ANS WINTER MEETING

Nuclear: Providing a foundation for sensible policy

Session coverage:

- *Climate talks worldwide, reactor closures at home*
- *Nuclear power under the Clean Power Plan*
- *Nonproliferation and the Eisenhower Award*
- *The All Energy Forum*
- *Fuel recycling and final waste disposal*

The American Nuclear Society's 2015 Winter Meeting and Nuclear Technology Expo was held November 8–12 in Washington, D.C. The meeting, which included two embedded topical meetings, the Young Professionals Congress 2015 and the 12th International Topical Meeting on Nuclear Applications of Accelerators (AccApp'15), attracted about 1,400 attendees. The theme of the meeting, "Nuclear: The Foundation of Sensible Policy for Energy, Economy, and the Environment," dovetailed with the just-concluded White House Summit on Nuclear Energy and the upcoming United Nations climate talks in Paris.

ANS President Eugene Grecheck welcomed attendees to the opening plenary session, noting what a significant time it was for members to be in the nation's capital. Over the past couple of months, he said, nuclear technology has been the subject of policy discussions on many fronts, and has even become a hot topic in the news and on social media. The good news in this regard, he said, is that ANS has become active in social media, and ANS's presence in Washington would provide an opportunity to change, or at least influence, the conversation on nuclear issues on Capitol Hill.

Grecheck

With the U.N. Climate Change Conference (COP21) approaching, Grecheck spoke about Nuclear for Climate, a global initiative that was launched in the summer of 2014 by the French Nuclear Society, the European Nuclear Society, and ANS and now includes about 140 nuclear societies and organizations around the world. Grecheck said that he would be joining representatives from many of these organizations in Paris for COP21, which would be taking on one of the most daunting technological and social challenges of our time: meeting the energy needs of a growing world population while reducing carbon dioxide emissions, with the goal of an 80 percent reduction by 2050. This cannot be achieved, he declared, without a very central role for nuclear power, a message that seems to have become more widely understood.

Grecheck had sent a letter to President Obama requesting that he direct the U.S. delegation to work for a technology-neutral approach to the negotiations to help ensure that the choice of nuclear for meeting a country's climate goals is not artificially constrained by its opponents.

Grecheck noted the huge gap in energy availability in the world, with over 1.5 billion people having no access to an electricity grid. "We are at a watershed moment for protecting the earth's climate," he said, adding that every country has the right to choose from the widest possible portfolio of low-carbon energy sources to meet their goals. He also said that it is "moral-

ly wrong" to restrict the use of electricity, and that all people deserve to have access to non-intermittent electricity. Grecheck said that studies have shown that it is unrealistic to expect the world to achieve the desired 80 percent reduction in CO_2 emissions without nuclear power.

Grecheck then turned the podium over to Donald Hoffman, general chair of the Winter Meeting and an ANS past president (2013–2014), who challenged attendees to respond to Grecheck's call to "all do our part." Based on the energy decisions that are being made, he said, a lot of work needs to be done to better inform the decision-makers. For example, he said, do policymakers understand not only the benefits but the limitations of renewables? If they don't, why don't they? And whose responsibility is it to tell them? It is up to us, he said, to change the conversation.

Hoffman noted surveys showing that the more people know about nuclear energy, the more they believe in it, and the more information they are given, the more likely they are to favor nuclear.

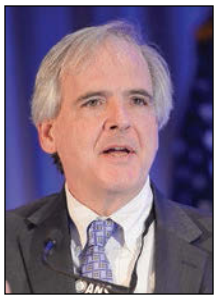
After the permanent shutdown of five reactors over the past few years, the United States now has 99 operating commercial reactors, and more closures have been announced. A battle is under way to make certain that nuclear technologies will continue to be available, Hoffman said, and with this in mind, he has proposed an initiative to the House and Senate for the United States' nuclear power plants to be considered national assets that cannot just be allowed to close. He has asked Congress to consider coming up with ways to facilitate the recognition of their value to the nation, and he said he would like to see operators be able to continue to run their plants until such a time that they are economically viable, or at least competitive in their region. Hoffman said that his initiative is supported by 29 congressmen and senators and that he will continue to work to get the rest on board.

Hoffman

Seeking sensible regulation

The session's first speaker was the chairman of the U.S. Nuclear Regulatory Commission, Stephen Burns, who has not only worked at the NRC, but also at the OECD Nuclear Energy Agency in Paris. The meeting's theme, he said, falls outside the scope of the NRC, which leaves energy policy to the Department of Energy, Capitol Hill, and the White House. But, he added, "We do have an important role in sensible regulation."

Burns then turned to the events at Fukushima Daiichi, in Japan. Soon after the March 2011 accident, he said, the commission directed a team of senior staff—the Near-Term Task Force—to come up with recommendations for strengthening safety at U.S. nuclear plants. The task force's 12 recommendations provided a starting point for a more in-depth assessment that also considered input from industry, the public, and other stakeholders, as well as from the NRC technical staff and the commissioners themselves. The result was a prioritization of the most significant work, with a focus on strategies for mitigating beyond-design-basis events; improving instruments for measuring water levels in spent fuel pools; inspecting and reevaluating seismic and flooding hazards at nuclear power plant sites; installing severe accident–capable vents for reactors with Mark I and II containments; and enhancing emergency preparedness communications and staffing.



Burns

Burns said that the response to the accident illustrated the positive outcomes that can be achieved when operators and the regulator work cooperatively, with due regard for their respective roles, to enhance the safety of nuclear facilities.

Looking to the future, Burns noted the growing interest in small modular reactors (SMR) and advanced reactors, and he said that the NRC expects to receive an application for the certification of NuScale Power's SMR design in late 2016. Also, Burns said, the agency recently cohosted a workshop on non-light-water reactors that was well received, underscoring the interest in new technologies. He added that the NRC believes that it could license a non-LWR under the existing regulatory framework. He noted, however, that the commission recognizes both the staff's and prospective applicants' potential knowledge gaps, with potential challenges related to research and modeling work regarding both the technical issues and code development. Some critical skill gaps may also exist, he said, and the NRC is working with the DOE to address them.

Burns also addressed the fact that the NRC's future workload will include more decommissioning activities. The five reactors that have been permanently shut down earlier than anticipated over the past few years have joined 14 other reactors that are in some stage of decommissioning under NRC oversight, and more closures have recently been announced. In response, he said, the commission has directed the staff to initiate a rulemaking to improve the effectiveness and transparency of the decommissioning process, with a final rule expected to be ready for consideration by 2019.

As changes have occurred in the industry, the NRC is undertaking a "right-sizing" exercise called Project Aim 2020, which is intended to be the blueprint for the agency's streamlining and rebaselining itself in response to the changing environment. The plan calls for a smaller workforce, but one that ensures that the right people are in the right place at the right time. "The commission is taking this seriously, and it will work," Burns said. The way the NRC does business will be adjusted in order to continue to be the responsible, credible, independent regulator that stakeholders and the industry want and need, he said.

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The next speaker was Tom Countryman, assistant secretary of state for international security and nonproliferation, who stressed that civil nuclear cooperation agreements are first and foremost nonproliferation tools. In negotiating these 123 agreements—named after Section 123 of the Atomic Energy Act—the focus is on nonproliferation, but the technical, economic, and political details are also important to U.S. foreign partners.

Countryman

Countryman also noted that although the United States is no longer alone as the global leader in civil nuclear energy, as it was 40 years ago, it still has advantages—including quality, technology, innovation, and safety, particularly passive safety designs—that make it a desirable partner in economic and nonproliferation cooperation. Also, he said, the reputation of the United States provides assurance to foreign governments that dealings will be open, fair, transparent, and non-corrupt.

Continued

Countryman noted that during negotiations for 123 agreements, the U.S. team encourages other governments to consider all of the advantages of such agreements with the United States. He also said that the United States is not just imposing requirements but is also exporting a culture of nuclear safety, security, and nonproliferation at operating reactors.

In 2015, ANS concluded 123 agreements with two important partners, China and South Korea, Countryman said. While a number of U.S. nuclear companies already supply China with equipment, components, and services, under the latest civil nuclear agreement, joint U.S.-China supply partnerships are possible if China should become a larger nuclear exporter. Those export opportunities could support tens of thousands of high-paying American jobs, he added.

At the same time, Countryman said, the U.S. nuclear industry does not have the same integration of industry and government that allows countries such as China and Russia to aggressively offer price discounts and attractive financing deals. Its other main disadvantage is the unresolved issue of spent fuel management. Russia is the only country that currently offers the take-back of spent fuel for permanent disposal as part of its reactor packages, which, he said, "is the best or only good reason" to take up its offer. Despite these disadvantages, Countryman said, there is still a strong basis for the United States to expand international civil cooperation and to do it in a way that is consistent with the president's nonproliferation priorities.

Regaining American leadership

Speaking next was Joyce Connery, who was recently confirmed as chair of the Defense Nuclear Facilities Safety Board. She was previously the director of nuclear energy policy for the National Security Council in the White House, where her job included supporting the competition of U.S. companies overseas.

The United States has shown tremendous leadership in the area of nuclear nonproliferation and nuclear security, Connery said, noting President Obama's "Prague agenda," which focuses on disarmament and a vision of a world without nuclear weapons. But the United States has fallen behind in the area of nuclear energy and is at risk of losing influence in the world. Without a strong nuclear industry, she added, this risk will continue to grow. She also warned that while the United States is fortunate to have world-class national labs and universities, without further investment in infrastructure to maintain U.S. primacy in innovation, the country will fall behind in this area and will lose the opportunity to lead the world in addressing the next great long-term security challenge, climate change.

Connery

Connery then addressed the latest nuclear power plant closures, warning that the United States cannot continue to shut down plants and expect to meet its climate goals. "You cannot accept the science of climate change and ignore the math on nuclear," she said. She added that she appreciates that U.S. utilities cannot make a good economic case for nuclear at this time, and that U.S. companies cannot offer the deals that state-backed nuclear industries can. She said that she heard one foreign counterpart say, "We are willing to pay more for American technology, but not double."

Connery expressed concern about developing countries implementing nuclear programs supplied by these state-owned industries. She gave the example of the build-own-operate contractual arrangement, under which a foreign state-owned company not only builds a plant, but also owns and operates it. "We need to consider what type of arrangements will be negotiated," she said, adding that each country should be responsible for the reactors being built on its soil, particularly its obligations in the event of an accident. Clearly, she said, it is in America's best interest that developing countries buy nuclear technology from the United States, because they will be committed to a nonproliferation obligation while obtaining a design and quality that will alleviate safety concerns.

> ***"We cannot wish our way into a future in which the next generation of nuclear technology suddenly becomes available, licensable, affordable, and deployable."***

Finally, Connery noted, the United States needs to keep the current reactors operating as long as possible while supporting interim steps, perhaps using SMRs to replace retiring coal plants. "We can't sit by passively and expect the situation to change," she said. "We cannot wish our way into a future in which the next generation of nuclear technology suddenly becomes available, licensable, affordable, and deployable. We can't wait to take action."

The next speaker was Andrew Kambour, program director of the Environment, Energy and Transportation Division of the National Governors Association, a bipartisan organization representing state governors. He said that he serves governors and their staffs in various ways, focusing on state-level policymaking and, where applicable, on federal policy that must be implemented at the state level. His talk focused on the states' perspectives on nuclear energy and the Environmental Protection Agency's Clean Power Plan. He said that the states need to know what their options are under the plan, and they need help to make the best decisions possible.

Kambour

Kambour pointed out that nuclear energy is generated in 31 states, and that another dozen states are part of electricity systems that include nuclear generators. About 12 states have restrictions on building nuclear plants, he said, some of which are related to the resolution of the issue of spent fuel disposal. Other states require some sort of legislative or statewide approval before nuclear plants can be built.

Generally, Kambour said, nuclear energy helps states meet many economic, environmental, and energy goals, such as lower emissions, uninterrupted power, low and stable fuel costs, economic development, and jobs. As the recent closures indicate, however, nuclear is under a lot of pressure, notably due to low natural gas prices. Other factors include a market that reflects mainly short-term interests, the rising cost of operating an aging fleet, and the slow growth of grid demand, as well as other grid factors further restricting the need for more baseload generation.

Nevertheless, the Clean Power Plan would seem to be advantageous for nuclear, as it aims to move the country toward a lower-carbon future. Kambour noted, however, that there aren't any direct economic incentives for nuclear "baked into the rule itself." How states opt to comply with EPA requirements will determine decisions to build new nuclear plants and to maintain the existing fleet.

Under the Clean Power Plan, the EPA sets CO_2 emission targets, and the states must figure out how to meet them. The EPA is promoting two main approaches for complying with the targets, either by using a mass-based system, where emis-

sions are measured in total short tons of CO_2, or a rate-based system, measured in pounds of CO_2 per MWh. According to Kambour, there is no real incentive for nuclear energy under the mass-based system, but a state may choose to set aside some EPA allowances specifically for nuclear plants that would otherwise go to fossil fuel or other forms of generation. Under a rate-based compliance system, certain facilities generate emission rate credits that are then used for EPA compliance purposes. Unfortunately, Kambour said, according to the rule as currently defined, existing nuclear plants are not eligible to produce emission rate credits, but new nuclear units or uprates are.

Kambour noted that the EPA's Clean Power Plan does not provide much in the way of short-term incentives for the use of nuclear power, even though it is a zero-emission form of generation. Nevertheless, he said, he expects that states with a sizeable nuclear component in their electricity mix will maximize the use of their plants to help meet their emission targets.

Blue Ribbon finale

The session's final speaker was Susan Eisenhower, chief executive officer and chair of the Eisenhower Institute, who served on the Department of Energy's Blue Ribbon Commission on America's Nuclear Future, and who also spoke at the recent White House Summit on Nuclear Energy. Eisenhower began by noting that this is a significant time in U.S. history as the country struggles to develop a plan to meet its carbon objectives. While the Clean Power Plan is a start, she said, it is not adequate to meet the requirements of the threat of climate change. "We need to be thinking about what we have to do over the longer haul, and then be sure we do not erect roadblocks to keep from meeting our long-term objectives."

Eisenhower

The plan, Eisenhower said, will reduce carbon, but it encourages the use of natural gas, and consequently builds short-term thinking into the system. She also said that she regrets the lack of discussion about how long natural gas should continue to be used to produce electricity, adding that more strategic thinking is needed about how to meet long-term objectives.

Another conversation that is needed, Eisenhower said, concerns the limitations of renewables. Many proponents of renewable energy—among whom she includes herself—have not yet addressed the transmission issues related to renewables. With those issues taken into account, she said, the ultimate costs of these energy sources will probably be different from what the public thinks they will be.

Eisenhower also remarked that unlike earlier generations, young people today have a very positive view of nuclear energy and don't carry the baggage of its association with weapons. She added that many young people are "energy agnostics," with no loyalty to a specific energy source, but with a passion driven by the climate issue, which provides a real opportunity for the nuclear industry to bring more young people into its ranks.

Eisenhower said that as a member of the Blue Ribbon Commission, it became clear to her that the issue of what she calls partially used fuel is one of politics, not technical capability. This is also an example of what she calls a "faulty" vocabulary. "If you call something waste," she said, "people think of it as something to throw away, something that has no value. If you call it partially used fuel, wow!—it sounds like we might be able to do something with it in the future." Eisenhower also argued that if Yucca Mountain had been framed as a national nuclear strategic reserve for partially used fuel, rather than as a nuclear waste dump, engaging the public around that issue likely would have been very different.

In closing, Eisenhower said that the strategy going forward must look at the long term, addressing the concerns of future generations. To advance a new plan that prompts utilities to continue shuttering plants, even after the plan has been introduced, indicates a very serious problem. She ended with a call to reenergize efforts to communicate about "this remarkable source of energy" for the future.

Long-term operation

The President's Special Session addressed the long-term operation of the existing power reactor fleet in the United States in terms of both the physical upkeep of plants and equipment and the economic factors that influence whether a nuclear plant can compete with other sources. The session began with short presentations by the chair, Kathryn McCarthy, of Idaho National Laboratory, and the four panelists: John Kotek, acting assistant secretary for nuclear energy in the Department of Energy; David Heacock, president and chief nuclear officer of Dominion Nuclear; David Brown, senior vice president for government affairs and policy for Exelon; and Judd Gregg, cochair of the citizen organization Nuclear Matters and a former U.S. senator from New Hampshire. A group discussion followed, with the panelists responding to questions from the audience.

As with other sessions at the Winter Meeting, this one included frequent references to the White House Nuclear Energy Summit, which had been held three days earlier. Heacock repeated some of what was said in a major announcement at the summit regarding Dominion's plan to seek second license renewals for the two reactors at its Surry site in Virginia. In response to questions at this session, however, Heacock added to the information that had been provided in Dominion's announcement during the summit. He said that he expects the plant's aging-management plan to grow during the ongoing first license renewal and that the

At the President's Special Session (from left), ANS President Gene Grecheck, DOE Acting Assistant Secretary for Nuclear Energy John Kotek, and Dominion Nuclear President and CNO David Heacock . . .

. . . and (from left) Exelon Senior Vice President for Government Affairs and Policy David Brown, cochair of Nuclear Matters Judd Gregg, and session chair Kathryn McCarthy.

plant's cables will be replaced. He added that he is not sure whether the steam generators will need replacement, but the current ones are already about 30 years old. (was the first nuclear power plant in the United States to have its steam generators replaced.) Asked what the second renewal will cost, Heacock said that he doesn't know yet, although later he said that it is estimated that life extension could run between $1.5 billion and $2.5 billion.

On the question of whether plant components in general would just be too old for operation beyond the 60-year mark at the end of a first license renewal, Heacock noted that pneumatic and analog equipment is still in place. He made a point that is not often addressed in the context of the expected changeover of plant controls from analog to digital: While analog controls may no longer be manufactured and thus would be difficult to replace like-for-like, digital controls have been seen to have shorter lifetimes than their analog counterparts.

Heacock also said that Dominion's decision to close the Kewaunee reactor in Wisconsin in 2013 had to do with the low price of electricity generated by coal from the Powder River Basin in Wyoming. This connected with the economic side of the session's theme. Dominion had operated Kewaunee as a merchant plant outside of the company's home region in Virginia, and the electricity was sold back to the owners that had sold the reactor to Dominion in 2005.

Even as the White House summit had produced a sort of upbeat buzz about nuclear at the Winter Meeting, the announcements over the previous month that Entergy planned to close two of its merchant reactors, Pilgrim and Fitz-Patrick, darkened an atmosphere that also included reports that Exelon was still considering plant closures despite short-term reprieves allowed by improved market conditions.

In response to a question from the audience as to what can be done in the short term to improve nuclear plants' economic viability, Heacock said that credit could be given to grid operators—who buy electricity from merchant plants that are not under traditional utility regulation—for reliable output and the presence of fuel on-site. Earlier he had mentioned the problems electricity providers had experienced with deliveries of coal and oil during the "polar vortex" of the previous winter. Brown said that Exelon has been working with regional transmission organizations and independent system operators to gain recognition for nuclear power's dependability, and that the Pennsylvania-New Jersey-Maryland Interconnection now has a capacity performance program that affects how nuclear power is treated in the grid's auction process.

Another question was asked as to why the Environmental Protection Agency's final Clean Power Plan does not allow states to credit the renewal of power reactor licenses toward meeting their assigned carbon emission reduction goals. If those reactors are not renewed, or are closed early for other reasons, a non-carbon energy source is lost, and the emission reduction goal becomes even harder to reach. Gregg said that on the whole, he thinks the plan is a good start. Kotek said that the EPA maintained that it had tried to put nuclear power and renewable sources on an equal footing, and he noted that in the final version, states can credit power uprates at reactors.

To the question of what nuclear professionals can do to influence policy matters, Gregg, a former legislator, gave an answer that has often been given before: Talk to Congress members and congressional staffers, and even bring up the topic to candidates for office. On a closing question about what single thing each panelist would attempt to do or improve, there was general agreement on getting all non-carbon energy sources to be treated equally. Kotek, who was the staff director for the White House's Blue Ribbon Commission on America's Nuclear Future, said that the commission's recommendations (which included a consent-based system for waste disposal siting) should be adopted.

The Clean Power Plan

The General Chair's Special Session brought together energy experts from state governments and elsewhere to discuss issues surrounding the Environmental Protection Agency's controversial Clean Power Plan, which has caused consternation among a number of states with its requirement for a 32 percent reduction in power plant emissions from 2005 levels by 2030.

The session, which was chaired and moderated by Donald Hoffman, featured Andrew Paterson, a principal with Environmental Business International; Donald van der Vaart, secretary of North Carolina's Department of Environmental Quality; Jessica Lovering, a senior analyst with the Breakthrough Institute; Michael Richard, Maryland's energy and natural resources deputy chief of staff; Hayes Framme, Virginia's advisor for infrastructure and development and chief energy efficiency officer; and Edward Kee, chief executive officer and principal consultant with Nuclear Economics Consulting Group.

Hoffman

Paterson led off the discussion by suggesting that "a level playing field" may not be the best metaphor for U.S. nuclear advocates to use going forward, given the support that the industry is currently receiving from legislators, including Sen. Lamar Alexander (R., Tenn.), and Obama administration officials, including Secretary of Energy Ernest Moniz, both of whom have called for more nuclear power to help meet the Clean Power Plan's emission reduction objectives. "In fact, the U.N. sustainability network put forward a vision for the United States with nuclear at

30 percent by 2050," Paterson said. "Nuclear is a pillar, not only for its lower carbon emissions, but for its reliability, particularly for urban areas. We just don't express that well enough in our pricing, and that's an issue we have to deal with in any discussion about the Clean Power Plan."


Paterson

The United States, Paterson continued, has lost its leadership of the nuclear industry and must begin to think more globally in order to regain it. "Internationally, the majority of new construction is overseas," he said. "And that's the point we have to make to some of the states. When you talk about vendors and how we're going to meet the Clean Power Plan and the nuclear role within that, we need to recognize at the state level that this is going to involve seizing export opportunities as well. You cannot sustain a nuclear U.S. industry with just domestic construction."

While noting the importance of climate objectives, Paterson asserted that the primary driver for the advance of nuclear energy outside of the United States is its ability to provide reliable, clean energy for major urban areas.

Paterson also pointed out that the majority of nuclear customers abroad are not the investor-owned utilities typically found in the United States, but sovereign governments, with long-term certainty and regulated rates. These governments, according to Paterson, do not have a problem picking winners. "Nuclear is a winner," he said. "Nuclear offers energy security, low emissions, reliability. But those big benefits are not reflected well in U.S. prices. . . . Here is how nuclear is sold: The vice president of marketing for Rosatom, President Putin, sells reactors to India—10 reactors in one meeting. This is how it's done—sovereign government to sovereign government."

While noting the importance of climate objectives, Paterson asserted that the primary driver for the advance of nuclear energy outside of the United States is its ability to provide reliable, clean energy for major urban areas. "Reliability is absolutely essential," he said. "Incentives like the Clean Power Plan can aid nuclear, but urban reliability is the true impetus behind new nuclear."

North Carolina's van der Vaart castigated the EPA plan (North Carolina is part of a coalition of 24 states suing the EPA over the new regulations), stating that the plan "attempts to regulate the entire power sector, and in a nefarious way, as the federal government is wont to do." He touted the environmental efforts of North Carolina, noting that it was the first state to develop a comprehensive coal-ash management law and that its work to reduce traditional pollutants from the coal sector has produced the collateral benefit of reducing CO_2 by 24 percent since 2005.


van der Vaart

"North Carolina has made huge reductions and cleaned up its power sector," van der Vaart said. "And we listen to the president when he says that natural gas is simply a bridge builder. We also recognize that there is real value in two things: not putting all our baseload capacity in natural gas, and realizing that renewables can't meet our modern-day model of electricity. . . . We know that natural gas pricing is not going to be stable, especially if [the Clean Power Plan] goes forward, because the only option for most states is to retire, perhaps prematurely, coal units and replace them with combined-cycle natural gas units." This, he added, will result in a huge increase in natural gas demand, but because efforts will be made to further reduce CO_2 emissions going forward, that demand will be short-lived.

"North Carolina sees this as an opportunity to leap-frog natural gas," van der Vaart continued. "We're looking to incentivize nuclear power so that we can be ready for the plan's compliance date, and I'm going to just loosely talk about that compliance date, because we do not think that the plan is legal. We also don't think it's going to benefit the environment to any significant extent. And we think it's going to drive up costs, because it's going to be a federal mandate."

On the subject of North Carolina's participation in the lawsuit against the EPA, van der Vaart suggested that the EPA is likely to "slow walk" that litigation. "There is an extension in the Clean Power Plan, and the EPA would love nothing better than for states to take that extension and let the utilities start to spend money, just like they did in the mercury and air toxics rule, to the point where utilities have gotten invested in the power plan," he said. He noted that North Carolina will take a different approach by not asking for the extension. "We have already developed our plan," he said. "It includes the only legal portion of the Clean Power Plan, which is an efficiency improvement of individual units. We're going to try to get that to the EPA." He added that he hopes that the EPA will follow the law to approve that plan, but if it does not, the state will have a right of action in its own appellate court.

Exhibiting disagreement with at least some of van der Vaart's views on the Clean Power Plan was the Breakthrough Institute's Lovering, who stated that the plan only regulates existing fossil fuel generation and is not a regulation covering the entire power sector. "What that means is existing low-carbon technologies like nuclear, hydro, and non-hydro renewables aren't actually covered," she said. "They can get some credits for new generation, but it's not a plan that looks at the power sector as a whole."

Sidestepping the issue of the plan's legality, Lovering suggested that state compliance should not prove particularly difficult, as U.S. emission levels have been trending downward since 2007, due largely to the power sector's ongoing coal-to-natural gas transition. "I think that the Clean Power Plan is primarily a 'business as usual' target," she said. "It takes the trends we've seen from coal to gas and keeps them going. It takes the trends we've seen in renewables and keeps them going. That's part of the reason I think the plan is fairly easy to comply with."

Among her recommendations, Lovering counseled states to choose the Clean Power Plan's mass-based goal over its rate-based goal. "I believe that mass-based is better for nuclear, unless your nuclear is under construction right now," she said. "It's also a little bit more honest with carbon emissions. And then try to meet your target with uprates or new nuclear power, if you can. I think the uprates are a little bit easier, but if you want to push really hard, new nuclear would be great. If you can get a new nuclear power plant built, that makes meeting your target really easy in terms of absolute quantity." In addition, Lovering said, states should think of the Clean Power Plan as a base-


Lovering

line to work from, and they should develop policies that more broadly support nuclear and cleaner energy.

Lovering expressed concerns with the plan's treatment of nuclear energy, however, pointing out that it specifically uses the word "nuclear" only a handful of times, primarily to indicate that new nuclear is one of the tools that states can use to reduce their carbon emissions. "I think that was a big oversight on the EPA's part," she said, noting that the plan appears to assume that all currently operating nuclear power plants will keep running until 2030. "That's probably not the case," she said. "There's nothing in the Clean Power Plan that helps existing nuclear. Now the EPA says we don't need help with existing nuclear, because it's already low-carbon, and we just want to keep it running. But as we all know, a lot of nuclear power plants are starting to close down prematurely, and we'd like to stop that." Lovering cited a Forbes analysis indicating that 10 nuclear power plants are currently at risk of early retirement over the next few years. She said that should those plants close, they will most likely be replaced by gas plants, resulting in a net drop in U.S. nuclear power production and higher U.S. carbon emissions.

Maryland's Richard stressed that energy policy is an issue of particular importance to his state's relatively new governor, Larry Hogan (elected in November 2014, Hogan is the first Republican to lead the state in some 50 years), in large part because Maryland "has some of the highest energy costs in the nation and certainly in our region." These costs, he said, are among the leading reasons that businesses cite for either leaving the state or deciding not to locate in Maryland in the first place. Referencing a 2015 Moody's report, he said that high utility costs are particularly burdensome to manufacturing and other mid-wage industries, such as transportation and warehousing.


Richard

Given Maryland's existing state laws and programs, Richard said, the Clean Power Plan should be less onerous for Maryland than for a number of other states. One of the ways he mentioned for meeting the plan's targets is through Maryland's membership in the nine-state Northeast Regional Greenhouse Gas Initiative (REGI), a market-based cap-and-trade program designed to reduce the emissions of CO_2 from fossil fuel units. "States participating in REGI require electricity generators to acquire, through a regional auction or a secondary market purchase, one CO_2 allowance for every ton of CO_2 emitted," he said. "An allowance is limited authorization to emit one ton of CO_2. The number of allowances auctioned each year is determined by a regional path, and each year the regional path is reduced. Therefore, the number of allowances sold is reduced, thus limiting emissions."

Richard also noted that Maryland has a renewable portfolio standard that specifies that 20 percent of the electricity sold in the state must come from renewable resources by 2022, and that it has passed environmentally friendly laws, such as the Greenhouse Gas Reduction Act, which specifically sets in-state power plant emission goals.

"Assuming REGI states stay on track," Richard continued, "we are on track in Maryland to make the Clean Power Plan requirements." The state's next steps, he said, are to (1) continue to analyze the details of the Clean Power Plan and work with other REGI states, as well as with states that are interested in a regional plan for cost-effective reductions; (2) consult with key stakeholders and constituents, including those in the gas, coal, and nuclear sectors; and (3) give priority to state efforts and programs, including the state's Climate Change Commission. "Maryland is also on track to meet its 2020 goal of reducing emissions by 30 percent, a state goal that was set against levels in 2006," he said. "It's really part of the reason for our growing transition to natural gas, and it's also because of our continued reliance on nuclear energy."

Virginia's Framme remarked on the different perspectives among the session's speakers as to what exactly the Clean Power Plan says, adding that "there are certainly a lot of questions that the EPA has yet to answer from the state perspective about the plan's implementation." He also stated, however, that when the final plan was issued, his boss, Democratic Gov. Terry McAuliffe, felt confident enough in its legal foundation and in Virginia's ability to be treated fairly and equitably by it to commit to developing a state compliance plan.


Framme

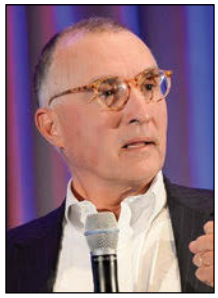
"When the proposed rule came up, the governor did have some pretty significant concerns with how it was constructed and what it meant for Virginia, in terms of how it treated some of our assets," Framme said. "When the final rule came out in August, it was completely different. They did a lot of things differently and got to their goals in a very different way. Speaking of equity, for instance, we did not feel the proposed rule treated us fairly in relation to our neighbors, but the consistent way in which the final rule established rates for gas and for coal units put Virginia in a much more equitable position, given that we had reduced our carbon emissions from 2005 to 2012 by 25 percent to 28 percent."

Virginia's compliance plan, according to Framme, is being developed as quickly as possible, and the state has begun implementing a public outreach and stakeholder process. "We've done an informal 60-day public comment period," he said. "We conducted listening sessions in all six regions of the state, including the far southwest, which is the state's heavy coal region. We have an ongoing Web page. We continue to meet with stakeholders. And we have identified and are working with vulnerable communities, which the EPA really put an emphasis on."

The state has also formed a public-facing, technical working group, Framme said, to elicit the opinions of as many stakeholders as possible. The group comprises representatives of utilities, local governments, cooperatives, industrial manufacturers, merchant generators, conservation groups, coal interests, and others. "We wanted to bring to the table everybody who has a direct or indirect stake in what a compliance plan might look like," Framme said. "It's 14 of the most directly impacted entities or interests within Virginia. . . . As you can imagine, with some of these groups, there are going to be some competing interests. We're not under any illusions that consensus is going to be an easy thing to reach or if it's even going to be reached. But we want to get as much input and as much advice as we can from the folks who are living this every day."

The next steps for Virginia, Framme said, are to complete the stakeholder process and the draft framework of the compliance plan, submit the plan for public comment (an EPA requirement), and then submit a draft plan to the EPA in late summer 2016. "Right now, we would like to be able to put a plan forth without asking for that one- or two-year extension, but we're not sure at this point," he said. "No decisions have been made."

The session's final speaker was Nuclear Economics Consulting Group's Kee, who quickly made his opinion of the EPA plan clear. "One of the things the government could have done, and still might do someday, is to put a price on carbon so that nuclear, with its zero-carbon emissions, has some value to definitively bring to society," he said. "Instead, we


Kee

get this Clean Power Plan, which might be called the Natural Gas Power Plan. The EPA bizarrely managed to craft this thing that purportedly controls carbon but ignores nuclear. How that happened, I don't know. I hope it doesn't stand."

The Clean Power Plan, in Kee's opinion, is not a solution to the nuclear industry's current problems. Instead, he suggested that certain actions taken by states might have a positive effect. "We can look at what some states have already done with respect to threatened nuclear plants," he said. "With Iowa and its Arnold plant, which had a power purchase agreement that expired, the governor and the state utility commission said, 'Yes, we will give you a long-term extension for benefits that include jobs, clean air, and economic impact.' It worked. New York put a contract in place for Ginna. It's a short-term contract about reliability, giving them extra revenue to stay around. Who knows, maybe over the 18 months that that thing is in place they can find other answers. And one of the things that might be done for FitzPatrick, and it's been discussed, is to have the New York Power Authority, which used to own it, buy it back. The price can't be that high. That could still happen.

The Eisenhower Award Panel, from left: Susan Eisenhower, James Hoagland, Sidney Drell, and George Shultz

"The Clean Power Plan could have been something great for nuclear, and it wasn't. Instead, the states are going to have to take action. Keeping the existing nuclear plants around is very important."

"The point is," Kee continued, "the Clean Power Plan could have been something great for nuclear, and it wasn't. Instead, the states are going to have to take action. Keeping the existing nuclear plants around is very important, whether you follow the plan or not, whether it gets challenged or not."

The Eisenhower Award

ANS's Nuclear Nonproliferation Policy Division, the society's newest professional division, marked its one-year anniversary at the 2015 Winter Meeting by sponsoring eight sessions, including one featuring the first recipients of the division's Dwight D. Eisenhower Award, former secretary of state George Shultz and Stanford physicist Sidney Drell. Joining the two Hoover Institution fellows on the first of the session's two panels were Pulitzer Prize–winning journalist James Hoagland, also a Hoover fellow, and Susan Eisenhower, the granddaughter of President Eisenhower and chairman and chief executive officer of the Eisenhower Group.

ANS President Eugene Grecheck introduced Shultz, who stressed the vital importance of nonproliferation work. "On the one hand, we have a huge opportunity in the use of nuclear materials to produce energy and help us in medical ways," Shultz said. "The ability to take advantage of the nuclear opportunity is a huge concern right now because, among other things, it's a source of power that has no emissions. I might say it also has an extraordinary safety record. On the other hand, you have these awesome weapons, and the ones available now are beyond human imagination in the amount of destruction they can cause. They make Hiroshima look like child's play. So getting it right, getting the weapons under control, and clearing the way for peaceful uses of nuclear power is the name of the game."

Shultz lauded the accomplishments in the nonproliferation area of fellow panelists Drell and Eisenhower, as well as of people such as Henry Kissinger, Sam Nunn, William Perry, and the staff at the Nuclear Threat Initiative, but he added a note of caution. "The nuclear weapons stockpile in the world is now about one-third of what it was in the mid-'80s, but all of a sudden, there's been a turn for the worse, and we now worry about further weapons proliferation," he said. "We have to keep after this subject energetically while we continue to push for the peaceful uses.

"Right now, we're at something of a crossroads, because proliferation is taking place, and nations are learning to enrich. So I think we have a huge problem on our hands on both sides of the nuclear equation. But it's vitally important that the United States maintain and rejuvenate, in a way, our ability on the peaceful side of the equation, because having been a leader, we are falling behind others who are doing more. I think it's very important we stay in the vanguard." Shultz said he has been working with Adm. Jim Ellis, former president and CEO of the Institute of Nuclear Power Operations, on the small modular reactor. "I think that's something that can have a big future," he said.

In response to a question from the audience regarding his calm demeanor and "lack of rancor and divisiveness," Shultz referenced his service in the Marine Corps. "I learned a lot," he said. "For instance, a sergeant handed me my rifle in boot camp and said, 'Take good care of this rifle. This is your best friend. And remember one thing—never point this rifle at anybody unless you're willing to pull the trigger.' No empty threats. It's a very important piece of advice—boot camp wisdom that we ignore all of the time."

Shultz also said that he learned much from working in various presidential administrations, including the Reagan administration. "In a sense," he said, "I learned if there was something really important that you had to work on, if you could get it moved into the nonpartisan category, it was a huge advantage. A lot of the things we worked on—nuclear stuff and negotiations with the Soviet Union—we moved into the nonpartisan category. It didn't mean there were no arguments. There were plenty of arguments, but they weren't partisan arguments. They were arguments on the merits or the substance. That's the key. If we can get into the habit around Washington of getting some things into a nonpartisan category, I think we would get a lot farther."

Drell spoke next, beginning his remarks by praising Shultz as "a man who went to Washington, came back, and did only good things. He is a man of unquestioned integrity and wisdom. You knew he wasn't there, as so many other people are, to build

a career, but to serve the country. I can't admire him enough." Drell also endorsed Shultz's nonproliferation comments, stating, "Everything he said, I agree with."

Drell touched on a number of subjects, including the Reagan-Gorbachev summit in Reykjavik in 1986, which he characterized as a turning point in the history of nuclear arms control. "It was the first time that the United States and the Soviet Union announced, as a goal, the reduction in the number of nuclear weapons," he said. "Not limitations, reductions. And that was a start. When they accomplished that, I remember being very, very pleased. I thought Reykjavik was a great success. I think that most people now realize that. If you read the record, you'll find it's a very interesting official record of what they were doing and how close they came to actually saying that we're going to get rid of all of the weapons. They knew and said that a nuclear war must never be fought—it can never be won. They knew the importance of that problem. But the world wasn't quite ready for it."

Drell also called for ratification by the United States of the Comprehensive Nuclear-Test-Ban Treaty. (Among nuclear states, China, Egypt, Iran, Israel, and the United States have signed but not ratified the treaty; India, North Korea, and Pakistan have not signed.) "It's a shame that the treaty became political," Drell said. "The CTBT is a no-brainer. Some people say, 'Well, then other countries couldn't test.' That's not what the treaty says. But certainly it makes it harder for a country to go nuclear. Almost every country in the world has signed—Russia, Japan, France, Germany, the United Kingdom. There is no reason not to ratify, as long as we hold to our promise to keep the laboratories strong."

Fielding a question on how best to convey to millennials a sense of the devastation that nuclear weapons can cause, Drell recommended the book *Hiroshima*, by John Hersey. "I think that should be required reading in schools," he said. "It shows the misery, the horror that was caused by the blast and by the fire, and then the beginning of the effects of the radiation damage. I don't think young people know what we're talking about. If you make a television program to tell them what an atomic bomb is going to do to you if it's dropped, they won't watch it."

Hoagland followed Drell, offering his impressions of the two inaugural Eisenhower Award winners. "They are an odd couple in many ways, but a perfect match in the most important ones," he said. "You would not think of George Shultz, Reagan conservative and consummate nuclear strategist, and Sid Drell as soulmates. Sid's political leanings are more to the Democratic and liberal side. But they deeply respect each other's intellect and integrity and love of country."

Shultz and Drell first met in early 1989, Hoagland said, and their conversation quickly turned to nuclear weapons and the events at Reykjavik, as well as to the question of what lessons could be learned from that summit. "So they organized a couple of conferences on Reykjavik to try to explore where the world could have gone and should have gone," he said. "The second conference occurred in 2007 and was attended by, among others, former secretary of defense William Perry and former senator Sam Nunn. Shultz took his notes from that meeting to Henry Kissinger, who was receptive to the idea of a bipartisan effort to educate the public on the need to free the world from the threat of nuclear annihilation. The result was an op-ed that ran in the *Wall Street Journal* and which had an impact that 'scribblers' like myself of op-eds can only envy. This article and subsequent articles by the 'gang of four' brought nuclear disarmament into the mainstream of American politics."

"In temperament and character, George Shultz and Sid Drell reinforce each other's strengths. Together, they have advanced our common understanding of what must be done to preserve human existence."

Although Hoagland admitted to an initial skepticism about the nonproliferation efforts of Shultz and Drell, he said he quickly discovered how serious they were about the work and how prepared they were to do the heavy lifting needed to create the required conditions. "These were not romanticists," Hoagland said. "These were not illogical people. These were serious, clear-eyed realists responding to the growing threats of catastrophic damage to the globe and the human race.

"I'll complete this on a personal note," Hoagland continued. "In temperament and character, George Shultz and Sid Drell reinforce each other's strengths. George, as you've heard today, is a lifelong study in integrity—a Marine who has lived by his code of honor and by his word. Sid is a man of science who is passionate about his beliefs and values. It is Sid's passion that really explains who Sid Drell is. Together, they have advanced our common understanding of what must be done to preserve human existence."

The session's first panel discussion concluded with brief remarks by Eisenhower, followed by audience questions, including a query regarding whether the panelists saw a conflict between nuclear nonproliferation advocates and promoters of peaceful nuclear energy. Eisenhower said that she believed there was too much "siloing" among people who are doing or studying the same phenomena. "You have industry people who've tried to stay far away from the nonproliferation community, and vice versa," she said. "Industry is seen as being part of another world, except where it overlaps in places like Iran. I think that's another exciting thing that ANS can do—make sure that both sets of scientists are fully aware of the issues affecting the other side of the coin."

Second panel

After a short break, the session continued with a panel featuring Eric Loewen, chief engineer for GE Hitachi Nuclear Energy and an ANS past president (2011–2012); Matthew Bunn, a professor at the Harvard Kennedy School of Government's Belfer Center for Science and International Affairs; Sharon Squassoni, a fellow at the Center for Strategic and International Studies (CSIS); Joseph Cirincione, president of the Ploughshares Fund; and Derek Lacey, a nuclear security and safeguards special assistant to the director general of the International Atomic Energy Agency.

Loewen kicked off the discussion with brief comments on two major U.S.-Russian nuclear nonproliferation efforts: Megatons to Megawatts, the 20-year program that converted 500 metric tons of Russian high-enriched uranium to low-enriched uranium for use in U.S. commercial reactors; and the Plutonium Management Disposition Agreement (PMDA), which calls for the United States and Russia to each dispose of 34 metric tons of weapons-grade plutonium, in part through the construction and operation of the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) at the Savannah River Site in South Carolina. Loewen hailed the success of the former project, but he had harsher words for the MFFF, which, as most *Nuclear News* readers are well aware, has been plagued by severe schedule delays and cost overruns. (While the estimated total project cost of the MFFF was

Loewen

$4.8 billion when construction began in 2007, a May 2015 congressionally mandated study put its total life-cycle cost at $51 billion.)

"The PMDA, as amended by the 2010 Protocol, talked about building this MOX facility in the United States that would be operational in 2016, with disposition by both countries beginning in 2018," Loewen said. "Well, to use an 'f' word, I would say that we failed as a community to [fulfill] that agreement. We failed from cost and schedule standpoints, of course, but I would say also that we failed because of partisanship. There was a very strong South Carolina delegation that was kind of against the rest of Congress. Its view was a 'you guys get more jobs than we do' sort of thing, rather than 'it is for the good of the world that we disposition this plutonium.'"

The Belfer Center's Bunn underscored the dangers posed by nuclear proliferation and terrorism, including the potential for individuals or groups to use nuclear explosives, sabotage nuclear facilities, or spread radiological materials with "dirty bombs." While emphasizing that nuclear energy is not the main driver of these dangers, Bunn maintained that it is nonetheless connected to them in two important ways. First, he said, the choices made regarding nuclear energy—especially the fuel cycle and nuclear facility and material security—can increase or decrease these risks; second, public, government, and investor fears can affect nuclear energy's future. For nuclear energy to be successful going forward, he said, "We have to convince people that it's going to be secure, and that it's not going to contribute to these kinds of dangers."

Bunn offered some good news on the subject of proliferation, including the fact that there has been no net increase in the number of nuclear weapons states in the last quarter of a century. Within that time span, he noted, North Korea has been added to the list of nuclear states, but South Africa has been removed, becoming the first real case of nuclear disarmament. "Admittedly," he said, "North Korea for South Africa may not be a great trade, but to have no net increase in 25 years—years that have included all the chaos after the collapse of the Soviet Union, the whole export period of the A. Q. Khan black market nuclear network globally, secret nuclear weapons programs in North Korea, Iran, Iraq, Libya, Syria—is an amazing public policy success story."

Bunn

An additional piece of good news on the nonproliferation front, according to Bunn, is that today there are more countries that initiated nuclear weapons programs and chose to give them up than there are countries with nuclear weapons. Efforts to persuade nations to eschew nuclear weapons succeed more often than they fail, he said, adding that today there are fewer countries seriously pursuing nuclear weapons than ever before in the nuclear age. "If I had to guess, 25 years from now there will be some more countries that we're worried about," Bunn said, "but I think it's at least within the realm of the possible that 25 years from now, if we follow the right policies, we'll have the same number of nuclear weapons states, maybe even fewer. After all, who knows how long the regime in North Korea can last?"

Future nonproliferation efforts, Bunn said, could be aided by the establishment of strong incentives that would allow countries to enjoy the benefits of nuclear energy without needing their own enrichment or reprocessing. "There have been a number of efforts in that regard, including the creation of fuel banks, so that if a country ever suffered an interruption of fuel supply, they would be able to draw on those fuel banks," he said. "But I think there's more to be done. I think we can expand our work with other countries on dry cask storage and other ways in which they can manage their spent nuclear fuel cheaply, safely, and securely, without separating plutonium that could be used in nuclear weapons." In a reference to the completed but not yet operational Rokkasho reprocessing plant in Japan, Bunn said, "I would argue that it really didn't make much sense before, but now that there's no prospect that Japan is going to have a big fleet of breeder reactors anytime soon, it really doesn't make sense for Japan to be separating more plutonium."

Bunn also argued in favor of stronger measures against the illicit procurement of these kinds of technologies. Both Iran and North Korea, he said, continue to receive technology from illicit procurement networks that "go through layers of front companies to hide what the real end-use of these technologies is. I've just finished editing a book with some colleagues on this topic, and there are many pieces of the issue. It's not just an export-control issue. It's an intelligence issue. It's a sanctions issue. It's a sort of internal corporate compliance issue."

Bunn delivered some good news on the nuclear terrorism front as well, including that "core, central" Al Qaeda has been greatly weakened and that a substantial amount of the world's nuclear material is significantly more secure than it was a couple of decades ago. The majority of countries that have possessed HEU or separated plutonium have gotten rid of it, he said.

Not surprisingly, however, much of Bunn's presentation concerning terrorist threats was less optimistic in outlook. "We have about 20 well-documented cases in the public record of seizure of stolen HEU or plutonium," he said. "We have repeated government studies in the United States and in several other countries that have found it plausible that if a sophisticated terrorist group got hold of either enriched uranium or plutonium, it may be able to make at least a crude nuclear bomb. Making something that is unsafe, unreliable, and of unknown yield that goes in the back of a truck is a much easier job than making something that a state would want to have in its arsenal."

The keys to preventing that scenario, Bunn said, are keeping control of the material and taking on terrorist groups. "I do worry about the Islamic State," he said. "So far, they are focused on building their caliphate and not on reaching out and conducting large attacks in Western Europe or the United States. But they have an apocalyptic ideology that envisions a final confrontation between the crusader forces, as they put it, and the Muslim community. And if they ever did turn toward pursuing nuclear weapons, they have more money, more people, more control of territory, and more ability to recruit experts globally than Al Qaeda ever had."

While Bunn concluded his talk by characterizing the state of U.S.-Russian relations as being close to its nadir, he also emphasized the importance of encouraging scientists and engineers to work together across national boundaries. "Often during the nuclear age, it has been dialogues among scientists and personal relationships among scientists that have helped come up with ideas, find ways past obstacles, helped get things across when governments were having a hard time talking to each other," he said.

The CSIS's Squassoni focused her remarks on four main points, the first being certain "negative implications" that have arisen from the Nuclear Nonproliferation Treaty's failure to restrict uranium enrichment and reprocessing (E&R). There are a number of reasons that those restrictions were not included in the NPT, she said, including that the conventional wisdom at the time suggested that fissile material production would be prohibitively expensive. "Think back," Squassoni said. "Gaseous diffusion, right? Enormous

Squassoni

facilities. Even if [E&R] could be afforded, we thought it would be detectable. Today, that is not the case, as we've discovered."

Instead, Squassoni said, restricting the spread of E&R has relied on a combination of luck, bad economics (including the price of uranium), and supplier controls. Regarding supplier controls, she mentioned the work of the Nuclear Suppliers Group, but stated that in her view, its efforts have been damaged by the U.S.-India nuclear deal in 2008 and by the revision to the group's E&R transfer guidelines, which has created new loopholes. "Now there is a loophole for research and development, and I would say some laser enrichment work fits in rather nicely there," she said. Squassoni also criticized the group for its failure to push through, as a precondition for NSG cooperation, acceptance of the IAEA's Additional Protocol, a supplement to IAEA Comprehensive Safeguards Agreements that grants the agency expanded powers to verify a member state's safeguards obligations.

Squassoni's second point was on nuclear industry structural changes and the new challenges for safety, security, and proliferation that those changes present. She pointed out that the United States, France, and Japan no longer dominate the nuclear export market. "Instead, we're looking at Russia, Korea, and China," she said. "I think in the future, even though right now they're just investing, they will be selling nuclear reactors to countries in Southeast Asia, the Middle East, and possibly Africa. I only make this point to say that when you're thinking about safe, sustainable nuclear energy into the future, it has to be a bargain on both sides. The suppliers have to make sure that they are exporting not only quality components and reactors but also safety and security culture. And the recipients have to be prepared to do a lot as well. I think the IAEA has done some fantastic work in trying to prepare these nuclear newcomers for these big responsibilities."

Squassoni's third point was that some emerging technologies could not only affect the nuclear industry's structure but could also become a proliferation risk. As one example, she mentioned laser enrichment, asking, "What will happen if the U.S. manages, through GE-Hitachi Silex, to commercialize the laser enrichment capability? Will that spur other countries to be more energetic in their pursuits? This really could introduce and change the magnitude of risks. With laser enrichment, there is a much smaller footprint, fewer detectable signatures, and a huge reduction in cost in terms of enrichment." Other technological developments that Squassoni said she believes could pose proliferation risks include additive manufacturing, cyber technology, pyroprocessing, and Generation IV reactors.

Squassoni's final point centered on U.S. nuclear cooperation policy, which she believes should reflect E&R risk-reduction objectives in a more uniform manner than is currently the case. "I might be the only person in the room who would cast a stone at the Eisenhower Atoms for Peace program," she said. "I would say in the nuclear security realm that we're still cleaning up from that, which is all the HEU fuel that we sent to research reactors around the globe. . . . I would say that our current policy still has some elements of good deals for good friends, which are India, Japan, and South Korea. There were recent rumors in the press about getting nuclear-weapons concessions from Pakistan in exchange for nuclear cooperation. I hope that's not going to come to pass. I think that's fairly ill-conceived."

The Ploughshare Fund's Cirincione gave an impassioned defense of the Iran nuclear agreement—officially, the Joint Comprehensive Plan of Action (JCPOA)—comparing it to the fall of the Berlin Wall and calling it "by far the strongest nonproliferation agreement I have ever seen, and that includes the Nuclear Nonproliferation Treaty." According to Cirincione, the JCPOA sets new standards for nonproliferation, prevents Iran from acquiring nuclear weapons for a generation or more, and creates opportunities for improving U.S.-Iranian relations in other areas.


Cirincione

"This deal wasn't about human rights abuses or about the threats to wipe Israel off the face of the earth," Cirincione said. "It wasn't about their relations with the Saudis. It wasn't a cure for cancer. It's not going to help you shed those unwanted pounds. It did only one thing, but it did it very well. It stops Iran from getting a bomb. But in the course of that, it's a gateway to other conversations, where the United States and Iran have overlapping strategic interests. Each nation, for its own national security purposes, might want to cooperate with the other on ending the bloodshed in Syria, stabilizing Iraq and Afghanistan, and defeating ISIS. There is no guarantee those conversations will go anywhere. But if they do, you're talking about a transformation of the geopolitics in the Middle East unlike anything we've seen in a very long time."

Under the JCPOA, Cirincione said, Iran's nuclear program has been put in reverse for the first time. "They're ripping out two-thirds of their centrifuges," he said. "They're preparing to ship out of the country almost all of their stockpile of low-enriched uranium. They're ripping out the core of their plutonium production reactor, drilling it full of holes and filling it full of concrete. Who does that? What agreement requires people to do that? This agreement."

Acknowledging that the agreement has a 15-year time frame, Cirincione encouraged the audience to become involved in efforts that might help dissuade Iran from seeking to reinstall its centrifuges at some point beyond that time frame. "Can we come up with an alternative plan?" he asked. "Maybe a regional enrichment facility, as the Europeans have. Or a fuel bank, the way some organizations have supported. Or if the Iranians are going to build new enrichment facilities, establish safeguards that can assure the program is for purely peaceful purposes and not for weapons purposes. Those are some of the kinds of challenges we have. . . . And if the deal can help to not just stop Iran, but to help stabilize over the next decade or two an increasingly collapsing Middle East, we may be able to create the security conditions that convince other countries that they should take the risk of reducing their nuclear weapons."

The panel's final speaker was the IAEA's Derek Lacey, who also discussed the JCPOA, but from a verification perspective. According to Lacey, the IAEA has long held the position that clarification of the possible military dimensions of Iran's nuclear program and the implementation of the Additional Protocol are the essential steps to resolving the Iran nuclear issue, and that the negotiations between the P5+1 nations and Iran that led to the JCPOA have provided a unique opportunity to achieve both of those goals.

Lacey provided a brief update on the IAEA's work in this area, covering topics such as the agency's Comprehensive Safeguards Agreement with Iran; the Joint Plan of Action, the 2013 interim agreement reached in Geneva between the P5+1 nations and Iran that preceded the JCPOA; the 2013 IAEA-Iran Framework for Cooperation, which outlines Iran's compliance with the agency's investigation into the possible military dimensions of Iran's past nuclear activities to clarify the agency's unresolved concerns about Iran's nuclear program; the Additional Protocol; and Iran's JCPOA-mandated nuclear-related commitments.

Regarding the general requirements of the Additional Protocol, Lacey pointed out that states must present to the IAEA an extensive, very detailed declaration of their nuclear activities. "We don't put that declaration on a shelf," he said. "We

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look at it in detail. And we don't take the declaration on trust. We seek to verify it. If we find inconsistencies, however small, or if we have any doubts, or if there are any areas where we have questions, we seek further clarification. We ask to review documents, or we seek access to undeclared locations. Also, the country has to accept these requests. They may propose alternative solutions, but if they do, they must provide the necessary clarification to the agency's satisfaction. And the obligation to present this detailed declaration is not just a one-time obligation. A country implementing the Additional Protocol must update its declaration every three months for an indefinite period." Lacey noted that Iran has informed the agency of its intention to provisionally implement the Additional Protocol on the JCPOA's "Implementation Day," the date for which, at this writing, had not been determined.

On the subject of Iran's nuclear-related commitments, Lacey said that the IAEA is now in the preparation phase for verification and monitoring. "Iran is doing a lot of work, and the agency is doing a lot of preparatory work," he said. "Iran is dismantling centrifuges. We're monitoring that. We're also putting in place the equipment to allow us to verify and monitor from Implementation Day onward. So, from that point and for the duration of the JCPOA, the agency will use its standard verification preferences to implement the necessary measures for the Iranian nuclear program. The scope of these verification and monitoring measures is far greater than would have been possible with a Comprehensive Safeguards Agreement and the Additional Protocol alone. It will extend to mines and mills for a period of 25 years, and to the containment and surveillance of centrifuge rotors and bellows for 20 years. The JCPOA verification and monitoring activities, therefore, further help the agency to better understand Iran's nuclear activities."

In closing, Lacey said that in the agency's view, taken together, the Comprehensive Safeguards Agreement, Additional Protocol, and nuclear-related commitments to the JCPOA "provide a clear net gain in verification terms."

Energy mix

Bringing together energy experts, scientists, and trade representatives, the "All Energy Forum" laid out an apples-to-apples comparison of all major forms of electricity generation, including coal, gas, hydro, renewables, and nuclear. In formulating the ideal mix of energy to power the world, the panel considered climate change, a growing global population, and various market forces.

Conca

"The big question is how much energy do we need and how are we going to get it," said session chair James Conca, senior scientist for UFA Ventures and a contributing writer to *Forbes.com*. In his opening presentation, Conca noted that the global population consumes about 17 trillion kilowatt-hours of electricity per year. To bring power to everyone on earth and eradicate poverty, about 30 trillion kWh/yr would be needed, he said. That would provide everyone with 3,000 to 6,000 kWh/yr, which Conca called a "just and sustainable" goal.

Reaching that goal while reducing greenhouse gas emissions would require a reduction of power use in some countries (the average per-person use of electricity in the United States is 12,000 kWh/yr). That has been the strategy of developed nations, which have been seeking to reduce consumption through conservation and efficiency while deploying more renewable energy sources. That strategy alone, however, ignores the almost 2 billion people in the world who have access to no electricity whatsoever, Conca said, adding that another strategy is needed to increase energy consumption among the impoverished nations.

"There are two different strategies for these two groups, and if we do not have two different strategies, we will fail. That is why Kyoto failed, that is why Copenhagen failed, and that is why Paris is going to fail," he said, referring to attempts to reach an agreement among countries on reducing carbon dioxide emissions.

Conca proposed a global energy mix that would rely on one-third fossil fuels, one-third renewables, and one-third nuclear by 2040 to 2050. Conca admitted that such a mix would require a lot of effort, including the building of 1,700 new nuclear reactors, each with an output of more than 1,000 MWe. The greatest challenge to achieving such an energy mix, Conca said, is the continued use of cheap coal. "We need to make it possible for the rest of the world to install anything but coal," he said.

The case for limiting the use of fossil fuels was made by Richard Somerville, a retired professor from the Scripps Institution of Oceanography at the University of California at San Diego. Somerville, who is involved in the Intergovernmental Panel on Climate Change, declared that the evidence is "unambiguous" that anthropogenic global warming is an actuality.

According to Somerville, global warming due to CO_2 and other greenhouse gases is changing weather patterns, resulting in warmer oceans, rising sea levels, and drier conditions in parts of the world. "Every extreme weather event that takes place today takes place in a world in which the environment has already been changed by climate change," he said.

Somerville said that there is a large gap between the amount of reductions in greenhouse gas emissions that industrial countries are willing to commit to and what is needed to limit global warming to a target rise of no more than 2 °C. Reducing emissions to the degree necessary, he said, will greatly depend on the energy mix of the future. Somerville warned that it would take not one or two things to reach that goal, but everything, including more attention to conservation and efficiency, greater reliability on renewables, research on advanced energy sources, and more nuclear power.

Photo: Sylvia Bal Somerville

Somerville

The potential of natural gas to contribute to a low-carbon energy mix was presented by Richard Meyer, manager of energy analysis and standards at the American Gas Association. Noting that natural gas production has increased by 30 to 45 percent (depending on what baseline is used) over the past 10 years, Meyer said that the AGA sees natural gas as a "foundation fuel" and an important part of the U.S. electric power mix.

One criticism leveled at natural gas is the historical volatility of its price. While prices are at record low levels due to the increased supply, Meyer maintained that we have entered an era of price stability. "This is not the same industry, not the same resource base, not even the same infrastructure from the last decade that is bringing these resources to demand centers," he said.

In addressing the potential impact of the Environmental Protection Agency's new Clean Power Plan, Meyer said that such policies may be reinforcing existing trends, locking in the movement away from coal to lower-carbon natural gas and to energy efficiency. "Natural gas will continue to play a role, not only in our goal of clean energy and climate, but certainly as an important fuel for our electricity mix," he said.

When discussing renewable forms of energy, talk typically is focused around solar and wind energy. Overlooked is hydroelectric power, which David Zayas, senior manager of regulatory affairs and technical services for the National Hydropower Association, said is often referred to as the "silent renewable."

Continued

Zayas said that the goal of the NHA is to double the contribution of hydropower as the country's "largest, most trusted flexible renewable energy resource" by 2030. According to Zayas, as of 2013, hydropower made up about 52 percent of renewable electric generation in the United States, representing 7 percent of the country's overall electricity generation. That equates to 100 GW of installed capacity, including 22 GW of pumped storage, with the net effect of avoiding the release of more than 200 metric tons of CO_2 into the atmosphere every year, he said.

Based on operational experience and research done by the industry, the government, and independent groups, there are no technical hurdles to additional license renewals.

Zayas projected that with the right policies in place, the United States could add another 60 GW of hydropower. That may not meet the NHA's long-term goal of doubling capacity, but it is certainly achievable, he said. Hydropower, however, faces many of the same challenges to growth as nuclear power does. Zayas said that hydropower projects often encounter long development lead times, large upfront capital investments, and intensive stakeholder involvement. There also is an amount of regulatory uncertainty in such projects, as the permitting and licensing process can take up to 10 years or longer.


Walters

The contribution of nuclear power to the energy mix was discussed by Doug Walters, vice president of regulatory affairs for the Nuclear Energy Institute, who noted that nuclear power accounts for 62 percent of the United States' carbon-free electricity. He said that without nuclear, the goals of the EPA's Clean Power Plan for reducing CO_2 emissions cannot be met.

In regard to the Clean Power Plan, Walters said that its effectiveness will depend on how it is implemented by the individual states. States can either use a rate-based system, whereby each generator would be required to make reductions based on capacity, or a mass-based system, which would set an overall cap on all emissions and would work similarly to a cap-and-trade system. Regardless of whether states choose a rate- or mass-based system, Walters said, NEI does not see how the stated reductions can be met without the existing nuclear fleet, along with some additional new nuclear generation.

Maintaining nuclear's contribution to the energy mix will mean that many of the current reactors that have been relicensed to operate for 60 years may need to apply for an additional 20-year license extension. Walters said that NEI expects to see an application for a second license renewal, to 80 years, in 2019 for Dominion's Surry (see page 52). According to Walters, NEI has developed a road map for the second license renewal process, which, he said, "is really no different from what we did to go from 40 to 60 years."

Walters said that based on operational experience and research done by the industry, the government, and independent groups, there are no technical hurdles to additional license renewals. "We know there are areas we need to focus on, but we do not see any technical showstoppers that would preclude us from going to an 80-year operating life," he said.

The session was to have included a presentation from a representative from the wind energy industry. The trade association, however, declined to send anyone, so Conca spoke on the topic of wind and solar energy. Using a cost-comparison approach, Conca concluded that taking into consideration capital costs, fuel and operational costs, and intangibles such as environmental and human health costs, there is little difference in how much would need to be spent to maintain the current energy mix as opposed to implementing his proposed mix of one-third fossil fuels, one-third renewables, and one-third nuclear.

"In the end," he said, "it does not make much difference what mix you have in terms of total cost." The choice, he said, is between spending on capital assets and infrastructure or on fuel.


Bresler

Stu Bresler, vice president of market operations for PJM Interconnection, provided the forum with a view from the perspective of a regional transmission organization. PJM operates a capacity market, described by Bresler as a "reliability pricing model," that commits to buying electric supply resources three years forward. Problems with that model, however, were brought to light during the 2014 polar vortex, Bresler said, when 22 percent of PJM's committed capacity resources became unavailable. Half of those resources were in natural gas–based generation, he said.

To resolve the supply issue, Bresler said, PJM has been implementing reforms in three primary areas. First, the company is enforcing stricter performance requirements in the energy market. Second, there are now higher nonperformance consequences during periods of high demand. Third, PJM is providing greater incentives for providers to make investments in both their physical units and their fuel supplies.

The session's last speaker, Bruce Lacy, principal of Lacy Consulting Group, provided a view of the nation's energy mix from the perspective of Wall Street. Citing a survey of Wall Street professionals that his company conducted, Lacy said that when discussing nuclear power, respondents projected that there would be a slight decline in the short term and limited growth in the long term. Lacy said that the cost and schedule overruns at the Vogtle and Summer nuclear construction projects likely accounted for the bearish outlook on nuclear. The accidents at Fukushima Daiichi and Three Mile Island, as well as the issue of spent nuclear fuel, were not major issues for Wall Street, he said.


Lacy

According to Lacy, nuclear faces a number of challenges in the eyes of Wall Street investors, including flat to limited growth in the demand for electricity, competition from cheap and plentiful natural gas, policies favorable to wind and solar power, and the emergence of energy storage systems and distributed energy. Lacy also said that there is a real possibility for more early retirements of nuclear power plants.

Global nuclear construction

A panel session titled "New Nuclear Construction Around the World" was cochaired by Ted Quinn, an ANS past president (1998–1999), and Corey McDaniel, chair of the ANS International Committee, which cosponsored the session with the Operations and Power Division.

The first overseas presentation was from the United Kingdom, which reversed its energy policy in the mid-2000s to return to nuclear power. Ron Cameron, of the U.K. Trade and Investment department, explained that Britain's decision evolved from having to decide on the best energy mix for the country. A lot of time was spent consulting on a possible role for nuclear, he said, and although many members of

the public said that they preferred that the United Kingdom not build more nuclear plants, when asked if nuclear should be part of a balanced energy portfolio, they answered yes.

During this period, the realization also grew that a dispatchable technology was needed to provide a secure supply of electricity for long periods of time. The answer to why nuclear, Cameron said, is that it provides a stable, secure supply of electricity with high availability; it is dispatchable, as it does not suffer from intermittency; and it is a carbon-free energy source.

In addition to making nuclear power a more attractive investment, many other issues had to be dealt with to make it feasible again in the United Kingdom, Cameron said. Those issues include the following:

- Providing a large and skilled work force at all levels. This included setting up a national skills academy with industry.
- Devising a program to help companies become fit to compete in the nuclear arena again.
- Introducing a guarantee scheme to help qualified vendors take on debt at favorable rates.
- Developing a generic design assessment (GDA) process through which the nuclear regulators can ensure that there are no fundamental reasons that a design cannot be built safely in the United Kingdom.

Three consortia are currently developing nuclear power projects in the United Kingdom:

- EDF/China General Nuclear Power Corporation, which is expected to announce soon a final investment decision for its first project, Hinkley Point C. It will then develop new units for Sizewell C, followed by Bradwell. The first two are to be of Areva's EPR design, which has already been approved under the GDA process.
- Horizon Nuclear Power (Hitachi/Hitachi-GE Nuclear Energy), which is planning to build ABWR reactors at two sites, the first at Wylfa Newydd in Wales.
- NuGen (Toshiba/Engie), which is planning to build AP1000s at its Moorside site in Cumbria.

Because all three consortia are looking to start up their first units around 2024, they will be competing for resources and to be first on the grid. This further demonstrates a need to organize the U.K. nuclear supply chain and provide other resources to support a large construction program.

Doug Walters, vice president of regulatory affairs at the Nuclear Energy Institute, focused on the lessons learned from using the Part 52 licensing and inspection process for the Summer and Vogtle new-build projects in the United States, highlighting areas that could be improved. First, however, he provided an update of the two projects, which are the first to test the 10 CFR Part 52 licensing process, as well as the first to use modular construction. The current schedule, he said, calls for the first units for both projects to start up in 2019, and the second units in 2020.

According to Walters, around 2000, when Part 52 was promulgated to move from a two-step to a single-step licensing process, no one thought it was perfect. NEI is considering proposing some modifications to make it more efficient and more effective, and the Nuclear Regulatory Commission has a similar effort under way.

The Part 52 process was intended to follow a sequence, starting with the identification of a suitable site and the submission of an application for an early site permit (ESP). The next step was to select a design and submit a combined construction and operating license (COL) application. The two lead projects, however, did not follow that process, and although taking a different path can work, Walters said, NEI's opinion is that starting with the ESP, which some companies are doing, is a better path forward.

Walters said that pre-application interactions with NRC staff and the quality of the COL applications are going to be key going forward, and NEI is considering how to help applicants. It seems, he said, that the level of information needed for the design certification documents and the final safety analysis reports has crept upward. NEI is working to ensure that future applications have the correct level of information, which may require an updating of guidance.

Walters said that NEI has also noted an increase in the number of requests for additional information (RAI) made by the NRC. For the AP1000 certification, NRC staff generated just under 7,000 RAIs; for GE's ESBWR, which received the last NRC certification, the number was in excess of 10,000. Some improvements are needed in this area, he said.

When certified, a design is somewhere between 35 and 40 percent complete, Walters said, but it is apparent that achieving a figure of 75 to 85 percent before the customer starts working with the vendor would be better. He also stressed that vendors and other main contractors need to better understand nuclear safety culture, and that NEI is looking at ways to facilitate this.

Assessing a plant by reviewing its inspections, tests, analyses, and acceptance criteria (ITAAC) is how the NRC determines whether a plant is built as designed, and NEI, Walters said, would like to see them more standardized.

Walters said that NEI is also looking at performance-based alternatives for regulating small modular reactors in areas such as emergency planning zones, security, control room staffing, and fees to the NRC. NEI also wants to create a licensing path that facilitates advanced reactor development.

Walters concluded with what he called nuclear's "solid value proposition," a list of the benefits nuclear power plants provide to a nation but that are not properly recognized in the market. He said, however, that he believes that this is slowly changing.

Fortum's experience

Kristiina Söderholm leads nuclear research and development at the Finnish power company Fortum, which is probably best known for its Loviisa nuclear plant, supplied by the Soviets over 35 years ago. The company also has a large stake in Finland's Olkiluoto nuclear station, operated by Teollisuuden Voima Oyj. Having recently visited the Olkiluoto site, she had some good news to report: For the first time, she said, she "believes the time line" given for the startup of Unit 3, the EPR being supplied by a consortium of Areva and Siemens, which is scheduled to begin operating in 2018. Her optimism was based in part on what she saw during the visit, and also on the fact that the I&C system has now been approved.

Söderholm

Söderholm acknowledged that many mistakes were made in the early days of the Olkiluoto-3 project, but lessons have been learned and the project is moving forward. She said that it will be a "beautiful unit" when it starts operating.

Fortum has recently taken a small stake in the Fennovoima project company, which applied for a construction permit in 2015 for its Hanhikivi project, an AES-2006 model reactor supplied by Rosatom, Russia's state atomic energy corporation, which also has a 34 percent stake in Fennovoima.

Söderholm remarked that back in the 1970s, Fortum discovered that the Soviet suppliers of the two Loviisa units did not provide a lot of support, adding that it is the same today. Fortum had to develop its own expertise and tools, such as the Advanced Process Simulator, to support the plant's operation. As is now widely appreciated, according to Söderholm, the company learned how to maintain extremely high performance levels at Loviisa. She also noted that the operating licenses for the two units will lapse in 2027 and 2030, when both reach 50 years of service. No decision has been made on renewing the licenses, although the company is making some preparations to submit an application.

Continued

Fortum is providing support for the licensing activities of the Hanhikivi project, she said, and in dealing with the Russians. The plant is scheduled to start operation around 2024.

Asked about the strong public support for nuclear power in Finland, Söderholm noted that the country's citizens are very pragmatic. Finland does not have a strong green party, and much effort has gone into educating the public about nuclear power from the beginning, she said. "We have built up a story step by step that both nuclear and renewables are needed."

Söderholm, who did her Ph.D. thesis on SMR licensing development, noted her concern that because Europe's nuclear regulatory regime is based on large reactors, she thinks there is a real challenge to create a regulatory environment to deal with passive plants and SMRs. Although it has no plans yet for building one, Fortum is involved in various SMR-related activities and wants to prepare for building them.

A new view of nuclear

Ann Bisconti, president of the public opinion and communications research company Bisconti Research, presented a new view of nuclear energy based on her extensive research over many years.

Her findings show that support among those living near nuclear plants is "broad and deep." The reason, she said, is mainly familiarity with the plant and staff who live in the community. Regarding the general public, most feel insufficiently informed about nuclear energy but are "open-minded."

The majority of the public, Bisconti noted, are fence sitters whose views are "highly changeable." She said that she was also surprised to discover that the 15 percent who are strongly opposed to nuclear are highly changeable as well, and that the more people are informed about nuclear energy, the more they favor it. Of the 11 percent who feel very well informed, she said, 55 percent strongly favor nuclear energy, versus 21 percent who strongly oppose it. She has also learned that "new information changes minds," creating an opportunity for a new view.

Bisconti

When asked which of a list of low-carbon sources provides the most electricity, most people selected nuclear, but 70 percent of the public were unaware that nuclear was the top source by far. "So there is really a lack of appreciation of nuclear energy's major role in the low-carbon energy mix," Bisconti said.

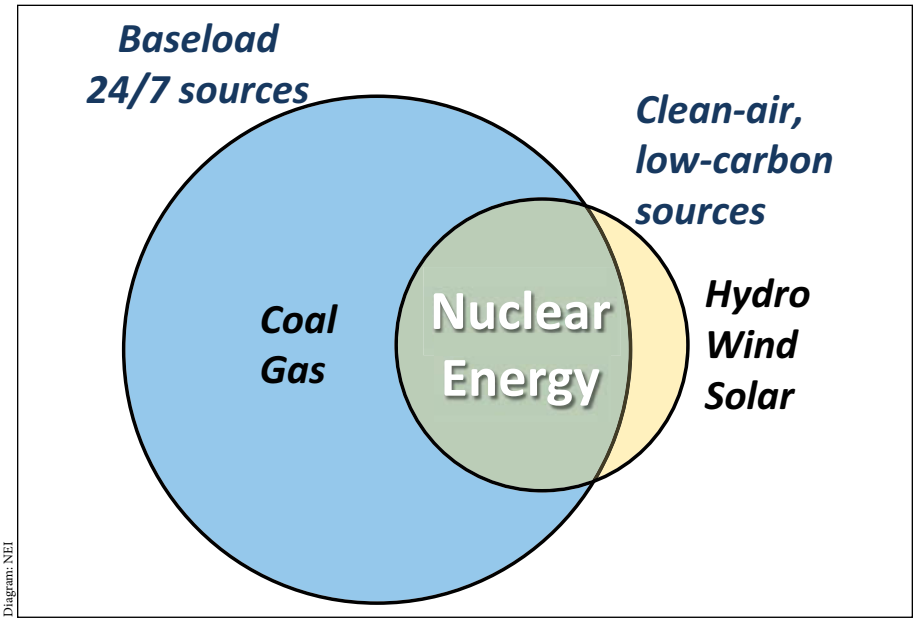

Diagram: NEI

Sources of electricity: Nuclear energy is unique and irreplaceable.

In the latest survey, people were told that in 2014, nuclear energy produced 63 percent of low-carbon electricity in the United States, and that hydro produced 20 percent, wind 14 percent, and solar 1.5 percent. They were then asked whether, given the Environmental Protection Agency's new plan to reduce carbon emissions from electricity generation and the fact that nuclear energy is the largest clean-air electricity source, nuclear energy should be very important, somewhat important, not too important, or not important at all in the future, and 84 percent said that nuclear energy should be important. That included 62 percent of those who initially opposed nuclear energy and 43 percent who initially strongly opposed nuclear energy. It appears, Bisconti said, that this information was quite eye-opening to a large number of people and changed a lot of minds.

Regarding the question about what makes nuclear energy "thriving and unique," Bisconti noted that the public still associates nuclear energy very strongly with advanced technology and also with reliable electricity. These traits about nuclear are believable, she noted. When asked, however, about energy topics that people had heard or read about during the past year, new nuclear power plant construction did not register strongly. There was a lot of discussion about solar plants, wind farms, and other new forms of energy, but only 25 percent of the public said that they had heard about new nuclear power plants being built in the United States, and only 25 percent had heard anything about small nuclear power plant designs as a new technology option.

Maria Korsnick, chief operating officer of NEI, had devised a diagram that Bisconti used to show the uniqueness and irreplaceability of nuclear energy. Its message is that "nuclear is one of the baseload sources of electricity, and it is also one of the clean-air, low-carbon sources of electricity. But nuclear is the only one that is both." And so, Bisconti said, nuclear is unique and has a special place in the energy mix, a message that the White House also recognized at the policy level by holding a nuclear energy summit.

Bisconti gave the following recommendations for promoting nuclear power:

- Build on traits that are believable, such as clean air energy, reliable energy, affordable energy, and advanced technology.
- Add surprising new information about nuclear energy's unique role.
- Raise the volume about new plants under construction and in design.
- Raise the dialogue with a positive vision and hope for the future.

She added one more piece of advice: "Start with feeling positive about nuclear energy yourselves.

Fuel reuse perspectives

A panel session titled "International Perspective of Electrochemical Recycling" was inspired by a 2014 report from the Department of Energy's Office of Nuclear Energy. The report concluded (as many other reports have done over the past several decades) that the recycling of uranium/plutonium or uranium/transuranics with new natural uranium in fast and thermal reactors offers better resource utilization and waste minimization than the once-through fuel cycle now employed in the United States. The session dealt mainly with the technical side of the subject, but in the case of at least one presentation, it was made clear that the application of the technology is desired in the near term to address a real-world issue.

Jinmok Hur, of the Nuclear Fuel Cycle Technology Department at the Korea Atomic Energy Research Institute (KAERI), reported on recent work done in South Korea on the development of pyroprocessing. He mentioned briefly that it likely will not be possible to locate a final repository for high-level waste in his country, so KAERI is looking for a way to recycle all transuranics and build a disposal facility only for fission products, with a 300-year hazard horizon. This has been South Korea's approach for several years, and the nation's desire to reprocess has become a sticking point in negotiations with the United States on the continuation of nuclear cooperation under Section 123 of the Atomic Energy Act (see p. 31).

Hur did not address the political aspects of the issue, apart from noting opposition to nuclear energy by some citizens of South Korea. Instead, he described the PyRoprocess Integrated inactive DEmonstration (PRIDE) facility at KAERI, which was installed in a closed and decontaminated uranium conversion plant to test the process on an engineering scale with depleted uranium and other surrogate materials. Test operation began in July 2012, and experiments with a simulated material, referred to as Simfuel, were to begin by the end of 2015. Hur stated that KAERI's development of the process includes the addition of a graphite cathode to recover uranium in the electrorefining system, a residual actinides recovery system, and crystallization to recover pure salt from the waste volume.

Depending on one's background and country of origin, there can be some overlap and ambiguity in the terminology used, with the terms "recycling," "processing," and "reprocessing" sometimes denoting the same thing, and sometimes with distinctions made for each term, such as the traditional use of "recycling" for plutonium use in thermal reactors and "reprocessing" for the full-scale recovery of all fuel potential with the addition of fast-neutron reactors to breed U-238 into Pu-239. Similarly, there may not be a consensus on the term "electrochemical recycling," although it generally indicates high-temperature pyroprocessing of spent fuel with an electrorefining stage in which actinides are collected on a cathode. This is categorically distinct from aqueous reprocessing, which is based on mechanical and chemical actions to separate spent fuel into fissile material, minor actinides, and fission products.

Fiona Rayment, director of fuel cycle solutions at the United Kingdom's National Nuclear Laboratory, summarized the lab's study of electrochemical recycling. Spent fuel would be treated with molten chloride or fluoride salts at temperatures greater than 400 °C, with no water or oxygen present. Rayment said that electrochemical recycling is seen as potentially complementary to aqueous recycling, but it is unlikely to be a competitor in the near term. Still, she added, the technology is seen as meriting further study.

Rayment said that work in the United Kingdom is emphasizing the industrialization of dynamic operations in molten salt, the management of process salt and waste salt, and the assessment of molten salt reactors and related systems. The REFINE project (REduction of spent Fuel vital In a closed-loop Nuclear Energy cycle) entails the use of a molten salt dynamic rig that had been built and used long before, but had been unused for eight years. Rayment noted, however, that this rig (which had thus far been used without radioactive material) developed a salt leak. Asked later whether this had resulted from impurities in the salt, Rayment stated that the cause was still being analyzed, but she thinks it was water ingress into a weld.

One aspect of nearly every discussion of the recovery of fissile material from spent fuel for the production of energy is that for most nuclear power countries, there is at least one piece missing from a true cycle.

Rayment noted that the United Kingdom has a closed fuel cycle, although with plutonium separated from spent fuel and stockpiled rather than used as an energy source. She added that U.K. policy calls for an open cycle, with a cycle that could be either open or closed after about 2045. One aspect of nearly every discussion of the recovery of fissile material from spent fuel for the production of energy is that for most nuclear power countries, there is at least one piece missing from a true cycle.

The presentation by Jean-Paul Glatz, representing both the Transuranic Institute and the European Commission's Joint Research Center (JRC), was necessarily steeped in this sort of speculation, with electrochemical recycling seen in the context of the arrival of Generation IV reactors, perhaps in the middle of this century. Nonetheless, work is being done to assess the potential of the technology, and it is centered on the JRC's Multi-purpose hYbrid Research Reactor for High-tech Applications (MYRRHA) in Belgium.

Glatz stated that while the main European Commission recycling system has for some time been envisioned as based on aqueous reprocessing, pyroprocessing is seen as having potential advantages: A facility can be more compact, lowering costs and reducing the number of transports; the salt is more radiation resistant, so fuel cooling times can be shorter; and the constituents can be adjusted to make the end product more proliferation-resistant. Glatz noted that the solid aluminum electrode in aqueous processes could also be used in the electrorefining portion of pyroprocessing.

Questions from attendees included one that is often asked: When will fast-neutron reactors be available in the speakers' countries? The approximate dates given were 2040 (by Hur) and 2050 (by Glatz and Rayment). A less common question was, where will the radiochemists be found to do the work if full-scale fuel reuse were to come to pass? The only reply was Rayment's statement that this would be a challenge for every nuclear power program.

Waste management

Meetings of the American Nuclear Society offer attendees an opportunity to learn what other countries are doing in the various fields of nuclear technology. For those concerned with the back end of the nuclear fuel cycle, the session "Updates on Nuclear Waste Repository Projects" provided a glimpse into the progress being made at three permanent nuclear waste repositories in the United States, France, and South Korea.

Speaking on behalf of the Department of Energy's Carlsbad Field Office, Tim Runyon gave an overview of the recovery efforts at the Waste Isolation Pilot Plant (WIPP), the deep geologic repository for transuranic waste near Carlsbad, N.M. Beginning with a recap of the two unrelated incidents in February 2014 that closed the facility, Runyon described the recovery work that has been done to date. As described in previous issues of *Nuclear News,* this includes stabilizing the underground, reducing radiological risks, and closing Panel 6 and Room 7 of Panel 7, where the breached waste container was identified.

Looking ahead, Runyon detailed the work that the DOE hopes to accomplish in 2016 prior to reopening the facility. (After it was determined that the original target date of March 2016 for reopening WIPP was no longer viable, the DOE was to issue a new recovery schedule by the end of December. That schedule had not been released as of this writing.) First, Runyon said, the DOE will complete revisions to WIPP's documented safety analysis

(DOE-STD-3009-2014), which demonstrates the facility's compliance with federal regulations. In October, it was reported that the revised safety analysis was 70 percent complete (*NN,* Dec. 2015, p. 50).

According to Runyon, other work in 2016 will include the final installation of the facility's interim and supplemental ventilation projects, which will increase airflow to the underground, and the start of integrated cold operations. Prior to receiving authorization to proceed with waste emplacement, operational readiness reviews of the DOE and its contractor, Nuclear Waste Partnership, will be conducted, Runyon said.

KORAD was successful in getting local consent for the Wolsong center in part by limiting it to only low-level waste and intermediate-level waste.

Next, Bernard Faucher, a senior expert at Andra, the French national radioactive waste management agency, gave an overview of the Cigéo project, France's proposed deep geologic repository for high-level radioactive waste. If the project is approved, HLW will be placed 500 meters (1,640 feet) below ground in an impermeable argillaceous rock formation in northeastern France. Although the repository reached the preconstruction phase in 2011, Faucher noted that it is not a "straight line" to building Cigéo. A license application for the facility will be submitted in 2017, and a pilot phase of operation is projected to begin by 2020, with full operations beginning sometime after 2030.

Once the facility is completed, HLW packages will be disposed of underground in horizontal disposal cells. This approach presents its own technical challenges, Faucher said. For example, a patented method for boring the disposal cells had to be developed. A robot will be used to place the stainless steel waste canisters in the cells. It was determined that to facilitate the placement of the canisters, low-friction ceramic pads will have to be installed on the waste canisters themselves. Once interred, the waste will be monitored for 100 or more years, Faucher said, adding that the ability to retrieve the waste is a concern.

Faucher also noted that in addition to the underground disposal shafts and cells, Cigéo will include two surface facilities, a nuclear facility used for receiving, inspecting, and preparing waste packages, and a nonnuclear facility consisting of mine shafts for construction and maintenance work. The surface facilities will be located in two separate municipalities approximately 5 kilometers (3 miles) apart, which will allow for greater site flexibility, Faucher said. The waste packages will be transferred to the underground facility via a 4.2-km (2.6-mile) sloping funicular railway.

The progress that South Korea has made in managing its radioactive waste was discussed by Sung-Tae Jung, vice president of the Korea Radioactive Waste Agency (KORAD) and head of the Wolsong disposal center for low- and intermediate-level radioactive waste. The Wolsong disposal center is located near the Wolsong nuclear power plant in the southeastern region of the Korean peninsula. Jung said that the first of eight construction stages was completed in 2014, and the placement of waste drums in underground silos began in July 2015 (*NN,* Aug. 2015, p. 156).

According to Jung, about 5,000 to 10,000 200-liter (50-gallon) drums of LLW and ILW will be disposed of each year in the center's underground silos, which will have a total capacity of 100,000 drums. In 2016, the center will begin the second stage of construction, which will include a near-surface disposal facility that when completed in 2019 will have a capacity of 125,000 drums, Jung said. He added that the Wolsong facility will be the first in the world to have both underground disposal and near-surface disposal at one site. When finished, the total capacity of the facility will be 800,000 drums. Nearly two-thirds of the accepted waste will come from South Korea's nuclear power plants.

Jung noted that KORAD was successful in getting local consent for the Wolsong center in part by limiting it to only LLW and ILW. South Korea's progress in managing its high-level radioactive waste and spent nuclear fuel has been more challenging, he said, describing the country's current approach to HLW management as "wait and see." South Korea has yet to formally decide whether to reprocess the approximately 750 tons of spent fuel it generates every year or place it in a permanent repository, a site for which has not yet been chosen. Jung said that the South Korean government was to establish a basic management plan for spent fuel by the end of 2015.

Plutonium-238 production

During the session on the production of plutonium-238 for space missions, Robert Wham, of Oak Ridge National Laboratory (ORNL), reported on studies that have been carried out to determine how existing facilities at national laboratories can reestablish production capability entirely within the United States. As noted in other papers presented at this session, Pu-238 would be produced through neutron irradiation of neptunium-237, which has a half-life of over 2 million years. The resulting Np-238 decays by beta emission, with a half-life of about two days, to Pu-238, with a half-life of about 88 years.

Pu-238 is considered a steady energy source for radioisotope thermoelectric generators (RTG) that are used to power onboard instruments for a variety of exploratory missions, such as the New Horizons spacecraft that flew close to Pluto in 2015, and even to provide some motive power, such as for the Curiosity rover on the surface of Mars.

Pu-238 had been available for RTGs as a by-product of nuclear weapons production. The work that produced the Pu-238 was closed down in 1988, and in 1992, the United States made arrangements to obtain Pu-238 from Russia. Tensions between the two nations have made it more difficult to obtain this supply, but it is generally believed that Russia has no more Pu-238 available. The National Aeronautics and Space Administration has carefully managed its remaining stock of Pu-238, and during the New Horizons mission, NASA stated that what is left can support space missions until the DOE can resume production.

Wham said that the DOE and NASA have jointly studied ways to use existing infrastructure for the resumption of Pu-238 production. The planned approach would involve a fair amount of movement of radioactive material among three regions of the country. Np-237 stored at Idaho National Laboratory (INL) would be fabricated into neptunium oxide/aluminum targets at ORNL's Radiochemical Engineering Development Center (REDC), with some of the targets then irradiated at ORNL's High Flux Isotope Reactor, and others sent back to Idaho for irradiation in INL's Advanced Test Reactor (ATR). Wham said that there are many useful in-vessel target locations in both reactors. All irradiated targets would then go through chemical processing at the REDC, which in the case of the ATR targets means another trip to Tennessee. The work needed to produce the plutonium oxide pellets for RTGs would be done at Los Alamos National Laboratory, and thus a trip to New Mexico would be required. Shipments of this kind and of this activity of material are already well established among the lab sites.

Keeping Pu-238 production within the national laboratory system involves more than just the ability to make use of existing infrastructure. The neutron flux that can start Np-237 on the way to Pu-238 can also irradiate Np-238 and Pu-238 and lead to the production of fissile Pu-239. This raises potential issues of criticality safety and proliferation, and the various actions in the Pu-238 production process must take these issues into account.—*E. Michael Blake, Tim Gregoire, Dick Kovan, and Michael McQueen* NN