We're looking ahead two to three years from now. There are a handful of power companies who are working toward being able to make a go/no-go decision in that period of time. So, our overarching objective is to help them make that decision, to enable that decision by taking out as much uncertainty and addressing as much risk as we can."

Sustaining plant performance

A 1998 study conducted on nuclear plants that were placed in extended shutdown found that one of the primary causes was lack of critical self-assessment, noted James Lash, general manager at FirstEnergy Nuclear Operating Corp.'s Beaver Valley station, during the session, "Operational Learning in a Success Environment." "We own one of those plants right now, Davis-Besse. Everybody knows about it. And I had a front-row seat during the 1990s at that power plant. I can tell you that's a valid conclusion about what can get you [into an extended shutdown]." Likewise, a 2001 assessment of plants considered excellent by the Institute of Nuclear Power Operations found that those plants made a habit of critical self-assessment, Lash noted.


Lash

Establishing critical self-assessment attitudes in workers is one of the key elements of both improving and sustaining performance at a nuclear plant, Lash said.

That was one of the objectives FENOC had in mind when it first acquired Beaver Valley station in an asset swap several years ago. Because the previous owners were looking to get rid of the plant, there was a short-term focus on plant operations. The facility had degraded somewhat, and the backlogs were high. In 2000, the plant's maintenance training programs were placed on probation. And, perhaps worst of all, the station had not maintained its engagement with the rest of the industry, Lash said. "My boss would tell you this was the biggest problem at the station at the time. He would say, 'Beaver Valley had become isolated.' That is a problem, as we've learned many times over—that when you do not keep pace with the industry and do not keep an eye on your peers, you fail to see where improvements need to be made in your own station," Lash explained.

"When I first set foot on the property, I took an operator around and asked the man who had been at the plant 23 years if he'd ever been at another nuclear plant. The answer was no. And he was representative of a number of folks at our plant. We've worked hard in the past few years to turn that around."

Plant management must engage the workforce in order to sustain performance, Lash said. Workers are the most critical tool in identifying and improving plant performance. "They're much closer to [equipment] than I am," he said. "They're out there putting their hands on the equipment. They're using the work documents. They're using the drawings. They're using the procedures. So, their feedback is extremely important."

A questioning attitude, in which workers "expect success, but anticipate failure," needs to be instilled, Lash said. Such an attitude can lead to a sense of ownership of the plant among workers, as well as to increased accountability. "I want everybody that touches a power plant to be uneasy about what they're doing. Because if they're not uneasy, they're probably complacent. They should be out there antici-

pating failure and being prepared for what could happen and what could happen wrong," he explained.

Perhaps the most important tool for improving plant performance is worker training. "Our folks can't help us improve in the area of human performance, they can't help us improve our organizational aspects of how we run our plants, if they haven't been adequately trained and given the skills," Lash said. "That goes without saying. Training is good business because it enables our folks to . . . feed back to us how well we're doing in a given area."

Among the ways Beaver Valley has used training programs, the plant negotiated with the local International Brotherhood of Electrical Workers to tie advancement and pay to training and qualifications. "So, that gets their interest in wanting to advance their training and knowledge," Lash said. To keep people fresh, the station rotates assignments between the line and the training organization on a regular basis. And the station makes good use of task-specific, just-in-time training. "The operators ask for it—not only the operators, the maintenance guys ask for it. We replaced a . . . valve on our RHR [residual heat removal] system in the last refueling outage in Unit 1. [The maintenance workers] wanted just-in-time training on how to do that job. Our operators have done just-in-time training on how to shut down and restore the unit to operation. And it has been a success for them," Lash said.

"Our workforce is our most important tool for sustaining performance. In order to improve human performance at our station, we need to improve the performance of our people. I think we all understand that."

Transferring critical knowledge

In the same session, the Tennessee Valley Authority's manager of workforce planning Ed Boyles outlined the company's program for maintaining the critical skills for safe plant operation by transferring important knowledge from retiring workers. Early in the summer, TVA won *HRMagazine*'s Innovative Practice Award for the program.

TVA—which employs more than 13 000 people (including 2900 nuclear-related workers) and is the country's largest public power producer—has refined a technique for measuring and retaining the knowledge and skills of its workers. Through training and development sessions and mentoring opportunities, senior members share their knowledge and skills with less-experienced employees. According to *HRMagazine*, the organization has been able to better retain specialized knowledge and skills within its workforce while promoting morale.

The first step in the process is the knowledge-loss risk assessment, which is designed to identify the positions and people where the potential knowledge loss is greatest. In quantifying the risk, the ratings include how close a worker is to retirement and how critical their position is. The highest position-risk factor is a 5, which indicates mission-critical knowledge. Such a person may have knowledge that is either undocumented or requires many years of training and experience, and for whom no replacement is immediately available. Boyles referred to these workers as "gunslingers." "These are our component specialists that we're worried about. These are our turbine specialists on-site. These are our systems engineers. These are the people that literally built the plants that we operate." And a 4 rating, for instance, still indicates critical knowledge and skills, but the position may require less training or there may be others who have the necessary experience to take it over. "What this does for us is it quantifies, in a numerical fashion, the risk of losing an individual," Boyles said.

The second step is to determine the best approach for capturing the critical knowledge. Skilled interviewers, known as elicitors, will sit down and have a discussion with the high-priority employees. And they produce a report that the employee eventually sees. "We have a very structured interview process," Boyles said. "The interviewers are very important. These are people who need to have a knack for doing this work. They can make this go a lot easier." Based on responses to the structured interview questions, the organization then determines how rare the knowledge is and how difficult it would be to recover from the loss of it as well as what it would cost. They then identify options for retaining the knowledge—such as writing a procedure, making a checklist, or in some other way codifying the knowledge.

The last step is simply keeping up-to-date with anticipated employee attrition. "We go back through the process because in today's economy—I hate to say this—but retirement plans change for a lot of our employees. So, we try to stay with them, discuss this with them, and keep that data as accurate as possible."

Precursors of disaster

History is a vast early-warning system, Bill Corcoran told the audience in the session, "Operations Lessons to be Learned from a Near-Miss." Corcoran is president of Nuclear Safety Review Concepts, Inc. (which carries the mission statement, "Saving lives, pain, assets, and careers through thoughtful inquiry"). He described a type of root-cause analysis that relies on examining precursors to the event.

A precursor, Corcoran explained, is a situation that has some, but usually not all, of the ingredients of a highly undesirable situation. In other words, a precursor is a near-miss. In Corcoran's terms, the "Real McCoy" is the actual bad situation; in an equation, the Real McCoy would be equal to a precursor plus exacerbating factors.

For example, for the Three Mile Island-2 meltdown in 1979 (the Real McCoy), the precursor was the similar problem of the pilot-operated relief valve sticking open that occurred at Davis-Besse in September 1977. The exacerbating factor was operator error. "If they hadn't run screaming out to the parking lot we wouldn't have had an event," Corcoran said.

So what keeps a precursor from becoming a Real McCoy? Mitigating factors, Corcoran said—or, often enough, luck. If the next occurrence of the precursor does not include certain defenses, barriers, or mitigating factors, an adverse event will result. "Ready to write this down? Luck is not a robust barrier," Corcoran reminded the room. An example was the avoidance of a meltdown after the complete loss-of-feedwater incident at Davis-Besse in 1985. "The mitigation here was heroic action using nonsafety-related communications. The thing that saved the plant was one operator who really knew what he was doing, and the plant announcing system," Corcoran said. "The announcing system—nonsafety-related communications—was what kept them from having this embarrassing situation."


Corcoran

A third type of precursor occurs when there are both the addition of exacerbating factors and the removal of mitigating factors. The sinking of the *Titanic* can be seen as a precursor to a greater accident, with the loss-of-life doubled. "How many people were lost on the *Titanic*? 1562. The reason why it was 1562 and not double that was, first of all, their policy on maiden voyages was to only sell half the berths. So, they had only half the passengers that they could have had. And the mitigating factor was the steamship *Carpathia*, which saved a lot of people. So, if they had been sold out and if the *Carpathia* had not been there, the loss of life would have been double."

A final type of precursor is actually a Real McCoy from which the lesson wasn't learned—"the ones that really scare you," Corcoran said. If an adverse event is not effectively investigated, the causes of it may continue to exist. For example, Corcoran mentioned that a woman was recently accidentally killed in a Connecticut hospital after having been given nitrous oxide instead of oxygen. One week later, another woman was killed in the same operating room and in the same manner.

Continued

Anecdotal evidence suggests that for every consequential adverse event, one can expect to see roughly 10 near-misses, Corcoran said. For every 10 near-misses, one can expect 100 compromises, or events in which protective barriers are missing. And for every 100 compromises, one can expect 1000 infractions or deviations—cases in which procedures aren't being followed.

"In the wonderful world of foreign material management, this is very easy to visualize. The consequentials are where you wreck the turbine because you had foreign material in the control oil system. The near-misses are where you had the foreign material in the control oil system, but somebody noticed it and got it out before you had any damage. The compromises were the cases in which important parts of the control oil system were left open or foreign material–producing activities were conducted near the control oil system, but none of it got in. And infractions and deviations are where people did not take into account foreign material management when they set up the procedures and the work packages for doing work on the control oil system."

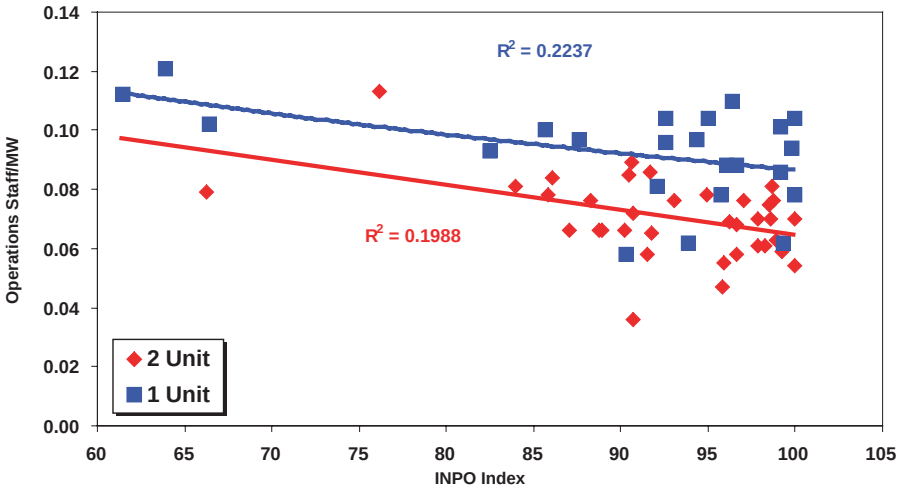
In general, compromises and infractions indicate process weaknesses more than anything else, while the consequentials and near-misses point toward command accountability issues, Corcoran said. "The people who were responsible for leadership decisions didn't have the picture, or didn't do what they were supposed to do. This is general, but it's very reliable."

Staffing vs. plant performance

Nuclear power plants may be able to reduce operations staffing without experiencing adverse results, contended Don Price, who works on organizational effectiveness and design for Navigant Consulting, in the session, "Operational Impact of Organization Streamlining." Price's evidence for this surprising conclusion included comparisons of plants with INPO index ratings to operations staffing levels, as well as the results of a recent informal survey of a number of chief nuclear officers. The key for nuclear stations, Price emphasized, is maintaining the staffing at levels critical for uncompromised plant performance. The problem is figuring out exactly where that staffing threshold is.

Price

By 2002, total staffing at nuclear power plants had dropped 20 percent since 1998, Price had found. During that same period of time, operations staffing had been about constant, seeing a small bump up in 2001 and bump down the following year. "Shouldn't be a surprise, I don't think," Price said. "I travel around to a lot of plants, interview a lot of managers. And essentially what I find is there hasn't been, over the last five years, much change in operations staffing compared to the decrease that we've seen in total staffing."



Plotting it out: Price's study revealed a relationship between higher INPO index scores and lower operations staffing levels.

Also during this period, total costs have decreased, partly because total staffing is a large part of total costs. But, surprisingly, plant performance has increased, both for the top 10 percent performers and the median.

So, with total plant staffing having decreased, costs having decreased, and performance having increased, the outlook is good for nuclear power, Price said. But all these changes have occurred with essentially constant operations staffing. "There continue to be cost pressures. Lots of organizations have cut [costs]. Operations has pretty much been unscathed. Will that continue to happen? What may happen if this occurs in operations?"

What would happen if operations staffing decreases, Price wondered. Price did a quick survey of a dozen or so chief nuclear officers—representing both large and small companies—and asked them what did they think would happen to performance if operations staffing decreased.

"The feedback, it surprised me, was fairly consistent. I was expecting it to be all over the place. But essentially the CNOs that I talked to said, 'There is a threshold in operations staffing, and as long as we recognize where that threshold is and don't go below that threshold, then we don't really see a tie between performance and operations staffing,'" Price explained. Instead, the CNOs believed that better performance was more closely tied to the material condition of the plant and instilling a questioning attitude in plant staff. The biggest operational staffing concerns of the surveyed executives were keeping the staffing pipeline well stocked in anticipation of retirements and coming up with ways to improve operations productivity through greater automation, Price said.

Price and his colleagues then began to look for evidence of what the CNOs were telling him—that above a certain level, greater operations staffing doesn't equate to better performance. Plotting out INPO index scores against operations staffing levels did not reveal any correlations; plants with a high INPO index had a wide range of staffing levels. But when he divided them into one- and two-unit plants, Price saw the beginnings of an inverse relationship. "Your INPO index score is actually higher if you've got lower staffing. If you've got higher staffing, you're not doing as well in the overall INPO index," Price said.

"So, you could draw a lot of conclusions from this. My own conclusion, from what I see at a lot of plants, is that plants that have high INPO index scores, it turns out, are also some of the low-cost plants that have . . . relatively low operations staffing. I believe that this actually does show the correlation. . . . I actually believe that some of the plants that have the fewest staff are doing pretty well on their INPO index as well as on their overall performance."

But the INPO index is just one indicator of plant performance. Price said he was unable to establish any correlation between operations staffing levels and, for instance, unplanned scrams or forced loss rates.

"So, what does that mean? You can try to explain it away, but I still find that the plants with the lowest staffing had lower production costs. It appears that plants can reduce operations. That's my conclusion from this. And that's also my anecdotal conclusion from being at lots of plants and talking to lots of people. There really are differences in what plants think they can operate with versus what other plants are actually operating with," Price concluded.

"Ultimately, the key is going to be to try to find out where that critical line is and not go below that critical line in operations staffing."—*Patrick Sinco* NN