ANS ANNUAL MEETING

Managing the global impact of economic and natural events

Meeting session coverage:

- *The effects of low doses of radiation*
- *Science and scientists in public policy*
- *Addressing the spent fuel dilemma*
- *A world view of new reactor construction*
- *Women's attitudes toward nuclear*

With the 2012 American Nuclear Society Annual Meeting held in Chicago, Ill., June 24–28, many staffers from the headquarters office—located in La Grange Park, about 15 miles west of the city—were able to assist with and observe the workings of a national meeting. And many members chose to attend the meeting in what is a beautiful, vibrant city to participate in special events, present and receive honors and awards, take care of committee business, and, most important, sit in on technical sessions in which the latest research, business, and problem-solving information is presented. The overall attendance at this meeting was nearly 1500, the highest for an Annual Meeting since the 1980s.

At the opening plenary session, which was based on the meeting's theme—"Nuclear Science and Technology: Managing the Global Impact of Economic and Natural Events"—Amir Shahkarami, the general chair of the meeting, introduced John Rowe, former chairman and chief executive officer of Chicago-based Exelon Corporation, who welcomed the meeting attendees.

Rowe

Rowe was chairman and CEO of Exelon from its formation in 2000 through to its acquisition of Constellation Energy earlier this year. During his career, he chaired the Nuclear Energy Institute (NEI) and the Edison Electric Institute, and he most recently served on Energy Secretary Steven Chu's Blue Ribbon Commission on America's Nuclear Future (BRC).

Rowe said he was pleased to welcome the meeting participants to Chicago, not only because of the city's historical association with nuclear energy, but also because of its many other attractions, most notably—in his opinion—the best 20th-century architecture in the world. For ANS, however, he also wanted to speak to some of the challenges that the plenary session would address—in particular, the impact of low natural gas prices and the Fukushima Daiichi accident.

Rowe opined that because of the low price of natural gas, it is probable that new nuclear plants will not be economical for a decade or two. And as for Fukushima, he said that it was the "accident that was not supposed to happen" and that it created a great deal of public uncertainty and did a great deal of genuine environmental damage. He noted that Japan has since gone through a period when all of its reactors were shut down, while in Western Europe, some countries—most notably Germany—are phasing out nuclear power, and in France, a new Socialist president has for the first time cast doubts on the country's commitment to nuclear power.

While admitting that his crystal ball is as clouded as anyone else's, Rowe said that he is confident that natural gas will be the dominant energy source for the next two decades. Beyond that, he said, "I am very uncertain about what follows." It could be the nuclear renaissance that was heralded a few years back, he said, or it could be a new mix of gas, wind power, and solar energy, or perhaps something very different. If it were based on nuclear, Rowe said, the new plants "would have to be a very simple, very easy to build, genuinely passive design." This, he added, would require considerable developments in passive designs and inherent safety.

Rowe said that despite these problems, he has faith that the industry can overcome the challenges. He noted, however, that his faith is not in technology, but in the people who work in the nuclear industry. "We are not the only ones, and the skills that lead to success in nuclear are not the only skills that are needed, but there is no better group than this."

Idaho Congressman Mike Simpson (R.,

Idaho), whom Shahkarami described as a leading advocate for a new energy policy and a renewed commitment to nuclear research and development, was the first speaker to take the podium. As a member of the House Appropriations Committee and the Energy and Water Development Subcommittee, Simpson has a particular interest in the funding of Department of Energy programs.


Simpson

After Fukushima, Simpson said, he was certain that public support for nuclear would plummet, and he was surprised at how little it fell. This indicates, he said, that the public recognizes the importance of nuclear power for the future.

Simpson posed what to him is an important question: How can an ongoing nuclear program that takes years to develop be sustained when political terms are two and four years? To answer this question, he said that he would appreciate more help from the DOE, which, he noted, has not been able to provide him with "a clear vision [of how] we create, distribute, and use power in this country today . . . [and] what do we expect 10 years from now, 20 years from now." When money is being appropriated for DOE programs, he said, he wants to know why money should be put into wind power, solar power, or other sources if it isn't clear what roles they will play in the future. Until those roles are defined, he declared, Congress will continue to have a real problem appropriating funds to run the department.

The mind-set of the House is that using Yucca Mountain for a spent fuel and high-level defense waste repository is still the law of the land, and as long as that remains the case, the project should proceed.

Regarding the Energy and Water Appropriations bill, Simpson noted that the controversy over Yucca Mountain is impeding the passage of an appropriations bill. The mind-set of the House is that using Yucca Mountain for a spent fuel and high-level defense waste repository is still the law of the land, and as long as that remains the case, the project should proceed. "There are certain senators who have a problem with that," he said.

He also discussed other related developments, including the BRC, which examined the waste situation and came back with several recommendations. The Senate has proposed a pilot program on interim storage at a willing site. While he has no problem with that, Simpson said, he questions what is meant by "interim," particularly as there is little idea when a permanent geological repository will be available. On an optimistic note, he said that Congress will work this out, but not before the November presidential election.

Simpson also noted that a proposed amendment to the energy bill, which would have effectively ended funding for nuclear research and development, garnered only 106 votes. The argument made by its proponents was that no energy sector should be subsidized. Simpson noted that most of the votes the bill received were related to the acrimonious debate on the national debt rather than to nuclear energy.

According to Simpson, all of Congress knows that to deal effectively with the debt problem, a balanced approach is required, and that it is necessary to reduce spending, reform entitlement programs, and generate more revenue. Political agreement, however, will not be possible before the next election, he said, adding that in the meantime, he fears that the bond market may crash before a solution is in place.

How to address the deficit problem and continue investing in R&D in nuclear and other areas such as education, which are necessary for the country's future, is a real problem, Simpson said, but despite the lack of clear answers, he remains very optimistic that a majority of Congress still supports nuclear energy and will fund nuclear R&D.

Next to speak was Hans Wanner, head of the Swiss Federal Nuclear Safety Inspectorate, ENSI, and chair of the Western European Nuclear Regulators' Association (WENRA), which he was representing at the meeting. WENRA, Wanner said, is a voluntary "club" of the heads of the regulatory authorities of the countries of the European Union, plus Switzerland. Its main goal is to develop a common approach to nuclear safety, and as its first common objective is to harmonize regulations among member countries, WENRA formed the Reactor Harmonization Working Group (RHWG). Harmonization is being promoted, Wanner explained, by using international safety standards to establish common "safety reference levels," of which there are now about 300 for nuclear reactors. WENRA also verifies that countries have implemented the safety reference levels in their legislation and regulations.

WENRA became a major player in Europe's response to the Fukushima disaster, Wanner said. Within days of the event, EU Energy Commissioner Günther Oettinger announced that all reactors should undergo a safety assessment, or "stress test." WENRA took the initiative of setting up an *ad hoc* working group, under the umbrella of the RHWG, to develop the idea, Wanner said, and to determine what such a test should and should not involve. WENRA decided that it should not be an overall reactor safety assessment, but a targeted reassessment of the safety margins of the plants in light of the Fukushima accident, which involved extreme natural events that overwhelmed the plant's safety functions. That view was formally backed by the European Commission (EC), as well as by the regulators.


Wanner

Developing a process for undertaking stress tests presented several challenges, Wanner said, particularly given the number of countries in Europe, with their differing regulations and reactor designs. Furthermore, the EC wanted results as quickly as possible and set a demanding timetable that required the final stress test results from each country by the end of 2011. It was impressive that not a single country failed to meet the deadlines, Wanner said.

The stress tests, he explained, were divided into three steps. The first was an assessment of each plant by the operator, and the second involved reviews of the operators' reports by the respective national regulators. For both of these steps, operators and regulators identified further safety improvements.

The third step was a two-part international peer review. The first part involved topical reviews for each country covering external events, safety functions, and severe accident management. The second part involved a team visiting each country to discuss the national and topical reports with the regulators and operators, visit sites, and draft final country reports. The visits were carried out during the first three months of 2012, and the final reports included recommendations and good practices.

The peer review, Wanner said, highlighted the need for operators to be better able to assess natural hazards. The peer review board recommended that WENRA develop guidance to address this need, as well as the following:

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■ Periodic safety reviews, which are typically done on a 10-year basis, were seen as particularly valuable and should be considered by all countries.
■ Containment integrity should be strengthened to ensure that function is maintained even during severe accidents.
■ Additional measures are needed to minimize accidents resulting from natural hazards and to limit their consequences.

As it is vital that countries implement the recommendations, Wanner said, a follow-up process will be defined by the EU regulators to ensure compliance. This will include additional site visits by peer review teams. A more important requirement to Wanner is ensuring that the good practices identified during the reviews are implemented.

Sylvain Costes, a biophysicist in Lawrence Berkeley National Laboratory's (LBNL) Life Sciences Division, described research he has done on the effects on humans of low doses of ionizing radiation. He noted that this research contradicts the linear no-threshold (LNT) hypothesis, the standard model used for predicting biological damage from ionizing radiation. Costes and his coworkers found evidence that the risk of cancer from low-dose levels is actually extremely low and is well below the level predicted by the LNT model, which holds that risk is directly proportional to dose at all levels of radiation exposure.


Costes

Costes described a mechanism by which damaged DNA is repaired, which explains why most DNA damage at low-dose exposure will be successfully repaired, unlike damage at high dose. This, he said, provides an explanation of why a linear extrapolation of risk from damage at high dose to low dose is not valid. He explained that damage to DNA by ionizing radiation involves a "double strand break," which means that the DNA double helix is completely severed. These breaks are repaired—that is, they are reconnected—in the cell at what he called "repair centers," with the repairs made by aggregations of proteins in the cell. At low doses the repair is quite efficient, but at high doses, when there are likely to be a number of DNA breaks (which he said tend to cluster), there is a much greater likelihood of a faulty repair, which can lead to a mutation (chromosomal rearrangement) and cancer. This explains why the risk of cancer is much larger at high doses, he said.

The research done by Costes and his team identified some of the shortcomings of the LNT hypothesis, including, in particular, that it does not take into account a number of factors that he said are essential to the process of damage and repair in the cell. For example, he noted, important biological processes are involved in cell repair that are time dependent, as well as dose-rate dependent. These are not considered in the LNT model, as it does not matter when the break occurs. Costes also noted that the LNT model does not take into account evolution, which would suggest that life forms would adapt to a background of low-dose ionizing radiation, ensuring that it would not be an important risk factor.

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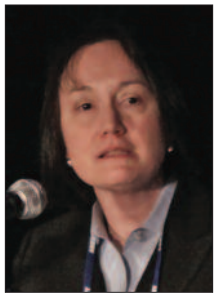
The final speaker was Kristine Svinicki, whose reappointment as a commissioner to the Nuclear Regulatory Commission was confirmed at the end of June. A longstanding member of ANS, she was presented with an ANS Presidential Citation at this session, the second time she has been so honored.


Svinicki

Svinicki said that she particularly appreciated the theme of the opening session. "We need to address impacts of the areas we are working in," she said, as Fukushima made clear. She then looked back at the establishment of the NRC, when Congress decided to separate the regulatory aspects of the Atomic Energy Commission from its other responsibilities, such as nuclear weapons development, the national laboratories, and the promotion of the peaceful uses of nuclear energy.

The NRC's independence, Svinicki said, was a very specific intent of the legislation. The commission's authority comes from the Atomic Energy Act, which has been described by legal scholars as "virtually unique in American statutory law." She noted that this refers to the extremely broad discretion given to the NRC, which is able to give meaning to statutory mandates.

Svinicki also pointed to the NRC's mission statement, which states that the NRC's primary responsibility is "to ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment." The intense focus on protecting public health and safety has resulted in an agency that has a very strong performance record, she added.

Svinicki also spoke of the need to maintain a stable and predictable regulatory environment that is supported by the Principles of Good Regulation issued by the commission in 1991. The principles are used to ensure "the quality, correctness, and consistency of our regulatory activities," she said.

The principles are as follows:

1. *Independence*—The highest possible standards of ethical conformance and professionalism must be upheld, but it does not imply isolation. All available facts and opinions must be sought openly, conflicting public interest must be considered, and final decisions must be based on an objective, unbiased assessment of all information and documented with reasons for the decisions explicitly stated. It is important that people know why a decision was made in a certain way, she said, adding that being able to review the rationale of her predecessors to discover why they made a particular decision has been very helpful to her.
2. *Openness*—Nuclear regulation is the public's business. The public must have the opportunity to participate in the regulatory process, and open channels of communication must be maintained.
3. *Efficiency*—The taxpayer, the rate-paying consumer, and the licensees are all entitled to the best possible management and administration of regulatory activities, which should also be consistent with the degree of risk reduction they achieve.
4. *Clarity*—Regulations should be coherent, logical, and practical, and commission positions should be readily understood and easily applied.
5. *Reliability*—Regulatory actions should always be fully consistent with written regulations and should be promptly, fairly, and decisively administered so as to lend stability to the nuclear operational and planning processes.

Svinicki said that these principles have been helpful to her in considering the relevant issues when making decisions in her role as a commissioner.

Low-dose effects

Two sessions at the Annual Meeting and one at the concurrent ICAPP addressed the issue of whether the long-standing presumption of the potential health effects of low doses of ionizing radiation (and doses received over long time periods) is valid. At

the Annual Meeting, the ANS President's Special Session, "Low-level Radiation and Its Implications for Fukushima Recovery," was followed by a panel session with many of the same speakers (see the session write-up that immediately follows). At ICAPP, a presentation was made by Sylvain Costes, a researcher at LBNL, whose team had published a paper last December on DNA repair mechanisms. He was also a speaker at the opening plenary session of the Annual Meeting.

The special session's organizers had prepared a book-length collection of policy statements, opinion pieces, and scientific articles (most of them reprinted from other publications), and copies were made available to attendees. Despite its title, *President's Special Session: Low-level Radiation and Its Implications for Fukushima Recovery,* the publication does not include the presentations made by the speakers at the session, but it does include earlier writings by four of the speakers. The publication is available at no charge as a download from the ANS Web site, at <www.new.ans.org/about/officers/docs/special-session-low-level-radiation-version1.4.pdf>, or go to <www.ans.org>, and from the "About ANS" dropdown tab, select "Elected Officers"; under Eric Loewen (now the immediate past president), click on the title of the publication.

At the President's Special Session, Kazuaki Matsui, executive director of Japan's Institute of Applied Energy, presented data on the estimated releases of radioactive material from Fukushima Daiichi. The largest estimate of the airborne total, presented as an equivalent of the radioactive isotopes of iodine, is roughly 900 petabecquerels. By comparison, the iodine equivalent release from the 1986 Chernobyl-4 accident was 5200 pBq. Matsui noted that the largest estimate of release to the sea is 27 pBq.

Matsui

Through the end of March 2012, the doses reported for Tokyo Electric Power Company workers at the site included six who had received more than 250 millisieverts, one who had received 200–250 mSv, 139 who had received doses in the 100–200 mSv range, and 3276 with doses below 100 mSv. Also, Matsui said, 21 of 17 600 contract workers had reported doses of more than 100 mSv. The external doses to inhabitants near the plant, in the Iidate and Namie districts, are estimated to be below 10 mSv for 99.3 percent, with the highest dose to an individual stated as 25.1 mSv. Internal dose is less than 1 mSv for 99.9 percent, with two people receiving doses of 3 mSv.

Matsui summarized the effects of the accident on the Japanese economy, including the increase in electricity costs as Japan's operable power reactors were kept off line after routine refueling and inspection outages. (In July, two reactors at one site resumed service; see *NN,* Aug. 2012, pp. 17 and 163.)

While Matsui mainly addressed the accident response, he did state that the low doses received by nearby residents would give rise to "probably minimal or no health effect due to the prompt evacuations." As to whether such doses should be any cause for concern, he closed with a chart showing the average lifetime radiation doses in several countries and in the vicinity of Chernobyl, which, by Matsui's earlier measure, released almost six times more radioactive material than Fukushima Daiichi did. The dose for Finland was the highest in this group, higher even than the region with the greatest radioactivity from Chernobyl. The chart was titled "Finland has not been evacuated."

Sakamoto presented data from his own experiments, starting in 1975, showing low doses to have promoted immunological response, rather than suppressing it.

To a large extent, the other speakers at the session presented material similar to what they would present in the later session (see the session writeup that immediately follows this one). These speakers were Kiyohiko Sakamoto, chairman of the board of directors of the Tohoku Radiological Science Center in Japan; Jerry Cuttler, president of Cuttler Associates, a consultancy based in Canada; Ronald Mitchel, researcher emeritus for Atomic Energy of Canada Limited; and Douglas Boreham, a professor in the Department of Medical Physics and Applied Radiation Sciences at McMaster University in Canada.

Boreham's presentation, on modern tools to understand genetic effects from low doses, cited evidence that low doses could enhance the ability to withstand high doses later. This was also mentioned by other speakers as one of the potential benefits of either administering radiation doses or reducing the concern over whether low doses have been received unintentionally.

Cuttler also cited research results indicating that low doses may prevent damage from higher doses, and he echoed Matsui regarding natural doses in some parts of the world being greater than doses from Fukushima Daiichi. Sakamoto presented data from his own experiments, starting in 1975, showing low doses to have promoted immunological response, rather than suppressing it.

The discussion at this meeting on whether the LNT hypothesis is valid took place in the midst of a growing debate on this topic in the nuclear community, with the most recent scientific developments coming from the paper published last December by Costes's group at Berkeley (*NN,* Feb. 2012, p. 61), and another published mid-year by a group based mainly at the Massachusetts Institute of Technology, stating that no radiation damage was apparent from long exposure to low doses (*NN,* July 2012, p. 78). To varying degrees, some participants in the larger debate call for repudiation of the LNT hypothesis, recognition of radiation hormesis, and wholesale revision of radiation protection practices to allow less cost and effort to be expended in the reduction of doses.

As the tools cited by Boreham become more powerful, however, it may be possible to develop a more precise awareness of dose response, rather than replacing the generalized LNT hypothesis with an equally generalized threshold/hormesis model. In his ICAPP presentation, Costes enlarged on the information in his group's paper from last December, in which double-stranded breaks in DNA molecules were observed to become surrounded by chemicals able to restore the broken strands, making the breaks into "repair centers" for the DNA. In addition to pointing out how DNA in general is thus able to restore itself from the kind of damage that can be caused at the molecular level by low radiation doses, Costes cited the importance of the data gathered so far on individual response. He said that different types of mice used in the study (which was carried out as part of the DOE's research program in low-dose radiation) have been found to respond differently in their DNA damage and repair abilities. It is possible, then, that a radiation dose that harms one organism may help another of the same kind and have no effect at all on a third.

Boreham

The panel session on the health effects of radiation—which was complementary to

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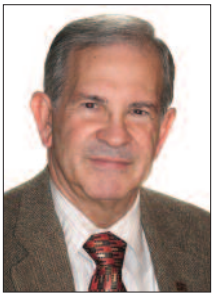
the immediately preceding President's Special Session—aired the views of a distinguished panel of experts from a variety of disciplines, including four participants from the special session—Jerry Cuttler, Kiyohiko Sakamoto, Ronald Mitchel, and Douglas Boreham—who were joined by Wade Allison, professor emeritus of physics at the University of Oxford and author of *Radiation and Reason*; Jim Welsh, a radiology oncologist at Fermi National Accelerator Laboratory; and Myron Pollycove, professor emeritus of laboratory medicine and radiology at the University of California at San Francisco.

All of the panelists, in one way or another, could be properly termed debunkers of the received wisdom on radiation exposure, as each presented evidence suggesting that not only are popular anxieties over radiation overwrought, but that low doses of radiation can, in fact, provide health benefits when properly administered.

Cuttler, the panel organizer and chair, led off the session with a look at some of the scientific research that supports the claims of salutary effects from low-dose radiation and casts doubt on the linear no-threshold (LNT) hypothesis—the model still widely acknowledged as the appropriate basis for radiation protection regulations—which holds that no level of radiation exposure is safe and that risk from radiation increases proportionately with the dosage received.


Cuttler

Research highlighted by Cuttler included work done by Pollycove and Ludwig Feinendegen, professor emeritus of nuclear medicine at Heinrich Heine University Düsseldorf, showing that low doses of ionizing radiation actually stimulate cell defenses that protect against disease in the process known as hormesis; a radon exposure study by the late physicist Bernard Cohen, a critic of the LNT hypothesis, indicating that lung cancer mortality rates were lower where radon was higher; and a 7417-patient study on cancer incidence and mortality following radioiodine treatment for hyperthyroidism, demonstrating a decrease in both cancer incidence and mortality.

Cuttler also discussed a number of historical examples of radiation therapy administered for medical purposes, including radiation treatment of gas gangrene infection and the controversial Nasal Radium Irradiation program, in which from 1945 to 1961, millions of children in the United States received radiation doses as a standard medical practice to shrink enlarged adenoids and tonsils, with no significant increases of thyroid cancer rates, according to Cuttler. Other data he cited included statistics on children who survived the atomic bombings of Hiroshima and Nagasaki, which showed no increase in congenital abnormalities, mortality, chromosome aberrations, or gene mutations.

In Cuttler's view, part of the problem in getting the word out to physicians regarding the benefits of low-dose radiation is that most radiologists are taught the LNT model in school as a matter of course. He singled out one particular well-known textbook, *Radiobiology for the Radiologist*, for specific criticism. "The book does not mention radiation hormesis," Cuttler said, adding that the book ignores copious amounts of scientific data showing that low doses and low-dose rate radiation provide beneficial health effects.

In his concluding remarks, Cuttler offered some recommendations for combating what he regards as the myths and scaremongering that surround the radiation issue, including that scientific societies organize more events to discuss radiation and health, that regulatory bodies and health organizations examine the entire body of scientific evidence, and that public communication programs be developed that include strategies on how to explain the reality of the hormesis effects of low-dose radiation.

Sakamoto (himself a recipient of radiation therapy, having opted for that treatment some years ago to deal with metastases following colon cancer surgery) discussed his research, which began in 1975 with a study of tumor-bearing mice to determine the minimum dose required to suppress immunological response. He discovered, instead, that irradiation with low doses, of 10 to 15 cGy, actually promoted immunological response, a finding he characterized as "a complete surprise."


Sakamoto

The finding led Sakamoto to perform a series of experiments over 12 years, funded by the Japanese government, on the effects of total- or half-body low-dose radiation treatments on some 200 cancer patients. Based on those experiments and other research, Sakamoto said, he has reached the following conclusions: (1) much information is known about the effects of low doses and low levels of radiation on living organisms, especially mice and people; (2) low doses of radiation stimulate immunity to cancer and biological defenses against DNA damage; (3) low-dose radiation can be used to cure/prevent cancer; (4) the dose or dose rate at which radiation starts to become harmful is known; and (5) there is no basis to fear low-level radiation.

Allison began his presentation with an explanation of why he wrote *Radiation and Reason*. "I'm an ex–particle physicist, and I've been spending the last few years getting angry about the discrepancy in attitudes toward different levels of radiation," he said. "So I wrote a book on the subject, with the idea of how can we get across to the general public and the politicians what the hell's going on. . . . Of course, nobody would publish it, so I published it myself."

"I've been spending the last few years getting angry about the discrepancy in attitudes toward different levels of radiation."


Allison

Allison drew a stark contrast between the response of the Japanese people to last year's earthquake/tsunami and their response to the Fukushima Daiichi accident. "When the earthquake struck," he said, "there were 500 000 people in the region subsequently inundated by the tsunami, and within 26 to 45 minutes, all except 18 880 had managed to escape." The reason for this remarkable performance, he explained, was that the Japanese people had been properly prepared for tsunamis. They had not, however, been properly prepared for a nuclear reactor accident like the one that occurred at Fukushima.

"The training and understanding of the Japanese people that was evident for the tsunami was absent for the release of radiation and radioactivity," Allison said. "Faced by an unknown threat, nobody knew what action to take, and few in authority knew either, so that rumor and panic, extending to the highest levels, led to serious social harm, widespread voluntary evacuation, failed businesses, and losses of confidence in society and nuclear power." Allison remarked that he finds it strange that society should fail to cope with such an accident, one for which no loss of life should be expected. "Fear of powerful energy is a protective an-

imal reaction," he noted, "but man has survived dangers through study, understanding, and mutual organization, but not in the case of radiation and radioactivity. Why not?"

Allison believes that the answer, at least in part, is the failure of the nuclear community to adequately communicate the nuclear reality. "Nuclear decay is safer than fire," he said. "It's safer than biological hazards. It cannot spread by contagion. It leaves very little waste, and what it does leave is essentially solid. It eventually diminishes, unlike chemical wastes. It is difficult to imagine that nuclear energy could possibly be physically safer than it is." But, he added, hardly any of that information gets disseminated to the public.

"So we have suffered from 60 years of nuclear-inspired political fear that has run wild, wasting enormous resources and diverting attention from the real global threats to civilization—socioeconomic instability, climate change, population growth, food, and fresh water," Allison declared. "Radiation should not appear on that list."

Mitchel returned to an examination of the validity of the LNT hypothesis, questioning whether it holds true at low-dose rates. A radiation exposure is a change in the environment that creates a stress, he said, and the basic rule of biology in a changing environment is "adapt or die." And, he said, adaptation to radiation has been shown to operate in everything from single-cell organisms to human cells.


Mitchel

"We know that low doses [of radiation] stimulate DNA repair," Mitchel said. "If the DNA repair isn't properly done, if mistakes are made, then the cell is supposed to die through a suicide program called 'apoptosis.' That's what's supposed to happen, and that's stimulated by low doses. But if that doesn't happen, we have something called 'bystander effects,' which means the neighbors of the cell recognize that there's an aberrant cell in their midst, and they send so-called death signals to the aberrant cell, which turn on the apoptosis program that the cell couldn't turn on itself. And if that doesn't work, then we call out the immune system, where T cells and natural killer cells go out and find these aberrant cells and kill them. And if that doesn't work, only then do you get cancer."

There exists, Mitchel said, an ability to repair broken chromosomes in cells adapted by exposure to low doses that is highly nonlinear. He cited a number of studies, including a 1996 study by Azzam, de Tolido, Raaphorst, and himself, showing that spontaneous neoplastic transformation frequencies—neoplastic transformation being the conversion of tissue with a normal growth pattern into a malignant tumor—did not progress in a linear manner. A 10-mGy treatment, in fact, resulted in a lower transformation frequency than a 1.0 treatment, which itself resulted in a lower number than the control category. Another study highlighted by Mitchel indicated that low-dose radiation can protect from chemically induced cancer as well, when the dose is given 24 hours before the chemical carcinogen is applied.

The implications for radiation protection, according to Mitchel, are that at low doses, all the basic LNT assumptions are wrong, and a new approach to radiation protection at low doses is needed.

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Welsh described the radiation therapy he has used successfully on cancer patients as being virtually identical to Sakamoto's approach. He added, however, that it is difficult to conduct this type of research in the United States because of opposition and skepticism from the medical community and the difficulty of getting things through a hospital's internal review board, which sometimes frowns upon this type of work. "Nonetheless," he said, "I do think that Dr. Sakamoto's data stands firm, and as a clinician, I've seen it work, and I believe we should exploit it further and find out what the true mechanism is."

Welsh also mentioned the "abscopal effect," one of the most fascinating observations he made while conducting these treatments. "As has been discussed several times today, a low dose prior to a large dose is protective," he said. "But what about the opposite? What if the high dose has already been given, and the damage has already been done? Can a subsequent low dose activate this adaptive response and undo some of the damage? This, in my opinion, is the most interesting question. If this mechanism is possible, then we would have a new therapy. And I believe the hypothesis is very consistent with Dr. Sakamoto's data."


Welsh

Boreham lightened the mood of the session somewhat by pointing out that due to the natural radioactivity in one's body from potassium-40 beta particles, sleeping next to someone for a year will give you the same radiation dose as getting an X-ray of your hand. "Everyone's worried about getting a hand X-ray, but nobody really worries about sleeping with someone," Boreham said. "Now mind you, one's given over a year, and one's given over a second, but if you believe in the LNT, they both carry the same amount of risk. So, pick your risk."

Pollycove ended the session on an optimistic note. "The reason I can answer the question of what's safe with great conviction and certainty," he said, "is that my attention was first called to this area when T. D. Luckey published a book in 1980, in which he cited a number of locations around the world in which the background radiation is high and the people there are uniformly living [to] between 80 and 100, and here they are living [to] between 60 and 80. And all these places have chronic radiation 30, 40 times, maybe 60, 70 times as much as we have in San Francisco."


Pollycove

DNA, Pollycove said, is not stable—it is constantly being destroyed and reconstituted in a process that is triggered by the chronic radiation described in Luckey's book. The low dose from background radiation in these locations stimulates repair, and the DNA ends up in better condition. "You can be very secure about chronic radiation," Pollycove declared, "and the ability to cope with acute radiation is well demonstrated by the therapy being done now."

Science and policy-making

The session titled "Science in Politics: Getting Scientists Elected" brought together an eclectic group of people to discuss and promote the involvement of scientists and engineers in public policy. The panel members included Dick Simpson, head of the Political Science Department at the University of Illinois at Chicago and a former Chicago alderman; Monica Metzler, chair of the Illinois Science Council's board of directors; nuclear engineer Chad J. Boyer,

the current ANS/American Association for the Advancement of Science (AAAS) Congressional Fellow, who is working in the office of Rep. Mike Simpson (R., Idaho); and Maggie Floyd DeCarlo, director of admissions at the University of Chicago's Harris School of Public Policy. Bill Foster, a former Fermilab physicist who served as a U.S. representative from Illinois from March 2008 to January 2011, had been scheduled to participate but was unable to attend.

The session was organized and moderated by Potomac Communications Group's Laura Hermann, who told the audience that the inspiration for the session came from her attending an AAAS meeting a couple of years ago and hearing Foster speak. "He had gotten tired of watching the budgets continue to shrink at Fermilab," Hermann said, "and decided during a special election to run for office." Foster won that race but was defeated in his 2010 reelection bid.

According to Hermann, only 2 percent of the current 435 members of the House of Representatives have scientific backgrounds (excepting medical doctors). "That means there's one physicist, one chemist, six engineers, and one microbiologist," she said. "Also, there are no senators with Ph.D.s at this time. And when we think about the type of challenges that are facing American society today, I think we can safely say there's probably a bigger role for scientists and engineers to play in policy-making. But under what conditions should a scientist or engineer consider becoming involved? What does it take to be a candidate, and what does it take to be elected?"

Dick Simpson began his remarks by cautioning against starting a political career with a run for high office, despite Foster's initial success. Politics, he said, is a craft and requires specific knowledge, just as do physics and engineering. "Or, perhaps more appropriately," he said, "like a carpenter or a plumber. Just because you saw a TV program on how to build a house, rushing out and just trying to do it without any practice, any understanding of how a house is put together, means the house is probably going to collapse."

Simpson

You need to learn the craft as you go along, Simpson said, and one good way to do that is to begin by working on other campaigns as a volunteer. And the higher up in the campaign you can get, the better you will be able to familiarize yourself with campaign structure and operation.

The former alderman also cautioned against assuming that a purely scientific mindset will work in the public policy arena. "Government decisions are not made by facts," Simpson declared. "They're made by votes. Having the facts may be useful, and you might be able to make an argument with them. But when I was a member of the [Chicago] city council, I used to make what I thought were brilliant speeches on the floor, and I never changed a single vote. It was the political maneuvering that got us what we finally wanted in terms of new laws, new policies, and changes."

Simpson also recommended some textbooks for those who might be considering a political career. "There are textbooks just like there would be for physics and engineering," he said. Simpson recommended a book he had written, *Winning Elections: A Handbook in Participatory Politics,* as well as *Campaigns on the Cutting Edge*, a compilation of essays published by Congressional Quarterly. "It is not a how-to book," he said, "but it tells you how to begin thinking about incorporating the newest techniques like social media, how to do micro-targeting, and what is the effect of all that."

"Having the facts may be useful, but it was the political maneuvering that got us what we finally wanted in terms of new laws, new policies, and changes."

Metzler agreed with Simpson's comments. "This is not something you jump into lightly," she said. "It's a huge undertaking. It's a very complicated sort of thing at any level, whether you're talking about local, state, or national." She added that she had spoken with Foster earlier—since he could not attend—and had asked him about his inspiration for running for office. "He told me that all scientists and engineers get frustrated when they see bad policy or illogical policy," she said. "So one reason to get involved is to fix that. And he said the other reason involves moving and shaping the debate or the discourse around certain issues to raise the quality of it."

Metzler

Boyer was eager to speak about the ANS/AAAS Glenn T. Seaborg Congressional Science and Engineering Fellowship, which provides a stipend to work in a congressional office (either the House or Senate) for one year, providing advice on science and engineering matters to a member of Congress and his or her staff. The purpose of the fellowship is to bring a reasoned and knowledgeable view of nuclear matters to Congress and to act as a science and engineering resource.

"So let me tell you about the fellowship," Boyer said. "Today, there are about 36 congressional fellows from AAAS. There are other fellowship programs . . . but this is the only scientifically focused one. What the fellows do differs from office to office. What I do is basically [brief] Congressman Simpson on issues, largely regarding nuclear energy, because he has INL [Idaho National Laboratory] in his district, but it can also be about natural gas, coal, geothermal, solar, whatever. It's just been a great opportunity. I would encourage everyone to think about doing it."

Boyer

DeCarlo also urged the audience to become more involved in the political realm, saying that as admissions director at a public policy school, part of her job is to encourage people whom she thinks would be good additions to the world of public policy-making to apply. "I try to bring as many different voices to those decision-making tables as possible," she said. "And if well educated, thoughtful people don't run for office, they're leaving the floor wide open for people who might not be nearly as qualified or effective, or as beneficial to a well-functioning society. Remember, we have two governors in jail in Illinois."

DeCarlo

Among Hermann's questions for the panel was one regarding the issue of money in politics, and whether the idea of creating political action committees to raise early money for candidates with science and engineering backgrounds was worth exploring.

In response, Metzler noted that Emily's List was created for just such a reason—to encourage abortion-rights women to run for Congress. "They recognized how critical

early money is to candidates and their long-term effectiveness and their long-term success," she said. "I think with the right leadership and the right enthusiasm, there absolutely could be an effort to do that for scientists and engineers."

"Your scientific background, your scientific training, does not dictate what your position would be on any given policy decision. I think there are scientists of all political flavors."

Simpson added to that endorsement, saying, "You're way behind a lot of other groups who have figured out that if they want particular policy results and good people in office, they're going to have to find ways to fund it."

The panel also fielded a number of questions from the audience, including one on the party affiliation breakdown of those members of Congress who are scientifically trained.

"Party doesn't matter," Metzler said. "The message I want to get across is that scientific questions inform policy decisions, but they are very different things. And for that reason, your scientific background, your scientific training, does not dictate what your position would be on any given policy decision. So for that reason, I think there are scientists of all political flavors."

Metzler also noted a "startling" fact that came out of a recent National Academy of Sciences colloquium on the science of science communication. "There were graphs that showed [that] if a scientist is talking about science, their credibility and respectability is huge," she said. "But if a scientist is talking about policy issues, not only do people lose all respect for the scientist's view on the policy issue, they also lose respect for the scientist's view on the scientific issue. So don't be mouthing off on the policy considerations of something unless you're being crystal clear that now you are speaking as a citizen versus speaking as a scientist."

Seismicity reexamined

A panel session on the reevaluation of seismic hazards at nuclear power plant sites was conceived as a discussion about the NRC's Generic Issue 199 and the implications of hazard estimate updates in the central and eastern United States. The session organizer and chair—Robert J. Budnitz, of LBNL—noted, however, that GI-199 has effectively been superseded by recommendations 2.1 (seismic hazard reevaluation) and 2.3 (plant walkdowns for seismic safety) in the report by the NRC's Near-Term Task Force (NTTF) on the Fukushima Daiichi accident and that the original focus on the central and eastern United States has widened to include all regions. In his opening remarks, Budnitz said that with the NRC following through on 2.1 and 2.3, walkdowns and seismic analyses—and, if deemed necessary, seismic probabilistic risk assessments (SPRA)—will be performed at all power reactors in the United States.

Seismic risk in the central and eastern United States has been rethought in recent years, and Norman Abrahamson, an engineering seismologist at Pacific Gas and Electric Company, addressed the matter of why hazard estimates have increased. He traced the increase to a 2004 revision of the Electric Power Research Institute's (EPRI) ground motion model. Although changes were made to various aspects of the point source stochastic model, Abrahamson cited as the main reason for the new model's increase the site parameter symbolized by the Greek letter kappa (κ), which accounts for damping in shallow rock. He said that this is the main reason for the model's increase in high-frequency content and that a further update based on inverse random vibration theory could adjust κ by removing some over-estimation for hybrid-empirical methods.

The NRC's intention is for the seismic walkdowns to be completed in about one year; the hazard reevaluations are to be done within four to seven years.

Although the August 2011 earthquake near Mineral, Va., was found to be slightly greater than the design basis quake for the two nearby North Anna power reactors, Abrahamson said that another parameter for the quake, known as stress drop, was in the average range, so there was no reason to question this aspect of the model. He added, however, that κ must be measured at a site, not estimated in a lab. Seismic instruments must be installed to determine κ, he said, and it could take 10 years to collect sufficient data. He encouraged the installation of free-field seismic measurement equipment at nuclear sites. (After the Mineral quake, Dominion Generation officials stated that they would install free-field equipment at North Anna.)

Jon Ake, senior seismologist in the NRC's Office of Research, provided the agency's perspective on the seismicity issue. He noted that while the post-Fukushima process has indeed succeeded the earlier pursuit of GI-199, the NRC's generic letter on the resolution of GI-199 was sent to all licensees, not just those in the central and eastern United States, and only later did NTTF 2.1/2.3 become the main focus. The NRC's intention is for the seismic walkdowns to be completed in about one year; the hazard reevaluations are to be done within four to seven years. Asked later by Budnitz what would happen if a reevaluation shows that a plant is at risk, Ake said that this is still under discussion, but it is possible that backfits would be required.

Greg Hardy, senior principal at the consulting firm of Simpson Gumpertz & Heger, referred to the combination of GI-199, the Fukushima accident, and the quake near North Anna as the nuclear industry's "seismic Bermuda Triangle." He stated his view that the two approaches traditionally used to assess potential hazard effects—the seismic margin assessment (SMA) and SPRA—are growing together. He cited the following as approaches to addressing a changing seismic hazard: demonstrating a small change, which then can be screened from further review; conducting a state-of-the-art SPRA or SMA; addressing high-frequency events through new, specific data on the seismic fragility of structures and equipment; retrofitting structures, systems, and components that have low capacity to withstand seismic damage; and installing new mitigation systems along the lines of the industry-developed FLEX concept based on diverse and flexible means for coping with external events.

Kimberley Keithline, senior project manager of Engineering and Operations Support at the NEI, summarized the industry's response thus far to the NRC's orders related to NTTF 2.1/2.3. The training of plant personnel for walkdowns is ongoing, she said, and the pilot walkdown was to take place in July at Dominion's Kewaunee pow-

er reactor in Wisconsin. All licensees had notified the NRC by June 10—within the agency's requested 90-day window—that walkdowns can be carried out at their plants in keeping with NRC-endorsed EPRI guidance.

In the subsequent panel discussion and opportunity for questions from attendees, the words "struggle" and "challenge" were used often in connection with meeting the schedule for 2.1/2.3, mainly because of the small number of available experts. One attendee said that there is already a high demand for PRA engineers in areas such as fire protection, and with prospects for Level 3 PRAs for power reactors. Keithline and Hardy, however, both said that there could be an even greater scarcity of structural modelers for the seismic reassessment work that is to be done at all power reactors.

What *do* women want?

Research has shown that women's attitudes toward nuclear energy are consistently less positive than men's, a phenomenon explored in "What Do Women Want? How We Can Build Support for Nuclear Energy," a panel discussion that immediately followed the session on science in politics.

The discussion, moderated by Potomac Communications Group's Mimi Limbach, featured Ann Bisconti, president of Bisconti Research Inc., Gwyneth Cravens, novelist and author of *Power to Save the World: The Truth About Nuclear Energy,* and Margaret Harding, president and chief executive officer of 4 Factor Consulting.

Limbach

Bisconti began the discussion with a presentation based on her 29 years of research on public opinion in the United States about nuclear energy, indicating that support has grown over the years. In 1983, Bisconti noted, the public was fairly evenly divided between those who favored nuclear energy and those who opposed it. But over the last three decades, support for nuclear energy has increased to a point where, even after the accident at Fukushima, two-thirds of the public hold a favorable opinion of it.

Bisconti

Bisconti's research also shows, however, that women's attitudes remain at a less favorable level than men's, although the gap is not as wide as in 1983. "Currently, 71 percent of men say they favor nuclear energy, compared with 57 percent of women," she said. In addition, Bisconti's research indicates that women are less knowledgeable about nuclear issues, have views that are less ardently held, and are less likely to associate nuclear energy with positive attributes.

In order to address this continuing nuclear gender gap, Bisconti stressed the need for more communication, especially from trusted sources.

"Communication is important, because women are less sure about nuclear energy, they're open-minded, they're willing to listen, and they're eager to learn more about the subject," she said. "But they're not as attentive to nuclear energy as men are, and they're less aware of the benefits. So getting their attention is a real challenge. Women and men both support nuclear energy as part of the low-carbon mix, and that's always a good message, to talk about nuclear energy as part of the mix. . . . And women and men rate nuclear scientists No. 1 as credible spokespersons on nuclear energy. So there's a real opportunity there, and a tremendous challenge."

"Women and men both support nuclear energy as part of the low-carbon mix, and that's always a good message, to talk about nuclear energy as part of the mix."

Cravens's approach to the topic was more personal, as she began by describing her own intellectual journey from an anti- to a pronuclear position. "I was afraid when Three Mile Island happened," she said. "I remember standing in my apartment in New York City and watching TV about TMI and thinking of the radioactive plume that was going to come to New York from Harrisburg and enter through the closed windows of my apartment and harm my daughter."

(Photo: Jerry Bauer)

Cravens

Cravens credits one particular person, her friend D. Richard "Rip" Anderson, a Sandia National Laboratories scientist and an expert in risk assessment and nuclear safety, as being the major force behind her change of heart.

"Rip put things in perspective," Cravens said. "Not all at once, never in a condescending way, never in a 'don't worry your little head about that' kind of way, but just very respectfully, without seeming like he had the superior mind, so that made me comfortable with him. Furthermore, I trusted him. I knew him socially, so I didn't think he was just going to lie to me because he worked on nuclear projects. By just taking some time, Rip led me carefully and gently and in a friendly way that I could trust through this labyrinth which is nuclear power."

Cravens's advice for changing people's minds—women's minds in particular—reflects her experience with Anderson. "Just be relentlessly friendly," she said. "That seems to work for me, anyway. And reach out to your neighbors and begin to move them from myth to fact. Just remember the things that you've been afraid of that were perhaps irrational but that you nevertheless had to deal with. Try to start the conversation, see what you have in common. Are you both concerned about climate change? Are you concerned about your children's health? What about places in the world that don't have electricity, where the lifespan is 43 years? Drop your prejudices. Move from us versus them to we."

Harding, former vice president of engineering quality at GE Nuclear Energy, offered her own unique perspective as a woman in a male-dominated industry.

Harding

"One of the nice things about having worked for a large corporation, especially one that was trying to figure out how to have women in leadership, was that they had lots of workshops to teach the men in leadership how to communicate with women," Harding said. "One of the things the woman who taught these workshops talked about was that we [women] like to all be even. We really hate it when somebody, especially another woman, is better than we are. So try to find ways to be equal to the people you're talking to and not come off as the superior, smarter person who knows more than they do."

Harding also described a difference between men and women when it comes to explaining their decisions. She said that according to her workshop trainer, women tend to give all of the reasons behind their

decisions, whereas men prefer to get to the bottom line quickly—a trait that may not work well when attempting communication with women. "If you're the guy standing up in front of the crowd and you say [nuclear energy] is perfectly safe, don't worry about it, you may not get very far," she said. "You need to build the story first."

Harding's major point is that there are some real differences in the ways women tend to receive information and talk about things. "One of the key things is building trust first," she said. "As the statistics that Ann [presented] showed, they [women] tend to trust us because we're the technologists and the engineers, but there's a little bit of distrust, and they want to know that you're part of the tribe. That doesn't mean you have to be a woman—there are so few of us in the industry that it's good that we don't require that you be a woman. But you have to make it clear that you care, that you have families, that you're concerned that your children can grow up healthy."

Women tend to give all of the reasons behind their decisions, whereas men prefer to get to the bottom line quickly—a trait that may not work well when attempting communication with women.

The technology-policy gap

As one of the world's most regulated industries, the nuclear industry is, for good or bad, heavily influenced by politics and policy. While it's safe to say that most nuclear engineers, scientists, and researchers would prefer to get on with their work and not have to worry about such governmental matters, nuclear policy plays an important role in how the technology is developed and implemented. For example, reprocessing spent nuclear fuel may be one way of dealing with the waste issue, but concerns about weapons proliferation shape policies governing that approach.

Bridging the gap between technology and policy was the subject of a panel session that brought together speakers with expertise in both fields. The panel members were Howard Hall, a nuclear engineering professor at the University of Tennessee's Institute for Nuclear Security; Melissa Scholz, a foreign affairs specialist with the National Nuclear Security Administration; Anthony Baratta, an associate chief administrative judge with the NRC's Atomic Safety and Licensing Board Panel; and Jeff Jay, from the Shaw Power Group's nuclear division at the Vogtle-3 and -4 project in Georgia.

Leading the session was Lenka Kollar, of Argonne National Laboratory, who asked the panel for insight into how practicing nuclear professionals can help bridge the technology-policy gap.

In looking at the overall issue, Jay said it is easy for those on the technical side to get trapped in a mind-set of their own specialized issues and to miss the larger, global picture. "As a political scientist by degree," he said, "what I've come to recognize in this technical industry that I've been in for so many years is that it's a constant challenge to think globally."

Hall, in agreement, said that schools need to instill in students a broader understanding of global issues. He added that students of nuclear technology need to realize that their education doesn't end once they receive their degree and take a job. "They need to understand that it is a springboard, not a destination," he said.

Baratta told the audience that it's important that they, as nuclear professionals, serve as educators to anyone they have interactions with and explain the industry to them. "You really have to get out there and explain to people that there are policy implications that drive what you do and how you do it," he said.

In discussing the impediments to teaching policy to technical students, Baratta said that he has seen a lack of appreciation among university administrators for such interdisciplinary education, and that they are usually reluctant to introduce political or social science courses into a nuclear curriculum. The divide between technology and policy in education, Baratta said, is comparable to that faced in genetic engineering.

It is easy for those on the technical side to get trapped in a mind-set of their own specialized issues and to miss the larger, global picture.

Remarking on the work of the Institute for Nuclear Security, Hall said that people from multiple scientific and academic disciplines—physicists, chemists, engineers, political and social scientists, and medical practitioners, as well as those in law, business, and the humanities—have a role to play in establishing an effective nuclear security program. Echoing that sentiment, Jay added that more social scientists are needed in the discussion of nuclear policy.

In regard to teaching policy issues to technical students, Scholz pointed to the work of the NNSA's Next Generation Safeguards Initiative, which was formed to strengthen and sustain international nuclear safeguards through policy development and international engagement. She said that the NGSI also works to develop human capital through education and training by supporting university curriculum development, internships, postdoctoral fellowships, and career development programs.

However, Scholz said, while the NGSI primarily teaches policy to a technical audience, it is equally important to teach technical issues to policy students. "Admittedly, it's easier to expose technical students to policy than to get policy students to really understand a lot of the technical implications that are at work," she said, adding that the two sides must meet somewhere in the middle.

New construction—worldwide

A panel session titled "New Nuclear Construction Around the World" was led by Paul Dickman, of Argonne National Laboratory, and Tom Sanders, of the Savannah River National Laboratory and a past president of ANS (2009–2010). The first speakers focused on the vital role of governments in supporting the expansion of nuclear energy.

Joyce Connery is the new director of nuclear energy policy in the National Security Council's Office of International Economics. The position, which includes a nuclear advocacy role, was created when the administration decided that nuclear energy should no longer be lumped together with renewables and conventional energy sources. In her position, Connery explained, she is able to keep tabs on visitors coming for trade talks and to ensure that senior officials are aware of any nuclear issues and how U.S. companies might benefit. For example, when the president is having a meeting about trade issues with a counterpart from overseas, she can ask his advisors to raise a particular topic. This, she said, is a fantastic tool for the industry. More generally, she said that her job is to ensure that all parts of the govern-

ment are conveying the same message on nuclear trade. Nuclear safety is also among her responsibilities, and Connery makes certain that government officials know the policy goals in this area, and that the goals are supported at international meetings.

Connery challenged some of the hype around shale gas, noting that it may be better than coal with respect to climate change, but that nuclear is significantly better and must have a major role in providing baseload power. She also said that while the United States is moving ahead with fracking, there is already a backlash in Europe against it due to environmental and other concerns, and so it might not be such a game changer there. Elsewhere, there is still a great deal of interest in introducing and expanding nuclear programs.


Connery

President Obama's approach, Connery noted, is to support a large portfolio of energy sources. Nuclear has big hurdles, such as its capital cost. Domestically, utilities do not now have the balance sheets to absorb the risk of undertaking nuclear projects, she said, and creativity will be needed to find ways to share that risk. Investors are certainly going to keep an eye on the Vogtle project, she noted, the success of which will be vital to attracting investment in new plants. Internationally, the United States has a good product to sell, Connery said, noting that in her experience, many countries want to have the United States involved in their new-build programs. In her view, small modular reactors (SMR) have a lot of potential. In the United States, SMRs will help to sustain not only the supply chain, but also America's intellectual capacity, keeping students interested in nuclear energy because they see a future in it.

SMRs will help to sustain not only the supply chain, but also America's intellectual capacity, keeping students interested in nuclear energy because they see a future in it.

Connery applauded ANS for the information made available on its Web site when the Fukushima Daiichi accident occurred. She said that she found it useful when putting together situation reports that were sent out to government offices as the accident was unfolding. She was also involved in setting up a Fukushima emergency operations center, which monitored the news coming out of Japan and elsewhere. One of its screens was always on the ANS Web site "because of the great information you had," which was clearly displayed and accessible.

The second speaker, Park Ro-byug, ambassador for South Korea/U.S. nuclear cooperation, described his country as a strong advocate of international agreements in nuclear energy matters. Bilateral agreements, he said, are essential instruments to achieving three major goals: facilitating cooperation in nuclear research and development, industry, and other areas; controlling nuclear exports and the retransfer of materials and equipment, thereby promoting nonproliferation aims; and advancing strategic partnerships among nuclear countries, thereby setting up cooperative networks around the world.

The changing global nuclear environment, Park said, has to be considered when negotiating agreements. New global players, such as China and India, are emerging, with very competitive nuclear markets developing, he said, and as about half of the nuclear plants now under construction are in Asia, bilateral agreements are increasingly important in this region.

There are also serious global nuclear issues where cooperation is vital, such as the proliferation risk presented by Iran and North Korea and rebuilding public acceptance and trust of nuclear power after Fukushima. Also, Park said, there is a need for an effective and sustainable solution to spent fuel management. He stated his belief that bilateral agreements can help deal with these challenges and can also provide a solid basis for developing a network of countries able to take a joint approach to nuclear challenges. Korea is taking a lead, he said, by concluding many nuclear bilateral and multilateral cooperation agreements in a variety of areas, such as fuel cycle activities, nonproliferation, nuclear construction, and operations. In the case of the contract awarded to a Korean consortium to build a nuclear plant in the United Arab Emirates, three bilateral agreements were needed. Besides the agreement between the governments of the two countries to conclude a nuclear supply contract, both countries had to sign separate nuclear cooperation agreements with the United States to allow the transfer of equipment that utilizes U.S. technology and the retransfer of U.S.-origin fuel.

Park also spoke of Korea's aims in negotiating a new nuclear cooperation agreement with the United States (the so-called 123 Agreement), as the current one expires in 2014. With no fossil fuel resources—not even shale gas—Korea considers nuclear a primary and strategic energy source and would like to upgrade the agreement to be on a par with that of Japan, so that it can develop vital fuel cycle technologies to ensure future energy supplies. In the meantime, Park said, Korea is providing good support to the United States in its policy to strengthen the global security, safeguards, and nonproliferation agenda. He said that he firmly believes that not only is it in Korea's interest, but also in the United States' interest to boost cooperation.

Russ Bell, director of new plant licensing at NEI, said he was extremely pleased `that nuclear plants are once again being built in the United States, but he cautioned that finishing the first plants on or near schedule and budget is vital. There are also particular challenges under the 10 CFR Part 52 licensing process, he said. As a first-of-a-kind project, changes during the course of construction are inevitable. An effective process for obtaining approvals must be in place, he noted, or the advantages of the combined construction and operating license will be lost as a result of the additional time that will be required. To its credit, Bell said, the NRC has established a new procedure to approve changes—the preliminary amendment request process—whereby a request for a preliminary amendment approval can be submitted along with the main license amendment request. The NRC approved the first such request, allowing the change to proceed, while the full amendment request is being reviewed. Ultimately, that amendment request can be denied, of course, so proceeding with that change is done at some risk. Nevertheless, this process is key to making the construction of a nuclear plant feasible under the Part 52 license, he said.


Bell

Another issue likely to come up during construction is the inspections, tests, analyses, and acceptance criteria (ITAAC) process, which has never been tried before. (ITAAC sets out criteria that a plant must meet before it's allowed to load fuel.) NEI is developing guidance with the NRC to clarify how it should work. "We need to make that process succeed," he said.

Bell also noted that there is a lot of ex-

citement about SMRs, which have broad, bipartisan support in Washington; even some critics of nuclear power see benefits. A number of major companies, including Bechtel and Fluor, as well as potential investors, are seriously interested in SMRs, he said. He listed a number of the advantages of SMRs: enhanced safety and security; smallness, but with scalability; viability in low-growth markets; modularity and reduced construction cost; and suitability for many sites and applications. SMRs also serve a number of U.S. policy goals, such as restoring manufacturing capability and jobs. There are hundreds of old coal-fired facilities ready to be replaced, presenting a great market for SMRs, Bell said.

But there are challenges here, too, Bell noted. NEI is working with the NRC to clarify a number of issues, such as emergency planning, security, and staffing, to ensure that any requirements imposed make sense for SMRs. Some of the assumed advantages of SMRs depend on having solutions to those issues, he said, and if the answers are right, SMRs can fulfill their promise. He also noted that the designs the DOE is expected to select this summer for development are pressurized water reactors. Other technologies, such as gas-cooled and liquid metal–cooled reactors, have another set of issues that will take longer to sort out. In conclusion, Bell said that nuclear support is broad, deep, and vigorous, even after Fukushima, especially for SMRs.

The final speakers covered two of the most exciting new projects that are now under way, one in Eastern Europe and the other in the Middle East. Although located in Lithuania, the Visaginas project is being shared with its two Baltic neighbors, Estonia and Latvia, which have provided strong support since the project was originally proposed. The project was described by Aurimas Kontautas, of the Laboratory of Nuclear Installation Safety at the Lithuanian Energy Institute, which is a leading international research organization and the technical support organization for VATESI, the State Nuclear Power Safety Inspectorate.

The site at Visaginas is adjacent to the Ignalina nuclear plant, which had housed two Soviet-era RBMK reactors, similar to the Chernobyl reactors, that began operating in the 1980s. Lithuania took control of the plants upon the collapse of the Soviet Union in 1991. When negotiating to join the European Union in 2004, the government was forced to agree to shut down both of these units, with the first closing at the end of 2004 and the second at the end of 2009.

The two Ignalina units not only supplied most of Lithuania's electricity, Kontautas said, but also allowed for the export of a considerable amount to its neighbors. The decision to close the plant was made against the wishes of Lithuania's citizens, who strongly supported the plant's continued operation. With this support, however, the government began developing a new nuclear project, he continued, and in 2007, the three Baltic countries and Poland agreed to undertake a joint nuclear project, although Poland later withdrew. The project's business model, Kontautas explained, which was completed in 2009, determined that attracting a strategic investor with nuclear experience to join the project would be the best approach. He said that in May 2011, following the assessment of proposals from Hitachi and Westinghouse, Hitachi was chosen to become the strategic investor and, along with its partner, GE Hitachi Nuclear Energy, to build an Advanced Boiling Water Reactor, which is expected to start operating between 2020 and 2022. In March 2012, the basic agreement was signed with Hitachi, which now has a 20 percent stake in the project, Kontautas added.

The UAE government's nuclear policy is based on complete transparency and a commitment to high standards of safety, security, and nonproliferation.

The other important new-build project—and the first in the Middle East—is the Barakah plant, which is now under construction in the United Arab Emirates. Hamad Al Kaabi, the UAE's permanent ambassador to the International Atomic Energy Agency, described the background of the government's decision to develop a nuclear program, along with the extensive infrastructure that has to be created.


Al Kaabi

In 2007, Al Kaabi said, a study of the country's future energy requirements determined that electricity demand will triple by 2020. A working group thoroughly examined various options, he added, including renewables and a range of hydrocarbons. With regard to renewables, the UAE is aggressively pursuing various technologies, including solar, but these can satisfy only a small proportion of demand, and because of the disadvantages of fossil fuels, nuclear was ultimately decided on as a viable option.

According to Al Kaabi, the government's nuclear policy is based on complete transparency and a commitment to high standards of safety, security, and nonproliferation. The nuclear program was also required to provide long-term sustainability, which means, he said, that it must be of an adequate size to support a viable commercial industry and the development of significant infrastructure, including a sustainable pool of nuclear academics, professionals, and other skilled workers; the creation of educational, research, and training institutions; and a strong regulatory system.

Taking lessons from other projects, particularly those suffering delays due to construction problems, Al Kaabi said that the UAE looked for ways to save time in other areas, such as the tendering and contracting process, which resulted in the contract being awarded—to a South Korean consortium—in a relatively short time. Good progress has also been made in putting in place the necessary infrastructure for a project, he said, including a regulatory system under the Federal Authority for Nuclear Regulation (FANR), all of which was verified by IAEA review missions that found that the country understands the long-term commitments and responsibilities necessary for implementing a nuclear program.

In line with its commitment to the highest standards of safety, Al Kaabi continued, the UAE responded to the Fukushima accident by issuing a statement saying that it would adopt any lessons learned from the event and would generally embrace the approaches being taken internationally. FANR also issued a request to the licensee, the Emirates Nuclear Energy Corporation (ENEC), to assess the accident and lessons learned and to submit a report that would become part of the construction license application (the license was granted in July—*NN,* Aug. 2012, p. 176). Al Kaabi noted that ENEC's assessment did not highlight the need for any major changes in the design, although additional improvements in terms of withstanding a severe accident were identified. FANR has added these to the construction license.

At the end of his presentation, Al Kaabi noted some lessons for countries embarking on a nuclear program. He recommended focusing on advanced designs of existing plants (although he acknowledged that there are not many), on the ability of the supplier and supplier country to deliver the project on time and budget, and on developing a strong, supportive partnership with the supplier and supplier country. Since a country that is developing a plant from

scratch will not have much infrastructure or expertise, Al Kaabi said, both the supplier and the customer must consider a package deal in which the customer is provided with support and assistance from the supplier (for example, training the customer's workforce) and the supplier country's governmental agencies (such as the national nuclear research institute and its regulatory agency). These considerations, he said, were a major factor in the UAE's choice of the South Korean consortium.

The spent fuel dilemma

Without a geological repository or consolidated storage facility, spent nuclear fuel and high-level waste continue to sit at both operating and decommissioned plant sites. And without a clear plan to deal with the materials, the ability to license the construction of new plants or extend the operating licenses of existing plants is in jeopardy.

The overturning of the NRC's waste confidence rules by an appeals court in June (*NN,* July 2012, pp. 71 and 18), the discontinuation of work on the Yucca Mountain Project and subsequent recommendations by the Blue Ribbon Commission on America's Nuclear Future (BRC), and the lawsuits stemming from the continued collection of Nuclear Waste Fund fees, as well as storage and transportation regulations, are just some of the issues raised by Steve Stamm, of Shaw Nuclear, during a panel session titled "Solving the Spent Fuel Dilemma."

"Obviously we've got a lot of spent fuel that is sitting in pools and at sites, including decommissioned plants," he said. "There are a number of technical issues that are going to be associated with that and [with] getting [the spent fuel] to a central or regional repository, if and when we get to that point."

Ann Bisconti, president of Bisconti Research, provided some insight into public perceptions and opinions about spent fuel and radioactive waste. In researching what is on people's minds when it comes to spent fuel and nuclear waste, Bisconti said, learning what is *not* on their minds is just as important. According to her research, she said, nuclear waste is not on their minds.

Bisconti

When asked why some people oppose nuclear energy, Bisconti said, "Nuclear waste is not the prevalent reason. It never has been and it is not now." In fact, she said, nuclear waste is more of a concern among those who favor nuclear energy, as they see it as a barrier to growth. "However, when you bring it up, waste is a concern to people." Then it becomes "scary."

One of the problems, and one of the reasons nuclear waste ignites fear in the minds of the public, Bisconti said, is that most people cannot visualize what spent fuel and nuclear waste look like. When asked to draw a picture of how they thought spent fuel/nuclear waste is stored at a nuclear power plant, most people drew the familiar, clichéd images of barrels with toxic fumes coming out. The "glowing green ooze," Bisconti said.

"So we're talking about a public that clearly does not have an image of spent fuel/nuclear waste in their minds," Bisconti said. "So the most important thing to remember whenever you're talking to anybody on the subject of nuclear waste is you have got to give them a picture. You have to help them visualize what it is you are talking about."

Bisconti also noted that 80 percent of people polled feel that the U.S. government should develop a final disposal facility, and that people want to know that at some point in time, the spent fuel/nuclear waste will be stored somewhere other than on site at individual power plants.

This topic was followed up on by Stefan Anton, vice president of engineering at Holtec International, who provided an overview of the spent fuel issue from the perspective of a company that manufactures products for managing the back end of the fuel cycle.

Anton

According to Anton, the on-site storage of spent fuel may be seen as a big problem, but the practice is technically viable. "If you look at the fine details, you may think we have more problems than solutions," he said. "But if you step back and realize that we have such a large number of fuel assemblies that are stored safely, and for quite some time, I think we can say that there is nothing principally wrong with the approach we are taking."

The problem, Anton said, is that the public doesn't agree with this strategy. While from a technical perspective, time may be on our side (the longer spent fuel is stored on site the less active it becomes and the easier it is to handle), from a public relations standpoint, time is against us, as the longer the material stays on site, the bigger the problem will be in the eyes of the public.

A decision has to be made to move the issue forward, he said. "That is something that we are looking for as an industry, that there is some kind of direction and decision to move forward with actually doing something that shows the public that there is a way of dealing with these things."

The recent recommendations of the BRC provide some guidance on moving forward, and that was the basis of a presentation by Adam Levin, director of spent fuel and decommissioning for Exelon Generation, titled "Technical and Regulatory Paths Forward for Accelerating Implementation of the Blue Ribbon Commission Recommendations."

Levin focused on three of the eight BRC recommendations: establish one or more geologic repositories, develop consolidated storage facilities, and prepare for the eventual large-scale transportation of spent fuel and high-level waste.

"The on-site storage of spent fuel may be seen as a big problem, but the practice is technically viable. There is nothing principally wrong with the approach we are taking."

Working from these points, Levin proposed a waste storage and transport approach that defines the spent fuel canister or cask as the waste form as opposed to the fuel assembly. In this way, the canister provides the necessary storage and transportation functions without relying on the integrity of the fuel cladding. The cladding integrity would "provide defense in depth through risk insights, but it is not required to demonstrate storage or transportation system safety," he explained.

Making the canister the waste form "really does provide the greatest level of public health and safety," Levin said. It minimizes the handling of fuel, applies additional defense in depth, and allows flexibility in transporting the material. Levin noted, however, that there are several hurdles to such an approach, including NRC regulations, the DOE's identifying the fuel assembly as the waste form in its standard contract for disposal of spent nuclear fuel and/or high-level radioactive waste, and the ability to demonstrate that the canisters are compatible with whatever repository design is eventually chosen.

Taking up the transportation issue was Robert Capstick, director of regulatory affairs for the Yankee Companies, a group that includes the decommissioned Con-

necticut Yankee, Maine Yankee, and Yankee Rowe nuclear power plants. All that is left of the three plants are their independent spent fuel storage installations, which combined hold 115 spent nuclear fuel casks and nine casks of Greater-than-Class-C waste.

Capstick

"From the perspective of the shutdown plants," Capstick said, "with respect to solving the spent fuel dilemma, the solution will involve the movement of the existing canisters that are stranded at these sites, and the effort to prepare them to do so should begin sooner rather than later."

Despite the lack of a place to ship spent fuel and nuclear waste, the DOE can take actions to address transportation issues and logistics, Capstick said. "Although the location of a future consolidated interim storage site is not yet known, the locations of the shutdown sites are known, and there's no reason to delay evaluating infrastructure needs around those sites to address the upgrades that will be needed to allow future fuel shipments, regardless of where the material is destined to go."

Moving to address transportation issues will demonstrate to the public and to state and local officials that the DOE is taking actions to meet its obligations to take responsibility for the spent fuel and waste, Capstick said.

The difficulty in getting the ball rolling was underlined by Phillip Niedzielski-Eichner, of the DOE's National Nuclear Security Administration, who noted that the BRC's plan for siting storage and disposal facilities requires negotiations and cooperation among federal, state, and local governments.

But that's not to say no action is being taken. Niedzielski-Eichner pointed to a current internal review of the BRC's recommendations by the DOE and all of its offices that have an interest in the issue, including the NNSA and the offices of Nuclear Energy and Environmental Management. The purpose of the review, he said, is not only to assess the recommendations but to supplement the BRC's work.

For example, Niedzielski-Eichner said, the BRC recommends the establishment of an independent, federally chartered organization to manage nuclear waste, and there are numerous models for such an agency. The internal review will provide guidance to policymakers on choosing the best model, he said.

Niedzielski-Eichner also noted that there are a number of incentives for action on the part of the government, including the "partial breach of contract" liability the government holds for not taking possession of the spent nuclear fuel—a liability that is currently being paid by taxpayers. National security issues and post–Cold War cleanup obligations are also drivers for action, he said.—*E. Michael Blake, Tim Gregoire, Dick Kovan, and Michael McQueen*

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