

ANS WINTER MEETING

Nuclear: The foundation of clean energy

Given the ever-increasing attention being paid to the issue of climate change in energy policy discussions, it may come as no surprise to nuclear energy supporters that the theme of the 2014 ANS Winter Meeting, held November 9–13 at the Disneyland Hotel in Anaheim, Calif., was “Nuclear: The foundation of clean energy.” The theme was taken up at the meeting’s opening plenary session as ANS President Michael “Mikey” Brady Raap, in introductory remarks, stressed the importance of spreading the word regarding nuclear energy’s low-carbon footprint. She pointed to results from a recent survey (conducted by Bisconti Research for the Nuclear Energy Institute) that looked at the U.S. public’s perceptions of nuclear as a clean energy source. The survey, Brady Raap said, found that 23 percent believe that nuclear energy releases a lot of greenhouse gas, while only 28 percent believe that nuclear can be properly termed “a climate change solution.”

Brady Raap also referenced a U.K. Department of Energy and Climate Change (DECC) online tool (at <http://my2050.decc.gov.uk/>) that prompts users to try their hand at determining the mix of energy sources that will allow the United Kingdom to meet its carbon-reduction goals and energy production needs by 2050. “What you get out of that exercise is that you can’t get there without nuclear,” Brady Raap said. “I think that’s a strong message.”

Brady Raap emphasized the need for nuclear professionals to consolidate on an international basis and to speak in a single, loud voice. “I’ve been working with the French Nuclear Society,” she said. “They



Brady Raap

Meeting session coverage:

- ◆ *How to communicate, and with whom*
- ◆ *Fuel cycle options and decommissioning preparation*
- ◆ *Safeguarding advanced design and UF₆*
- ◆ *New reactor construction in the United States and worldwide*

have an initiative called Nuclear4Climate, the objective of which is to get the societies and the industry forums together to be consistent on messaging. If I say nuclear emits little CO₂ and someone else says it emits no CO₂, that’s a hard message to give to the public because it seems inconsistent. It doesn’t do any good to go back and say, well, when she said ‘a little,’ her viewpoint was from cradle to grave, including mining operations, and when he said ‘none,’ he was really just talking about burning fuel for power generation. We want not to have to draw that fine line. We need to work on that voice.”

Brady Raap underscored the need to work with international nuclear groups in order to find synergies. “We have agreements of cooperation with 34 other international societies,” she said. “There is no reason to stop at representing 11,000 members. We need to be representing nuclear professionals across the world.”

Edward Halpin, senior vice president and chief nuclear officer of Pacific Gas and Electric Company (PG&E) and general chair of



Halpin

the Winter Meeting, focused much of his talk on the clean energy theme as well. He lamented the complacent attitude of some toward climate change, noting that “some get it, some are acting on it, and others are saying, ‘it’s not real’ or ‘perhaps it’s some climatic cycle.’ Well, maybe it is. But I think you have to admit that dumping millions of tons of greenhouse gases into the environment can’t possibly be good for our planet.”

The major challenge facing nuclear professionals, according to Halpin, is being able to deal with climate issues while also being able to provide for the electricity needs of future generations. “If we don’t solve this issue, we’re in for a showdown with Mother Nature, and we’ll not meet our obligations to set our children and grandchildren up for success,” he said. “But I know that through

your leadership, through your focus, by telling your story, we can ensure that nuclear is not just the foundation of clean energy, but that it is the bedrock of clean energy. We want to make sure we let the world know that.”

Halpin also commented on his home state of California’s “aggressive” goals with regard to renewable energy and the reduction of greenhouse gases, including requirements

working closely with their Japanese counterparts to understand and share lessons learned. “That same contingent from Japan was back here just recently in Phoenix to continue the dialogue,” he said. “There is some amazing technology that is coming out of that experience. Japan has not turned its back on nuclear power, and we’re hopeful to help them as they return units to service in 2015.”

Other environmental reasons for supporting nuclear power are that using nuclear would result in a decrease in air pollution, as well as a lessening of the environmental degradation caused by coal mining.

that all major utilities provide 33 percent renewables to their customers by 2020 and that greenhouse gases be reduced to 80 percent below the 1990 level by 2050. “We know that it’s pretty ambitious, but it’s something the state is determined to make happen,” he said. “Renewables play a part in that. The challenge we have is the issue of renewable integration. When you bring renewables online, it does, in fact, affect the grid and the voltage profile. And the load profile. And as operators, we have to deal with that. So that requires us to have smart technology to invest in the infrastructure of the grid. The reality is, as promising as renewables are, when the sun doesn’t shine and the wind doesn’t blow, they’re not there for us. That is why it’s essential for us to have, as the backbone of a clean energy profile, nuclear power.”

On the question of what the future holds for the nuclear industry, Halpin was optimistic. “If we listen to some of the naysayers, they’ll point to recent plant closures and say that we’re on our deathbed. Well, when that happens, I often turn back to the great Mark Twain, who said, ‘The report of my death was an exaggeration.’ Take a look, folks, at what’s happening throughout the world. Here in the United States, we’re constructing five reactors. Our hats go off to the team from Southern and SCANA and TVA for the work they’re doing. And throughout the world, there are 72 that are under construction. More nuclear power plants are now under construction than ever in history. The world gets it.”

Halpin also addressed the Fukushima Daiichi accident, stating that CNOs from the United States toured the area in 2013,

was Jessica Lovering, a senior energy analyst with the Breakthrough Institute, an environmentally focused and pronuclear non-profit think tank based in Oakland, Calif. Lovering’s primary message was that good reasons exist for supporting nuclear energy regardless of one’s stance on climate change. (According to Lovering, in exit polling conducted during the recent U.S. mid-term elections to gauge the public’s priorities, climate change came in at the bottom of the list.)



Lovering

country, and the percentage of electricity produced by nuclear power. Countries with a lower carbon intensity, she said, tend to have more nuclear power in their electricity mix (the exception being those nations that are “geographically blessed” with robust hydroelectric resources). This is important, Lovering said, because “if you, as a country, have a large amount of clean baseload and reliable low-carbon electricity, you tend to electrify more sectors. You tend to electrify public transport, some heavy industry, etc. What that means is that your entire energy system is much cleaner, not just your electricity system.”

Other environmental reasons for supporting nuclear power, and perhaps more tangible ones, Lovering said, are that using nuclear would result in a decrease in air pol-

lution, as well as a lessening of the environmental degradation caused by coal mining. In addition, she said, there is the issue of land use by renewables. “This is not talked about that much now, but I think that it’s going to be an emerging concern, especially as renewable energy penetrates more of the electricity market,” Lovering said. “Renewables take up a lot of land. We hear a lot about how great they are, that they’re distributed, small-scale, maybe more egalitarian. But what that means is that they also take up a lot more space. It’s a real environmental issue that doesn’t get talked about.”

To better illustrate her point, Lovering displayed a graphic from the DECC showing the space taken up by the Hinkley C nuclear project compared with the space that would be needed for solar or wind turbines to produce the same amount of energy. “It’s very dramatic,” she said. “What is interesting is that the DECC actually had to take this graphic down in about an hour because they received so many complaints from renewable energy supporters in the United Kingdom that it was unfair. Luckily, a lot of people on the Internet took screen shots of it before it was removed.”

Lovering began by presenting a graphic showing the carbon intensity of the energy supply, by country, and the percentage of electricity produced by nuclear power. Countries with a lower carbon intensity, she said, tend to have more nuclear power in their electricity mix (the exception being those nations that are “geographically blessed” with robust hydroelectric resources). This is important, Lovering said, because “if you, as a country, have a large amount of clean baseload and reliable low-carbon electricity, you tend to electrify more sectors. You tend to electrify public transport, some heavy industry, etc. What that means is that your entire energy system is much cleaner, not just your electricity system.”

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Lovering also discussed some of the nonenvironmental justifications for supporting nuclear power, including its capacity for dealing with what she termed the “energy poverty” in much of the developing world. For example, she said, there are approximately 1 billion people who lack access to electricity and are forced to use wood, dung, or charcoal to cook their food. “What is sad is that a lot of the really mainstream scenarios for mitigating climate change—like the ones from Greenpeace, the World Wildlife Fund, and even the International Energy Agency—leave most of these people in energy poverty,” Lovering said. “It’s actually really good for the climate if these people don’t get access to electricity. But if you care about human development, gender equality, these sorts of broader issues more than just climate change, you want to provide these people with access to electricity and you want it to be a clean source. And that is where nuclear power comes in.”

Robert Willard, president and chief executive officer of the Institute of Nuclear Pow-



Willard

er Operations, called the Winter Meeting’s clean energy theme “a perfect one, and representative of how ageless and adaptable the commercial nuclear industry can be.” A few years ago, Willard said, in his former position as commander of the U.S. Pacific Command, he invited two leading climate change experts to visit the com-

mand's headquarters in Hawaii and address senior military leaders on the global warming debate.

The first expert, he said, promoted the idea that the climate change the world was experiencing was a natural phenomenon—the next cyclical global warming event in geologic time. The argument included historic timelines and geologic proof of previous glacial periods and episodic warming events, and Willard and others found the assessment highly convincing. The second expert made an equally compelling argument that the measurable global warming occurring was almost entirely man-made, Willard said, and that any cyclical warming patterns that might be occurring were inconsequential when compared with the harmful effects of greenhouse gases and the acceleration of mean global temperatures.

Despite their different perspectives, however, both experts shared predictions of dire consequences should humankind prove incapable of curbing its CO₂, methane, and nitrous-oxide emissions, he said. “In the end, we concluded that at varying levels, both experts were right, and the fast pace of warming was due to the combined effects of entering the next geologic warming cycle, accelerated by humankind's uncontrolled greenhouse gas emissions,” Willard said. “We concluded that we were already seeing the effects of global warming across the Asia-Pacific region: in China, where arid deserts were expanding and where there was a fight over water in the Mekong River Basin; in the South Pacific, where we were busy mitigating food, fuel, and water shortages at the same time that we were preparing for human migrations from islands that were being lost to a rising Pacific Ocean; and also across South Asia, as the Himalayan glaciers disappeared.”

Assuming that his experts' predictions were accurate, Willard said, the demand for clean, safe energy will continue to grow. He said he believes that the United States should be looking to the nuclear industry as a “foundational cornerstone to the environmental dilemma in which we find ourselves. I ask you, who imagined in 1979 that this would be the case—that the industry they were forging then would become so pivotal to solving man's 21st century problem now? There is an industry leadership element to this story of mine, and it must be addressed. For although it's a time in our history when everyone should be viewing the nuclear industry as foundational, we know that many of our citizens aren't. So who among us will make the case to the American people? Do we expect the Nuclear Energy Institute to carry this burden by and large alone? Or should more of us own it, too? Nobody else is likely to shoulder this responsibility for us—neither the next administration nor the next Congress. At INPO, we applaud ANS for doing its part this week, and now we

think it's time for the rest of us, as nuclear professionals, to do ours.”

Willard also provided an overview of INPO's role in the nuclear industry, stating that in the 35 years since the organization's creation, the industry has made significant strides in safety, ranging from the reliability rates of safety-related equipment to unit capacity factors and emergency preparedness. “We're a proven learning industry, deeply committed to information sharing, the frequent exchange of best practices, and applications of lessons learned, as has been illustrated in the aftermath of Fukushima,” he said. In Willard's opinion, the “powerful combination” of INPO, the Nuclear Regulatory Commission, and INPO's international counterpart, the World Association of Nuclear Operators, has helped shape industry safety and foster continuous improvement, such that the U.S. nuclear industry continues to become safer and stronger every year.

The industry continues to face challenges, Willard said, and it's the responsibility of INPO to recognize and anticipate those challenges and to change or adapt its efforts strategically and proactively. Currently, he said, INPO prioritizes its support across six challenge areas: (1) improving the capacity for self-awareness and continuous improvement at the utility corporate headquarters and at the nuclear site, (2) advancing learning and the ability to address industry trends by fully leveraging operating experience and analysis, (3) sharing early signals of performance decline so that they can be quickly reversed, (4) maximizing worker knowledge and proficiency through advancements in education and training to account for generational turnover and workforce challenges, (5) incorporating the industry's high performance standards into nuclear suppliers' and vendors' standards, and (6) advancing the skill of the industry's senior leaders to quickly and sustainably recover lower-performing plants so that they never pose significant risks to the industry.

In addition, Willard said, INPO is spearheading advancements in leadership development and organizational effectiveness through its National Academy for Nuclear Training and is working closely with industry experts to reduce the cumulative impact of over-administration to allow more time for “industry managers to manage and supervisors to supervise.”

“I share all of this with you to emphasize the many ways that our industry continues

to advance both in safety and in overall performance,” Willard said. “We think that the assurance of having an INPO immersed in promoting improvements across our industry, or better yet, the combined efforts of INPO, WANO, and the NRC to raise industry operational performance to its highest possible levels, should help to single out the nuclear industry as a safe, strong, and uniquely fostered foundation for clean energy at a time that our nation and the world need it most.”

The opening plenary session's final speaker was NRC Commissioner William Ostendorff, who focused his remarks on the



Ostendorff

NRC's mission as a safety regulator. He described in some detail the agency's Reactor Oversight Process, characterizing it as “a fairly robust, disciplined process that we as a regulator understand well, and so does industry. We believe it allows us to objectively assess and identify problems in licensees' performance and respond to declines in performance.” That process, he said, includes a classification system known as the action matrix—a table that categorizes U.S. operating nuclear pow-

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er reactors in terms of performance. The highest performing units, Ostendorff explained, are located in the first column of the matrix, Licensee Response, requiring only standard NRC oversight; as performance declines, units are moved to higher-numbered columns, resulting in increased agency oversight, up to column five, Unacceptable Performance.

The NRC's inspection programs, Ostendorff said, include baseline inspections, largely conducted by on-site NRC resident inspectors and covering 10 areas, including operations, maintenance, security, and emergency preparedness; reactive inspections, conducted to respond to plant events; and special inspections, conducted to examine the implementation of new requirements,

such as cybersecurity or post-Fukushima enhancements. “On average, in 2013, we spent just under 7,000 man-hours as a safety regulator at each site in the United States,” he said.

Ostendorff also offered comments on the NRC’s safety assessments of U.S. reactors currently under construction: Summer-2 and -3 in South Carolina, Vogtle-3 and -4 in Georgia, and Watts Bar-2 in Tennessee. “I had a chance to visit the Summer and Vogtle sites earlier this year, in June,” Ostendorff said. “If you have a chance to visit one of those sites, I encourage you to do so. You’ll see about 2,500 to 3,000 workers on-site. It’s a very impressive operation. Most of my interest in it is in seeing how our inspectors are assessing the state of construction. Our resident inspectors down there are what we call ‘boots on the ground.’ Every day, they look at what is going on, assess rebar installations, concrete pours, cable runs, etc. I also think it’s a really important part of our regulatory responsibilities to ensure that our inspectors are fully equipped with the resources they need to do a very complex inspection regimen.”

Regarding Watts Bar, Ostendorff said that he visited the Spring City, Tenn., site in January 2014, spending time “crawling up and down ladders with Mike Skaggs, the senior on-site vice president, who showed me all the components that they’ve been replacing or refurbishing since the construction at

good-news story to be told there. I agree with ANS President Mikey Brady Raap that it’s up to everybody to tell that story. I believe that the American public needs to hear from each and every one of you. I think that everybody will benefit from your communication and your outreach.”

Q&A

A question-and-answer session followed the presentations, with PG&E’s Halpin reading questions from cards supplied to the audience at the start of the session. The first question came from a student, who asked, “What can we, as students, do to ensure that nuclear power is a part of our clean energy future?” Lovering advised students in the nuclear field to copy some of the tactics of environmentalists, who, she said, tend to be more outspoken in their beliefs.

“Something that I’ve noticed is that in a lot of environmental science programs or energy programs at different universities, people who work in renewable energy are very vocal about their support for what they work on,” Lovering said. “They go to climate change marches. They have T-shirts about their bio-fuels or solar panels. They are very vocal, and I don’t see that as much with students of nuclear power.”

Willard suggested that students not “over articulate,” but instead strive to make the argument for nuclear power in a way that is easily understood by the public. “Putting it into just a common framework and lexicon, I think, is a really important aspect of this that we are often, at least in my experience, not very good at,” he said. At the same time, however, he counseled students to be sure they possess the necessary knowledge to debate the topic. “ANS and organizations like Jessica’s are great sources of information to expand your

particular knowledge of this industry and of the technology and its importance,” he said.

Halpin encouraged students to take their friends on a tour of a local nuclear power plant. “There is nothing like people seeing the whole process and the technology to understand it,” he said. “You, as the young generation of people who are advocates, can help with that process by letting people see it for themselves.”

Another question asked was what ANS members could do to build ties to environmental groups that don’t traditionally ap-

prove of nuclear energy. Lovering stated that it might, in fact, be more productive to engage people who are not actually part of the environmental movement but who are nonetheless concerned about the environment. “There are certain methods and tactics Breakthrough has used to try to get the mainstream environmental groups like the Sierra Club to support nuclear power,” she said, “but because of their member base and the way they raise money, it doesn’t look like that’s going anywhere fast. I would say that an easier tactic is to find what people care about with regard to the environment. Do they care about climate change? Do they care about air pollution? Do they care about land use? Then you skew your arguments toward those concerns, because nuclear does address a lot of those issues. I think it’s much easier to do that than to try and change the minds of environmentalists with a capital ‘E.’”

Halpin noted the importance of outreach programs, pointing to PG&E’s team at Diablo Canyon as an example. “I want to brag on my team for just a little bit,” he said. “Under Tom Jones’s leadership, we received the Top Industry Practice Award from NEI for community relations. We work very hard at it, trying to build those relationships—whether it’s a government official or just people living in the area. We bring 3,000 people each year to Diablo Canyon to give them a tour to see what it’s really like. Personally, from a leadership standpoint, I work hard on being public throughout the community and the state, trying to answer the hard questions, having the open forums, doing it in public, everything being transparent, and then trying to talk about the facts. There are some people who have their mission, and maybe you’re not really going to get to a point of agreement. But what I always offer to people is that our overarching mutual interest is the protection of the health and safety of the public. We have that in common, so let’s start there. You can have some good conversations with them. You just have to keep working at it. Work on those relationships. Use the facts. Be out in public. Have the dialogue.”

President’s Special Session

In introducing the President’s Special Session, ANS President Michael “Mikey” Brady Raap referred to the session organized by then President Donald Hoffman at the 2014 ANS Annual Meeting in June. To mark ANS’s 60th anniversary, Hoffman had brought together four past presidents to talk about the previous six decades of the society and its achievements and challenges. Taking her cue from that session, Brady Raap decided to focus on the next 60 years, recognizing that while there are many common threads, today’s nuclear professionals face many new concerns that go beyond the traditional goals of ensuring the safe and efficient operation of nuclear power plants

“I will tell you that there is a very good-news story to be told there. I agree with ANS President Mikey Brady Raap that it’s up to everybody to tell that story. I believe that the American public needs to hear from each and every one of you.”

Watts Bar-2 was halted back in 1985. The NRC had a meeting just two weeks ago on Watts Bar, and we’re finalizing our safety review as that plant looks to being licensed in 2015. There is a lot of effort going on there by the construction teams and the NRC inspectors, as well as by TVA.”

Ostendorff ended his presentation with a “pitch.” “As a commissioner,” he said, “I’ve had the opportunity to spend a lot of time with international regulators and others who are building reactors overseas, with our nuclear industry, with INPO, NEI, and our licensees. I will tell you that there is a very



Brady Raap
clear energy.

Brady Raap said that her vision for the next 60 years is for ANS to move forward as a global leader in nuclear science and technology, with a focus on nuclear power plant safety through the use of passive safety features, accident-tolerant fuels, and nuclear systems that reduce the burden of large regulatory and fuel cycle support systems.

One particular area of interest for Brady Raap is furthering the public's understanding of radiation dose. "I want us to be the ones who lead the way in developing a public system for explaining dose," she said, perhaps through a Richter-type scale as is used for seismic events. This doesn't mean changing the way experts talk about dose to each other, she added, but rather changing the way dose is discussed with the public. Also, she said, the discussion must make it very clear that radiation is part of our natural environment, the result of the big bang, which means that we live in a sea of natural radioactivity. "We need to get nuclear to be something out there that people can talk about," she said.

Brady Raap had asked several ANS leaders to look at ANS's future, particularly the challenges and opportunities facing future nuclear professionals. "We need to focus on making the next generation of nuclear professionals the best that they can be," she said. "That is our legacy, our responsibility."

In introducing the first speaker—Gale Hauck, principal quality engineer with Westinghouse Electric Company—Brady Raap said that she had asked Hauck to address the issue of what ANS needs to do for the next



Hauck

generation of nuclear professionals. Hauck began by sharing a story about someone she knows whose first job after college was at a nuclear power plant. This person found a national society and was approved to go to a meeting to develop her professional skills. While she learned a lot at the meeting, she was disappointed in regard to professional development. According to Hauck, her attempts to volunteer to take part in the work of the society didn't lead to anything.

and generally improving the quality of life. Today there are other priorities and responsibilities, such as providing clean energy and environmental protection, energy security, economic development, and ensuring the peaceful use of nuclear energy.

The professional society involved was ANS, Hauck said, and this should never have happened, particularly if members want to ensure the legacy of the nuclear industry and of ANS. "But each one of us must be part of that solution—industry leaders, experienced members, and young professionals alike," she said. "We all need to work together."

Hauck then had some advice for all concerned. Young professionals who want to get involved must provide some specifics, she said. "Explain your background and skills. Say what you are looking to develop, what your interests are, and what you can and are willing to do. If you are interested in communications, ask to work on the division's newsletter. If you would like to work on your project management skills, ask to lead a small subcommittee or task force. I [as a leader] can do something with that," Hauck said.

Hauck said that it's ANS members' responsibility to develop new leaders. A leader is empowered to delegate, she said, adding that it's something she does, and often aggressively. As the 2012–2013 chair of the ANS Young Members Group, Hauck had a list of projects and tasks to be done, and when members volunteered to help, she would show them the list and ask them to select an item to handle. She would not, however, just leave them wondering what their role would be, but would make certain that they were introduced to the appropriate people, provide information about what their role would entail, and give them her contact information in case they had follow-up questions. This is essential, she said. "If I am delegating, it is my responsibility as a leader to ensure that the person I'm delegating to is successful."

But what are members who cannot attend the national meetings offered, besides a membership card and "an awesome magazine," Hauck asked. Every member needs to be able to access the vast expertise of ANS's members. "But if we allow our membership to dwindle and decline, that isn't going to happen."

Hauck then told another story about someone who attended an ANS national meeting for the first time, and although she didn't know anyone, she made friends, learned a lot, and had fun. While she was unable to attend the next meeting, she eventually became chair of her local section and gained approval to attend another national

meeting. A past president of ANS who was a member of her local section took her around and introduced her to everyone. Soon she was nominated for a position on the Executive Committee of the Young Members Group, and a couple of years later she became its chair. Then things really got going, Hauck said. Now she is serving as a

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member of the Board of Directors and was asked by the society's president to speak at the President's Special Session.

While this is Hauck's own story and may be unusual, every young professional who wants to get involved should be able to do so, she said. They should be provided help and encouragement by ANS's leadership and experienced members.

The second speaker, David Pointer, a technical lead at Oak Ridge National Laboratory, recently spent two years as the chair of the ANS Public Information Committee (now the Communications Committee). When Pointer was a new graduate and was paying "real" ANS dues for the first time, he began to question what he was getting for



Pointer

his money. He fired off an e-mail to Gail Marcus, who was the ANS president at the time, about what he thought was lacking in ANS. Marcus's response, he said, while nice and polite, was basically "do something about it." Within a year, Pointer found himself appointed to the PI Committee by then ANS president Larry Foulke, and he later became a chair of the task force that was set up to look at how ANS engages the public and to draw up a strategic communications plan for going forward.

Important aspects at the start of this effort, Pointer said, were to understand what ANS is trying to accomplish in regard to public engagement and what current public attitudes are toward nuclear power. Market research sources, he said, found a strong

level of support in the United States both before and after the Fukushima Daiichi accident. Polls carried out by Bisconti Research for the Nuclear Energy Institute, Pointer said, showed a backing of 65 percent. While that is quite high, he said, this support is very broad but not very deep, and efforts are needed to sustain it.

The strategic communications task force then began to look at how to effectively use the limited resources available. The key here, as in so many activities, Pointer said, is “focus and prioritization,” and a narrowing down of what ANS is trying to accomplish was in order. This led to three major messages being identified:

■ Radioactivity is a natural part of our world. Getting this message across, Pointer said, is the fundamental challenge that all of nuclear science and technology faces in gaining public acceptance.

■ Nuclear technology works. A strong message here should help convince target audiences that this is the right path forward.

■ Nuclear technology enhances our quality of life.

After much discussion within ANS, the audiences for these messages were also identified. First and foremost, it became clear that one important audience had been neglected by previous communication efforts: nuclear professionals. ANS hadn't really done a good job, Pointer said, in telling its own members what its messages are. This also became evident in the questions raised when talking about communication efforts with ANS members.

While the second and third priority audiences—the media and opinion and policy leaders—were as expected, the fourth, he said, is very interesting: kindergarten through 12th grade educators and students. He noted that this is important for nuclear to maintain that 65 percent support base.

Having identified the primary messages and the main audiences, getting the messages across is where the main effort is focused. In the strategic communications plan, there is an emphasis on training and educating. Through its Center for Nuclear Science and Technology Information, ANS is conducting a series of seminars for Capitol Hill staffers, providing an introduction to the basics of nuclear science and technology. The topics covered include radiation, how nuclear power plants and the fuel cycle work, and special topics relevant to pending legislation. About 400 participants have attended these to date, and plans are being made to launch a similar program for members of the media.

In addition, ANS began training a core of spokespersons who are able to effectively address current topics and concerns. ANS also has a very strong presence on the Web and in social media, including Twitter, LinkedIn, Facebook, and YouTube. Its public information materials, which are available to members for use in their own out-

reach efforts, are also being updated.

The focus of the next speaker, Carol Berrigan, senior director of supplier and workforce policy at the Nuclear Energy Institute, was engagement with industry. In thinking about a message for this session, Berrigan said that she looked back at her early experience with ANS, which began in 2003. At the time, she was working for Angie Howard, at NEI, who



Berrigan

suggested that she attend a meeting of the ANS Special Committee on the Nuclear Workforce. At that time, the industry and ANS were very concerned about nuclear engineering program enrollments, which had dwindled to a few hundred students by 2000.

Berrigan said that she found ANS to be strongly engaged with industry in a way that was relevant and timely and added tremendous value by bringing together researchers, educators, and students with industry to work collaboratively on current problems, as well as on possible future challenges.

Nuclear professionals know the tremendous value of nuclear energy, Berrigan said, which includes providing grid stability and price stability in electricity markets; generating power when needed, regardless of a polar vortex or fossil fuel shortage; being highly reliable; and providing clean air. “These are wonderful things that make us feel good to be in the profession,” she said. But, she noted, there are also challenges, such as plants closing down and difficult market conditions. Berrigan said, however, that the industry has a great future “if we work together and collaboratively” and get out ahead of problems. This will lead to operating current plants more safely, building new plants, and developing new designs, which will also create a future that attracts young people to the industry. ANS, she said, has a great opportunity to influence that.

Berrigan said that ANS can also make a great contribution on technologies, such as small modular reactors, that can help the industry grow in the future. She also stressed ANS's ability to reach out to all sectors of the technology, the regulators, the national laboratories, and government officials, as

well as industry, fostering collaboration and the sharing of information and experience. Berrigan challenged ANS members to engage with industry as the technology is developed, as it is deployed, and as problems are identified. Be out there in front, she said, developing solutions.

And, finally, Berrigan had ideas about professional development, a key area in which ANS has always done very well, she said. Certainly, ANS student sections offer numerous professional development opportunities. A gap exists, however, between the professional development phase and moving into a leadership position, as Hauck described. Berrigan said that bridging that gap is very important for moving ANS forward.

David Rossin, an ANS past president (1992–1993), spoke on the need for action by ANS and its members to return regulato-

Berrigan found ANS to be strongly engaged with industry in a way that was relevant and timely and added tremendous value by bringing together researchers, educators, and students with industry to work collaboratively.

ry policies on low-level radiation to a more



Rossin

credible and sensible basis after decades of being based on the linear no-threshold (LNT) model of radiation health effects, which assumes that cancer risk is directly proportional to dose at low as well as high levels of exposure to radiation. The issues surrounding this hypothesis—and the controversy that goes with it—are set to be thoroughly aired as the National Academy of Sciences (NAS) begins a new assessment effort in its Biological Effects of Ionizing Radiation (BEIR) report series. An eighth BEIR report is needed, Rossin said, to reflect the advances made by the medical and scientific worlds since the last NAS report, BEIR VII, was issued in 2005.

The LNT concept had and is still having a negative impact on the nuclear industry and on the value that nuclear science and technology can bring to the world, Rossin

said, and it continues to be used as a weapon against the use of nuclear energy. But, he noted, “The scientific evidence supporting the LNT is simply not there.”

Besides noting evidence against the LNT model, Rossin, a former U.S. assistant secretary of energy, referred to other factors that support the need for change. He described an investigation showing that the LNT hypothesis was known to be incorrect by many scientists as far back as the 1940s, when important research was carried out. He also noted the impact of the Fukushima Daiichi accident, which included confusion and panic-driven decisions by the Japanese government that led to unprecedented actions, including the “dangerous, extended, and costly evacuation of tens of thousands of people who lost their homes, their communities, and family members to the tsunami, but none to radiation, just to the fear of it.” The Japanese government also took political actions that had considerable consequences, including the shutdown of Japan’s fleet of nuclear plants, a decision that continues to have environmental as well as economic consequences. Fear also led other nations to decide to shut down and/or phase out their nuclear programs.

To prompt more action on removing the LNT model as a basic assumption in setting regulations, Rossin and other ANS members prepared a letter urging ANS to support the BEIR VIII study and to increase efforts to gain a more reasonable approach to the regulation and control of low-level radiation. Ending the use of the LNT model “will take serious thinking and negotiations,” Rossin said. “We need to replace it with real science and common sense.”

The letter, which can be seen on the Web at <http://tedrockwellmemorial.org/>, provides further information about the LNT hypothesis, its consequences, and what ANS can do about it.

During the question-and-answer session following Rossin’s presentation, Ruth Weiner asked a question that she said she imagined anyone would after listening to Rossin: If the LNT is not a valid concept, why do the regulatory agencies all insist on using it? She then followed this up with another question: How can ANS get the regulatory agencies to stop using it?

Pete Lyons, U.S. assistant secretary for nuclear energy, gave probably the clearest answer. He said that while work done by the Department of Energy very clearly shows that the LNT cannot be correct at low doses, what has not yet been determined is what is correct. The regulators, he said, are going to make use of the advice given by the NAS, the National Council on Radiation Protection and Measurements, and the International Commission on Radiological Protection in setting their rules. To change them, he said, research must be done to provide an answer as to what is correct.

Nonproliferation

A session sponsored by the Nuclear Nonproliferation Technical Group (which became the Nuclear Nonproliferation Policy Division on November 13 at the ANS Board of Directors meeting), and chaired by Los Alamos National Laboratory’s Rian Bahrman, featured six presentations on proliferation-related topics.

The first presentation was by Matthew Swinney, of the Nuclear Security Science and Policy Institute (NSSPI) at Texas A&M



Swinney

University (TAMU). Swinney presented the results of work performed as part of the Nuclear Forensics Analysis of Separated Plutonium project, which is aimed at using computational and experimental methods to identify and measure possible signatures—unique intrinsic physical characteristics—inherent in weapons-grade plutonium produced in certain types of reactors.

Swinney explained that one of the reactors of interest is a design that is likely to be operated in a nonsafeguarded environment in the near future: the fast-spectrum breeder reactor. If a reliable “fingerprint” could be found and linked to specific reactor designs and environments, he said, it could serve as a valuable deterrent and nuclear forensics tool.

The efforts to date on this project, Swinney said, have involved the characterization of an experimental irradiation of depleted uranium-oxide samples at the High Flux Isotope Reactor at Oak Ridge National Laboratory that is intended to emulate the irradiation of uranium in the blanket of a fast breeder reactor.

Matthew Cook, of the University of Tennessee’s Institute for Nuclear Security, presented progress on extensive computational studies conducted on a variety of topics pertinent to the application of hybrid k-edge densitometry (HKED) to pyroprocessing in order to determine

Cook

how and where in a pyroprocess line HKED will be adapted. HKED is an X-ray-based method currently employed as a safeguards measurement technique in aqueous reprocessing lines that could be adapted to pyroprocessing.

Cook described pyrochemical reprocessing of spent nuclear fuel as a promising technique that could be applied in conjunction with currently used aqueous re-

processing methods to form a viable option for dealing with spent fuel. This method’s ability to handle more freshly discharged fuel makes it suitable for handling nonlegacy fuel, he said. One challenge Cook noted that must be overcome is the development of appropriate safeguards-measurement methods for pyroprocessing. Cook demonstrated that HKED measurements may be taken in the presence of high-radiation fields and through optically thick materials like those found in pyroprocessing.

A presentation by Royal Elmore, also from TAMU’s NSSPI, highlighted the application of the Proliferation Resistance Analysis and Evaluation Tool for Observed Risk (PRAETOR), which was developed at



Elmore

TAMU to analyze the intrinsic and extrinsic proliferation resistance of nuclear fuel cycle facilities. According to Elmore, the inclusion of containment, surveillance, and physical protection system attributes is an important step in the evolution of PRAETOR. He demonstrated the application of the new PRAETOR attributes to five case studies: (1) a diversion of natural uranium from a mill, which is normally exempted from International Atomic Energy Agency safeguards, (2) a 5 percent-enriched uranium hexafluoride diversion from a commercial fuel fabrication facility, (3) a separated plutonium diversion from a small reprocessing plant liquid stream, (4) a recently removed, noncooled spent pressurized water reactor fuel diversion from the plant cooling pool, and (5) a 30-year cooled spent PWR fuel diversion from the plant cooling pool.

At the state level, Elmore said, these attributes have broadened the range of nuclear material acquisition scenarios that could be assessed by PRAETOR, which is especially important as decision makers at multiple levels need to ascertain where resource allocations will provide the greatest nonproliferation benefits.

Andrew Giminaro, of the University of



Giminaro

Tennessee’s Radiochemistry Center of Excellence, said that in the wake of any nuclear event, it will be imperative to determine the composition and origin of the device accurately and expeditiously. The center is aimed at developing these capabilities, he said, while at the same time providing academic opportunities and support

for students in the fields of radiochemistry, geochemistry, nuclear physics, nuclear engineering, materials science, and analytical chemistry.

One of the center's goals, Giminaro noted, is to reduce the time required for accurate post-detonation analysis of nuclear debris through the development of improved radiochemical separation and analysis methods. Because there is no existing nuclear urban melt glass, Giminaro showed that the center is working toward surrogate melt glass debris. An urban matrix formula was developed that determined the elemental contribution by weight percent of soil composition, land-use data, infrastructural compositions, vehicular compositions, and traffic data. Giminaro demonstrated surrogates that were produced for New York City and Houston, Texas, for a blast of up to approximately 10 kilotons, which, Giminaro said, is a reasonable upper bound for a surface burst.

Manteusz Monterial, of the University of Michigan, discussed the application of Bayes' Theorem for pulse shape discrimination to such areas as nuclear nonproliferation, nuclear data, and criticality safety. For neutron-specific measurements in highly mixed fields, Monterial showed an experimental improvement in the gamma-ray rejection rate with the application of Bayes' Theorem for pulse shape discrimination in comparison with other standard discrimination methods.

The session's final presenter was Kaichao Sun, of the Massachusetts Institute of Technology. As a result of the Department of Energy's goal to convert all civilian research reactors from the use of high-enriched uranium to low-enriched uranium, the MIT research reactor is to be converted to use monolithic uranium-molybdenum LEU fuel while still achieving neutron fluxes



close to that of HEU. Sun said that his work, which focused on reactivity worth and nuclear-heating capability, led him to conclude that the reactivity penalty of the MIT High Temperature Irradiation Facility experiment is less significant in the LEU core than in the HEU core by approximately 30 percent due to the harder neutron spectrum in the former, which implied a generally larger reactivity margin for in-core experiments with the use of LEU fuel.

Construction worldwide

The panel session titled "New Nuclear Construction Around the World" was co-chaired by Ted Quinn, an ANS past president (1998–1999), and Corey McDaniel, chair of the ANS International Committee. The session was sponsored by the ANS Operations and Power Division.

McDaniel provided a brief account of the International Committee, which includes some 40 members, half of whom are from outside the United States. He said that the committee for the first time now includes members from India and China. At the 2015 ANS Winter Meeting in Washington, D.C., he said, the session on new nuclear construction will include an expanded program with officials from many countries.

The first two speakers for this session provided an overview of efforts to expand new nuclear construction in the United States, along with the related licensing issues. They were followed by presentations on Russia's international new-build activities and efforts to develop a nuclear program in Mongolia.

Sal Golub, associate assistant secretary for nuclear reactor technologies in the Department of Energy's Office of Nuclear Energy (NE), described what the DOE is doing to facilitate the next wave of nuclear construction projects, which, he said, can provide the foundation of a clean energy future for the United States.

While nuclear power faces a variety of challenges, he said, NE is focused on research, development, and demonstration activities designed to reduce the technical, financial, and regulatory risk, improve the management of used nuclear fuel, and minimize the risk of nuclear terrorism and proliferation.

Golub highlighted some of the innovative approaches and technologies being developed to support the construction of new plants. Reducing capital costs is a key requirement for future nuclear deployment, he said, adding that the economics must be favorable enough for potential owners and investors to agree to make the significant financial commitment required.

Given today's cheap natural gas, and in the absence of a price on carbon emissions, Golub noted, the government has introduced a number of measures to make nuclear power more affordable, including economic incentives such as insurance to reduce the risk

of licensing delays, a production tax credit to provide financial benefits for first movers, and loan guarantees.

Given the potential of small modular reactors, Golub said, the DOE is also helping to jump-start an SMR industry through the SMR Licensing Technical Support Program, which supports first-of-a-kind SMR design certification and licensing activities through cost-sharing partnerships with industry. Golub also explained the advantages of introducing SMRs into a utility's generation portfolio, noting that the more risk-averse the power producer is, the more interested it should be in having SMRs in its portfolio in order to minimize exposure to volatile fossil fuel technologies.

An important aspect of all new units under construction is the introduction of improvements over the existing fleet, including passive safety features and simplified designs, which have dramatically reduced the number of components and commodities needed, Golub said. This in turn has substantially reduced the material, labor, and operation and maintenance costs. The use of standard designs, as well as advanced construction techniques—such as off-site module fabrication and on-site module assembly—will also reduce costs and improve overall construction schedules.

Golub then focused on the Advanced Methods for Manufacturing Program,

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which is part of the DOE's Nuclear Energy Enabling Technologies Program. This program, the specific goal of which is to reduce the costs and schedules for building new plants, aims to develop innovative techniques to fabricate nuclear plant components better, faster, and cheaper. Current projects include the following:

- Advanced welding processes to reduce welding time and labor in fabricating thick-section components. These include electron beam welding, hot wire laser welding, and

hybrid laser gas metal arc welding. Tools to monitor and provide real-time welding control information and real-time nondestructive examination inspection of welds are also being developed. This will reduce the amount of rework needed and minimize the residual stresses associated with repairing welds.

■ Laser direct manufacturing, often referred to as 3-D printing, is a breakthrough technology that has the potential to transform manufacturing.

■ Powder metal hot isostatic processing is another technique that can be used to manufacture large or complex components, such as primary circuit valve bodies and T-junction pipes.

■ Innovative civil structural materials and techniques can improve the way nuclear plants are built. Research to further develop steel concrete composite wall construction is being undertaken. A new class of self-consolidating ultra-high-strength concrete is being developed that can lead to thinner, lighter, and stronger concrete structures that can be built more quickly and easily.

Next, Frank Akstulewicz, director of the Division of New Reactor Licensing in the Nuclear Regulatory Commission's Office of New Reactors, looked at new projects in the United States and elsewhere from the perspective of licensing activities. He presented a list of countries engaged in construction and new reactor licensing activities that clearly shows China's leading position, as well as the growing number of newcomer countries planning to develop nuclear programs.

Among new reactor trends, Akstulewicz noted the development of SMRs and Generation IV non-light-water reactors, as well as the continuing efforts to learn from the Fukushima Daiichi accident. To these he added an international regulatory initiative, the Multinational Design Evaluation Program (MDEP), which has developed into a global forum for regulators and safety specialists to discuss issues, not only of particular designs, but also of technical concerns such as digital instrumentation and controls (I&C), codes and standards, and vendor inspection. The MDEP structure ensures that a broad spectrum of regulators and specialists from a range of countries takes part in discussions on licensing and safety issues as designs move forward. This, among other things, has led to common regulatory positions on various issues in several countries. Probably the best example of this is the digital I&C design issues that are associated with the EPR design, which the regulators of Finland, France, and the United States have been tackling in the same relative time frame. Although not generally appreciated, Akstulewicz said, MDEP has had an impact on licensing activities worldwide.

Akstulewicz gave a status report on the unique licensing process developed in the United States, which includes design certi-

fications, early site permits (ESP), and combined construction and operating licenses (COL). Three designs are now under review: the US EPR, the US-APWR, and the APR-1400 (in the pre-application phase). Four ESPs have been issued, and 18 COL applications have been submitted, with licenses having been issued in 2012 for Vogtle-3 and -4 and Summer-2 and -3, all Westinghouse AP1000 designs. Eight COL applications are actively under review.

With regard to SMRs, the designs developed by NuScale and mPower appear to be at the forefront of SMR efforts in the United States, and although the efforts on mPower have slowed, NuScale is aggressively pursuing the completion of its application for certification, which the NRC expects to receive by late next year. Holtec is also moving forward on a design, Akstulewicz said, but has not indicated when it will submit an application. (For further information on these and other advanced reactor designs, see the Special Section on Advanced Reactors, *NN*, Dec. 2014, p. 43).

One challenge related to Fukushima that Akstulewicz mentioned is the differing regulatory expectations seen across the world, which can lead to differences regarding the introduction of Fukushima-related safety measures in reactor designs. This is being played out on the AP1000, Akstulewicz said, where China's National Nuclear Safety Administration told the NRC that it is thinking about changing some design requirements that the NRC is not even considering. This could lead to some loss of standardization as designs go forward, he said.

Akstulewicz also discussed lessons learned during recent licensing activities. First, he noted that having a very high-quality application will avoid problems and questions down the line. This has led to additional guidance being prepared as to what constitutes a satisfactory application, as well as an awareness of the importance of pre-application interaction between design developers and the NRC to enhance the ability of the agency to complete its reviews. The application to certify the APR-1400 design developed in South Korea will soon be submitted, Akstulewicz said, and the NRC believes that given the extensive pre-application work that has been done, the certification process will take half the time that others have taken.

The process is also driving some design standardization, he added, noting that with regard to AP1000 applications, utilities are

working collaboratively to keep designs as similar as possible.

Following the discussion of U.S. efforts to expand its small new-build program, it was fitting to hear from Rosatom, the state atomic energy corporation of Russia, which has an enviable backlog of construction orders. Alexander Superfin is a vice president of Rosatom subsidiary Rusatom Overseas, with responsibility for business development in North America. Before taking this job, he was chief executive officer of the Akkuyu project in Turkey, the first nuclear project being carried out under a build-own-operate contractual arrangement. Superfin had also worked for the Bechtel Group for many years.

Rosatom, Superfin explained, is a vertically organized federal corporation that brings together over 350 nuclear companies and research and development institutions covering both civil and defense activities. Today it has 19 units under construction or under contract outside Russia, and 10 units under construction in Russia.

The workhorse of Russian nuclear plants is the VVER design, which belongs to the larger family of pressurized water reactors. The latest evolution of the design is a Generation III+ system offered in two sizes, 1,000 MWe and 1,200 MWe. Superfin stressed Rosatom's ability to customize project proposals to the specific needs of individual countries or customers in those countries—for example, offering complete plants on a turnkey basis or acting as an engineering-procurement-construction contractor—and under a variety of commercial arrangements. As a state-owned corporation, it is also able

One challenge related to Fukushima is the differing regulatory expectations seen across the world, which can lead to differences regarding the introduction of Fukushima-related safety measures in reactor designs.

to provide project financing and offers a range of associated services, such as institution building, professional training and education, and full fuel cycle services, including spent fuel management.

Superfin then described some of the company's international projects, starting with his personal favorite, the Akkuyu project in Turkey, for which Rosatom will design, construct, and operate a total of four

AES-2006/VVER-1200 units. Rosatom is responsible for financing the entire project, the cost of which is estimated at \$20 billion. Under the intergovernmental agreement signed with the Turkish government, Rosatom is to hold a stake of not less than 51 percent in the project. Turkey has also agreed to sign a power purchase agreement guaranteeing to buy on average 50 percent of the electricity generated over the first 15 years. The balance is to be sold in the commercial market and through bilateral contracts with customers. The project also presents an opportunity to sell power to the European market.

Rosatom is officially in the construction phase of projects in three countries:

■ **Belarus**—Two 1,200-MWe units are under construction under a turnkey contract, with Russia providing substantial financial support.

■ **China**—Having completed two units at the Tianwan site, Rosatom is working on another two units at the site. In this case, Rosatom is generally responsible for the nuclear island. Both units should be completed in 2018.

■ **India**—Rosatom is committed to completing four units at the Kudankulam site. The first unit is now in operation, while Unit 2 is nearing completion. The contract for the next pair of units is still being negotiated. For these plants, Rosatom will provide nuclear island equipment, installation services, fuel supply, and training. India is responsible for the balance of plant and general construction.

Over the past couple of years, Rosatom has concluded intergovernmental agreements or contracts with several countries, including Finland, Hungary, Jordan, and Kazakhstan. For Kazakhstan, the number of units and their capacities have not been decided, Superfin said, adding that there is the possibility of including SMRs.

The final international speaker was Tseren Davaadorj, director of information and analytical services at Mongolia's National Security Council and a director of the country's Radiation Safety and Nuclear Technology Association. He is also involved in establishing the country's nuclear energy policy and technical programs.

Sandwiched between Russia and China is not always an easy place to be, Davaadorj said, but there are some advantages, as these powerful countries supply about 20 percent of the power needs of his country. Mongolia, which is a young democracy, is a large territory with a small population of under 3 million. It is very rich in natural resources, however, with sufficient coal and uranium reserves to eventually fuel its own power needs and to export resources to its energy-hungry neighbors. It also has significant wind resources, and a number of wind farm projects are being planned.

According to Davaadorj, electricity demand is expected to increase substantially

over the next few years. Mongolia needs energy for developing its infrastructure, including the electrification of vital railways, for expanding its mining activities, and for the construction of housing and social facilities.

It is clear to the government, Davaadorj said, that to promote economic development and to reduce the environmental impact of burning coal, which contains significant levels of uranium, the country needs to develop nuclear energy. Plans for introducing nuclear power, however, have been stalled because of domestic politics and a growing anti-nuclear movement.

The creation of a national nuclear energy program was included in Mongolia's millennium development goals and an action plan set out by the Parliament in 2008. This led to policies and measures to implement a nuclear program, including the establishment of the Nuclear Energy Agency. Also, bilateral cooperation agreements were signed with China, France, India, Japan, Russia, South Korea, and the United States. Joint ventures for uranium exploration have been set up with a number of foreign companies, including Areva, China National Nuclear Corporation, Denison Mines, and Korea Electric Power Corporation.

In 2010, Mongolia began a prefeasibility study for a medium-sized nuclear power plant to be used for mining projects in the south (Gobi) region and for a nuclear plant of 100–200 MWe in the western region, which has few coal reserves. In 2011, further studies began on a range of issues and topics important for developing a nuclear power program: selecting a reactor technology, reactor supplier, and fuel supplier; site selection; human resource development; and regulatory and licensing procedures.

Fuel cycle options

In December 2011, the Department of Energy's Office of Nuclear Energy chartered a study to evaluate possible nuclear fuel cycle options for the United States. The product of that study, *Nuclear Fuel Cycle Evaluation and Screening—Final Report*, was published on October 8, 2014, and was discussed during the panel session "Fuel Cycle Options Analysis I."

Session organizer Patricia Paviet, director of the DOE's Office of Systems Engi-

neering and Integration, provided some background on the fuel cycle study and its scope. According to Paviet, in trying to identify options for an improved fuel cycle, the DOE specified nine evaluation criteria:

The creation of a national nuclear energy program was included in Mongolia's millennium development goals and an action plan set out by the Parliament in 2008. This led to policies and measures to implement a nuclear program, including the establishment of the Nuclear Energy Agency.

nuclear waste management, proliferation risk, nuclear material security risk, safety, environmental impact, resource utilization, development and deployment risk, institutional issues, and financial risk. The first six of these criteria reflect the potential benefits of developing and deploying a new fuel cycle in the United States, while the last three reflect possible challenges.

The study, Paviet said, does not make policy decisions regarding a fuel cycle, nor does it decide on a preferred fuel cycle option. It does, however, provide a framework and process to allow decision-makers to evaluate the impacts of policy decisions and a screening tool to identify fuel cycle options that have the potential to provide "substantial improvements" to today's open fuel cycle. The study also provides information to help the DOE prioritize its nuclear fuel research and development programs, she said.

The challenges to implementing a new fuel cycle that Paviet identified relate to time (it will take years to build the infrastructure to support a new fuel cycle), regulations (the licensing process will be long and complex), and money (it will take "several hundreds of billions" of dollars to implement).

Reiterating some of the points made by Paviet, Roald Wigeland, national technical director for the DOE's Fuel Cycle Options Campaign and lead author of the report, said that the main purpose of the study was to identify potential fuel cycles that would offer a substantial improvement over the United States' current open fuel cycle policy. "The DOE was looking for what they like to

refer to as high-risk, high-payoff research,” he said.

Wigeland explained that the DOE’s study of fuel cycle alternatives does not mean that it intends to abandon any efforts to site and build a geologic repository for nuclear waste. “It is really important to remember that any effort the DOE engages in to support the R&D on alternative fuel cycles is in addition to developing and opening one or more repositories in the U.S.,” he said, adding that all of the fuel cycles the DOE studied would require some geologic disposal.

Noting that the study took a technology-neutral approach, focusing on the physics of possible fuel options and not on the technologies or facilities needed to implement them, Wigeland said that nearly 4,400 combinations and permutations of fuel cycle options were developed. Those were then reduced to 40 evaluation groups for the study. Of those 40, Wigeland said, three groups were found to consistently perform better than the others, regardless of the relative importance of the six benefit criteria. All three groups would use continuous recycling of fuel (uranium/plutonium and ura-

who brought a utility-informed perspective to the fuel cycle panel. Answering his own question, Sowder said, “The fact that I’m even here at all and [EPRI] paid my bills for traveling [means] yes.”

Sowder reminded the audience that commercial utilities are primarily concerned with the business models that can be made from a new fuel cycle—how it can be used to provide a product or service to customers on a commercial basis. Fortunately, he said, the work that the DOE has done on alternative fuel cycles turns out to be complementary to EPRI’s research. While the DOE has focused on “end-state and equilibrium,” EPRI has focused on understanding the difficulty in implementing the new technologies.

Sowder broke the process of transitioning to a new fuel cycle into three levels. First is the strategic level, which asks the overarching questions of what and why. “What are you trying to presume and why? Because before you go and ask the question of how we’re going to get there, you at least need to know where you’re going and why,” he said. Next is the tactical level, which

looks at how the new fuel cycle is implemented and how difficult it is. At the final, “most granular” level, Sowder said, an assessment of the readiness of the technology is developed, including all aspects of the necessary infrastructure, such as licensing, financing, and institutional frameworks. “It is great to develop a technology, but it’s really not commercially viable un-

Commercial utilities are primarily concerned with the business models that can be made from a new fuel cycle—how it can be used to provide a product or service to customers on a commercial basis.

nium/transuranic elements) with the feed-in of new natural uranium fuel. Two of the groups would employ fast critical reactors and one would use both fast and thermal critical reactors. When taking into account the importance of the challenge criteria, Wigeland said, a fourth group that would use continuous recycling of uranium/plutonium with new natural uranium fuel in fast and thermal reactors was added to the list of most promising options.

“I think the message here is fast reactors, reprocessing, continuous recycle, and, I should also mention, not using uranium enrichment,” Wigeland said.

From a market perspective, any discussion of the development of advanced fuel cycles and fast reactors raises the question, “Do utilities even care about such research?” That was the point made by Andrew Sowder, senior technical leader at the Electric Power Research Institute (EPRI),

less you can license it and someone can provide the money to finance it,” he said.

Fiona Rayment, director of Fuel Cycle Solutions at the United Kingdom’s National Nuclear Laboratory, provided a perspective on how other countries are handling the fuel cycle question. Rayment pointed out that with its fleet of Magnox reactors and advanced gas-cooled reactors, the United Kingdom has primarily utilized a closed fuel cycle. (Sizewell B, a pressurized water reactor, uses an open fuel cycle.) Based on its new nuclear policy, however, the country is moving toward an entirely open fuel cycle. “After 2040, we don’t know whether we’re going for a closed or open fuel cycle, and all options are open,” she said.

Regardless of what option is chosen, Rayment said, a “holistic approach” must be taken. “We can’t just look at the reactor. We can’t just look at the fuel. We need to understand whether we’re going for direct dis-

posal or reprocessing prior to that,” she said. Also required, she added, is an understanding of the waste management and decommissioning issues involved in whatever fuel cycle is pursued. In researching fuel cycle options, Rayment said, her lab is using the Orion software tool to assess various fuel cycle options and model reactor systems. Like any model, however, it is only as good as the data provided, she said.

The session’s final speaker, Luc Van Den Durpel, vice president of strategic analysis and technology prospectives at Areva, concluded by offering his company’s perspective on the future of nuclear and possible fuel cycle scenarios.

Van Den Durpel said that the years 2020 to 2050 will be an extremely important transitional period for nuclear because renewables are unlikely to be able to fully replace fossil fuels. If nuclear energy reaches 20 percent or more of the world’s energy supply mix, he said, a closed fuel cycle must be developed. “We need to begin exploring possible fuel cycle scenarios now if we are to overcome the technical and economic uncertainties that will allow us to meet the energy needs of tomorrow,” he added.

UF₆ cylinder safeguards

The ANS Nuclear Nonproliferation Technical Group (now the Nuclear Nonproliferation Policy Division) sponsored four sessions at the Winter Meeting, including one on efforts to keep better track of uranium hexafluoride (UF₆) cylinders, the contents of which could prove useful to a state intent on diverting uranium for clandestine use. “International Safeguards for UF₆ Containers” was chaired by Alicia Swift, a doctoral student at the University of Tennessee currently working at Los Alamos National Laboratory.

Jim Morgan, senior associate at InSolves Associates, began the session with a look at current industry practices regarding UF₆ cylinders. He provided an overview of the Global Cylinder Identification and Monitoring System (GCIMS) project, which was launched in April 2011 by the National Nuclear Security Administration’s Next Generation Safeguards Initiative to investigate a unique identification (UID) system for UF₆ cylinders and develop a cylinder-monitoring concept that could be used by facility operators and the International Atomic Energy Agency.



Morgan

According to Morgan, who is a member of the GCIMS project team, each facility currently maintains its own system for numbering and marking UF₆ cylinders. “There is no industry-wide standard for

numbering and no widespread automated system,” he said. “If you go through an enrichment facility particularly, or a fabrication facility, or any facility on the front end of the fuel cycle—and that would include the depleted-uranium facilities—you will see that there is no standard marking on cylinders. You’ll see that they have a standardized name plate, either to an ANSI standard in the U.S. or to an ISO standard globally, but the nameplate itself is not particularly large, and you have to get quite close in order to be able to read the numbers. You might see a number painted on the side of a cylinder, or you might see barcode stickers—a lot of effort to try to make the cylinder easier to read for the operator. But again, nothing is standardized.”

The drawbacks of the current system, Morgan said, include the time expended by the operator or the inspector to locate and identify cylinders on-site, the increased likelihood of error in reading and recording cylinder IDs, and the limits that the system places on the IAEA’s ability to automate on-site inspection tasks and to detect a diversion of materials or misuse of a facility in a timely manner.

The GCIMS project’s plan includes six tasks, Morgan said, four of which have been completed: defining the baseline problem, developing a preliminary concept of operation for an identification and monitoring system, determining technology requirements and identifying available technologies, and developing a preliminary cylinder registry concept. The two remaining tasks for the GCIMS project team are system integration and demonstration of proof of concept.

“Today we are working on how to integrate the UID and the registry, realizing that there is still work to be done on the UID,” Morgan said. “And really, the work to be completed on that will, to a large extent, drive a good part of what the registry will eventually look like. The ultimate goal of this program is to be able to demonstrate a proof of concept of the principal elements of this system, where we would demonstrate our capability to identify these cylinders with their unique IDs and be able to, through the use of our database, track those cylinders through their life cycle.”

In April 2014, Morgan said, the GCIMS team held a meeting with representatives of the IAEA and industry, including cylinder manufacturers. “Out of that,” he said, “a World Nuclear Transport Institute (WNTI) working group took the lead in establishing a committee to look at developing a concept for a standardized UID. They are working now on drafting their work scope and team objectives. They’ve had a couple of conference calls, and their first scheduled face-to-face meeting will be at the WNTI semi-annual meeting in London. The real beauty of this is that you have industry working

together to determine the best solution for going forward.”

Chris Pickett, leader of the Safeguards and Security Technology Group in the Nuclear Security Technology Division at Oak Ridge National Laboratory, spoke on safeguard considerations for identifying, tracking, and monitoring the cylinders. Among the major safeguards concerns regarding UF₆ cylinders, he noted, is that



Pickett

once the UF₆, which is direct feed material for enrichment plants, has been enriched to reactor-grade uranium, 70 percent of the effort to get it to weapons grade has been accomplished.

“It has been estimated that if a UF₆ cylinder enriched to reactor grade was further enriched, you could get two significant quantities of material from that further enrichment,” Pickett said. He also stated that the A. Q. Khan network has disseminated enrichment information and technology and that the world share of enrichment capacity in nonnuclear weapons states is expected to double from 10 percent to 20 percent. “The theft or diversion of UF₆ will become increasingly attractive as the capability to enrich uranium becomes more broadly available,” he said.

Pickett defined a good UF₆ cylinder as one that will detect or deter tampering or breach of containment, provide for effective sealing, be authenticatable, and facilitate inventory taking. “Most containers are designed only for the safe storage and transport of the material asset, but the container is part of the safeguards system and should be considered in the system design,” he said. “Unfortunately, it rarely is. With almost every container I’ve worked with in this industry, we’ve had to retrofit it for safeguards purposes. A container with the appropriate features, however, can provide delay, effective sealing, support for verification, and inventory taking.”

Pickett also stressed the importance of being able to tell whether or not a cylinder is counterfeit. “We don’t use the word tamper-proof,” he said. “That’s like saying your Microsoft Operating System is hack-proof—someone will prove you wrong. We don’t want to challenge our adversaries by bragging about how good our containers are. We

want them to be tamper-indicative. We want to be able to detect counterfeits. That is the important thing about authentication. We need to know whether or not a particular container is the same container we started with.”

A good cylinder UID, Pickett said, in addition to being truly unique, would also be authenticatable; difficult to lift, counterfeit, or spoof; have a tamper-indicating attachment; and be readable at a distance. It would also be readable with automated data entry technology, which would reduce transcription errors and support data authentication.

Current UF₆ cylinders do not have unique identifiers or any standard method for labeling, Pickett said, noting that markings can range from welded plates to paper labels to grease-pencil markings, and that the labels can be easily removed and new ones applied. “Having a universal or common identifier would be a really good thing,” he said. “And if that’s all that comes out of this, it would be a great benefit both for safeguards and industry.”

Pickett touched on the pros and cons of a variety of technologies that could potentially be of use to a new global safeguards system for UF₆ cylinders, including tamper-indicating devices designed to leave non-erasable, unambiguous evidence of access or entry, also referred to as seals; barcodes; and radio frequency identification (RFID) tags. Tags that support both RF and barcode

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functionality are available, Pickett said, adding that if they could be incorporated into a verifiable sealing attachment or implemented as a sealing device, they might be the best option for UF₆ cylinders. Converting a cylinder’s valve into a sealing device was an additional option he presented for consideration.

For the further development of a global cylinder ID and monitoring system, Pickett recommended that technical people and policy people get together earlier in the process. “It’s very important that certain options get ruled out or weeded out before they go too far down the road,” he said. “We do this in arms control, but with a lot of technical people, the sooner you give them

the requirements, the sooner you're going to get a solution. Working together, we can eliminate a lot of effort that is often duplicated when you work separately."

The session's final presenter, Faranak Nekoogar, technical program lead for radio frequency and ultra-wideband technologies at Lawrence Livermore National Laboratory, spoke on the remote monitoring of UF₆ cylinders by passive (battery-free) RFID with an integrated fiber-optics seal. The right RFID technology could significantly improve current cylinder monitoring methods in a variety of ways, she said, including by preventing diversion activity, detecting undeclared activity, and reducing human-induced errors and maintenance requirements. Operational requirements for UF₆ tracking with RFID, Nekoogar said, would include tolerance for harsh environments and the capacity for working reliably on metallic components. "We all have cell phones, and when we get on an elevator, we have dropped calls," she said. "It's the same thing with a tag and a reader. It's wireless communication. As soon as you put it on a metallic object, you run the risk of a 'dropped call' between the tag and reader."

Nekoogar

Other requirements for the technology, Nekoogar said, include a long life cycle, long-range detection, data encryption, and authentication and tamper-indication capabilities. Commercial RFIDs fall far short of meeting the requirements for safeguards applications, she noted. "Basically, RFIDs were made for Walmart, because everybody wanted to go for the big market and reduce the cost," she said. "The desire for sensitivity and security and encryption authentication—none of those really existed on the street. The companies wanted to go to a mass market, have a very cheap RFID, and make money."

LLNL and its industrial partner, Dirac Solutions, have developed long-range passive tags integrated with fiber-optics seals that have proven to perform well in realistic environments, Nekoogar said. The passive tag and seal communicates the unique ID and seal tamper status to its remote reader with data-security features employing encryption and dynamic authentication. Communication with the reader is accomplished by a "backscattering" technique in which tags do not actively transmit, but instead get their power from a remote reader antenna and reflect the received signals. "By not using any batteries in these tags and seals, we increase their reliability and lifetime and eliminate the need for battery maintenance," Nekoogar said. "Further-

more, the backscattering feature of each passive tag and seal reduces the security and safety concerns regarding active transmission by a large number of active tags and sensors in nuclear facilities."

Reactor D&D

The panel session titled "Industry Perspectives on the Decommissioning of Nuclear Facilities" provided insight into the processes involved in decontaminating and decommissioning nuclear reactors from those who have worked in the trenches. The panel's first speaker, Jeff Hays, vice president of commercial decommissioning for Areva, emphasized what is at stake, stating that the nuclear industry must handle the decommissioning of its closed reactors effectively and responsibly if it expects to continue to advance and grow.

Hays noted that over the next 20 years, about 200 nuclear power plants worldwide, mainly in Europe, will be closed and ready for decommissioning. Most of those plants will have reached the end of their licensed lives, while others, such as Germany's nuclear fleet, are being closed for political reasons. In the United States, about 38 reactors will close by 2035 as they come to the end of their licensed lives, Hays said, adding that the forecasted cost of decommissioning the currently shutdown reactors is about \$8 billion.

Hays discussed two decommissioning options available to nuclear reactor licensees under Nuclear Regulatory Commission regulations—SAFSTOR (deferred dismantling) and DECON (immediate dismantling)—and some of the pros and cons of each. For nuclear power plant owners, the biggest factor in deciding between SAFSTOR and DECON is the health of the plant's decommissioning fund, Hays said, adding that most plants that have closed prematurely tend to have insufficient decommissioning funds. While SAFSTOR allows time for the decommissioning trust fund to grow through accrued interest, he said, it also makes assumptions about inflation rates and future disposal costs that "may not be true across the board."

Hays also said that once a licensee commits to the SAFSTOR approach, it is difficult to reverse course, because early decommissioning requires a full-system chemical decontamination, a process that is not easily carried out if reactor systems have already been mothballed. In addition, the owner is likely to lose key personnel who have knowl-

edge of the systems once a reactor is put into SAFSTOR. "The difficulty factor starts rising on you," Hays said.

Hays said that he recommends a phased approach to decommissioning, which he described as finding the "sweet spot" between the two approaches. For example, he said, the immediate decontamination of a reactor's cooling system and containment building will remove 95 percent of the source term, allowing the remainder of the plant structures to be dismantled when funds allow.

Michael Lackey, vice president of nuclear operations for Fluor Corporation, outlined some of the decommissioning projects in which his company has been involved, noting the importance of planning and innovation in D&D. "Innovation is key in a decommissioning project, because every one is different," he said. As an example, Lackey said that Fluor, which along with its partner, Cavendish Nuclear, has been awarded a 14-year contract by the United Kingdom's Nuclear Decommissioning Authority to decommission 26 reactors at 12 sites, will save

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the United Kingdom £1.5 billion (about \$2.4 billion) as a result of process innovations and strategic planning.

Lackey also provided the following guidelines for achieving a successful D&D project:

- Set up an experienced leadership team with clear accountability and a focus on teamwork.

- Establish a professional project management infrastructure.

- Establish a regulatory framework that supports the efficient execution of the project.

- Take advantage of expertise found in the supply chain.

- Charter a decommissioning advisory board.

- Facilitate a community engagement panel.

The panel's next speaker, Mark Gake, chief engineer for nuclear projects at Black & Veatch, also spoke on what he believes are some of the keys to successfully completing a nuclear D&D project. Gake emphasized the importance of careful project planning, especially since there are likely to be surprises in any D&D project.

Continued

“It sounds very simple—to plan the work and then work the plan—but too often that doesn’t happen,” Gake said. The problem, he said, is that people start with what they believe is a clear understanding of the scope of the project, but within the first month of starting the project, they begin deviating from their execution approach. It is extremely critical, he said, to understand the project scope, define the execution approach, and reevaluate and update the plan anytime there is a deviation.

A few concrete examples of some of the types of surprises that can come up during a D&D project were provided by Robert Woodard, project director for Energy-Solutions, who has been involved in the decommissioning of the Zion nuclear power plant in northeastern Illinois. Woodard specifically talked about some of the non-radiological hazards that are likely to be faced in large D&D projects, such as contamination caused by silica, asbestos, and hexavalent chromium.

“If you’ve never thought about hexavalent chromium, when you go to decommission a plant, you ought to think about it,” he said. According to Woodard, hexavalent chromium is a particularly difficult contaminant to deal with because it has an extremely low permissible exposure level value, which is easy to exceed when doing hot work. “Any time you take a torch and you put it on stainless steel, you’re going to have hexavalent chromium,” he said.

Workers discovered asbestos at Zion in places they never would have expected it to be, including the electrical wiring. Miles of asbestos-coated cabling had to be cut and the ends encapsulated with glue, and then wrapped and packed separately as an asbestos hazard.

Woodard also noted that workers discovered asbestos at Zion in places they never would have expected it to be, including the electrical wiring. The plant had miles of asbestos-coated cabling that had to be cut and the ends encapsulated with glue, and then wrapped and packed separately as an asbestos hazard. Workers were required to attend a 14-hour class to learn how to properly deal with the hazard, he said.

Woodard also pointed out the importance of the lifting and rigging equipment when decommissioning a nuclear power plant, warning that turbine and reactor cranes are not designed for the continuous heavy use involved in D&D work and must be well maintained. Cranes also must be maintained if the plant is going to go into SAFSTOR, because parts may become obsolete, he said. To illustrate his point, Woodard noted that a polar crane motor at Zion burned out and could not be replaced because the manufacturer no longer made it, and a licensed company that could rebuild it could not be found. Fortunately, a Google search of the motor’s model number turned up a replacement in nearby northern Indiana. “Be kind to your cranes,” he said.

Wrapping up the session, Richard McGrath, senior project manager for the Electric Power Research Institute (EPRI), emphasized the importance of industry collaboration in making D&D projects more successful and of taking advantage of past experiences. McGrath noted that EPRI has been documenting successful D&D projects, as well as ones that “have not gone that well,” for some time. Over the past 20 years, he said, EPRI has published more than 100 reports related to decommissioning.

U.S. reactor construction

As the first Westinghouse AP1000 reactors approach the completion of construction, technical sessions focusing on new reactors

have been broadened to address what will be done with these and other Generation III+ reactors once they have been built, tested, and cleared for startup. At the session on new reactor construction in the United States, Fausto Franceschini, a fellow engineer at Westinghouse Electric Company, gave a presentation on the fuel and core design for the AP1000.

Franceschini said that much of the core design work has been based on the work

done for the Westinghouse AP600, a reactor design that was certified by the Nuclear Regulatory Commission but was never used in a license application, let alone built or operated. Enrichment in the AP1000 core will vary from 0.74 percent U-235 (essentially natural uranium) to 4.34 percent. The AP1000 has four banks of control rods, with more rods than in current Westinghouse reactors. Three-dimensional codes have been devel-

oped to adjust for control rod movement within the core. With the addition of the BEACON core-monitoring system and a tungsten absorber, Franceschini said, the AP1000 core can have smooth power distribution and load-following capability.

Jeff Gasser, executive vice president of Southern Nuclear, reported on the operational readiness of the third and fourth reactors at the Vogtle site in Georgia and the integration of the new reactors with the already-operating Units 1 and 2. He said that this has turned out to be a bigger effort



Gasser

than he had thought it would be. Gasser noted that the preferred security system was found to be one that treats all four reactors as a single site. One effect on the existing units arises from the placement of the new transmission line. Breakers and related gear have already been replaced on Unit 1 and are in the process of being replaced on Unit 2.

The pipeline for reactor operators for Vogtle-3 and -4 is almost filled, Gasser said, with 74 of 89 operators being AP1000-qualified, and the Engineering Department is mostly filled. In regard to an upcoming

task more closely related to the ongoing construction, Gasser addressed the issue of how to treat inspections, test, analysis, and acceptance criteria (ITAAC) that are completed early in the construction process but might be affected by later work. He said that Southern is developing uncompleted ITAAC forms on which blanks will be left for the later addition of content such as test data.

A presentation showing construction progress at Vogtle or the other AP1000 reactors under construction in the United States, SCANA/Santee Cooper's Summer-2 and -3 in South Carolina, has become a standard feature at sessions such as this, and this time it was delivered not by the plant owner but by the prime contractor. Brian Hobbs, director of project management for CB&I, showed recent photos of Vogtle and Summer, where the placement of containment structure rings has begun. Issues that Hobbs said CB&I must contend with include the many license amendments that have been sought for both projects, as the AP1000 design certified by the NRC as standard had many aspects that did not satisfy the customers, and the competition for skilled craft workers, who are in relatively short supply given the number of large projects inside and outside of energy production.

Jeff Simmons, vice president of nuclear business development for Toshiba America Nuclear Energy Corporation (TANE), spoke on what he said would be the issues

facing the next reactor order in the United States. Toshiba Corporation is the majority owner of Westinghouse, but TANE more directly represents the boiling water reactor work of Toshiba itself. Simmons is involved with Nuclear Innovation North America's license application for Toshiba ABWRs at the South Texas site. Simmons stated that a nuclear project cannot be financed in a merchant electricity market without government support (South Texas-3 and -4 are, in fact, a merchant project, and there is currently no such support), and that nuclear is the only energy source that has never received production tax credits.

During the question-and-answer period, an attendee asked whether modular construction costs are turning out to be lower than those for a stick-built project. Hobbs said that the cost of commodities is unchanged, but the benefit derived from scheduling is giving modular construction about a 20 percent advantage. Asked about AP1000 load following, Gasser responded that while the reactor is designed for it, Southern is planning to use the new reactors entirely for baseload generation. Prior to full-scale operation, a test could be performed on readiness for load following, but it is not required for normal operation, and Gasser said that Southern may skip this test.—*E. Michael Blake, Tim Gregoire, Dick Kovan, and Michael McQueen*