ANS ANNUAL MEETING

Nuclear technology: An essential part of the solution

The 2015 ANS Annual Meeting, the society's 60th, was held June 7–11 at the Grand Hyatt in San Antonio, Texas, just a few blocks from the historic Alamo, and while the nuclear industry may not be adopting "Victory or Death" as a slogan any time soon, a bit of that fighting Alamo spirit was on display at the June 8 opening plenary session, where the speakers addressed the meeting's theme, "Nuclear Technology: An essential part of the solution."

Outgoing ANS president Michaele "Mikey" Brady Raap specifically referenced the famous Texas monument in her introductory comments, stating, "Like the defenders at the Alamo, I sometimes get the feeling in the nuclear community that we're battling great odds—in our case, in the fight for nuclear equality. The economics and the environmental impact of nuclear-generated electricity are seldom presented on an equal basis with other forms of sustainable energy." Part of this unequal treatment, Brady Raap said, is the result of antinuclear groups' success, as well as a persistent bias in the media. To illustrate the latter, she noted that following the recent release of the disaster movie *San Andreas*, NBC aired a program in which a U.S. Geological Service seismologist was interviewed concerning the film's accuracy. "I can't remember the last time a nuclear expert was invited to be interviewed to check the facts in a nuclear-themed disaster movie," she said. "I'm pretty sure it didn't happen with the remake of *Godzilla*."

Brady Raap

Meeting session coverage:

- *Nuclear's role in stabilizing climate and electricity grids*
- *One test reactor proposed for many new concepts*
- *Communicating the benefits of radioactivity*
- *Environmental monitoring at Fukushima Daiichi and elsewhere*
- *Effects of long-term dry storage of spent fuel*
- *Barriers among laboratories, universities, and industry*

In Brady Raap's view, this antinuclear sentiment needs to be opposed by a nuclear community willing to make its opinions known, and forcefully so, regarding the benefits of nuclear science and technology. As an example of how that strategy can be successful, she pointed to the ANS-led grassroots campaign conducted at the society's Winter Meeting last November in connection with the Environmental Protection Agency's proposed Clean Power Plan Rule, which, ANS believes, dramatically discounts the clean-energy contribution of current nuclear facilities, while penalizing states with new plants under construction. According to Brady Raap, the campaign resulted in the submission of more than 500 comments to the EPA from ANS members and others, leading the agency's administrator, Gina McCarthy, to announce in February that the EPA would be reconsidering its treatment of nuclear power in the final version of the rule. "Our voices were heard," Brady Raap said, "and I want to thank all of you for participating in that and for lending your voice and taking action on this important topic."

Continued

Brady Raap also cited the new global initiative, Nuclear for Climate, the purpose of which is to ensure that all nations recognize nuclear as a low-carbon form of energy. "Thirty-nine professional nuclear organizations from around the world are currently involved in the Nuclear for Climate initiative," she said. "I was proud to represent ANS at the International Congress on Advances in Nuclear Power Plants conference in May and was the ANS official signing the Nuclear for Climate declaration." In addition, Brady Raap said, these nuclear groups have called for the new United Nations Framework Convention on Climate Change protocols to recognize nuclear energy as a low-carbon energy option and to include it in its climate-funding mechanisms, as is already the case for all other low-carbon energy sources. "Everyone decided that it's time to draw our line in the sand," she said, again invoking the Alamo. "We think it's time for us to stand and fight, because the industry, which is basically the net that captures all the things we do, is being challenged."

The plenary session's featured speakers were introduced by Dale Klein, former chairman of the Nuclear Regulatory Commission and associate vice chancellor for research at the University of Texas System, who was the general chair of the meeting and the session moderator. The first speaker was Doyle Beneby, president and chief executive officer of San Antonio's CPS Energy, the largest municipally owned natural gas and electric service utility in the United States and 40 percent owner of the South Texas Project. In brief comments welcoming ANS to San Antonio, Beneby expressed his view that despite having certain economic and other hurdles to overcome, nuclear energy is likely to be a significant component of the future energy portfolio in the United States. "Just yesterday, the G7 Western countries announced that the goal will be to have, by the year 2100, no more fossil fuels," he said. "Now, that's a great and ambitious goal, and if you assume that that will be the case, it bodes well for the argument that nuclear will play an even more important role beyond 2050."


Klein


Beneby

Speaking next was Tom Fanning, president, chairman, and CEO of Southern Company, who declared that nuclear must be a "dominant solution" to future U.S. energy needs. "For all the challenges facing the world today—when you look at still unacceptably high unemployment, the lack of wealth creation in our households, event risk and uncertainty in Russia and the Middle East, the lack of transparency in China, our own problems at home—I am proud to say that what you do, what we do, in terms of providing this nation with clean, safe, reliable, and affordable energy, is a way for Americans to play offense in an otherwise challenging environment," Fanning said. "I really think that hard-working American families, making tough kitchen-table economic decisions every day, are thirsting for a way forward. What they want for their children is a better place to live, better education, better food on the table, better medical care. When I think about what we're able to do with a full portfolio of American energy resources, we can make that a reality. . . . If we can provide energy security for this great nation, we can promote national security and economic security. Nuclear is central to that."


Fanning

Fanning characterized Southern's efforts toward providing that security as an "all-of-the-above" energy strategy that includes new nuclear. Regarding the utility's current new nuclear project—the construction of Units 3 and 4 at the Vogtle plant near Waynesboro, Ga.—Fanning admitted to schedule delays and cost overruns, but maintained that "benefits developed along the way have far overwhelmed any cost increases." While a 12 percent rate increase in Georgia was projected when the project was first approved, he said, new estimates put the likely increase at between 6 and 8 percent.

According to Fanning, three characteristics of the Vogtle project have allowed work to proceed despite the nuclear chill cast by the Fukushima Daiichi accident: First, Vogtle is not exposed to the kind of flooding risks found at coastline locations; second, the plant is not situated in a seismic-sensitive area; and third, the technology deployed at Vogtle is superior to its predecessors. "We are deploying the Westinghouse AP1000, which, in my opinion, is the newest, safest technology around," Fanning said. "When I talk about energy policy broadly, I always use the four-word phrase 'clean, safe, reliable, affordable.' It is important to use that phrase because it resonates with the public. The public understands that clean is important. Safe is the next most important thing. Nuclear fulfills that. And when I think about affordable and reliable, nuclear does that as well."

Fanning also touched on the other components of Southern's energy portfolio: coal, natural gas, renewables, and energy efficiency. Although coal is undeniably waning in importance in the United States, he said, it must remain, for the time being at least, a U.S. energy resource. He described the deployment in Mississippi of Southern's coal gasification technology—Transport Integrated Gasification, or TRIG—which strips out 65 percent of the CO_2 from the coal. "From a carbon-footprint standpoint, it's cleaner than natural gas," he said. "We'll produce more electricity, and the CO_2 will be used for enhanced oil-recovery processes. Imagine that. A native resource that otherwise goes unused and produces more electricity, more oil, and at a price that's attractive to Mississippi's customers." Fanning also noted that while the United States has reduced its reliance on coal for electricity generation in recent years, from about 50 percent to about 40 percent, Southern has made a more dramatic shift. Prior to Fanning's tenure as chairman, approximately 70 percent of the company's energy production came from coal. This year, that number is expected to drop to about 32 percent, with the slack taken up by natural gas, which, in the same time frame, has risen from 16 percent of Southern's energy production to some 48 percent.

"When I talk about energy policy broadly, I always use the four-word phrase 'clean, safe, reliable, affordable.' It is important to use that phrase because it resonates with the public."

While maintaining that Southern is one of the biggest investors in solar, Fanning argued against the notion that renewables, coupled with energy efficiency, will be able to solve the nation's energy problems in the future. Wind and solar tend to be located in lightly populated regions of the United States, he said, requiring a long-haul transmission system in order to bring those resources to more populated areas. "We know

from blackouts in the United States that the greater the distance, the greater the risk," Fanning said. "That is why I believe technologies that rely on long-haul transmission will have their day in the sun, but they are not the right long-term solutions." He also observed that wind and solar, unlike nuclear, are intermittent resources, and that they receive "enormous tax benefits from the federal government, 100 times more than that available to coal, oil, and gas and 35 times more than that available to nuclear. How long can the U.S. afford to do that?"

In his closing comments, Fanning spoke to the issue of cybersecurity, describing his involvement with the Electricity Subsector Coordinating Council, which he chairs. (The ESCC serves as the principal liaison between the U.S. electric power sector and the federal government and is tasked with coordinating efforts to prepare for, and respond to, critical infrastructure threats, including cyber-terrorism.) "Effectively, the Department of Homeland Security segmented American commerce into 16 pieces, and electricity is one of those," Fanning said. "There has been a report sent to President Obama from the National Infrastructure Advisory Council that will call out five of the 16 sectors as having the highest priority. The convening body will be the electricity sector, the other four being telecom, transportation, finance, and water. Our expectation is that as the president has received this report, he will sign it and put it into place, and that we CEOs will be leading an effort representing a public/private partnership under the primary responsibility of DHS, to build flexibility and a great deal of optionality into our responses to, and hopefully preventing, these enormous threats."

Following Fanning to the lectern was David Scott, president and founder of Investment Diplomacy Group and former executive director of economics and energy affairs at the United Arab Emirates' Executive Affairs Authority, who spoke of his leading role in the UAE's decision to develop a nuclear energy program and of the lessons learned from the experience. Successful nuclear energy programs, Scott said, are based on long-term, sustainable needs, as well as on a rigorous decision-making process regarding the choice of technology to embrace. Context is particularly important, he noted, because all forms of energy have appropriate and inappropriate contexts. There are some locations where nuclear power is the right answer, and some where it is not, and the same concept applies to oil, gas, coal, solar, wind, or waste energy. "The art in finding context is looking at all of these characteristics, not merely geographic and not merely technical, but also the social issues, financial issues, and capabilities of industries," he said.


Scott

Once context is established, Scott continued, a process should be developed that follows five rules. First, the process must include all relevant decision-makers, meaning all entities or individuals with the power to bring the project to a halt, including, among others, government policymakers, regulatory bodies, utilities, and large industrial customers. Second, the process must consider all the available energy options. The only way to get an effective, reliable, and sustainable energy portfolio for the long term, he said, is by putting all options in competition with each other and allowing the numbers to speak for themselves. Third, a comprehensive benefit metric should be utilized in order to avoid arriving at a decision based solely on a particular technology's potential financial performance, which, according to Scott, can lead to a distorted outcome. Fourth, the process should rely on long-term rather than short-term data. "What I would suggest as part of a robust process is to expand the data stats on which you base your choices," Scott said. "And I'm not talking about five years or 10 years. I'm talking about looking at trends of 30 years and beyond." Fifth, a decision-support function should be created and carried out by a multidisciplinary team with reliable access to decision-makers.

The only way to get an effective, reliable, and sustainable energy portfolio for the long term is by putting all options in competition with each other and allowing the numbers to speak for themselves.

"You need to have financial analysts, accountants, your technical engineering types, public opinion and political interest experts, parties familiar with the regulatory structures, and the regulators themselves," Scott said. "That multidisciplined team can create a decision package that is responsive to all those decision-makers. In the case of the UAE, that's exactly what we did. It allowed us to come up with a robust decision packet. And the great thing about that kind of decision process is that when you get to the end of it, everybody has had their say, everybody has had their particular proposal compared against other proposals and has understood why some were dropped and some were adopted. It creates an automatic alliance, because you have all of those decision-makers and stakeholders involved in that process."

Scott also discussed the importance of having a detailed and robust implementation plan, characteristics of which include an honest evaluation of capabilities, both in terms of expertise and suppliers; a preference for a mature technology; a built-in process for keeping decision-makers, including the public, engaged throughout the project; and the willingness to spend "lavishly" up front. "We've all heard the statistics that people talk about—a change post-construction is 1,000 times more expensive than a change preconstruction," he said. "And that is absolutely true. It's almost impossible from my perspective to overspend in the early planning stages of a nuclear deployment. The more money you spend to make sure that you have that engineering design correct and accurate and mature and that you have your plan for meeting all the outside-the-fence requirements, the more you're going to save yourself money at the end of the day."

Important lessons learned from the UAE nuclear project, Scott said, include making sure that regulators are appropriately resourced early in the deployment process, that quality surveillance and assurance is prioritized and aggressively funded, that all decision-makers receive proper induction training, and that contractual structures are put in place that remove fence lines. "We have a unique structure in the UAE," Scott said. "We did something called the 'prime contract.' We wanted a one-stop shop because we knew that our big constraint would be bandwidth. So we tried to create a contractual structure that brought all of the engineering, procurement, and construction contractors and component manufacturers, as well as the actual NSSS [nuclear steam supply system] supplier, under one contract. It's not easy to create that because it does limit your options in terms of who can supply, but through our tender process, we were actually able to create about four different prime contract–capable suppliers. And because that prime contract brought everyone under the same tent and removed those fence lines, the process has been much more efficient. Everybody is in the same

boat. Everyone is jointly and separately liable. Everybody wants to make sure the project is successful."

The session's final presenter was Scott Tinker, director of the Bureau of Economic Geology at the University of Texas and the Texas state geologist, who discussed the rise in shale gas production and its possible impact on nuclear energy. Tinker characterized the hydraulic fracturing (or "fracking") process as "an evolution rather than a revolution, but a rapid evolution of technology and risk taking." Through an extensive slide presentation, he provided session attendees with information on the science and economics involved in fracking and took a close look at the current output and future potential output of the four major U.S. shale basins, the Barnett, Fayetteville, Haynesville, and Marcellus.


Tinker

Tinker declined to categorically label the fracking phenomenon as either "bubble" or "boom," stating instead that "as with many things, it depends on your time frame." Oil and gas will be part of the energy mix for decades, he said, notwithstanding intentions. "They're dense forms of energy that are available, reliable, and affordable, and somewhat sustainable," Tinker said. "Shale represents a large, expensive, technology-heavy resource, and it will be developed, globally, slowly, differentially, until such time as other options come forward. The Stone Age didn't end for lack of stones, and the oil age won't end for lack of oil or methane. It will end when demand shifts to other more affordable and reliable things."

"The Stone Age didn't end for lack of stones, and the oil age won't end for lack of oil or methane. It will end when demand shifts to other more affordable and reliable things."

Following their presentations, the speakers fielded a number of questions from the audience, including a query from *Atomic Insights* blogger Rod Adams, who asked the panelists what they were doing to spread the word to decision-makers in the investment community that now is an opportune time for nuclear power plant construction. By way of response, Scott said that the UAE, as the first Arab country in the world to embrace peaceful nuclear energy, needs to have a successful deployment experience. "That would probably be the most potent commercial in the Middle East region for other parties to say that it's doable and that we should look at it seriously," he said. "If we can deliver reliable, commercially competitive, and environmentally sound energy to the UAE, which has been dominated by natural gas, it's going to send a message to other hydrocarbon-focused economies that they should start looking at this as an option."

Scott said he believes that nuclear energy makes the most sense in environments that are countercyclical to demand. "I think that what Southern is doing is a great idea right now," he said. "I think the cost of the nuclear plant is aided by the fact that they're building in a period where there's not that much demand. If oil prices and natural gas prices were to shoot up in 10 or 15 years and we're seeing $6, $7, $8 gas, then everyone's going to want to build nuclear power plants, and the people that decide to build then will get the most expensive plants. The people that build now will get the cheapest plants."

The only clear disagreement among the panelists occurred in response to an audience question concerning the deployment of small modular reactors in the United States. Citing security concerns and the not-in-my-backyard syndrome, Fanning said that he opposed the idea, while CPS Energy's Beneby suggested that it might be a possibility for certain regions.

"In some locales like Texas," Beneby said, "where you have an energy-only market, perhaps small modular reactors might be the adoptive technology because of the lower initial capital investment and the opportunity for investors to not have their funds tied up over a decade or so and risk political upheaval, cost overruns, and the like. So if you presume that the technology gets to the point where some of the concerns that Tom just outlined could be mitigated, I think this might be a place where SMRs make sense."

Fanning responded, saying that "high capital cost investments that require a long term to pay out with cheap energy, which is typically what you see with nuclear, require some mechanism to recover cost over time. . . . Value is a function of risk and return. There is no risk premium that exists that will support high capital investments in energy-only markets." [In an energy-only market, utilities are paid only for the energy they generate, whereas in a capacity market, they are paid for maintaining reserve capacity.]

A question on whether the proposed EPA regulations for carbon pollution from power plants could be an opportunity for nuclear was answered strongly in the affirmative by Fanning. "Yes," he said, "and that's where I think we've got to get real. Look, as I said earlier, as a CEO, I'm responsible for a balance of clean, safe, reliable, affordable energy. I think EPA gets clean. I don't think EPA really has a good idea of safe, reliable, affordable. Nor should they; it's not their job. That's where we need Congress to get back into the role of setting policy. I hope I'm not being Pollyannaish here, but as I said, I think that Americans are thirsting for a way to play offense. Frankly, I think Congress is getting tired of being labeled as frozen and intransigent. I actually think that our prospects in Congress for comprehensive energy legislation, and tax reform—they have to go hand-in-hand—are good. It may take a new administration so that all of this good work won't get vetoed, but that's my belief."

New reactor concepts

The General Chair's Special Session addressed new reactor concepts and licensing, overlapping the themes of a few other technical sessions at the meeting. In this session, there were three papers devoted to concepts that would require major developments in the licensing process, and two on the less-challenging integral pressurized water reactor (iPWR). Dale Klein, the general chair of the annual meeting, set up the session so that the audience could ask questions after the first three papers, and then again after the last two.

New reactor concepts involve many different kinds of fuels, coolants, moderators, neutron energies, enclosures, and effluent streams, but John Parmentola, senior vice president of energy and advanced concepts at General Atomics (GA), has proposed the development of a single test reactor that could be used to develop materials and try out operational modes for many of the advanced reactor concepts that have been proposed recently. His presentation was intended to build support within the nuclear community for the funding and licensing of such a reactor.


Parmentola

The proposed Versatile Advanced Test Reactor (VATR) would, in Parmentola's view, be a 500-MWt liquid-metal–cooled unit using mixed-oxide fuel in plate form, with a peak fast flux of 10^{16} neutrons/cm^2-sec. The active core would be 1.1 m in height and di-

ameter, with a central test diameter of 0.2 m. There would be test loops to circulate helium, molten salt, liquid metal, and light water, up to 1,000 °C. Test duration in the reactor would be as long as six months.

GA would certainly make use of the VATR to assist in the development of its Energy Multiplier Module (EM^2) concept, but Parmentola stressed that the reactor would not favor one company's concept, as shown by the different coolant loops. (GA might be involved with only the helium loop, since the EM^2 would be gas-cooled.) He said that the advanced reactor community should determine general user facility requirements; that the DOE should then issue a funding opportunity for design, construction, and licensing; and that an industry-led team should collaborate with the Nuclear Regulatory Commission on licensing. Parmentola also stated that the project would enhance U.S. nuclear leadership in the world and support national security by enabling the development of new energy options for the country's future.

Kevan Weaver, director of technology integration for TerraPower, gave a presentation on future world energy needs in general and TerraPower's approach to meeting them through the Traveling Wave Reactor, a breed-and-burn system that by now is familiar to nuclear professionals. (Details on this design, and on GA's EM^2, can be found in articles in the December 2014 issue of *NN*, pages 50 and 77). More pertinent to the discussion at this session, Weaver noted that while TerraPower is working with numerous companies, universities, and laboratories in the United States, it has had to go elsewhere for some of the necessary fuels and materials testing: BOR-60 in Russia. Weaver said that it took TerraPower two full years to get the Department of Energy's approval under 10 CFR Part 810 to use the BOR-60 reactor. TerraPower would much prefer to be able to do such testing at a facility in the United States.

Weaver

While every non-light-water reactor, and also the VATR, would require a great deal of money to advance toward realization, perhaps an even higher hurdle is the NRC's lack of familiarity with non-LWRs and its mandate not to issue licenses for what it does not yet fully understand. Gary Holahan, deputy director of the NRC's Office of New Reactors (NRO), spoke on the history and possible future of licensing strategies for advanced non-LWRs. The gist of the presentation was that while the "one-step" licensing process in 10 CFR Part 52 (which is now in use for LWRs that are being planned and built) can provide predictability and low risk for projects based on reactor designs that have been certified by the NRC, a modified version of the original "two-step" process (which was used for the reactors now in operation) may work better for still-developing non-LWRs.

Holahan

A key to the enhanced two-step process would be what Holahan called a "preliminary design approval or certification," with the "or" indicating that the NRC has not worked out exactly what this is, let alone made it usable through rulemaking. This approval could be used to support a construction permit application, with greater details to be worked out for the NRC's review of an operating license application.

Holahan said that the "minimal elements" required for the issuance of a construction permit are the principal architecture and engineering criteria for the design; the major features or components to protect public health and safety; identification of further technical or design information needed for completion of the safety analysis; description of features and components that require research and development; and any other features on which the applicant seeks issue finality. To meet these requirements, a preliminary design approval or certification should focus on fuel, core, reactor coolant system, containment/confinement, the spent fuel pool, safety systems/severe accident features, general plant layout/principal structures, instrumentation and controls concept, the safety analysis required at this point, and generic dose assessment in keeping with 10 CFR Part 100. Holahan added that the NRC and the DOE will hold an advanced reactor workshop in September.

During the question-and-answer period after the first three papers were presented, Parmentola stated that it would be decades before any non-LWR concept could recover its development costs, so neither the VATR or any design-specific test facility could reasonably be backed with private money. Klein concurred that this kind of test reactor project would have to be federally funded. Asked whether the VATR could be licensed through the existing regulations for research reactors, Holahan said that the relative ease of this kind of licensing arises from the small size and core capabilities of research reactors, which to date have not exceeded about 2 MWt. At 500 MWt, the VATR would be held to stricter standards.

The other two papers were on a topic that has been addressed frequently at recent meetings, including in other technical sessions in San Antonio: the development of the only small modular reactor (SMR) currently being actively pursued, the NuScale Power Module, and the NRC's readiness to license and regulate iPWRs in general and the NuScale model in particular. Some of the items mentioned by the presenters as pending have since been overtaken by events; for instance, the draft design-specific review standard for NuScale was issued by the NRC in late June (see page 22, this issue).

While the "one-step" licensing process in 10 CFR Part 52 can provide predictability and low risk for projects based on reactor designs that have been certified by the NRC, a modified version of the original "two-step" process may work better for still-developing non-LWRs.

Tom Bergman, vice president of regulatory affairs for NuScale Power, gave a presentation on the prospects for the 45-MWe iPWR to be used as a diverse energy platform, with capabilities for desalination, production of chemical feedstock, and variable power output to supplement wind power or other intermittent sources. Bergman noted, however, that the application to the NRC for design certification, now planned for December 2016, will be for baseload electricity only. He said he expects that it will cost $500 million to get through

Bergman

the NRC safety review, and another $500 million to get to final design; the fees to be paid to the NRC for the certification reviews are estimated at $80 million.

Michael Mayfield, director of NRO's Division of Advanced Reactors and Rulemaking, said that the NRC is ready to review iPWR applications and has assessed key policy and infrastructure issues. Mayfield noted that progress has been made this year with the proposal for lower annual fees for SMRs than for existing LWRs, recommendations to the commissioners on emergency planning, and standard review plan updates. As one of his slides phrased it, however, "some key issues continue to develop" with emergency planning, the reactor's mechanistic source term, multi-module control room staffing, and the insurance and liability aspects of SMRs. As to whether SMRs could spread through the "repowering" of closed coal plants and the use of those sites' existing infrastructure, Mayfield said that in many locations where coal plants have closed, the population has increased, so emergency planning issues still must be resolved.


Mayfield

Asked how long the certification process might take, Mayfield said that the 40-month time frame sought by NuScale (ending around mid-2020) might be possible. He added that if NuScale's first potential customer, Utah Associated Municipal Power Systems, applies for a limited work authorization before a combined operating license (COL), the NRC might be able to issue the COL around the end of 2022.

Radiation conversations

The President's Special Session was devoted to the communication of accurate, understandable information about radiation and dosage to the general public and policymakers, and how nuclear professionals should approach this task.

ANS President Michaele Brady Rapp opened the session, giving as an example of inaccuracy an article published by *Consumer Reports* that cited an Australian study in which the recipients of computerized tomography scans were found to have an increased risk of developing cancer. Brady Rapp said that the study did not adjust for the health conditions that had made the scans necessary. She then provided an overview of the Radiation Dose Communications Summit hosted by ANS and the Health Physics Society on February 4 in Norfolk, Va. Three items that were placed on the "message board" from the summit were the topics addressed by the other speakers at the session: natural radiation occurs everywhere in the environment (by Mary Lou Dunzik-Gougar), radiation from human activities has direct and indirect benefits (by Alan Waltar), and a mature knowledge of radiation effects exists in the scientific community (by John Boice).

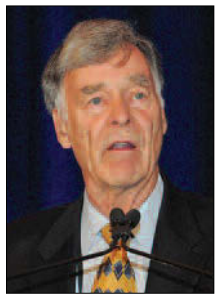

Brady Raap


Dunzik-Gougar

Dunzik-Gougar, acting chair of the Nuclear Engineering and Health Physics Department at Idaho State University, presented her approach to explaining to a nontechnical person, in a limited amount of time, the existence of natural radiation in the environment. She advised using the "rule of three," citing it as a trick of the communications trade. She said that people can typically remember about three related points, and any more than that may be wasted. To develop what she called an "elevator speech" of 30 to 60 seconds, she would use these three points: that radiation is everywhere, that radiation can be measured and controlled, and that radiation applications improve our lives. She added that it is also important to know your audience and to use multiple methods to deliver your message, including spoken and written words, static and dynamic images, three-dimensional objects, numbers (to be used carefully, so as not to alienate the listener), and activities. Among the tools that can be used to show radioactivity in nature and the dose a person receives from it are ANS's radiation dose chart and the radioactivity counter smartphone application.

Enlarging on the items in the first rule of three, Dunzik-Gougar said that radiation in nature can be described to include sunshine, ultraviolet light, living tissues (including the human body), bananas (which contain potassium-40), and granite used in buildings. It can also be pointed out that radiation levels are naturally higher at high altitudes than at sea level, and that public exposure standards are about 20 times lower than natural levels. Measurement and control can be explained by pointing out the ability to detect very low levels, the effectiveness of shielding, and the setting of medical procedures within the natural radiation range. Examples of improvements in human lives can include heartier food crops, nuclear medicine, and electricity with little or no carbon emissions.

Taking the benefits-of-radiation argument much farther was Waltar, retired director of nuclear engineering at Pacific Northwest National Laboratory and an ANS past president (1994–1995). After citing the benefits of nuclear-generated electricity (including high energy density, fuel abundance, energy security, and carbon dioxide emission avoidance), he moved on to agriculture (optimization of water and fertilizer use, speed breeding of improved crops, improved animal production, insect control, food irradiation), industry (process control, diagnostics, materials development, testing and inspection), medicine (materials sterilization, drug testing, imaging, therapy), transportation (much of the same uses as in industry, with inspection and materials testing of vehicles, airplanes, and trains; also, propulsion of submarines and in some cases surface ships), space exploration (radioisotope thermoelectric generators used in existing missions, power systems proposed for more ambitious missions), public safety (smoke detection, exit signs, support for law enforcement forensics, inspections to avert terrorism and clandestine weapons activities), arts and sciences (carbon-14 dating, authentication of art works), environmental protection (tracers to improve water use management, seawater desalination), and the economic impact of all of the above.


Waltar

It is important to know your audience and to use multiple methods to deliver your message, including spoken and written words, static and dynamic images, three-dimensional objects, numbers, and activities.

Waltar covered all of this—an impressive display of the technology's applications—in about 20 minutes, too much, perhaps, to

be captured in an elevator speech. Also, depending on the audience (to recall another of Dunzik-Gougar's points), some parts of the presentation could be more effective than others. For example, listeners might respond more meaningfully to Waltar's recounting of his own nuclear therapy (which included an image of the 109 iodine-125 seeds he received) than to the mention of how nuclear technology helps ensure the uniformity of the thickness of sheets of paper.

Most of what was presented by Boice, president of the National Council on Radiation Protection & Measurements, on the state of knowledge of radiation effects, was related to the Million Worker Study, a federal interagency collaboration on the health effects on Americans who spent their working lives in varying degrees of proximity to radioactive material. (This study may not fully indicate mature knowledge since it is still in progress, and, if funded to completion, will remain so for at least another four years.)


Boice

Making up the group are 360,000 people connected with the Manhattan Project, 115,000 atomic-era armed forces veterans, 150,000 nuclear utility workers, 132,000 industrial radiographers, and more than 250,000 workers categorized as "medical and other."

Boice estimated that about 400,000 of these people have probably already died, given that some of them became nuclear workers more than 70 years ago, and the researchers have not yet found all of them or determined their cause of death. In many cases, a dose reconstruction process is necessary because dose records are either incomplete or nonexistent. As large an undertaking as this is, however, some conclusions have been drawn from the results available to date. Among the 32,000 radiographers who worked in Navy shipyards and who have died, an unexpectedly high number (162) had mesothelioma. Boice said that in these cases, the cause was found to be not radiation exposure, but proximity to asbestos, which was widely used for many years in shipyards, often without any procedures to limit contact or inhalation.

Boice also noted there could be a further addition to the study group: the 85,033 naval personnel who have served on nuclear submarines. A further complication to the study, however, is that many people who worked for long periods in one nuclear sector also worked in other sectors.

In addition to whether the study can connect adverse consequences to occupational exposure, it may be possible for the anecdotal "healthy worker" effect to be given some confirmation. If nuclear workers are found to have had fewer adverse health effects than the population in general, from all causes (not just exposure to radioactivity), this might lend support to the often-controversial concept of radiation hormesis, in which exposure to some level of radiation conveys health benefits, perhaps including a greater tolerance for higher levels of radiation.

Waste management

Among the sessions sponsored by the ANS Fuel Cycle and Waste Management Division at this year's Annual Meeting was the panel session "International Status of Used Fuel and HLW Management: A Review of the 2015 International High-Level Radioactive Waste Management Conference" (IHLRWM). As well as providing an overview of the status of international progress toward the permanent disposal of used nuclear fuel and high-level radioactive waste, the session provided a recap of the IHLRWM conference, held April 12–16 in Charleston, S.C. The session, which was organized by Andrew Sowder, senior project manager for the Electric Power Research Institute (EPRI), covered the three themes of the IHLRWM conference: geologic disposal, waste storage, and transportation.


Apted

Michael Apted, principal geochemist with INTERA Inc., began the session by highlighting the various countries that have begun the process of siting and building deep geologic disposal facilities for used fuel and HLW, and how those programs are progressing. Apted noted that a number of countries are making "real, strong progress toward geological disposal." Two countries at the top of that list are Finland and Sweden, he said, and other countries, including France, Switzerland, Canada, and China, also are making notable progress. Down near the bottom of the list, however, are countries such as the United Kingdom and Japan, where progress has considerably slowed down or stopped.

As for the United States, Apted said that if the Nuclear Regulatory Commission restarts the licensing process for the Yucca Mountain repository, the country will move toward the top tier of countries developing geologic disposal options. If, however, the United States decides to pursue a "generic, consent-based restart of a new repository," it will move closer to the bottom of that list, he said.

One aspect Apted noted that distinguishes the programs of the more successful countries from those that are progressing at a slower rate is the interplay between repository site selection and host community consent. For example, Finland has chosen a process whereby the country first began studying siting and disposal concepts on a technical basis before reaching out to potential host communities. Less successful countries, he said, chose to seek out volunteer communities before studying the suitability of the site. "Eventually, yes, you need that consent," Apted said. "But which comes first? Should we look for volunteer sites, or should we look for, on a technical basis, where we want to be?"

Finland has chosen a process whereby the country first began studying siting and disposal concepts on a technical basis before reaching out to potential host communities. Less successful countries chose to seek out volunteer communities before studying the suitability of the site.

Turning from radioactive waste disposal to storage, John Kessler, manager of the used fuel and high-level waste program at EPRI, noted that the IHLRWM conference is seeing a "significant uptick" in the number of papers and panel sessions on waste storage, including both wet and dry used fuel storage. Kessler said that interest in issues related to storage has been growing since the suspension of the Yucca Mountain Project. Some of the papers presented at this year's conference dealt with the behavior of used nuclear fuel during storage, the degradation and monitoring of welded stainless-steel canisters, regulatory issues, and the thermal modeling of fuel cladding, he said.

Continued

Long-term dry storage, in particular, presents many technical challenges. There are "new degradation mechanisms" associated with long-term storage, Kessler said, and they were the subject of many of the conference papers. Examples include research into the integrity of stainless-steel canisters over long periods of time, which encompasses issues related to stress corrosion cracking. Other subjects of interest include the development of inspection capabilities and improved canister designs.

The loss of ductility in high-burnup fuel during extended storage was also addressed. In regard to high-burnup fuel, Kessler said, "The concern is that as you continue to burn the fuel in the reactor, you pick up more hydrogen due to the reaction with water, and some of that hydrogen finds its way into the cladding." This can result in the formation of radial hydrides in the fuel cladding, which can cause it to be more brittle.

On the subject of chloride-induced stress corrosion cracking (CISCC), Kessler noted that there are around 1,700 welded stainless-steel canisters in use around the country, and the challenge is for the nuclear industry and the NRC to develop an aging-management plan that addresses CISCC issues. Kessler said that EPRI and a number of other organizations believe that CISCC will eventually lead to cask failure. "'Eventually,' though, is the big question," Kessler said. "It could be a very long time, or maybe not so long." This, he said, leads to the question of how to develop canister inspection schedules based on the type and location of the canister. Kessler added that EPRI is working on inspection technologies to better monitor used fuel canisters.

Radioactive waste transportation issues were also a topic of discussion at the IHLRWM conference, as noted by Ruth Weiner, principal member of the technical staff at Sandia National Laboratories.

While the transportation of waste and used fuel covers a wide variety of subjects, Weiner noted that transportation itself is the part of the nuclear fuel cycle that is most visible to the public. This has resulted in a number of "mythologies" regarding the risk of transporting waste that perpetuate despite continued analysis showing that transportation risks are minimal. "As a colleague of mine has said, 'We keep calculating different values of zero,'" she stated, noting that new transportation modeling work done at Sandia has shown that the assumed risks of transportation are lower than expected.

Weiner

Despite the verifiable low risk of transporting nuclear materials, the high-profile nature of transportation makes the planning of routes, whether by truck, train, or other means, a critical component of the enterprise. Weiner noted that two IHLRWM papers dealt with the formulation of transportation routes and the development of routing software. The Department of Energy, through Oak Ridge National Laboratory, has developed a routing software tool called webTRAGIS (Transportation Routing Analysis Geographic Information System). The system can be used to identify legally compliant transportation routes along rail lines, highways, and waterways, as well as to provide population information to assess risks.

On transportation in general, Weiner said that the number of transportation accidents involving hazardous materials that have resulted in damage to the cargo is minimal. "It is small enough for radioactive materials that they do not even show up in Department of Transportation data," she said, adding that among utilities, there have been no recorded accidental releases of radioactive material.

Finally, Steve Nesbit, director of nuclear policy and support at Duke Energy, provided his observations on the IHLRWM conference as one who has attended the last three conferences. Nesbit noted that there was much discussion at the conference on the possibility of the Yucca Mountain program's being restarted. In addition, he said, there was discussion regarding the prospects for the start of a consent-based process for siting a second repository. "That has a lot of appeal to a lot of people," he said, "because it gives you more than one path to success. It also gives the consent-based people a chance to prove their point." Proposing a second repository, however, could cause a political firestorm, he said.

Nesbit

On the question of progress in the high-level waste program in the United States and whether or not the country is moving forward, Nesbit compared it to riding aboard a steam locomotive. They are powerful engines, he said, but they don't have a lot of pickup and move very slowly at first, making it difficult to get a sense that the rider is moving. "There are signs of activity, and we might be going somewhere," he said. "I'm an optimist, so I certainly hope that is the case."

It was noted during the session that the next IHLRWM conference will be held April 9–12, 2017, in Charlotte, N.C.

Breaking down barriers

Advances in nuclear science and technology are made by universities, industrial firms, and national laboratories, but these three realms have inherent differences that might act to put barriers between them, perhaps preventing even greater advances.

Despite the verifiable low risk of transporting nuclear materials, the high-profile nature of transportation makes the planning of routes a critical component of the enterprise.

Brycen Wendt, a graduate student at Idaho State University, gathered speakers from all of these realms to address whether such barriers exist and what can be done to break through them.

Daniel Cole, director of the nuclear engineering program at the University of Pittsburgh, described how the university broke a barrier by gearing some of its nuclear curriculum to the needs of the many nuclear-related industrial firms in and around Pittsburgh. These firms employ a great many engineers, but not all of them have been trained specifically in nuclear fields. Cole said that in addition to a master's degree track in nuclear engineering, Pitt has developed certificate programs to meet what employers described as a major need: nonnuclear engineers with enough grounding in nuclear to support the companies' nuclear work.

Cole said that the industry needs engineers with a knowledge of integrated nuclear plant operations, an understanding of the cause and effect of events separated in space and time, and the ability to work across disciplines, including reactor operation, instrumentation and controls, maintenance, licensing, refueling, and spent fuel disposition. He said that Pitt is also developing research in areas such as thermal and fluid analysis, spent fuel storage, I&C, and advanced materials.

Jess Gehin, director of the Consortium for Advanced Simulation of Light Water Reactors (CASL) at Oak Ridge National Lab-

oratory, described how CASL has broken a barrier between national lab research and industry implementation. CASL is one of the Department of Energy's four Energy Innovation Hubs (the others are the Joint Center for Artificial Photosynthesis, the Joint Center for Energy Storage Research, and the Critical Materials Institute), and through its massive computing power and virtual modeling capability, it is intended to increase understanding of power reactor safety margins while addressing operational and design challenges, to engage the nuclear energy community through modeling and simulation, and to deploy new partnerships and collaboration paradigms.


Gehin

The simulations are intended to address real-world issues at power reactors so as to predict or describe the progression of fuel pellet interaction with cladding, cladding integrity during a reactivity insertion accident or a loss-of-coolant accident, departure from nucleate boiling, fretting between fuel rods and support grids, and corrosion (including crud buildup).

Gehin gave as an example of CASL's work the analysis of the startup of Westinghouse's AP1000 reactor, which is under construction in the United States and China but has yet to operate. Monte Carlo research performed by the University of Michigan, the Massachusetts Institute of Technology, and ORNL was combined with modeling and simulation in the TITAN supercomputer to provide high-fidelity neutronics solutions that Westinghouse used to generate reference startup solutions. The calculation covered 1 trillion particles from runs done on 230,000 potential cores.

Schedule regular meetings and send out agendas in advance; compromise when necessary; and, after all discussions, make sure that everyone understands and agrees on the path forward.

Victor Snell, of the consulting firm EGS Solutions, described an industry-university collaboration in Canada, the University Network of Excellence in Nuclear Engineering (UNENE). This program combines offerings at different universities (and, like Pitt's, makes some use of distance learning), with facilities available for some research work (the Reactor Materials Testing Facility at Queen's University and new hot cells at McMaster University). UNENE is thus able to offer a master's degree in engineering.

Up to this point, the speakers had given examples of how barriers have been broken. Steve Nesbit, director of nuclear policy and support at Duke Energy, described a barrier that still exists. In his view, most nuclear research is not relevant to the issues he faces in the operation of a fleet of power reactors. (An exception, he said, is aging-management research for reactors that may operate past the 60-year mark.) In general, Nesbit said, academic research is "not traditionally a nimble area." If he has a problem at a plant, he needs it fixed tomorrow, he said, not by a grad student next semester. What is needed for research to become more relevant, Nesbit said, are a better definition of problems and solutions, a focus on scale-up and deployment, realistic expectations and endpoints, collaboration, "right-sizing" of the research infrastructure, and "suspicion of the interesting and the traditional."

From the vendor side of the industry, Rita Baranwal, director of technology development and application at Westinghouse, returned to the success story theme. As recent examples of successful collaboration, she cited the development of thermoacoustic sensors for a sodium-cooled fast reactor (with Argonne National Laboratory and Pitt); the design of an integral inherently safe light-water reactor (with Georgia Tech and other universities and labs); accident-tolerant fuel development; and the CASL work mentioned by Gehin.

The final presentation came from an organization that was set up by industry to carry out research, so in theory there should be no barriers at all. Dennis Hussey, senior technical leader at the Electric Power Research Institute, gave advice to people on both sides of the barrier. To industry: Clearly define what's desired from research work; learn the researchers' resource needs before authorizing full funding; and understand that there will be emergent work. To researchers: Stay focused on the defined work, because new ideas that arise along the way may not support the project goal; realize that the project manager is accountable for results; and understand that resources and time are finite. To both groups: Schedule regular meetings and send out agendas in advance; compromise when necessary; and, after all discussions, make sure that everyone understands and agrees on the path forward.

Environmental monitoring

Environmental monitoring of nuclear sites was the subject of a panel session organized and moderated by Jean-Francois Lucchini, a radiochemist with Los Alamos National Laboratory's Repository Science and Operations group and past technical program chair of the ANS Fuel Cycle and Waste Management Division, which sponsored the session. Panelists from Japan, France, and the United States provided overviews of environmental monitoring programs in their countries or at specific nuclear sites.


Lucchini

A report on the current status of waste monitoring and management activities at the Fukushima Daiichi nuclear power plant was delivered by the session's first presenter, Akira Kirishima, an associate professor at the Institute of Multidisciplinary Research for Advanced Materials at Tohoku University in Japan and a member of the Atomic Energy Society of Japan's special committee on Fukushima radioactive waste management. He described the March 2011 accident at Fukushima in some detail, stating that it generated a huge amount of radioactive waste, both on-site and in the surrounding area, including contaminated water and secondary waste from water treatment, fuel debris, and environmental waste, such as building debris, tiles, soil, and wood. Current decommissioning and dismantling efforts, he said, have been focused on the water—largely contaminated with cesium-134 and -137—and the secondary waste generated by the various contaminated water treatment systems.


Kirishima

According to Kirishima, although radioactive waste monitoring is being conducted, monitoring capacity is extremely limited. As an example, he cited two 2013 analyses of the contaminated/treated water, one by the Japan Atomic Energy Agency involving 10 samples per year, the other by site operator Tokyo Electric Power Company involving one to two samples per month. He noted that two "hot laboratories" are now under construction at the site to increase decommissioning and monitoring activities, but he said that the real problem is a

lack of sufficient human resources. "There is a shortage of well-trained radiochemists and technicians in the country," Kirishima said, in part because nuclear engineering and radiochemistry programs are unpopular at Japanese universities.

Speaking on France's environmental monitoring program was Guillaume Manificat, head of the Department of Environmental Radioactivity Studies and Monitoring at the Institut de Radioprotection et de Sûreté Nucléaire (IRSN). Manificat characterized IRSN as a public body that conducts industrial and commercial activities under the joint authority of France's defense, environment, industry, research, and health ministries, with an annual budget of €305 million (about $339 million), 40.2 percent of which is devoted to research. IRSN's fields of activity, he said, include nuclear safety; the protection of workers, the public, and the environment against ionizing radiation risks; emergency preparedness and post-accident operational support; the protection and control of sensitive nuclear materials; the protection of nuclear facilities; and the transport of radioactive and fissile materials.


Manificat

The objectives of the French monitoring program, according to Manificat, are to "verify, alert, and evaluate." He noted three "geographical scales" to the program—national, regional, and local—and three "compartments"—atmospheric, aquatic, and terrestrial. In addition, he pointed out some of the challenges that environmental monitoring programs face, including determining the proper amount of detection equipment to be used, how low the results should go, and how quickly the data should be released.

"During the Fukushima event, IRSN put real-time gamma dose rate results online," Manificat said, "and the website received 600,000 visitors in four hours, and despite the absence of FAQs or explanatory text, there were no complaints." In the annual IRSN study of 2012, he added, the majority of French people, 64 percent, declared that it is better to receive extensive real-time information in the event of a radiological emergency than to wait for slightly delayed but more thoroughly explained data. In order to accommodate this preference, Manificat said, IRSN has been working on a smartphone and website application called TELERAY, which would broadcast gamma dose rate levels measured by the IRSN probe network. The data would be nearly real time and uncensored, and would be tagged with the terms "under investigation," "normal," or "validated," he said.

Robert Hayes, a certified health physicist and principal engineer at Nuclear Waste Partnership (NWP), the operating contractor for the Waste Isolation Pilot Plant (WIPP), discussed environmental monitoring improvements at WIPP. He recounted the much publicized February 2014 radiological release at the New Mexico facility—the nation's only deep geologic repository for defense-generated transuranic waste—which led to the plant's closure. In April 2014, Hayes noted, the Environmental Protection Agency inspected the air sampling programs and the waste management and storage operations at the surface of the WIPP facility. In two separate reports issued in October, the EPA stated that the radiation release from the WIPP underground into the environment was low and localized and that potential doses to the public did not approach the standards set under 40 CFR Part 191, Subpart A, *Environmental Standards for Management and Storage*, or the limits set in 40 CFR Part 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*.


Hayes

In two separate reports issued in October, the EPA stated that the radiation release from the WIPP underground into the environment was low and localized.

The EPA identified actions to be taken to improve the monitoring program at WIPP, Hayes said, including the following: (1) update the ambient environmental monitoring network by improving the design, positioning, maintenance, and overall area coverage of the ambient environmental air monitoring network around WIPP, (2) strengthen the emergency response protocols by enhancing the integration of routine and incident procedures to improve preparedness of multiple organizations' field and laboratory staffs to respond to releases, and (3) ensure the highest-quality laboratory results by implementing stricter sample collection, sample tracking, and documentation procedures to provide the highest-quality, most defensible data possible at all times.

Hayes also mentioned a number of improvements that NWP has already implemented, two of the most significant being the addition of nine Low-Vol Air Program (LVAP) sampling locations to the existing monitoring network and an increase in the number of LVAP samplers in the network to 24. Among possible future improvements, Hayes said, are the addition of two LVAP sampler locations to the north and east of the facility, digital LVAP samplers, and a remote sensing/monitoring capability.

The session's final speaker was Punam Thakur, principal radiochemist at New Mexico State University's Carlsbad Environmental Monitoring and Research Center (CEMRC), which provides independent environmental monitoring of WIPP. Thakur gave some background on her organization and talked about the role it has played in maintaining community support following the radiological event at WIPP.

Independent monitoring began prior to WIPP's opening, Thakur said, initially through the Environmental Evaluation Group and later through CEMRC. "CEMRC was born out of regional community demand for independent monitoring," Thakur said. "Its purpose was to independently establish a baseline before operations began, and then to evaluate the radiological fingerprint of the facility in its environmental setting throughout its operational lifetime."


Thakur

CEMRC's monitoring, Thakur noted, focuses on ambient air in the vicinity of WIPP, WIPP underground air, drinking water, surface water/sediments, soil, whole body counting, and research and development on monitoring methods and technologies. All results, she added, are made public through press releases and reports posted on the organization's website (<www.cemrc.org>).

"Following the release event at WIPP, the timely dissemination, through local newspapers and town hall–type meetings, of information independently measured and interpreted by CEMRC provided the public a key element of trust and transparency," Thakur said. "Public access to the monitoring data and the public's ability to directly participate in CEMRC's whole body counting, a state-of-the-art *in vivo* bioassay facility, helped to alleviate fears among con-

cerned citizens after the event. The concentrations of plutonium and americium detected in the air were indeed very small, localized, and well below any level of public health or environmental concern."

In concluding remarks, Thakur stated her belief that while the WIPP incident was certainly newsworthy, it proved not to be dangerous to members of the public. Once WIPP has completed its recovery process, she said, the facility can again be a safe, permanent disposal solution to America's Cold War legacy of transuranic nuclear waste.

Following the speakers' presentations and a question-and-answer period, session chair Lucchini enunciated a major point of agreement between the panelists and the audience. "A well-prepared and structured environmental monitoring program is crucial to confirming the credibility of the nuclear industry among the public and stakeholders, especially in the event of an emergency or a radiological release," he said. "The success of any nuclear facility is strongly tied to the degree of public participation, acceptance, and understanding that is established. Environmental monitoring around nuclear facilities can help in establishing that trust."

Accident-tolerant fuel

The March 2011 accident at Fukushima Daiichi in Japan generated a great deal of rethinking of the operation and safety of power reactors, and not just in terms of emergency preparedness and potential equipment modifications. Perhaps the most technical effort to arise from Fukushima has been the exploration of what are proposed as "accident-tolerant" fuels, which could be less prone to melting, to reactions that produce hydrogen, and to the release of radioactive material during conditions in which a reactor's primary coolant system is undergoing a severe failure.

Six papers were presented at the technical session on accident-tolerant fuel, but in what may be an indication of the priority given to this topic in the nuclear community in general, all but one of the papers' authors were from laboratories and universities, with one coauthor from the research center of a company involved in fuel manufacturing. Separate discussion by *Nuclear News* with some of the session participants indicated that overall, the companies that manufacture fuel, and the reactor licensees who use it, have thus far had less involvement in this research.

The Department of Energy has taken the lead (and provided funding) on research into accident-tolerant fuel, with some work also being done or guided by the Electric Power Research Institute on behalf of the industry. Some of the DOE money is going to fuel manufacturers, generally in cost-shared projects, but the results of manufacturers' research were not presented at this session.

Some of the lab and university work is still at an early stage, and its exploratory nature is such that some papers describe dead ends, which may need to be found and discarded before real progress can be made. The session's first paper, presented by Charles Arnold, of Los Alamos National Laboratory, was on the modeling of cerium solid transport in metallic fuels, with the intention of gaining an understanding of fuel-clad chemical interaction. Cerium was used to represent a generic fission product that could migrate from fuel, and the BISON program was used to develop a solid-state diffusion model. Despite a number of attempts, from solid-state transport to precipitation to liquid-like transport, nothing conclusive was derived. Arnold noted that Ohio State University is getting some data on cerium solubility, perhaps leading to another approach.

The search for alternatives to the mainstream fuel used in light-water reactors (cylindrical uranium dioxide pellets clad in a zirconium alloy) has been going on since long before the current campaign for accident tolerance, and now the knowledge base from this earlier work is being used in the new campaign. Brian Jolly, of Oak Ridge National Laboratory (ORNL), reported on work aimed at coating uranium nitride spheres with various substances to form a TRISO fuel particle, intended to consume plutonium and retain fission products. He said that one problem with an early batch was the spray-coating of a silicon carbide layer, which was prone to developing voids and inclusions. This work is also at an early stage. Jolly said that during fiscal year 2016, the spheres to be coated will be low-enriched uranium, for irradiation testing.

The search for alternatives to the mainstream fuel used in light-water reactors has been going on since long before the current campaign for accident tolerance.

The presentation by Ian Stewart, of the University of Tennessee, also dealt with coatings, assessing their effects, if any, on reactor performance and safety. The work to date has shown no significant effect, although Stewart noted that a boron coating was considered, and it was concluded that this would be "a disaster" because it could absorb so many neutrons as to prevent fission from sustaining itself.

Yutai Katoh, of ORNL, looked at the minimum stress allowable for silicon carbide as a cladding material, given the material's two main feasibility issues, microcracking that can allow the escape of fission product gases, and hydrothermal corrosion in normal operation. Here again, the work was not firmly conclusive. Katoh said that it is still necessary to determine the definition of failure.

Two papers presented at the session addressed the possible use of iron-chromium-aluminum alloys (FeCrAl, pronounced "fee-kral"). Kurt Terrani, of ORNL, noted that the formation of aluminum oxide by corrosion is what makes the fuel accident-tolerant (by its retention of fission products and lack of exothermic reaction with water) and stated that this fuel will be more expensive than conventional fuel. Dong Jun Park, of the Korea Atomic Energy Research Institute, reported on a project to spray FeCrAl over zirconium-alloy cladding, but he said that this work, like much of the DOE-backed research, is still at an early stage.

The concept of accident-tolerant fuel may not yet be agreed upon fully by all researchers. One attendee at the session responded to the topic of FeCrAl in general by stating that in his work, he has decided to get rid of aluminum altogether and seek improved results with just iron and chromium. The response from the speakers was that if aluminum is not included, the fuel will not be accident tolerant.

Advanced reactors

During the annual meeting's opening plenary session, Tom Fanning, president and chief executive officer of Southern Company, made it clear that he feels there is little market for small modular reactors. But what about other advanced nuclear reactors, such as liquid-metal fast-breeder reactors, high-temperature gas-cooled reactors, or other proprietary fast reactor designs? Is there a market for them? The answer is a resounding yes, at least according to the speakers in the panel session, "Are There Customers in the U.S. for Advanced Nuclear Reactors?"

Incidentally, the most passionate "yes" came from Fanning's employee, Nick Irvin, program manager for advanced energy systems at Southern Company. Noting that even people who are aware of the many benefits of nuclear power do not believe that there is a market for advanced reactors, Irvin said he has no doubt that a market can and does exist. Building new reactors will be critical, he said, for meeting the demand for clean, safe, reliable, and affordable ener-

gy as current aging nuclear and coal power plants are retired. Citing the Electric Power Research Institute, Irvin noted that 250 GWe of new nuclear capacity will be needed by 2050 to meet the country's energy needs. "It will take a lot of work," he said, "but if not us, then who? If not now, then when?"

While projections show increased demand for electric energy, Irvin said, there is also great uncertainty about the future of energy supply and demand, including the role renewables and distributed energy will play in the market. The uncertainty created by nontraditional energy sources requires options that will include advanced reactors, he said. Irvin said that Southern Company would like to see the successful demonstration of multiple advanced reactor options that will lead to a robust nuclear market by the mid-2030s.

Everett Redmond, senior director of policy development at the Nuclear Energy Institute, echoed Irvin's timeline. Redmond said that NEI's priorities include having advanced reactors commercially available in the 2035–2040 timeframe, with a demonstration reactor running by 2025. "That is what we are targeting, and that is what we will be working toward," he said. Redmond added that NEI priorities also include maintaining the country's existing nuclear fleet and having small modular reactors operational by the 2020s.

Redmond said that he sees strong potential for the advanced reactor market as evidenced by the significant amount of private investment being put into the technology. This includes investments by high-profile companies, such as TerraPower, as well as many small, startup companies that are working on their own advanced reactor designs. Redmond also noted that there is growing interest from environmental organizations such as the Clean Air Task Force that recognize the potential of reactors to reduce greenhouse gases, as well as interest by the U.S. Congress, which he said is interested in finding ways to facilitate private investment in advanced reactor technology. Within the government, Redmond noted that the Department of Defense is interested in studying advanced reactors for a number of uses, including reducing dependency on fossil fuels in remote operations.

As for industry, Redmond said that NEI is reviewing licensing paths for both a demonstration advanced reactor and a commercial model. While Redmond admitted that licensing an advanced reactor through the Nuclear Regulatory Commission will be challenging, he said he is confident that from a regulatory standpoint, reaching the goal of having a demonstration reactor running by 2025 is achievable.

With its Traveling Wave Reactor and the backing of Bill Gates and Nathan Myhrvold, TerraPower is one of the higher-profile suppliers of advanced reactor technology. Kevan Weaver, TerraPower's director of technology integration, said that while there is a market for advanced reactors in the United States, the potential global market is even bigger. "There is a huge market outside the U.S.," he said. The market, he said, will be strongest among the countries of Sub-Saharan Africa and Asia, where population growth and rising standards of living will spur demand for clean, reliable energy, which will include advanced nuclear reactors.

Weaver

Weaver said that advanced reactor innovation is difficult but the reward is great. TerraPower is fabricating and testing fuel and components, he said, and the company is taking steps toward building a prototype. Getting a prototype reactor to market, however, will take significant private and public support. "We do need substantial government support, and I'm not talking about money," he said. "This is the support where the government backs you up and says they are willing to help us get through this process."

Within the government, the Department of Defense is interested in studying advanced reactors for a number of uses, including reducing dependency on fossil fuels in remote operations.

John Mahoney, principal consultant at High Expectations International, discussed the potential of high-temperature gas reactor (HTGR) technology to meet a number of industrial needs. He described his work with the NGNP Industry Alliance, a nonprofit consortium of companies that is promoting the development and commercialization of HTGRs.

Mahoney noted that HTGRs are a mature technology and the concept has been around for a long time. The U.S. industry has invested more than $1 billion on HTGR development, he said, and the U.S. government has invested more than $600 million in the development of tristructural-isotropic (TRISO) fuel for use in the reactors. In addition to electric power production, Mahoney said, HTGRs are easily adaptable to a number of industry applications, including processing oil from deposits in shale and sand, converting coal to liquid fuels, hydrogen production, seawater desalination, and the production of process steam.

When discussing the hurdles to getting advanced reactors built, Mahoney said that the associated business and financial risks may be different for non-electric power companies, which may have a different "perspective" than an electric utility. "Sometimes a chemical company or a refinery may be able to make a better financial model in order to design and build [the reactors]," he said. Other hurdles facing advanced reactor development are shared with current light-water reactors, Mahoney said, including overcoming economic, commercialization, and regulation barriers. Mahoney, however, remains optimistic about the market for advanced reactors and nuclear power in general. "When we invest in research and technology and innovation, we have no other way to go but up," he said.

Spreading the word

The importance of promoting the benefits of nuclear energy has become one of the major messages at ANS annual meetings in recent years, and the 2015 event continued to promulgate that message, both at the opening plenary session (see page 137) and at two "Focus on Communications" sessions, sponsored by ANS's Education, Training, and Workforce Development Division. Laura Hermann, a partner with Potomac Communications Group and the incoming chair of ANS's Communications Committee, moderated the back-to-back panel discussions, the first of which concerned nuclear energy endorsements. "Part of the genesis of these communications sessions has always been that the nuclear industry talks to itself too much," Hermann said in introductory comments. "If we really want to think about how to improve the reputation of nuclear energy, we also need to start thinking about ways to improve what other people say about us and not just what we say about ourselves."

Each of the session's three featured panelists offered brief opening remarks before settling into an extensive and free-flowing discussion period with Hermann and members of the audience. The first to speak was Kevan Weaver, director of technology integration for TerraPower, who addressed the concept of celebrity endorsements. "From my perspective, this is personal, because we have some high-powered names behind our

At the Focus on Communications: Endorsing Nuclear Energy session, Laura Hermann (second from left) moderated a discussion among (from left) Ben Holtzman, Tami Hollar, and Kevan Weaver.

company," said Weaver, whose firm includes tech icons Bill Gates and Nathan Myhrvold as chairman and vice chairman, respectively. He noted that in his experience, the most effective way to convince people to consider or accept nuclear energy is to get them talking about it. "That is probably the hardest thing to do," he said, "but one of the ways to do it is through celebrity attention. If you have somebody who has a high-powered name, and they start talking about nuclear, it's easy to open up that conversation."

As an example of the benefits that celebrity endorsements can bring to the pronuclear side of the argument, Weaver referenced the 2013 Robert Stone documentary *Pandora's Promise*, which highlighted nuclear energy endorsements from a variety of well-known, and formerly antinuclear, figures in the arts and sciences and which received a number of positive reviews from corners of the media world not normally thought of as particularly nuclear-friendly. "Celebrity endorsers, if judged to be trustworthy, can increase the credibility of nuclear professionals in the eyes of those outside the industry," he said. "These highly visible individuals draw attention to the industry, help generate discussion with members of the public, and enable those of us within the industry to share our passion for nuclear with the public. But the conversation has to be started and continued. Like Laura said, we tend to talk too much just amongst ourselves."

Tami Hollar, associate director of the Nuclear Power Institute (NPI) at Texas A&M University, spoke on what she termed "local-to-local" endorsements. To illustrate the concept, she gave a brief history of her organization and described some of the services it provides. Established in 2007 in response to a need identified by the nuclear industry to develop the new nuclear workforce, NPI is a partnership of six Texas universities, three community colleges, industry, governmental agencies, high schools and middle schools, teachers, and elected and civic leaders, Hollar said. Academic programs at the two-year and four-year levels have been developed and implemented, and innovative approaches have been created to inform and encourage high school students to enter academic programs leading to STEM careers, including careers in the nuclear industry.

"Our primary focus is in developing the human resource infrastructure for the nuclear industry," Hollar said. "We have taken an integrative and comprehensive approach to that. We begin with students in elementary school. These young people then turn around and mentor upcoming students." Hollar also noted that NPI has established programs for teachers. "These have been a huge success," she said, "because nuclear used to be a taboo subject for the teachers. They didn't understand it. So now we have programs that help educate them on how to teach about nuclear and how to weave it into their lectures." In addition, Hollar said, NPI features a nonacademic program at the university level called Multidisciplinary Experiences for Undergraduates, which provides engineering students the opportunity to gain valuable experience by working on real-world projects as part of a multidisciplinary team. "The program allows them to acquire engineering skills beyond their major by interacting with students from other engineering majors and provides professional development that better prepares them for their engineering careers," she said.

According to Hollar, the success of these and other NPI programs has led to inquiries from other school districts in Texas, as well as from other countries. "What we've seen happen over the last few years is that we're beginning to get more and more countries interested in our programs," she said. "They tell us that they've seen a program we developed for someone else, and they ask us if we can do something similar for their needs."

Ben Holtzman, a licensing engineer with Westinghouse, stressed the value of being able to market a pronuclear message differently to different audiences. "The general public," he said, "is not a single entity. I know that I'm 'preaching to the choir' when I talk about nuclear energy here, but I change my 'script' when I do teacher workshops or judge science fairs. And if I'm working in licensing or working in India, talking with customers or members of the public about nuclear power, I have to realize that they have a very different perspective. What they are looking for and how the information can be communicated is very different. Different people respond to different things."

One effective method of communication employed by Westinghouse, Holtzman noted, is its use of a George Westinghouse impersonator. "He goes out there and makes connections on an emotional level and tries to have you connect with Westinghouse the brand," he said.

The discussion segment of the session kicked off with a question from Hermann regarding the benefits and liabilities of celebrity endorsements. Weaver said that having Bill Gates as the chairman of the company was a double-edged sword. "The good side is that he has a high-powered name. He's a recognized individual. His name opens up a lot of doors. And a lot of people talk about it, which is what you want. But on the other side, because he is so well recognized, he becomes a lightning rod, in a sense."

"Just because you recognize someone doesn't necessarily mean that the individual would be a good spokesperson for nuclear energy. Credibility, like beauty, is in the eye of the beholder."

Continued

Holtzman cautioned against the notion that celebrity status automatically confers credibility. "Just because you recognize someone doesn't necessarily mean that the individual would be a good spokesperson for nuclear energy," he said. "Credibility, like beauty, is in the eye of the beholder. We need to make sure that the person giving the message is able to provide that message to the public effectively."

Hermann pointed to public opinion research indicating that celebrity spokespersons consistently score low on credibility. "People might think of celebrity endorsements as a way to start a conversation, but it's not a way to make a decision," she said.

To an audience member's question regarding whether people such as Stuart Brand and Gwyneth Cravens (two of the pronuclear "converts" featured in *Pandora's Promise*) have really done much to convince anyone on "the other side," Weaver replied that only a small percentage of people on the far side of any issue are going to be persuaded by a celebrity endorsement. "I think the focus should be on the people who sit in the middle," he said, "and that's a larger population anyway. The best example I can think of is western Washington. Because of the demographics, you might think it would be fairly antinuclear. And there are pockets of antinuclear. But the fact that Bill Gates backs nuclear has made a difference with those in the middle. Have a conversation with anyone in Seattle, Bellevue, or Redmond. The vast majority of them are actually pronuclear and supportive. This is completely the opposite of what I thought would be the case. And when I asked them why, they said, "Well, there's that company that Gates is backing, right? That nuclear company."

Near the session's close, Hermann challenged the panelists to think of an example in which they had to cultivate an endorsement from either a person or an institution. Holtzman recounted his experience in India, working as an assistant to the then ANS president Eric Loewen, when he and others attempted to get an article into the *Times of India*, the largest-selling English-language daily in the world. "In order to do this, we pretty much had to pitch it to them," Holtzman said. "We ended up creating a news conference in Mumbai. We explained who the people attending would be and how it would tie into the local constituency who read the paper all the time, and why the *Times* should cover it. We got them to send out a reporter who, in fact, did do a news article for us, which helped to raise awareness of what we were doing over there."

Weaver also responded to Hermann's question, mentioning a list of congressmen and staffers with whom TerraPower has built relationships. "You need to continuously cultivate these friendships," he said. "You can't just drop them. When I go back to D.C., which happens quite often, I make sure that I go down the list and question myself as to whom I've seen recently and whom I haven't. And I don't 'have' to go see them. I 'need' to go see them. For the technical community, the scientists and engineers, it's not an easy thing to do. Let's be honest, most of us are introverts. We're what I call 'pizza scientists.' Let me sit in my office, slide the pizza under the door and don't bother me. But you have to get out of the box. You have to go out there and talk to people."

Advocating for nuclear

The second communications session followed after a short break, with a change of focus, from endorsements to advocacy. As in the earlier session, the panelists first spoke individually, then engaged one another in discussion moderated by Hermann. The panel, introduced by Hermann as a "communications panel made up entirely of communicators," included Maureen Brown, Southern California Edison's (SCE) senior media relations manager at San Onofre; Scott Peterson, the Nuclear Energy Institute's senior vice president for communications; Buddy Eller, STP Nuclear Operating Company's general manager of corporate communications and external affairs; and Bryan Wilkes, CB&I Project Services Group's chief communications officer.

Brown touched on the three core principles for the decommissioning of SCE's San Onofre nuclear power plant—safety, stewardship, and engagement—detailing the utility's community engagement panel, formed, she said, to bring stakeholders together and to open a two-way conduit of information and ideas between SCE and the public. "One of the first things we did after the San Onofre shutdown was to sit down and do a long self-assessment," Brown said. "We figured out that we had not done particularly well in terms of listening to and engaging with the community. We also concluded that we had waited too long to combat splintered, local antinuclear activists who surged under strategic guidance from national groups—using the same playbook, by the way, that is now being used against Diablo Canyon."

Brown touched on the three core principles for the decommissioning of SCE's San Onofre nuclear power plant—safety, stewardship, and engagement—detailing the utility's community engagement panel.

SCE's engagement panel holds public meetings at least four times a year and consists of 18 members, including nuclear experts, critics, mayors, councilmen, county board supervisors, and nongovernmental organizations, Brown said, adding that while the panel lacks decision-making authority, it is able to wield significant influence. "The chair of our panel, David Victor, a professor at the University of San Diego, is very good," she said. "He's written academic papers on grassroots engagement, and he helps drive this panel to action. The biggest issue we've dealt with since the shutdown is what to do with the used nuclear fuel. David built coalitions on the panel and convinced them to write a letter to the California Energy Commission, the governor's liaison with the NRC, urging it to actively advocate for interim storage solutions for used nuclear fuel. David has the intellectual tenacity and industry connections and know-how to basically shine a light on the inaccuracies of antinuclear activists and do so in a thoughtful way without being combative, but that is nonetheless very effective."

Brown also stressed the transparent nature of the panel, noting that all meetings are videotaped and subsequently posted on the San Onofre decommissioning website, at <www.songscommunity.com>. "Transparency is a very important part of what we're doing," she said. "Anyone can have access to it."

SCE combines the community engagement panel's efforts with more standard advocacy tactics, Brown said, such as targeted advertising, tours, and education fairs. "Since the first of the year, I think we've had 800 to 1,000 people come through on tours," she said. "I'll give you two examples of why it's effective. First, a week after taking our tour, a mayor was at a city council meeting and was able to refute an antinuclear activist on something that was factually incorrect. Second, an activist came on one of our tours with a Geiger counter and admitted that the radiation in his backyard was higher than at the plant. When an activist attests to our veracity, that helps us."

Speaking next was Peterson, who addressed NEI's advocacy efforts. "We are focused on policy issues at NEI," he said.

"That is our charge. So we are focused on the policy community—whether in Washington or, more frequently now, in the states. We talked about endorsers in the first session, and endorsers are a huge part of what we do from an advocacy standpoint. The number and breadth of endorsers have never been more valuable." The need for that breadth, according to Peterson, is due to the current polarized state of American politics. "There is no middle ground where these two parties come together anymore," he said. "So you really have to develop advocates that have the ability to reach into both ends of the political spectrum. A lot of our communications are built around getting to that policymaker community, whether it's on the federal or state level, and making sure we have the broadest possible advocacy group to back our solutions."

Peterson

Citing a Morning Consult survey, Peterson said that 60 percent of men and 75 percent of women in the United States have no real opinion on nuclear energy. "That really raises the stakes for our advocacy work," he said, "when there is that much of a middle group that's moveable." Peterson also cited an Edelman Trust Barometer survey involving 27,000 respondents from 27 countries indicating that only 41 percent of the public around the world has trust in the nuclear industry. "That was an astounding figure for me," he said. "Those were the global figures. I went back to my contact at Edelman and asked for the U.S. number, because surely it had to be better than 41 percent. No, it's 41 percent. Just that figure alone really put a stamp in my head that we really have to establish trust."

"The company's regular employee is trusted at a much higher level than the executive suite–level employee. So in your communities, you really have a huge advantage in terms of being a credible spokesperson, being an everyday advocate for this industry."

One way to establish that trust, Peterson said, is for people in the industry, including members of ANS, to become advocates. "According to the Edelman survey of U.S. respondents, it's the academic and technical experts who rate the highest on this trust barometer for people who want to know about energy issues," he said. "The very people in this room are the most trusted on that issue. And it's 'regular' employees of a company, not CEOs, not the executive suite. The company's regular employee is trusted at a much higher level than the executive suite–level employee. So in your communities, you really have a huge advantage in terms of being a credible spokesperson, being an everyday advocate for this industry."

Continued

Peterson also mentioned the Nuclear Advocacy Network, which, he said, is designed to educate and mobilize advocates around legislation related to nuclear energy, science, and technology. "It pulls together a lot of different people within the industry, including ANS," Peterson noted. "We work very closely with [ANS Washington Representative] Craig Piercy to make sure that through this network we can actually trigger advocacy on industry issues from ANS, the North American Young Generation in Nuclear, U.S. Women in Nuclear, Energy Consumers Alliance, Nuclear Matters, and our organized labor friends. We have the ability through that network to really activate tens of thousands of people on industry issues. If you are not part of that, I would encourage you to work within ANS to figure out how you can become a part of that. I think that as an industry, that's the most valuable resource we have collectively—to be advocates for our industry."

STP's Eller discussed what he considers to be the key points of a successful advocacy strategy, including the need to understand your audience, listen to people's concerns, and take the time to build relationships in the local community. "We've worked very hard over the past five or six years to build a strong relationship with the local communities," Eller said. "For example, a few months after Fukushima, everyone in the industry was being bombarded daily by the media. We had a reporter from *USA Today* spend several days in Bay City, Texas, the closest city to our facility. We knew she was there. About two or three days after she arrived, I got a phone call from her. I will never forget one of the things she said to me. She said, 'I talked to a lot of people in the local community over the past few days, and I don't really have any questions for you.' After a long pause, she said, 'Do you know what people told me? I'll share it with you. They told me, "We don't trust the people in the media, but we trust the people at STP."' When she said that, I knew we had moved the needle from an advocacy standpoint and that we had a strong community relationship."

Eller

Successful advocacy efforts also require the use of simple, well-researched messages, according to Eller. "We work in a complex industry, and from a communications perspective, complexity kills," he said. "It's all about effective messaging. Are you doing the research? Are you doing the focus group? Do you know if your messages are effective? Are you really moving the needle? We have to ensure that our efforts have a broad, critical collection of voices articulating our messages right now."

The final presenter, CB&I's Wilkes, also encouraged the audience to become more involved in advocating for nuclear energy, including through the use of social media. "I hope you will all be inspired to run out of here at the end of this session and go do something. If you're active on social media right now, that's a great place. Basically, our greatest influence is in our professional and personal networks, and especially in social media. That's why politics and political campaigns immediately jumped on social media. They understand this. Just becoming active in social media and promoting nuclear energy and science is very important. You have a lot of people in your networks who are not specialists like you are."

Wilkes

Wilkes also emphasized the importance of building relationships with members of the media, as well as creating citizen groups and contacting members of Congress. "This is very important," he said. "I can tell you as a former congressional staffer, every call and letter and e-mail that comes into the office is tracked. They know what their constituents are saying. And don't write to every senator and congressman. Write to *your* senator, *your* congressman, even if they are pronuclear. It's very important for them to hear it. Take the time."

The use of social media as a tool for advocacy resurfaced in the session's ensuing panel discussion, as Hermann posed the question, "How does social media really drive communications at the local level?" Peterson said that the NEI staff spends a significant amount of time every day engaging in social media activities. "We have three official NEI Twitter accounts and have recruited a number of our issue experts to start their own Twitter accounts. We have a Facebook account, which has now overcome our Twitter accounts in terms of influence. We really channel our advocacy issues into these social media accounts every single day. We send out an e-mail every Monday to all of our members, saying we'd like them to Tweet about the following issues. And we give them sample Tweets to help them do that, so that we can get some scale in terms of our messaging on social media. More and more of our advertising dollars go into social platforms and to digital advertising where you can target the people you want to reach by zip code, by e-mail, by IP addresses. Your advertising dollars are so much better spent by reaching the people you want to reach. Digital has really changed the way that we operate."

Brown noted that as part of SCE's proactive outreach efforts at San Onofre, the utility is digitally targeting zip codes in the neighborhood of the plant. "Those are the supporters and the fence-sitters whom we want to keep on our side and educate, particularly as we know the state commissions are going to be hearing very important permit applications from us. Using this approach means we can ignore Los Angeles, where they don't even know we exist, or don't care."

Eller fielded a somewhat provocative question from fellow communicator and *Atomic Insights* blogger Rod Adams, who asked, "Why should we listen to a panel with people who have been communicating about nuclear for more than 20 years each? What successes have you had, since I've watched the industry essentially deteriorate to a very tiny organization in the last 15 years?" Eller responded by relating a success story involving community outreach when he was with Progress Energy in Florida, and then said, "Obviously, we're sitting here today working through the aftermath of the 2007 recession and Fukushima and trying to work our way back up. But I think it can be done. When you look at the campaigns that NEI is doing—the Future of Energy campaign and others—I think we're moving in the right direction. It's not going to happen overnight. We're fighting low natural gas prices right now. But I think over time it will happen, when you look at the need for baseload energy over the next 15 to 20 years."—*E. Michael Blake, Tim Gregoire, and Michael McQueen*

"We're sitting here today working through the aftermath of the 2007 recession and Fukushima and trying to work our way back up. But I think it can be done. I think we're moving in the right direction."