ANS ANNUAL MEETING

Nuclear takes steps toward a greater tomorrow

THE MANY RECENT steps taken by the nuclear industry seemed to be captured by the theme of the ANS Annual Meeting, held June 14–18 at the Hyatt Regency Hotel in Atlanta, Ga. The meeting's theme was "Advancing Nuclear Technology for a Greater Tomorrow."

During the opening plenary session, ANS President William Burchill, who was nearing the end of his year-long term, listed some of the notable developments taking place in the industry: Georgia Power has begun preliminary groundwork for two new power reactors in Georgia; the Nuclear Regulatory Commission is reviewing applications for combined construction and operating licenses (COL) for more than two dozen new power reactors (with more applications expected to be submitted); Areva and Northrop Grumman Corporation are expected to break ground soon for a nuclear components manufacturing facility in Virginia; four new uranium enrichment facilities are in various stages of development in the United States; the Department of Energy is building a mixed-oxide fuel fabrication facility in South Carolina; the Tennessee Valley Authority has announced that some of its reactors will use the MOX fuel from the DOE facility; and the NRC has received letters of intent from three different groups saying that they plan to submit applications for reprocessing facilities at some point in the future.

Other activities highlighted at the opening plenary session or during various meeting sessions included the programs established by the industry, the government, and institutions to secure a future nuclear workforce; the industry's efforts to make its voice heard on the political stage and by the general public; and the blossoming of the "new media"—bloggers and tweeters—that is making much of the industry's news-and-opinion communication an instant occurrence.

Meeting session coverage:

- *Status of the effort to build the nuclear workforce*
- *Delivering the nuclear industry's message in politics, and through new media*
- *Plans to inspect new reactor construction*
- *Experience in conversion from analog to digital instrumentation and controls*

Burchill commented that there had been some question about the Obama administration's support for nuclear power, but that support now seems to be apparent, based on a statement on the White House Web site that says, "We must advance U.S. energy supplies through responsible development of domestic renewable energy, fossil fuels, advanced bio-fuels, and nuclear energy." The U.S. Congress, too, has been offering "good bipartisan support," Burchill said, and he urged ANS members to continue with the "Getting the Word Out" campaign by encouraging lawmakers to support and become knowledgeable about nuclear energy and the applications of nuclear science and technology.

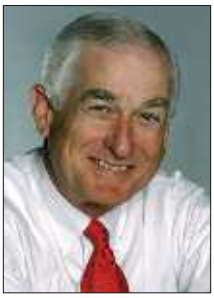
Burchill

Jeffrey Gasser, the general chair of the meeting and the chief nuclear officer of Southern Nuclear Operating Company, followed Burchill at the podium to welcome ANS members to Atlanta and to remind them that the meeting's theme was appropriate because nuclear is no longer a "should we or shouldn't we" debate. Instead, he said, that issue "has been debated and been decided as a policy here in the United States and around the world. So, the discussion now is how to use nuclear technology safely, reliably, and cost-effectively, in a manner that promotes public confidence."

Gasser

The first of the opening plenary session's speakers was David Ratcliffe, chairman, president, and chief executive officer of Southern Company, who gave an overview

of the company's role in the nuclear renaissance. Southern, he noted, has ranked first in customer satisfaction in an industry survey for nine out of the past 10 years. The company has 22 000 MWe of generating capacity, most of it (about 70 percent) coming from coal-fired power plants, but about 6000 MWe of capacity coming from nuclear power. Southern operates three two-unit nuclear sites—Farley in Alabama, and Hatch and Vogtle in Georgia. As Burchill had mentioned, the company plans to build two new units at the Vogtle site, to become operational in the 2016–2017 time frame. Ratcliffe said that the company anticipates receiving an early site permit for the new units in September 2009 and the COL in 2011.


Ratcliffe

Ratcliffe commented that even if the nuclear industry follows through with plans to build all of the new reactors that have been announced, "the mix of nuclear capacity as a function of the total generating capacity in the country will simply remain at 20 percent," the same as it is today. But the industry's 30 years of safe and reliable operation in the United States has earned it "the right" to build more units, he said. "We know how to do this. When it comes to our desire to create jobs and to stimulate this economy, we believe there is no better way to do that than a serious commitment to expand our nuclear capacity. I believe there are some 15 000 to 100 000 jobs available to us when we commit to expand nuclear capacity."

"When it comes to our desire to create jobs and to stimulate this economy, we believe there is no better way to do that than a serious commitment to expand our nuclear capacity."

In the United States, Ratcliffe said, certain segments of the public have come out against various forms of electricity infrastructure. "We've been through the NIMBY syndrome—not in my backyard. And I believe now we're moving through BANANA—build absolutely nothing anywhere near anybody. Someone suggested we might even get to NOPE—not on planet Earth," he quipped.

Ratcliffe said that the way to get past public skepticism is to build public confidence. "We have to make sure that we continue, day in and day out, to deliver safe, operational excellence. That is absolutely fundamental to our success," he said.

Ratcliffe's message about safe operations was seconded by Sam Nunn, cochairman of the Nuclear Threat Initiative (NTI) and a former U.S. senator from Georgia. NTI is a nonprofit agency founded in 2001 to help strengthen global security by reducing the spread of nuclear, biological, and chemical weapons and by reducing the risk that they will be used.


Nunn

Before he got into the heart of his talk, Nunn told the audience that he had been with President Obama on three occasions when the president said that nuclear energy had to be part of the energy mix.

Nunn said that as the use of nuclear power increases, the industry must be diligent about its safety and security. "We are facing a gathering storm," he said of the growing threats of nuclear terrorism, and he went on to list some of them: Terrorists are seeking nuclear weapons, and if they get them, they will use them; the materials needed to make nuclear weapons are in about 40 countries, at military and civilian facilities; the know-how that terrorists need to build a weapon from these materials is widely available—"not a piece of cake, but doable"; the number of states possessing nuclear weapons has nearly doubled since the Nuclear Non-Proliferation Treaty came into force in 1970; the number of nations seeking the capacity to enrich uranium and separate plutonium is also rising; and every nation with nuclear weapons or the capacity to make nuclear materials increases the chance of a nuclear catastrophe, "either by design, or by accident." By adding all of these challenges into a cyber world, along with the proliferation of submarines with nuclear weapons, "you have the potential for a perfect storm," he said.

The bottom line, Nunn said, is that the world must develop safeguards to expand nuclear power without expanding the capacity to make bombs. He wondered whether a system could be created under which everyone would play by the same rules on enrichment and reprocessing. To do so would require governments to have an interest in the commercial success of the nuclear industry, and would require the nuclear industry to have an interest in the security concerns of governments. "We must develop solutions that are sustainable—scientifically, politically, and commercially—through a broad discussion that involves industry, governments, international organizations, security experts, technical experts, and the public," he said.

Adm. John Grossenbacher, director of Idaho National Laboratory and president of the Battelle Energy Alliance, opined that the United States would be using nuclear power—"fission as an energy source," he said—for the next 100 years. This means that there has to be a collective and long-term view on how to deploy new technologies into the industry.


Grossenbacher

Grossenbacher said that most of the policies, processes, and interactions of the DOE, the NRC, and the U.S. nuclear industry were created 30 or more years ago and that they largely have not existed in an environment of rapid technology development, demonstration, and deployment.

As technology is being "reborn," he said, it is important to consider how to incorporate it effectively into all parts of the industry so that the general public will embrace rather than reject the benefits of nuclear technology.

According to Dale Klein, an NRC commissioner and the agency's immediate past chairman, another area worth investigating is whether the United States should link its educational supply chain to its long-term science and technology needs.


Klein

Klein said that the United States is risking its future economic and national security if it does not focus on expanding scientific and engineering education and on promoting technological excellence. He called this inactivity "a risky gamble" because, regarding nuclear safety, it has been "at the root of some excellent nuclear plants' encountering problems."

One of the challenges for ANS members, he said, is to make efforts to explain to students the many different skill sets that are needed in the nuclear power industry. There is need, he said, for skilled crafts people, technicians, and engineers, and so more outreach to high school and community

college students could be beneficial.

Klein said that the lack of basic scientific literacy has paved the way for alarmists with an agenda to make exaggerated statements about the dangers of nuclear. "Unfortunately, the media often contribute to the public's inability to evaluate these statements because they don't shed light on the technical or scientific merits of these claims," he said. The more that people understand the nature of radiation and the important role it plays in their everyday lives, he said, the less likely they are to be afflicted by "radiation phobia."

Klein said that some of the industry's Web sites are good sources of "clear, concise, and accurate information," and he gave a nod to the Health Physics Society for its site at <www.radiationanswers.org>. Klein also showed some images of antinuclear groups' Web sites that displayed bright colors and "danger" symbols such as skull-and-crossbones and cartoon bombs, which a casual browser might find darkly attractive and alluring. He contrasted that with a page from the ANS Web site, which was visually bland, showing black text on a white background with some blue and gray bordering. The audience gave an audible gasp at the difference in the two Web pages. (To be fair to ANS, however, what Klein displayed was a lead-in page to a society position statement that was five clicks away from the ANS main page.—*Ed.*)

(And, on the same subject, during another session at the meeting, past ANS president Larry Foulke said, "We can't lose sight of the fact that we are a professional society whose aim is to provide credible information. We cannot and we should not do the kind of splashy journalism that you find some of these Web pages doing that Dale Klein illustrated. We have to keep our wits about us as to what we are about. We're not lobbyists. We're not promoters, so much. We're credible sources." Foulke added, "Even saying that, I believe that we can do some things to make the Web site more colorful, with pictures, with some things like that.")


Foulke

Klein concluded by saying that in his opinion, the nuclear renaissance in the United States will succeed only if there is a rebirth of learning. "One hundred years ago, schools taught agriculture because we lived in an agrarian society," he said. "Today, we live in a technological society—and this has to be taught as a basic subject, alongside English, history, and the natural sciences."

Adm. Jim Ellis, president and CEO of the Institute of Nuclear Power Operations (INPO), agreed with the importance of educating young people, and he talked about the role that the industry's leadership must play in this endeavor. Ellis called to mind Adm. Hyman Rickover, under whom the U.S. Navy conceived and produced the nuclear submarine the U.S.S. *Nautilus,* "whose keel was laid, and then 18 months later it was launched. We couldn't write the specification today in 18 months," Ellis said, adding that "clearly, it was aggressive and effective leadership that put that ship to sea."

Others who were bulwarks of leadership included President Dwight D. Eisenhower, who delivered a speech in 1953 to the United Nations that laid out a vision of "atoms for peace" and the global deployment of nuclear technology for the betterment of mankind; Bill Lee, president and CEO of Duke Power, who in 1981 challenged his colleagues in the industry by saying that if they could not subscribe to the principles of INPO regarding the collective approach to nuclear safety, they should shut down all their nuclear plants; and Adm. Eugene "Dennis" Wilkinson, the first commanding officer of the *Nautilus* and the first president and CEO of INPO.

The leaders of tomorrow must understand the special nature of nuclear power and have a healthy appreciation for its history and safety-focused culture.

The challenge for the industry going forward is to find a way to train the leaders of tomorrow, according to Ellis, who said that the future leaders must understand the special nature of nuclear power and have a healthy appreciation for its history and safety-focused culture. The transfer of this knowledge must be done in ways that are effective and compelling, he said.

Ellis illustrated his point by noting that at an INPO seminar earlier this year, 75 percent of the industry personnel in attendance had not been born at the time of the Three Mile Island accident in 1979. "We are seeing a new generation of workers that are perhaps the best educated, most technologically savvy ever," he said. "They are smart, enthusiastic, and interested in making their mark in the industry and in the world. This new generation of workers learns in different ways than the traditional classroom structure we've come to rely upon that is not necessarily the best way going forward. So, a solid technical understanding of the industry has been and will always be vital to our continued success."

Ellis said that the nuclear power industry has a special obligation to build and sustain a strong safety culture. "It is my firm belief that safety culture is part of who and what we are as an industry," he said. "Safety culture is not a program, a checklist, or a handbook. It cannot be infused by a pill, injection, all-day meetings, or the most expensive corporate consultants. It is not a figment of a regulator's imagination, the latest in pop psychology, or some recent management trend."

What it is, he said, is "a reflection of the broader organizational culture and is always a reflection on all of us as leaders."

President's Special Session

Titled "Getting the Word Out—Selected Words," the ANS President's Special Session focused on a theme that outgoing President William Burchill pursued throughout his term in office. For this session, Burchill chose four topics that he felt members should be better informed about for advocating the benefits of nuclear science and technology.

The first speaker was Ward Sproat, former director of the DOE's Office of Civilian Radioactive Waste Management, who successfully led the DOE's effort to develop and submit the license application for a national repository for spent fuel at Yucca Mountain, in Nevada. Sproat reviewed the history of the project, described where it stands now, and discussed what he thinks the future may hold. In particular, he described the legal barriers to abandoning Yucca Mountain and discussed the political realities that cannot be ignored.


Sproat

The Nuclear Waste Policy Act (NWPA), Sproat noted, is a federal law governing the selection of the site, establishing the Nuclear Waste Fund (NWF) to finance the repository project, and describing the role of the federal government in the process of disposing of commercial spent fuel and defense high-level waste. The NWPA, which was signed into law in 1983 by President Ronald Reagan, also gives the DOE the responsibility to take possession of all commercial spent fuel.

The DOE then began a site selection process, identifying nine potential sites in 1984. This number continued to be nar-

rowed down until in 1987 the NWPA was amended to authorize the DOE to study only one site, Yucca Mountain. The DOE then spent a great deal of time and money to characterize the site, and in February 2002, it formally recommended the site as a national repository to President George W. Bush, who approved the recommendation. The governor of Nevada vetoed that decision but was overridden by a joint resolution of both houses of Congress later that year.

Sproat described some of the legal conditions attached to the NWPA that will make it difficult for politicians to abandon Yucca Mountain. For example, under the NWPA, the DOE cannot take spent fuel from the plants until Yucca Mountain receives authorization to begin construction. This means, for example, that it cannot even transfer spent fuel from power plants to an interim storage facility. Furthermore, the NWF, which is now theoretically valued at about $22 billion, cannot be used for any purpose other than for a national repository. To do anything else requires new enabling legislation.

Regarding the role of politics in decision-making on this issue, Sproat said that engineers "often think that with a really good technical solution, the politics will take care of itself. . . . I am here to tell you that this is absolutely not the case." He described decision-making at the federal level as a "technically informed" political process. A way has to be found, Sproat said, to work with the politicians in order to get anything done.

At the federal level, the fact that Sen. Harry Reid (D., Nev.) is the Senate majority leader does not bode well for the project's moving forward, Sproat said. He provided some insights into how Reid succeeded in boxing-in the two leading Democratic presidential candidates, Hillary Clinton and Barrack Obama, to come out against Yucca Mountain. He noted, however, that Reid does not have the votes required to change the NWPA any time in the near future.

Yucca Mountain won't be dead until and unless the NWPA is amended, and that will not happen in the next three or four years.

Sproat said that there is bipartisan support in Congress for continuing with the Yucca Mountain licensing project.

Ultimately, he said, Yucca Mountain won't be dead until and unless the NWPA is amended, and that will not happen in the next three or four years. In the meantime, he said, the licensing process will continue, but slowly: In his opinion, the NRC will not reach a decision before 2012.

Sproat also warned that the opponents of nuclear power are already trying to derail the new-build program by arguing that licenses should not be given without a solution to the waste issue. Fortunately, he said, the legal conditions in place—including the spent fuel contracts between utilities and the DOE—should allow projects to continue. It is vital, he noted, that the nuclear community understands the legal and political issues associated with HLW and is willing to challenge those actively trying to use the waste issue to block new plant licensing.

The next topic was fuel reprocessing and recycling. The speaker, Dominique Greneche, of Areva, began by providing France's arguments in favor of reprocessing and recycling. Reprocessing, he said, avoids the accumulation of spent fuel and makes waste management easier and safer, with very low environmental impact. It provides a reliable solution for long-term storage and saves natural resources.

Reprocessing allows for greater flexibility in managing waste and in implementing innovations such as the COEX process, which involves the co-extraction of plutonium and uranium.

As an example, Greneche noted that France has reduced the volume of HLW by a factor of 4 or 5 in comparison with conditioned spent fuel. The French strategy also improves the situation regarding low-level waste: For every metric ton (t) of spent fuel that is reprocessed, only 1 cubic meter of LLW is produced.

Regarding the waste's residual thermal load and radiotoxicity, reprocessing makes it possible to remove the main isotopes responsible for these conditions. The thermal load can be greatly reduced in the near term by removing strontium and cesium, and, for the longer term, americium and plutonium. Furthermore, as plutonium accounts for up to 80 percent of the material's radiotoxicity, there are obvious advantages to removing this from the waste. Looking at spent fuel on its own, it takes 300 000 years for the radioactivity to diminish to the level of natural uranium. By removing the plutonium, Greneche said, this time is reduced to 30 000–50 000 years. In the future, by removing all minor actinides as well, the inventory returns to natural levels after a few centuries.

Reprocessing, Greneche continued, allows for greater flexibility in managing waste and in implementing innovations such as the COEX process, which involves the co-extraction of plutonium and uranium, with the mixed product being made directly into new reactor fuel. It also allows for the separation of actinides for transmutation purposes, he said, as well as for the removal of isotopes such as radioiodine and tritium in order to reduce the environmental impact and provide better safeguards.

France also benefits from using recycled uranium as well as plutonium recovered from reprocessing, he added. In fact, he noted, about 25 percent of France's electricity comes from recycled uranium and plutonium.

Another interesting statistic Greneche presented is that some 24 000 pellets of spent fuel have been reprocessed at the La Hague facility. This, he said, is equivalent to 10 years or more of all the spent fuel generated in the United States and has been achieved without any significant safety problems. In addition, some 200 t of MOX is produced each year at Areva's Melox fabrication plant.

An insightful introduction to the costs involved in building new nuclear plants was given by Steve Winn, CEO of Nuclear Innovation North America, the partnership established by NRG Energy and Toshiba to market and build ABWRs in North America. NRG and Toshiba are already involved in a joint venture to build South Texas Project-3 and -4.

Winn said that his goal is to create as much cost certainty as possible in all areas of a project, and as little risk as possible for investors. He summed up his general philosophy on dealing with risk: first, try to eliminate it; second, if you can't eliminate it, find someone else to hold it; and third, if you need to hold it yourself, ensure that you get paid very well.

One basic aspect of creating cost certainty, Winn said, is to avoid doing things for the first time. That is what led NRG to choose ABWR technology, as these reactors

are already being successfully built and operated. Also, he said, choose a site where there is already good local and state support and a market for power, such as the South Texas site, which also has the advantage of having originally been developed to hold four units. NRG also wanted a partner with recent experience in actual construction—and the "battle scars" to prove it. This, he said, pointed to Hitachi and Toshiba.

As part of NRG's approach, Winn said, a decision has to be made every year as to whether or not to continue to invest in the project the following year, based on the company's ability to take additional risk off the table.

The quest to remove risk includes treating nuclear projects the same as any big power development project, seeking contracts with guarantees on price and delivery. He admitted, however, that there are a few things that are not straightforward about nuclear. One is the licensing process, which is expected to take four years, during which time outside events could affect costs. To deal with that, some of the risk was shifted to the vendor. NRG has also become involved in preconstruction preparation activities, including bidding for equipment, negotiating rates, and even negotiating contingency fees. Once the NRC licenses the project and construction can begin, however, NRG will want to sign a fixed-price contract, which it will do only if it gets the right price.

Another risk concerns foreign currency volatility, since much of the equipment will be bought from overseas. Measures should be put in place to manage or at least limit this risk.

Transporting equipment and materials is a major component of total cost and needs to be controlled, Winn said, perhaps by contracting domestic suppliers, even if their basic price is higher than that charged by foreign suppliers. Labor, he said, is the biggest total component of cost and is worth spending a lot of time and effort to manage.

Finally, he said, minimizing risk means analyzing every component of cost and risk and trying to take as much as possible off the table before a lot of money is spent on a project.

The final speaker was Laura Holgate, a vice president of NTI, who had previously served in senior positions in the Defense and Energy departments. NTI's view, she said, is that a secure future requires support for both the advancement of nuclear energy and the reduction of nuclear threats. The more fuel cycle facilities there are, she said, the more weapons materials are produced and the greater the risk of diversion or theft. Furthermore, in this interconnected, globalized economy, the threat cannot be managed effectively by any single actor—no nation or industry can insulate itself.

It is impossible to imagine sustainable development without an increased role for nuclear power, Holgate said, but to reap its benefits, new approaches are needed that respond to the risks. This is being done to some extent in the development of the next-generation reactors, which incorporate the aims of nonproliferation. Current approaches to reprocessing, however, have created large stockpiles of weapons-usable plutonium. The spread of enrichment and separation technologies makes it extremely difficult to distinguish between legitimate fuel cycle activities and illicit weapons programs. New approaches are required, she said, especially to maintain and expand political support for nuclear power.

The international fuel bank proposed by the Nuclear Threat Initiative would be a way to jump-start action toward eliminating the spread of enrichment technologies.

Holgate said that the international fuel bank proposed by NTI would be a way to jump-start action toward eliminating the spread of enrichment technologies. Solutions to spent fuel management, reductions in high-enriched uranium and plutonium from weapons dismantlement, waste storage, electricity transmission, and other issues will also have to be addressed. Such efforts are likely to require extensive international cooperation, she said.

Holgate also described an NTI study of fuel cycle issues as they relate to the goal of a world free of nuclear weapons. The study, she said, avoids a discussion of specific fuel cycle technologies. Instead, it begins with the end in mind and tries to identify attributes and models that might be applied to nuclear energy systems. The central proposition is that nuclear energy and disarmament are mutually reinforcing, and that the path forward must involve aligning the objectives of nuclear commerce and nonproliferation. It asks what kind of system will eliminate commercial gain from dangerous behavior and reinforce the profitability of actions that enhance nuclear security. An international conference will be convened this fall to present some initial findings and propositions and to discuss a path forward.

Work so far on this project has led to the development of a set of notional attributes by which various fuel cycle models could be judged in determining their compatibility with the goal of nuclear weapons elimination (see table above). Holgate noted that the current nuclear energy system scores poorly on all six attributes.

Attributes of a Secure Nuclear Fuel Cycle

- Produces the smallest quantity of weapons-usable material in the fewest facilities in the fewest countries
- Ensures the world-class physical security of all weapons-usable materials, both in facilities and during transit
- Sustains the system in the midst of changing technologies, economies, and political climates
- Designs financial incentives into the system to strongly encourage compliance
- Exposes bad behavior early and enforceably
- Ensures equitable and reliable access to nuclear power by all countries

Construction inspection

Three years from now, a number of power reactor construction sites could be up and running in the United States. License applicants and the NRC are already in advanced preparations for that time, and status reports were provided at a session on construction inspection.

Loren Plisco, deputy administrator in the NRC's Region II Office in Atlanta (from which he walked to the session in 10 minutes, he said), noted that the ultimate goal in new-reactor construction under 10 CFR Part 52.103(g) of the regulations is the determination by the commissioners that all inspections, tests, analyses, and acceptance criteria (ITAAC) have been met. The NRC's construction inspection effort, which is based at the Region II Office, has established the Construction Inspection Program Information Management System to collect the data already being gathered.

In the near term, the NRC was to send a team to Japan Steel Works in early July to observe the work being done on ultraheavy forgings. Next summer, Plisco said, the agency is to begin training and assigning resident inspectors for the new reactor sites. Still to be worked out are the roles of the regional offices, especially in cases where

new reactors would be sited with operating reactors, and the development of programs in areas such as enforcement and problem identification and resolution.

Charles Pierce, the Vogtle deployment licensing manager for Southern Nuclear Operating Company, spoke on behalf of the project that will probably be the first to be on the receiving end of construction inspection, Vogtle-3 and -4 in Georgia, which could receive an early site permit and limited work authorization (LWA) before the end of the year. Pierce said that the company expects to begin safety-related work under the LWA in February, with NRC inspectors expected at the site in November to oversee programs such as fitness-for-duty. Southern Nuclear will provide the NRC a trailer in January, with the first resident inspectors to occupy it soon afterward. Offices for the NRC contingent are to open in mid-2010.

Pierce said that the new reactors will be built on engineered backfill because the existing soil has been deemed unsuitable to support the structures. A 100-foot-deep hole will be dug and then partly filled with acceptable backfill. The pace of the excavation will be such that the equivalent of a dump truck full of soil would be removed every 40 seconds, he said.

Although South Carolina Electric & Gas Company refers to its new reactors as Summer-2 and -3, Allen Torres, the project's construction manager, said that the project is technically at a greenfield site because it is about a mile from Summer-1, taking advantage of hard-rock terrain. He said that pre-construction activity is already taking place on laydown areas, sediment basins, and rail lines. Construction work on Summer-2 and -3 will not begin until 2012 at the earliest, he added, but techniques are already being studied. Torres noted that fly ash, a waste product from coal combustion, can be mixed into concrete to improve its flowing during pours and avert the development of voids in the concrete. He said that the ash could be as much as 28 percent of the total bulk of the concrete and still meet regulatory requirements.

Construction work on Summer-2 and -3 will not begin until 2012 at the earliest, but techniques are already being studied.

Russell Bell, director of new plant licensing at the Nuclear Energy Institute, in his presentation titled "ITAAC—Cradle to Grave," traced the process for determining whether commitments made in a COL application have been met. The extent to which public involvement is possible in determining whether an ITAAC has been closed out prompted Andrew Kadak, professor of the practice of nuclear engineering at the Massachusetts Institute of Technology and an ANS past president (1999–2000), to ask from the audience how a licensee can avoid a full-scale second hearing on the project, which would effectively be the same as the two-hearing licensing process that was used on the reactors now in operation. Bell said that the bar is to be set very high on any challenge to a specific ITAAC, but, he admitted, "I'm nervous too."

The role of the reactor vendor was described by Thom Ray, licensing integration engineer for Westinghouse's AP1000 reactor. Ray said that some ITAACs can be open for years; the reactor vessel's Charpy V-notch ITAAC has already started for U.S. AP1000 customers. Ray said that Westinghouse and its architect-engineer, Shaw Stone & Webster, develop ITAAC closure packages and letters. The utility will verify completeness and accuracy and send the letters on to the NRC.

There are 803 ITAACs for an AP1000: 45 on engineering analysis and security, 127 on components (closed out only when the components are on site or in place), 330 construction-related tests (300 walkdown, 30 hydrostatic), and 301 pre-operational tests. The scheduling is such that the number of closure letters to be resolved for a twin-AP1000 plant would peak at about 600, roughly one year before fuel load.

In later discussion, Plisco noted that the people who write ITAACs are not the people who have to close them. He advised that ITAACs still being written might be made smaller and more straightforward.

Planning for life after 60

The panel session titled "Ensuring the Long-term Safe and Sustainable Nuclear Energy Option" kicked off with two presentations on the long-term operation (LTO) programs of the DOE and the Electric Power Research Institute (EPRI).

The DOE's Richard Reister explained that the agency began looking at light-water reactor sustainability after realizing that even if the nuclear renaissance comes to fruition, it would still be a good idea to continue operating the existing plants beyond their 60-year licenses, if possible. To accomplish this, these plants must remain economically viable, safe, and licensable.

Reister said that four new plants are to be put into operation each year beginning in 2021, increasing to eight plants per year starting around 2050. Nevertheless, assuming that the current plants are retired after 60 years of operation, total nuclear capacity will stop increasing and will remain at about 200 GWe for some time before starting to rise again. By extending the life of existing plants to 80 years, however, nuclear capacity will continue to increase.

The DOE began work on LWR sustainability as part of its Generation IV activities. Of the main areas being studied, Reister said, materials is probably the key, particularly for components such as piping, concrete, and reactor vessels. The focus of the work is on passive components, since a lot of work has already been done on active components, he said. Advances in instrumentation and controls will also be needed for monitoring plant systems to better predict potential problems so that they can be avoided.

John Gaertner, an EPRI technical executive involved in the organization's LTO project, said that one of EPRI's tasks is to ensure that there is a process in place for the continued operation of the existing plants. Gaertner stressed, however, that EPRI's main objective is to establish a technical basis for high-performance operation of the current fleet through 2030, when the first 60-year plants will begin to be retired. But EPRI is also interested in establishing the technical basis for "life beyond 60" so that license renewal from 60 to 80 years is achievable. The NRC has assured us, he said, that the license renewal process now in place would be the foundation for a new process. Utilities say that the barriers to license renewal and continued long-term operation are primarily technical.

One point that is sometimes forgotten, Gaertner said, is the need to continue to demonstrate the safety of the current plants. From 1992 to 2005, nuclear safety was improved in measurable ways, not just through better safety analysis methods. Various equipment failure modes were eliminated, and trips, transients, and errors were reduced, while plant modifications improved the ability to respond to incidents.

U.S. plants were made safer by a factor of five over that time period, Gaertner said. But, he warned, the promise that new plants will be between one and two orders of magnitude safer does have consequences for the existing fleet. While it doesn't mean that existing plants are not safe enough, it does mean, he said, that the industry will be challenged to operate these plants more safely and, more important, to demonstrate to all stakeholders that it is doing so. For that reason a pathway has been developed to improve safety analysis capability. This will be particularly helpful to demonstrate that safety margins are adequate for long-term operation, he said.

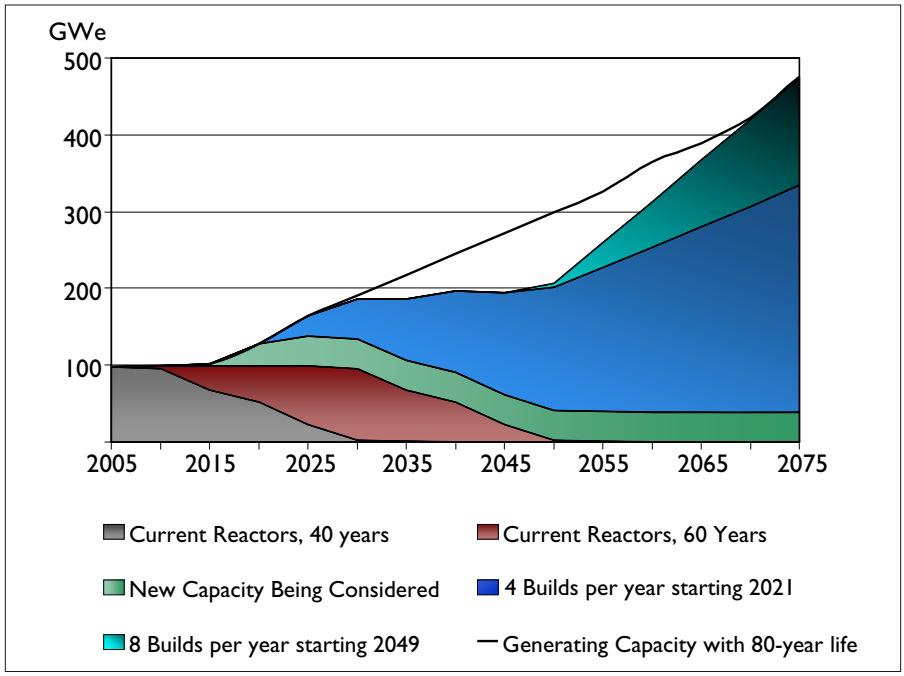
Continued

Regarding the cost of establishing the technical basis for license renewal and long-term operation, Gaertner put the figure at about $100 million, saying that this is quite small compared with the total investment that is to be made in the current fleet, which will be on the order of $100 billion–$200 billion. This is a good investment, he said.

EPRI's LTO program focuses on life-limiting issues, typically concerning reactor pressure vessels, internals, and concrete, which could be showstoppers, Gaertner said. It also covers life-cycle management issues and looks for opportunities to modernize and upgrade plants and implement new technologies that will improve safety and economics. He also stressed that even though no plant will reach 60 until 2029, tangible results from this program will be needed in the time frame of 2013–2019, because that's when many critical long-term planning investment decisions will be made.

Two current LTO projects have to do with metal aging, Gaertner said. One is on intergranular stress corrosion cracking, and the other is on irradiation-assisted stress corrosion cracking of primary metals. The focus of these projects is to establish a predictive capability for crack growth, or at least for determining when aging effects of those components may appear. Another materials project concerns concrete performance. While EPRI does not think that concrete aging and degradation will be an issue for the first 60 years, he noted, it may become an issue beyond that time period. On the safety side, one project concerns developing risk-informed safety margin analysis capability to improve LTO safety cases. Gaertner also noted "exciting projects" in I&C, such as advanced pattern recognition and online monitoring of active equipment to help identify potential problems.

Future work will cover topics such as establishing the technical basis for decisions on the refurbishment and replacement of major components and developing quantitative methods for estimating the potential life of reactor vessels, internals, and other critical components. It will also consider lifetime issues of balance-of-plant components.



Reliance on existing nuclear power plants: The graph shows that with a 60-year license period, current plants would start shutting down in 2030, resulting in a steep reduction in nuclear electricity generation if no other measures are taken. Extending the operation of existing reactors for 20 additional years (that is, to 80 years) will allow nuclear capacity to continue to increase, will avoid the emission of about 12 billion metric tons of CO_2, and will provide electricity for about 70 million homes.

Advances in instrumentation and controls will be needed for monitoring plant systems to better predict potential problems.

Sudesh Gambhir, vice president of technical services at Energy Northwest, was previously division manager for nuclear projects at Fort Calhoun, one of the nation's older plants. In the 1990s, it was not clear, because of economics, whether the plant would continue to operate until 2013, when it would reach 40 years. This uncertainty was reflected in decisions that were made, Gambhir said, such as management's decision not to undertake a power uprate. Fast-forward a decade, he said, and the plant has had its license renewed for operation until 2033, with over $400 million having been invested in it. Most major components—the steam generators, pressurizer, reactor pressure vessel head, turbines, and condenser—have been replaced. These components will last beyond 2033, he said, and continued operation could be the best option.

Gambhir referred to license renewals as a bridging strategy to make up for the shortfall in nuclear capacity that will occur as the 60-year-old plants cease production, until the time when enough new nuclear capacity comes on line to compensate for that loss. He also noted some underlying prerequisites for LTO decisions, including the following:

- Safe and reliable operation of existing plants.
- Successful implementation of the first wave of license renewals.
- Successful completion of refurbishments. (Gambhir said that at Fort Calhoun, it was clear that if the refurbishment was not successful, "I could have buried the company.")
- Continued stakeholder trust.
- A stable and predictable regulatory framework. (Gambhir said that in his opinion, the introduction of the NRC's risk-informed oversight process set the stage for the renaissance because it meant that the industry could focus on what really needed to be done.)

Because the life-beyond-60 issue is still fairly far in the future, and given all the pressure the utilities are under today, Gambhir thinks that not many people are thinking about it now. "But someone has to," he said. "Someone must take the leadership role to make it happen." EPRI's leadership in providing the technical basis for license renewal and long-term operation needs to move forward, he said, and the Nuclear Energy Institute needs to take a leadership role to ensure that a stable and predictable regulatory framework is established. The DOE also has a very important role, he added, because these plants are national assets, and protecting the energy future of the country is the DOE's mission.

An international perspective was provided by Sama Bilbao y León, technical head of the Water-Cooled Reactor Technology Development Unit at the International Atomic Energy Agency, where, among other roles, she is in charge of activities related to the development of advanced water-cooled reactors and their as-

sociated fuels. The IAEA has a particular interest in reactor aging, she said, to ensure that member states can manage the long-term operation of their plants. The agency is working with member states to put together the means, the processes, and the technology to achieve this.

The introduction of the NRC's risk-informed oversight process set the stage for the renaissance because it meant that the industry could focus on what really needed to be done.

The IAEA's Second International Symposium on Nuclear Power Plant Life Management, held in October 2007, produced a number of ideas that are helping to shape the agency's programs in this area, Bilbao y León said. The focus is on making continuous improvement and avoiding large, single investments. There is a need for continuous monitoring of components, systems, and materials, she said, and for developing a long-term plan in order to minimize costs. Other important topics include probabilistic safety analysis, proactive aging-management, and the sharing of operational experience and good practices. Effective systems of communication are needed to ensure good information flow among the key parties (including vendors, consulting companies, research institutes, regulators, and other operators), she said, and to ensure that knowledge is not lost but is captured and continuously transferred to where it is needed.

The IAEA produces publications and holds conferences, workshops, and other types of meetings on topics such as plant life management, pressure vessel integrity, heavy-component replacement, and aging management, Bilbao y León said. A meeting is being held later this year on reactor vessel embrittlement mechanisms, she noted.

The IAEA also provides peer reviews and other services to assist member countries in the areas of plant life management and long-term operation, including sending teams to assess the current state of these activities at plants and to help develop and implement programs to improve plant capabilities. The agency also publishes guides for these activities.

Il Soon Hwang, director of the Nuclear Transmutation Energy Research Center of Korea at Seoul National University, focused on research in areas such as materials and reliability, which deal with life-beyond-60 issues. He champions proactive management in maintaining plant condition and performance, using advanced inspection techniques and online monitoring, and integrating risk into the management of materials degradation.

As a country that imports over 97 percent of its fuels, South Korea has a huge incentive to expand its nuclear program, Hwang said, and by 2030 it plans to increase nuclear production from 36 percent to 60 percent of total electricity generation. This includes keeping the 20 existing plants operating as long as possible. With South Korea's plants having an average capacity factor of over 93 percent, it will be a great challenge to maintain this level of performance in the long term, he said.

Korean plants have experienced many materials problems, including fatigue, corrosion, embrittlement, wear, and swelling, Hwang said, and the industry's response has been to undertake more intensive inspection and mitigation campaigns and, most important, risk-management measures. In the future, the industry is looking toward a more predictive and proactive approach to prevent the occurrence of problems in the first place. To achieve this, an expert group was formed within the Korean nuclear community to develop a strategy.

By 2030, South Korea plans to increase nuclear production from 36 percent to 60 percent of total electricity generation.

Hwang showed a number of examples of the technology being developed in South Korea for improving inspection, reducing and mitigating damage, and making repairs. He also highlighted the work being done on understanding the fundamental mechanisms of materials degradation processes and noted that work is under way to demonstrate the potential effectiveness of risk-management programs for long-term operation, most notably in developing risk-informed inspection campaigns.

The final speaker was session chairman Gene Carpenter, who is the head of aging management issues in the NRC's Office of Nuclear Regulatory Research (NRR). He said that NRR is instituting research into potential technical issues that affect or challenge the operation of existing plants beyond 60 years. The proposed program aims to expand the understanding of materials degradation mechanisms and to answer other questions needed for the NRC to make its regulatory decisions. While there is a fairly good understanding of what is going to happen over the next 20 years, he said, beyond that, much more information is needed. The components of most concern include reactor vessels and internals, cable insulation, buried/submerged structures, and concrete that is exposed to high temperatures and radiation.

Carpenter noted that the industry has already said that starting in 2013, it wants to begin license renewals to extend plant operation to 80 years. "This is like tomorrow for us," he said. Basically, utilities will have to begin the renewal process in sufficient time to decide whether to go ahead with a new renewal application, and then, assuming the decision is positive, to undertake all the necessary activities, including obtaining regulatory approvals and financing, ordering components, and carrying out other pre-project preparations.

While it is not the NRC's job to solve possible aging degradation issues, Carpenter said, the commission would like to collaborate with the industry so that it is as well informed as possible and can avoid having to conduct additional lengthy confirmatory research. A multiyear collaborative program is being planned with industry, other government agencies, national labs, academia, international partners, and others to share expertise, information, and resources.

Nuclear communications

The preferred term these days for nuclear power plants seems not to be nuclear power plants. Instead, it is "nuclear energy facilities," at least for those who might respond to public opinion polls. The reason is that the term "nuclear power" seems to have negative connotations, as in "Iran is trying to become a nuclear power."

These bits of interesting and useful information were offered during the "Focus on Communications" workshop, which featured an open dialogue among the audience members and the workshop's hosts, Mimi Limbach, of the Potomac Communications Group, and Craig Piercy, ANS's Washington, D.C., representative. The audience may have been in a relaxed mood because of the provisions at the refreshment bar provided by Westinghouse Electric Company.

Continued

Limbach opened the workshop by showing a number of slides, including one of Sen. Harry Reid (D., Nev.), the Senate majority leader and, as those in the nuclear industry know, the most vocal opponent of the Yucca Mountain repository. She also showed slides of other senators who are not as well known and who support the technology, including Blanche Lincoln (D., Ark.), Mary Landrieu (D., La.), and Tom Carper (D., Del.). "There are a lot of new faces, and not all are Republicans," Limbach said. "It seems we all have this view that Republicans are our friends and the Democrats are our critics. In reality, it's probably a lot more mixed."


Limbach

Limbach said that the agenda for the workshop was to talk about how ANS can "fight the good fight" on the political stage by combining strategies for ANS government relations and public relations and by explaining how ANS members can make a difference on issues by being in contact with their elected officials.

House and Senate members listen to their constituencies, she said, and so when the antinukes get their people to contact lawmakers about an issue, it's extremely important that ANS members add their voices to provide balance. "That's something I think we've gotten a little bit better at in the last couple of years," she said. "I think the Nuclear Advocacy Network [NAN] helps."

NAN is the grassroots advocacy program established by ANS, the Nuclear Energy Institute, and the North American Young Generation in Nuclear (NA-YGN). The network (online at <www.nuclearadvocacynetwork.org>) is designed to enable nuclear supporters throughout the United States to join together and add their voices—and their phone calls, faxes, and e-mails—to the support of issues important to the nuclear renaissance.

When the antinukes get their people to contact lawmakers about an issue, it's extremely important that ANS members add their voices to provide balance.

Limbach said that NAN members recently made their voices heard before a vote of the House Energy and Commerce Committee, which is chaired by Rep. Henry Waxman (D., Calif.). "From the Nuclear Advocacy Network, we got about 400 phone calls that went into Henry Waxman's committee office to support the legislation," she said, adding that the legislation—on climate change—passed 51 to 6.

She said that more will be revealed in the next year about how the society can play an important part in "winning hearts and minds" over to nuclear's side. "The number of people who talk about energy policy or have opinions about it versus the number of people who actually understand it is very small," she said. "There is also the asymmetry between the people who think they understand nuclear technology and those who actually do. We have a really strong role to play here in just trying to promote that understanding."

Limbach then presented the results of a March 2009 Gallup poll that showed that only 47 percent of the women who responded to the poll were in favor of nuclear power (compared with 71 percent of the men). A second poll done by another group—this one was just released in June—collected opinions from 800 women nationwide, and the results shocked Limbach. "Fifty-four percent of those polled said they believe that nuclear energy releases a lot or some air pollution," she said. "An identical number—54 percent—believe that nuclear energy is the cause of global warming."

Limbach added that when people have such a strong bias against an issue, it is important to use messages, phrases, and words that break through those biases. Research done with focus groups over a six-month period showed that the use of the word "nuclear" by those outside the industry tended to have negative connotations, such as "nuclear means bombs, something ominous," she said. The advice given was to never use "nuclear" alone, but to always use "nuclear energy" because it tested far better than "nuclear power."

Rod Adams, who writes the nuclear blog "Atomic Insights" (<atomicinsights.blogspot.com>), chimed in from the audience that when the term "nuclear power" is typed into the Google search engine, "almost half the time it comes up with a weapons-type return. It's about 'Iran trying to become a nuclear power.'"

Also, when talking about nuclear energy with those outside of the industry, Limbach said, it is important to promote the benefits of "new nuclear energy facilities," because people love hearing about things such as "jobs, jobs, jobs." Market testing has shown that high-level skills, well-paying careers, and community economic benefits are very important.

Limbach stressed that it is also important to link nuclear energy with renewables and to position it as part of a diverse, carbon-free energy portfolio. "The truth is," she said, "most people really don't care about where their electricity comes from or how it's generated. They care whether it's clean, or safe, or reliable." She noted that the phrase "clean air" tested "off the charts as positive" and that a key is to describe nuclear as environmentally friendly.

It is important to link nuclear energy with renewables and to position it as part of a diverse, carbon-free energy portfolio.

Turning to methods used to promote nuclear technology to worldwide audiences, Piercy brought up blogs, tweets, and the Web site "YouTube," specifically a rap music video posted there (at <www.youtube.com/watch?v=j50ZssEojtM>) about Europe's Large Hadron Collider. The video was produced by a student from Michigan State University with a budget of only $500. So far, the marketing results have been amazing, as the video has received more than 5 million hits and a cumulative 5-star rating (termed by YouTube as "awesome") from viewers.


Brown

Gil Brown, of the University of Massachusetts Lowell, commented from the audience that even with the steps that the nuclear industry is taking to promote itself, there will always be the "yeah, but . . ." issues that come from people who are leery of the technology. Those issues are proliferation, waste, and Chernobyl. Brown said that the waste issue is at the forefront, but the way he approaches it is to explain that "everything leaves a footprint." There has been a call to sequester carbon released from fossil-fueled power plants, he said, and that would require capturing it. Mean-

while, the sequestration of waste products is already done in nuclear power. "I think we have a very strong case to tell, and we need to address the 'yeah, but' part of this conversation," he said. "But we'll get to a certain point and we'll never break through the barrier."

Piercy agreed in part with Brown's assessment but said that the conditions of nuclear's role in the world have changed.

Piercy

Once upon a time, he said, the nuclear role consisted of scientists who were afraid to talk to the press and afraid to extol the virtues of the technology because they lived in an environment that was secretive and was caustic to nuclear. But things are changing, he said, looking into the audience and seeing the faces of nuclear professionals who were born after the Three Mile Island accident in 1979 and Chernobyl in 1986. "They don't carry that baggage with them," he said. "They can look rationally and objectively at the technology and see the benefits it can provide to society."

Piercy admitted, however, that industry professionals can talk facts all they want, but what needs to be changed is the public's perception of the technology. "At the end of the day, it's highlighting the people and highlighting the 'vibe' around the technology," he said. "We have to create a different aesthetic about nuclear than what we have now."

Industry professionals can talk facts all they want, but what needs to be changed is the public's perception of the technology.

Digital I&C issues

The conversion of power reactor systems from analog to digital instrumentation and controls is still in the fairly early stages, especially for safety-related systems. Of the few conversion efforts to date, some have been arduous for the licensees, and the rough going between the licensees and the NRC was cited frequently during the session on digital I&C regulatory issues.

Steven Arndt, senior advisor in the Engineering Division of the NRC's Office of Nuclear Reactor Regulation, noted that the drivers toward digital I&C are as practical as they are visionary. If nothing else, it is becoming increasingly difficult to obtain replacement parts for 1960s-vintage analog equipment. Arndt said that digital I&C is better than analog but more complex. Not all of the failure modes are known, and the NRC is concerned about common mode failures. A steering committee was set up in January 2007 to work toward interim staff guidance (ISG) for predictable licensing of digital I&C. Nearly 200 public meetings have been held, and the staff has produced guidance on cyber security, diversity/defense-in-depth, probabilistic risk assessment, control room communication (between safety and nonsafety systems, to ensure that the latter do not create problems in the former), control room human factors, and licensing. An ISG for fuel cycle facilities is still being developed.

Arndt

While the ISGs might improve the process for new conversion requests, Arndt said, earlier applications have been difficult for all concerned. He noted that the agency has completed work on Wolf Creek Nuclear Operating Company's request to use field programmable gate arrays (FPGA) for the main steam and feedwater isolation systems at Wolf Creek and is making progress on Duke Power Company's proposed conversion of the reactor protection systems and engineered safety features actuation systems at the three Oconee reactors. Arndt said that things are now going well on the Oconee project, but past problems in the review process for Oconee continue to be cited by professionals at utilities and consultancies as examples of the kind of difficulties that could await any new applicant for digital conversion.

Scott Patterson, program manager for I&C obsolescence management at Pacific Gas and Electric Company's (PG&E) Diablo Canyon plant, provided a status report on the digital replacements for the reactor protection systems at the two Diablo Canyon reactors. He said that the company has been replacing analog with digital on various plant systems for some time, and because of the rapid development of digital technology, is now, in some cases, replacing old digital with new digital. This opens the issue of whether different generations of digital I&C, based on different platforms, are compatible. Patterson said that Wolf Creek's use of FPGAs—which, at least theoretically, are not subject to common mode failures—has encouraged PG&E to include FPGAs at Diablo Canyon.

Patterson

Exelon Generation has done a few digital conversions, limited to systems outside a reactor's nuclear island. Chris Wiegand, of Exelon, who also chairs EPRI's I&C Working Group, said that his company's first safety-related conversion is intended to be on the reactor core isolation cooling system at the Clinton reactor in Illinois, with a target date of 2012.

Wiegand

Although many indicators may encourage digital conversion, Wiegand said that from his EPRI perspective, he does not see much urgency among utilities to get started, with capacity factors high and I&C modifications needing to compete for utility resources with more pressing issues, such as buried-pipe upgrades and corrosion mitigation. He said that "uncertainty and a lack of confidence in vendor performance" are having a negative effect on the overall conversion effort.

New reactors can be designed with digital I&C, but as with conversions at existing reactors, new reactors must also adjust to the NRC's still-developing approach to regulation and approval. Richard E. Miller, engineering manager for I&C and electrical systems for new reactors at GE Hitachi Nuclear Energy, spoke on lessons learned from the development of NRC interim staff guidance and how it affected the control room design for the ESBWR. Miller said that the ESBWR appears to have no problems with the guidance on any digital system, although some responses to requests for additional information are still being assessed. Feedback from senior reactor operators and other users, however, prompted an alteration of the control room design to include larger consoles and a more versatile wall display.

Miller

During the panel discussion, the question came up whether license renewal would effectively come to require a large-scale digital conversion. The general view was that conversion remains the licensee's decision, and although the NRC is interested in

maintaining a plant's life cycles, this could be done through inspection, not necessarily licensing. Arndt later said that the extra 20 years of operation granted by renewal might give licensees more confidence that digital conversion would pay off.

Modular construction

The panel session titled "Modular Construction for Nuclear New-Build Projects" was chaired by Keyes Niemer, of the Shaw Power Group, which is now completing the first U.S. module fabrication plant at Lake Charles, La. According to the session's opening speaker, Pat Neuschwanger, of Westinghouse Electric Company, module fabrication is scheduled to start at the new facility during the first week in October.

Neuschwanger, who has been involved in the development of the AP1000 module program, discussed the benefits and some of the drawbacks of modularization. In general, the advantages are that it shortens construction time, uses manpower more effectively, yields higher productivity, and allows for better control of the fabrication process.

Modularization has a significant impact on costs, Neuschwanger said, particularly because it allows much more work to be done off site. And once the modules are at the site, he said, a significant amount of work can be done "out of the hole," the "hole" being the areas where the main reactor containment, auxiliary, and turbine buildings are being constructed. "Out-of-the-hole" work involves assembling modules before they are lifted by crane into position in the hole.

Transferring a lot of the construction work off site can drastically shorten construction schedules, Neuschwanger said. Westinghouse is working toward a five-year order-to-operation schedule, and within that, a three-year construction schedule from first pour of concrete for the nuclear island to hot functional testing.

Modular components, which account for only about 15 percent of the plant's steel inventory, do not make up the majority of a nuclear plant, Neuschwanger said. Modules are mainly located in the containment building, the auxiliary building, and the turbine island.

Modularization has a significant impact on costs, particularly because it allows much more work to be done off site.

There are costs involved in modularization, including high upfront costs, Neuschwanger noted. Previously, project cashflow was often stretched over a 10-year period. Now, however, a large part of the funding has to be spent during the first three years of a project because that is when most of the components and modules are fabricated and installed. This has a significant impact on project financing.

Having work done off site reduces the amount of the more expensive manpower used on site, he said, and fabrication plants allow for activities such as component inspection and testing to be carried out using existing quality assurance programs and support services. Neuschwanger also noted that the time advantage of this approach follows a 1:3:8 ratio—one hour of work in the shop is equivalent to three hours of work at the site out of the hole, or eight hours of work in the hole.

Transportation constraints largely define the maximum size of modules, he said. Modules are shipped to the site and assembled as required before being lifted into position and then connected. He showed visuals of some large assembled structures that had dozens of rooms on several levels and weighed thousands of tons.

Neuschwanger showed pictures of modules being built in China and transported to the plant site. He also noted that the Chinese are challenging Westinghouse to increase its design effort to keep ahead of the construction schedule and that the company is working hard to do this.

Dan Magnarelli, construction manager at Areva's U.S. organization, said that modularization is seen as part of the company's wider construction optimization effort. He warned that while modularization can help shorten construction schedules, if solid construction programs and processes are not in place, the problems the industry experienced 30 years ago could occur again today. Magnarelli also stressed that the NRC expects its licensees to implement very robust programs to fulfill its nuclear safety requirements, such as those set out in 10 CFR Part 52 licensing, ITAAC (inspections, tests, analyses, and acceptance criteria) work, corrective action programs, and many others.

Many of the lessons learned in the past are still valid, he said. One in particular is the need to complete the design early in the process. Areva is looking for 90 percent design completion before construction is begun on a plant in the United States. This goal has not been achieved for the four EPR projects under construction, one each in France and Finland, and two in China.

With respect to Areva's lead EPR project at Olkiluoto in Finland, the short time between the award of the contract and the start of construction led to early construction problems. More generally, Areva has experienced quality problems with material and equipment supplied by vendors in Europe who do not have nuclear experience. The company is also concerned about the shrinking pool of craft people in the United States who are trained to meet the quality standards needed to work on nuclear projects.

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Areva's partner in the United States for its new-build program is Bechtel, which acts as project and construction manager. Areva is implementing Bechtel's in-house constructability program that has been developed over 30 years. Magnarelli also mentioned keeping close tabs on all Areva projects on a daily basis to identify lessons that can be learned. One individual from the U.S. group spends 50–60 percent of his time at Areva's two EPR plants in Europe, and as the China projects ramp up, he will be sent there as well.

Areva will not do modularization for the sake of modularization, he said. It will be done only where it makes sense. But when opportunities for modularization present themselves, he said, Areva will take them. In fact, Areva has set out some guiding principles for identifying such opportunities, which include schedule certainty, reducing on-site labor, minimizing work "in the hole," and performing work off site at facilities with good resources. On this last point, he advised, "don't bring the resource to the work site, take the work to the resource," and added that the most useful activity to move off site is work that would be on the critical path at the site.

Once a potential opportunity is identified, Magnarelli said, it goes through an initial screening process. Those that survive are then sent to an assessment group made up

of people from the engineering, procurement, and construction (EPC) disciplines. This group considers what precisely the proposal would involve and determines the impact it could have on EPC schedules. About 600 opportunities have gone through that process, 60 of which are going to be implemented. Those are the ones that "provide the biggest bang for the buck," Magnarelli said. Behind them are 250–300 others that will probably be pursued but are on a much smaller scale. This program is expected to improve with each successive project. Eventually, there will be an optimized construction process that includes modularization, he said.

Magnarelli described the benefits achieved by some of the modularization being introduced. One involves the in-containment reactor water storage tank (IRWST), and another the safety injection pump room. The IRWST installation is not on the critical path, but by modularizing its fabrication, substantial savings were achieved through reducing the manpower needed "in the hole" and maintaining higher quality and productivity in the shop by using better production tools for the measuring, cutting, and welding operations. In the case of the safety injection pump room modules, among other advantages, placing them in position required six crane lifts instead of 30.

The final design of modules has to accommodate different modes of transportation, Magnarelli said. For land-locked sites, as is the case for most U.S. locations, modules must travel by road, which limits their size, but whenever possible, barge transportation will be used.

Frank Gillespie, a senior vice president for Mitsubishi Nuclear Energy Systems who was previously with the NRC, is responsible for reactor design certification and the associated COL applications. Gillespie began his presentation by showing a video of construction activities recently completed at Tomari-3, the latest of 24 nuclear units built in Japan by Mitsubishi. The video showed the containment dome being set in place, with tolerances of less than a quarter of an inch. He said that most of the American constructors he has spoken to said this could not be done here. Gillespie also found considerable resistance to and discomfort with the 40–44-month construction schedule.

Gillespie also pointed out a potential problem of modularization that he said is not often heard. Because modules can be built far from the plant site, many will be transported over long distances, putting considerable stress on the structures and possibly overstressing them, which could be a concern to the NRC. They may have to be monitored to ensure that they remain in a qualified state once they arrive at the site.

When welding together modules and other structures, the pipe connections are critical, Gillespie said. He explained that the piping is not fixed in the final position in the modules and that there is considerable room to move the pipes after the modules are placed in their compartments.

In addition to the problems associated with the transportation of modules to the site, the efficient movement of these and other components around the site is paramount, Gillespie said. The logistics are extremely complex, he added, and working them out requires advanced modeling tools. As an illustration of this, he projected 3-D CAD images of a site showing the position and spread of every crane (Mitsubishi uses about 30) to demonstrate that every module and component can be moved to where it needs to go. The real challenge, Gillespie said, is not making modules, it is getting them in the right place at the right time to be installed in the right sequence and at the right speed.

The regulatory and inspection aspects of modular construction were described by the final speaker, Alan Blamey, chief of the NRC's Construction Projects Branch 2 and the lead for the work being done at the Center for Construction Inspection (CCI) in the NRC's Region II office in Atlanta to develop a dedicated inspection program for new reactors.

The CCI was born in October 2006, Blamey explained, with the mission of ensuring that nuclear facilities will be constructed according to approved design criteria using appropriate practices and materials. This involves inspecting the entire construction process, including fabrication, assembly, installation, and testing, as well as ITAAC verification activities, which are designed to ensure that the components satisfy design intentions as well as safety and other requirements before the NRC will allow the plant to load fuel.

Blamey described how a credible ITAAC sampling program was developed to ensure that the plants are built in accordance with the design. In devising the sampling program, an expert panel considered all ITAAC activities against particular criteria, including whether an error could go undetected or a plant condition could be confirmed by means other than direct observation. Other considerations used for the selection process were construction and testing experience and safety significance. The panel then established a numerical ranking to identify the most important of the ITAAC activities to be inspected, which turned out to be about 35 percent of the total.

The inspection of modules covers more than their basic fabrication and assembly, Blamey said. It also involves looking closely at any special processes used in module fabrication, the quality assurance procedures implemented, and other programs dealing with, for example, identification and resolution of problems, reporting of deficiencies, and training and qualification of the construction staff, which are also crucial for ensuring that the work is carried out properly.

Blamey described what is involved in specific cases. For example, the inspection of steel structures must verify that the components were constructed properly, the material procurement procedures were done correctly, workers were qualified, construction activities were performed in accordance with the appropriate work documents, any special processes such as welding were properly controlled, and the record of the work is complete and accurate.

In the area of structural concrete, he said that the inspection of an on-site concrete batch production plant should verify that the quality assurance procedures are carried out properly, that plant operators are qualified, and that the appropriate concrete mix is produced. Regarding the concrete structures themselves, inspections will check, for example, that testing of the concrete was done; that special considerations, such as weather protection provisions, were in place; that the placement of expansion anchors was properly controlled; and that water barriers were provided for the foundations.

In addition to the problems associated with the transportation of modules to the site, the efficient movement of these and other components around the site is paramount.

The inspection of a valve includes verifying that special processes, such as welding, were properly controlled and carried out by properly trained and qualified people, that the materials used were verified, that test data reports were certified, that code stamps were current and valid, and that the valve was hydrotested.

One of the challenges for the NRC, Blamey said, is integrating all the different inspection activities needed with modularization. It is necessary, he said, to have the right inspection skills at the right place at the right time.

Continued

Employment issues

The nuclear industry appears to be rising to the challenge of the projected manpower shortage. While industry statistics show that many nuclear plant workers are nearing retirement age, the private and public sectors have partnered with schools and other organizations to establish an employment pipeline.

Two sessions highlighted steps the industry is taking to meet the workforce challenge. One session dealt with what some utilities are doing to fill the employment pipeline, and the other with how the DOE is finding new employees to work on the Mixed Oxide Fuel Fabrication Facility project at the Savannah River Site (SRS) in South Carolina.

In the session "Strategies for Attracting, Developing, and Retaining Talent in a Growing Nuclear Industry," John Wheeler, manager of workforce planning for Entergy Nuclear, said that a perception once existed among some utility executives that new employees would show up once the next generation of nuclear plants was built. But this will not be the case, Wheeler said. He referred to a scene from the movie *Field of Dreams,* where ballplayers materialize out of nowhere to play baseball in an Iowa cornfield. "Somehow, I don't think that's going to work for us," he said. "They're not just going to appear when we need them. We need to work on it. We need to invest our time, our money, and our effort into creating the workforce of tomorrow."

Wheeler

About three years ago, he said, Entergy determined the types of employees it would need to hire, when they would be needed, and where they would be located geographically (since Entergy operates nuclear plants in eight states). The plan was to steer away from certain business areas, such as accounting, communications, and human resources, because those talents are available across the board and are interchangeable with other industries, and instead focus on areas specific to the nuclear industry, such areas as engineering, operations, and I&C. Wheeler noted that these new employees would have to come out of accredited training programs.

Taking into consideration its own workforce-demand forecasts, age demographics, trends in the industry, and new-construction predictions, Entergy developed long-range forecasts for each of its nuclear sites. For the Pilgrim plant in Massachusetts, for example, Wheeler said that the company established a target for the number of I&C technicians, control room operators, and radiation protection specialists that would be needed each year for the next decade. "Then we knew who we would need to hire, where, and when," he said.

The next step was to determine where the new employees would come from. The company had found from experience that employees who are hired out of the military generally stay around longer if they are rooted in the area where they work. What this means, Wheeler said, is that after working at a plant for five to seven years, ex-military employees are likely to move back to their home area, which may be in another part of the country. This situation creates an unnecessary amount of turnover, he noted, explaining that Entergy still recruits military talent, but now hires from within the region in which the plant is located.

"We need to invest our time, our money, and our effort into creating the workforce of tomorrow."

Entergy has also reached out to local colleges and technical schools to form partnerships to create new training programs. "In some cases, it's a matter of infusing nuclear science and technology curriculum into existing programs," he said. "In other cases, we're creating entirely new programs from scratch."

Wheeler said that Entergy has worked with Idaho State University, Linn State University in Missouri, Louisiana State University, Rensselaer Polytechnic Institute (RPI) in New York, and Lake Michigan College in Illinois, among others, to help develop nuclear-based degree programs. The programs are all funded through federal grants and Entergy's partnerships with other utilities. For example, to fund nuclear engineering education at RPI, a grant was received from the NRC and a funding partnership was developed teaming Entergy with Brookhaven National Laboratory, Constellation Energy, Pacific Gas and Electric, Dominion, and a few other utilities.

Wheeler said that the amount of federal funding available is growing, thanks to the current stimulus package and the focus on "green" energy. In Mississippi alone, he said, $30 million is available for workforce development associated with clean forms of energy. Entergy is also partnering with the Center for Energy Workforce Development, whose "Get Into Energy" Web site (<www.getintoenergy.com>) shows where energy sector jobs are available by zip code. The site offers other features as well, such as videos that provide information about working in the nuclear industry.

Wheeler noted that one of the strategies Entergy employs to retain talent is to foster the growth of chapters of the NA-YGN at all of its plants. Two years ago there were no NA-YGN chapters at Entergy plants, but today there is a chapter at every plant and a total of more than 200 members.

Entergy has also provided funding to the Utility Workers Union of America to help develop apprenticeship programs for careers in the nuclear industry. "Organized labor has a tremendous infrastructure of training programs and training facilities all over the United States," Wheeler said.

Dee Torres, senior pipeline recruiter for Exelon, has a relatively new job within the utility. Two to three years ago, Exelon employees would have responded with "I have no idea" had they been asked what a pipeline recruiter was. But the utility realized the necessity of creating a department just for employee recruitment purposes. Today, Torres said, the pipeline recruiting group is staffed by six employees who work to develop strategies for getting new people in the door and retaining them.

Torres

Torres said that retirements at Exelon will peak in the next five to 10 years, but for now that tendency has slowed because of the current economic climate, which has resulted in people staying on the job longer.

A new program developed at Exelon is the hiring of high school science teachers to work in the company's training department during the summer. Torres said that the program offers dual benefits to Exelon. First, the hope is that the teachers will go back to the classroom and be advocates for nuclear power. Second, Exelon hopes to learn how the teachers get through to their students to keep them interested in subjects such as chemistry and physics.

Another area of focus at Exelon is employee knowledge transfer and retention. In 2008, the company launched an internal Web site called "Nukipedia," where employees can go to access knowledge archives by using an advanced search engine to pull up PDF, Word, and Excel files.

Like Entergy, Exelon is also partnering with universities and technical schools to help fill the workforce pipeline. In October 2007, Exelon created a "champions" program, which has partnered with 13 universities. The champions are Exelon executives who work to recruit students. "We have a healthy competition among the champions

about who can get the most interns and new hires from the schools," Torres said. "Around the champions, we've built campus teams. They accompany recruiters at events, career fairs, info sessions, and sponsored activities." Some of the partner schools are Joliet Junior College in Illinois, Linn State, Olive-Harvey College in Chicago, and Delaware County Community College.

Torres said that Exelon has had success with its college internship program. For example, in 2008, the utility retained 75 percent of its interns as full-time employees. "We're excited about that," she said. "Once we get the students into the plants, they begin to understand it and they like it. We're trying to demystify nuclear. This is an industry that's not on any reality TV show. This is not an industry where people are clamoring to join it."

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At STP Nuclear Operating Company (STPNOC), a program was started in 2006 to identify the key components needed to attract and retain employees. Clarence Fenner, the nuclear workforce development coordinator for STPNOC, explained that the company partnered with Luminant (which operates the Comanche Peak nuclear plant in Texas) to work with Texas A&M University to open a funding path to the Texas governor's office. The partnership was able to secure $2 million in funding from the governor to establish the Nuclear Power Initiative (NPI), which, Fenner said, governs the business of developing degree programs at institutions to help meet nuclear staffing needs.

The NPI has worked to develop two-year degree programs that meet specific industry needs, such as for radiation protection and I&C personnel. A barrier in marketing the programs was that students didn't seem enthused about striving for a two-year degree, according to Fenner. "I haven't found a bumper sticker yet that says, 'My son graduated with a two-year technical degree,'" he said.

A key to overcoming that negative perception, he said, is to involve the parents of the prospective students, just as college coaches pursue touted athletes. "It's not enough to engage the counselors and educators," he said. "You have to go to those homes and recruit the parents. [Students] will sign if they have parental support."

In 2008, STPNOC launched its Educational Incentive Program, which provides the cost of tuition, textbooks, and fees—plus a monthly stipend—for up to 60 students annually who enroll at local colleges to earn a two-year degree in nuclear power technology. Fenner said that 60 percent of STPNOC's entry-level personnel needs will be met through the program, for which he has secured funding through 2017.

One of the best marketing tools for the program, Fenner said, is a video clip from a national cable TV news station that was posted on YouTube. In the video, a reporter asks a student enrolled in the nuclear power technology program at Wharton County Junior College what he thinks of STPNOC's Educational Incentive Program. "I never thought I would have an opportunity like this," the student said. "Do you realize what STP is going to pay me when I complete this program and start working at the plant? It's the chance of a lifetime!"

"You can't buy that kind of marketing value," Fenner said.

MOX employment planning

The challenge of workforce planning was also the focus of the session "MOX Gateway: Roadmap to Human Resource Development for the Nuclear Renaissance." The Mixed Oxide Fuel Fabrication Facility is under construction at SRS.

Clay Ramsey, the National Nuclear Security Administration's project director for the MOX facility, said that the DOE realized in 2003 that it had better look closely at its workforce demographics. The DOE learned that nationwide and at SRS, the average age of an NNSA employee was 50 years and that half of them would retire within six years. The DOE then started an aggressive campaign to bring in workers just out of college, which was a new approach for the NNSA because it had largely been hiring experienced professionals. Ramsey said that while the strategy of hiring seasoned employees was useful, it also contributed to the issue of having an aging workforce.

Ramsey

One of the DOE's initiatives is the Future Leaders Program, which hires some of the "finest college graduates" to work for the NNSA, Ramsey said. The graduates receive two years of traditional training to understand the business of the NNSA and become vested in doing nuclear work. About 200 future leaders have been brought into the NNSA in the past five years, and 12 of them are working on the MOX project at SRS. "They reinvigorated our workforce," he said. "They've been a lot of fun to have and yet they're also very good, very talented, and extremely knowledgeable."

Ramsey recalled that when he joined the MOX project in 2006, Shaw Areva MOX Services was in the process of moving from its location in Charlotte, N.C., to Aiken, S.C., (where SRS is located) to work on the MOX facility. About 65 percent of the workforce opted not to make the move, in part because the project did not have solid congressional support behind it, which meant that it could be canceled for lack of funding. The large-scale departure of employees left the company shorthanded, and there was no alternative but to augment the staff by hiring high-priced consultants. The company realized that it needed to take a long-term view of hiring for the MOX facility because it had a long-term contract with the DOE tied to the facility.

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Dave Stinson, president and CEO of Shaw Areva MOX Services, explained that the company started a scholarship program for engineering students at South Carolina State University to help meet employment needs. The SRS area will need 10 000 nuclear professionals in the next decade, and 35 000 will be needed in the Southeast, he said.

The NNSA and Shaw Areva MOX Services have also started a program that reaches out to local high schools to establish education curricula and training in hopes of attracting a future workforce.—*E. Michael Blake, Dick Kovan, and Rick Michal*

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