ANS WINTER MEETING

# Deploying new nuclear technologies

THE 2002 ANS Winter Meeting in Washington, D.C., was held only weeks following the decisive November mid-term elections, and already there was a buzz about how the new tilt in power would affect several issues relevant to the nuclear industry.

"Congress will once again try to produce an energy bill," noted the meeting's general chair, David Christian, Dominion Energy's senior vice president of nuclear operations and chief nuclear officer, during the ANS Plenary Session on November 18. "Appropriations for research projects and the national labs will be debated. Homeland security will likely dominate the landscape. We still need to get renewal of Price-Anderson legislation. And, yes, there's the issue of getting the funding to ensure the progress is sustained and accelerated for the Yucca Mountain project."

Congress is not usually in session during the ANS Winter Meetings in Washington, D.C.—which are traditionally held there during even-numbered years—but was so during this meeting, which took place November 17–21. Taking advantage of the opportunity, attendees were invited by ANS President Harold Ray to coordinate with ANS visits to members of Congress during the week to impress upon them the importance of the issues Christian listed.

The more than 1200 meeting registrants, however, did not have to step outside the hotel to hear the government's perspective on the key nuclear issues. Five of the six speakers during the opening plenary session work or have worked for the U.S. government. Higher-up voices from within the U.S. Senate, the Nuclear Regulatory Commission, a national laboratory, and NASA, as well as that of a former White House chief of staff, were all represented at the plenary. Each in his own way cogently addressed the meeting's theme, "Building the World Nuclear Community—Strategies for the Deployment of New Nuclear Technologies."

Greater weight, however, was decidedly given to the second element of that phrase.

The interest in deploying new nuclear technologies in the United States is the result of the "vastly improved performance" of the current generation of nuclear power plants over the last decade, NRC chairman Richard Meserve mentioned at one point during the session. Industry-average capacity factors have increased from 65 percent to nearly 90 percent during that time, and the annual amount of electricity generated by nuclear plants grew by 40 percent with eight fewer plants on line, he said.

Meserve

"At the same time, we have seen safety performance improve substantially, with the number of significant events declining by more than an order of magnitude, and other safety-related performance indicators showing similar trends," Meserve said. "These factors have combined to reduce the production cost of nuclear-generated electricity to the point where it is, on average, less than that from coal or natural gas."

Among the matters emphasized throughout the plenary session were the industry's opportunities in hydrogen production, the need to put the world's store of fissionable materials to peaceful use, and the NRC's development of a "technology-neutral" model of regulation. The morning was particularly highlighted by the challenging yet well-received words of a prominent former governor and White House staffer on what he called "the great failure" of the nuclear industry—as well as its new opportunity—and by the current NASA administrator's outlining of the astounding possibilities that await when using nuclear technology in space, which would help the agency "inspire the American people with bold and stunning feats of exploration."

***Major themes of the plenary:***

- *U.S. nuclear plant safety has improved*
- *Congress recognizes nuclear's role*
- *Fixing proliferation with new fuel cycles*
- *Doing technology-neutral regulation*
- *End wrangling within the industry*
- *A grand plan for space nuclear power*

*View from the Hill*

Throughout his career, Sen. Jeff Bingaman (D., N.M.) has paid particular attention to the nuclear industry. In February 2001, he introduced a bill, S. 242, that called for significant increases in investment by the Department of Energy in university-based nuclear engineering programs. As chairman of the Senate Committee on Energy and Natural Resources, Bingaman incorporated provisions of S. 242 into the comprehensive energy bill. Bingaman said the provisions "enjoyed great support" in the Senate and in conferences with the House of Representatives.

"I believe that members of the House and Senate have begun to recognize that nuclear technology has played a role in a great deal more than just the production of energy," Bingaman said. "It's clear to me and to many of my colleagues in congress that nuclear technologies play important roles in national security. They play important roles in such diverse areas as manufacturing, health care, environmental restoration, and space exploration. As such, it's imperative

that we maintain an adequately maintained nuclear workforce.

"I applaud the universities and the Department of Energy for the work that they have been doing to boost enrollments in nuclear engineering programs," Bingaman continued. "And I understand that those enrollments are up over 50 percent over just a few years ago. I expect a large part of that increase is due to the renewed attention that's being paid to nuclear technologies as a way to meet our energy needs and to enable space exploration and to ensure our national security."

One possibility for nuclear energy that Bingaman foresees playing a bigger role in coming years is in the field of hydrogen production. The Bush administration's long-range plans to develop fuel cells for powering vehicles—the Freedom CAR initiative—has driven research on developing a hydrogen-powered fuel cell vehicle for consumer use. Of course, Bingaman noted, one of the difficult issues is how to produce the enormous volumes of hydrogen that would be required to fuel such vehicles. Several current processes release carbon dioxide into the atmosphere.

"I'm encouraged to see that the Department of Energy is investing in research on emissions-free hydrogen production techniques," Bingaman said, "including nuclear-based water-splitting cycles. And I encourage DOE to accelerate that research as part of this overall vision that they have expressed of moving us to a hydrogen-based energy economy."

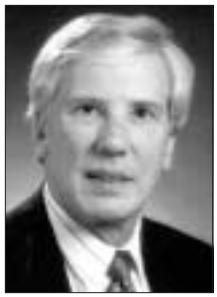
*Nonproliferation in the next era*

C. Paul Robinson, director of Sandia National Laboratories, emphasized the nuclear security needs and nonproliferation concerns that must be addressed in what he called the second nuclear era. To underline the dangers, Robinson brought up a recent study that estimated the amounts of high-enriched uranium (HEU) and plutonium available in the world: 20 tons of civilian HEU, 1750 tons of military HEU, 250 tons of military plutonium, and 914 tons of civilian plutonium.

"Just putting the numbers in rough form, you realize this represents a potential worth, converted into weapons, of many hundreds of thousands of nuclear weapons," he cautioned.

And therein, Robinson said, lies the problem that must be solved: Either the peaceful use of these assets is to be promoted and enabled, or their existence will continue to be worried about well into the future. "We can use this fuel, not only the civilian fuel but the military fuel, for power production. This is the preferred path. Or else we've got to worry about the continuing existence of materials, not only tomorrow but for the foreseeable future."

Robinson said the problem can be solved through new fuel cycles that consume these materials as they supply energy. Exportable, efficient burners, Robinson believes, can be designed and built with an East and West industrial partnership, such as those being pursued between U.S. and Russian national laboratories and research centers. Uses of all the fuels—uranium, plutonium, recycled fuels—and focusing on systems that would provide a significant breeding factor, are the directions for the future, Robinson said.



Robinson

"We believe the time is right for this new beginning. The end of the Cold War, the events of September 11, and Russia's support have brought us to the threshold of a new era of cooperation, common front, and what we think is the best opportunity for shared management of past, present, and future shared nuclear stresses.

"It is a time for visionary leadership, the best technical ideas, to provide a basis for peace with prosperity and reduce some of the tensions that will have to grow as the needs for finite resources continue [to grow] around the world.

"Finally," Robinson concluded, "truly the swords-to-plowshares approach is consistent with the directions we will pursue in achieving proliferation resistance, both through partnerships and improved transparency of the technology that we've been working on for the last two decades."

*Regulating new technology*

Noting that the NRC should encourage the development and deployment of "appropriate" new technology, NRC commissioner Richard Meserve reviewed the regulatory programs in place to evaluate new technology and said that the NRC is attempting to develop a "technology-neutral" model of regulation.

The NRC is trying to establish a regulatory approach to streamline the licensing of new plants and to reduce uncertainty in the licensing process, Meserve said. There are three major elements in this approach: the first, design certification, has already been tested; the second, early site permits, is about to be tested; and the third, issuance of a combined construction permit and operating license, has yet to be exercised, he said.

Design certification is, in essence, regulatory approval of a standardized design through rulemaking. Once a design is certified, it may be referenced in an application for a combined license, without the need for review of any technical issues resolved during the certification process, Meserve said. An early site permit comprises advance approval of a potential site for a nuclear power plant, which may then be banked for future use. Once again, Meserve noted, issues resolved in the early site permit review are not re-reviewed in the combined license process. Once the license is issued, the plant may be constructed and then proceed to operation, after the NRC finds that the as-built plant conforms to the license conditions, he said. "These changes reduce uncertainty by making regulatory decisions as early in the process as feasible," Meserve added.

The NRC has certified three designs: GE's ABWR (Advanced Boiling Water Reactor), Combustion Engineering's System 80+, and Westinghouse's AP600. A fourth design, Westinghouse's AP1000, is currently being reviewed, and the NRC is engaged in precertification discussions with vendors representing five other designs, Meserve said. "We expect the early site permit process to be tested within the next year, when we receive three applications for such permits. Only the combined license process will remain untested. For that, we must await a licensee who determines that it is time to build a new nuclear plant."

The three designs that have been certified and the one that is currently under review represent relatively modest advances on the technology of operating plants, Meserve said. The ABWR and System 80+ are large light-water reactors that retain many of the features of the newest operating plants. It was, therefore, possible to review these plant designs with relatively little change in the existing approach to reactor regulation. The AP600 and AP1000 are both "passive" Pressurized Water Reactors—they use safety systems that do not rely on pumps, but operate using either stored energy or natural processes. To support certification of these designs, Meserve said, Westinghouse performed extensive testing to demonstrate the performance of elements of the passive safety systems and to develop data to permit plant performance to be modeled analytically. The NRC also performed confirmatory testing to support development of its own analytical codes and to examine passive system performance beyond the plant's design basis, Meserve said. Since these plants are cooled and moderated by light water, the technical issues can, for the most part, be resolved using current regulations.

"We need to look to a future, however, in which other types of reactors may be brought to us for review," Meserve noted.

He said that one design that may soon be submitted for certification is the gas-turbine modular helium reactor, or GT-MHR. Although the NRC has reviewed gas-cooled reactor designs in the past, its regulations deal almost exclusively with technical issues arising in water-cooled reactors, Meserve said. "This raises two potential problems. First, the performance of the fuel in the GT-MHR is an essential part of the

plant's safety case and the NRC has little data on this type of fuel. Second, and even more fundamental, significant modification of our LWR-based regulatory system will be necessary to assess the GT-MHR design. Thus, the NRC's current efforts extend to the establishment of the technical capability within the agency to evaluate novel reactor designs."

The revision of the NRC's overall regulatory approach may provide an opportunity to make use of increasingly sophisticated methodologies for the quantitative assessment of risk, he said.

"Ideally, we might seek a regulatory structure that is applicable to any reactor type—a regulatory system that is 'technology-neutral.' We are currently undertaking work in developing such a regulatory system.

"I do not want to minimize the effort that will be required to build a new risk-informed, technology-neutral regulatory structure. It will take a significant investment of both time and resources. But the payoff, in terms of a consistent approach to the regulation of new technologies, could be substantial, because we could avoid the need to 'reinvent' our regulations every time we look at a technology that has not previously been considered."

*Failures and opportunities*

One problem the nuclear industry often encounters, general chair David Christian pointed out, is that those professionals who understand the technical aspects of the nuclear field often do not have or grasp the political know-how to maneuver deftly on political stages. Likewise, those who understand the politics often miss the technical side. Yet accountability in the political ring is a direly needed skill for the nuclear industry, stressed John Sununu, one-time chief of staff to President George H. W. Bush and a former three-term governor of New Hampshire, who holds a Ph.D in engineering from the Massachusetts Institute of Technology.

Sununu was governor during the industry's midnight hour—the contentious commissioning in the 1980s of the Seabrook station. "I was governor for three terms in New Hampshire. There was only one political issue I was ever attacked on, and that was Seabrook. And it was a very difficult time," Sununu remembered. "My single biggest problem was I could not get the professionals in nuclear power to come up and address in a constructive way the technical issues that [opponents] were challenging the licensing of that plant on. It was then and is, in my opinion, today the great failure."

And if the professionals will not stand up and take the risk of public accountability and make the statements in a way that are clear and unequivocal, then those professionals have no right to criticize nontechnical policy-makers for failing to take the same kind of risk, Sununu emphasized.

"We must understand, whether we like it or not, until more of us get more involved in the political process, that in the long run, the ultimate decision on hard issues of this nature will be made by people who have no instinctive feeling about the difference between a part per million and a part per billion. And, therefore, we must frame it in ways that they can understand the advantages, the ramifications, the implications, and the potential consequences."

If there is a problem with the implementation of nuclear power in the United States, in Europe, or anywhere else in the world, it is the industry's fault because it failed to communicate what it knows in a way that makes those who make policy comfortable enough to move things forward, Sununu said. "And it will not change. It will not change—underline all those words—until we accept the discomfort of public participation in the debate."

**"If we have four camps and everyone is sniping at each other, it is easy for the opposition to point out that every idea is opposed by 75 percent of the professionals."**

Sununu believes, however, that there is a new opportunity for the industry to begin again and renew its political responsibility. "There's an odd opportunity. Because the industry lost so badly—and it did lose badly . . . that in a sense the public is now ready. It has not been biased by the hammering of the opponents and the Luddites. It has not been scared to death by the issues of nuclear power and the trauma of a nuclear explosion or the myth of a nuclear explosion occurring at a power plant.

"There is a clean sheet of paper that we can write on, if we write on it intelligently and we write on it patiently and we write on it effectively."

Sununu said he saw evidence this past year during the legislative wrangling over Yucca Mountain. "I can tell you, never in my professional life [have I] found a public so receptive to constructive technical arguments of the issue. And I think we failed to take full advantage of the opportunity even though we succeeded in getting the policy approved with a Congressional vote. I think we failed to take advantage of the slight tuning in of the public on that issue and didn't fill, if you will, the airwaves and the press with good, meaty, factual [information on] what the public benefits are of these systems that we support and we feel can make such a tremendous contribution to quality of life around the world for future generations.

"I believe that opportunity is still there. And I believe if we make a concerted effort in educating ourselves in how to speak to the public and then take advantage of speaking to the public to educate them, it will create a groundswell of support for the kind of policies that can make the difference."

Last, Sununu emphasized that it is important for the nuclear energy industry to stop its infighting.

"I have been trying to talk to people on the technical side, with whom I have a historic relationship in the area of nuclear power. And they are still tugging and wrestling, whether it is for funding or for ideas, about the concepts that they hope will not be the next generation, but really the *next* next generation of nuclear power. The argument is on fuel cycles. The argument is on alternatives for waste disposal. The argument is on how to deal with the issues of proliferation. The argument is on what we ought to do about available energy content in our already-utilized fuel.

"All these issues have created camps within the technical community. And as each one tries to define the perfection, if you will, of their own idea, they unfortunately yield to the temptation of sniping at the others.

"If we have four camps and everyone is sniping at each other, it is easy for the opposition to point out that every idea is opposed by 75 percent of the professionals.

"Understand that is a reality. And we must find a way to argue amongst ourselves in a way that is constructive and technically appropriate and is the heart and soul of science and engineering progress. But do it in a manner that does not undermine the progress that has to take place for the technology and the industry as a whole.

"It may sound like a minor point, but it is so critical that we mature to that point and recognize that the pursuit of the perfection should not prevent us from implementing the good technology that is available today and in the short term."

Nonetheless, Sununu concluded that he is "absolutely excited" about the potential for rebirth of an industry that at one point had to retrench. "I think there is a second generation of activity that can constructively be looked at to begin to take its first aggressive steps in the next three- to five-

year period, and I hope that it lays the foundation for what in fact will be a third generation that may finally meet the promise of what nuclear power was supposed to be in dealing with the really long-term energy needs of a world whose quality of life is absolutely dependent on the availability of energy."

Sununu was warmly applauded.

*The Age of Steam*

One of the areas where new uses of nuclear science and technology can certainly be expected is in the space program. Nuclear systems used for propulsion and power conversion technologies appear to be the key to not only long-term space exploration, but human space exploration. NASA administrator Sean O'Keefe relayed NASA's vision of using nuclear energy to advance beyond what he called "the initial *Nina, Pinta,* and *Santa Maria* stage of space exploration, where we are now."

O'Keefe said nuclear technologies can be used to send sophisticated robots and human explorers anywhere in the solar system to stay as long as needed in order to address the most fundamental science questions—questions such as, How do planets form and evolve? How can exploration of the solar system revolutionize our understanding of physics, chemistry, and biology? Does life in any form, either simple or complex, carbon-based or otherwise, exist elsewhere other than on this planet earth?

O'Keefe

"The fact is we can barely scratch the surface of these kinds of questions because of the enduring, persistent limitations that we have today of the technology of power generation and propulsion," O'Keefe said. "Indeed, at this particular stage . . . we really are at the beginnings of space exploration. We are in the Age of Sail, as it were, of that particular activity, given the persistent reliance upon the fundamental laws of physics that have been with us all along. We have not been able to transcend those."

As part of NASA's plan for future space exploration activities, the agency has determined that it is "absolutely necessary" to develop new power generation systems, O'Keefe said. "Our goal is to enhance the ability of our robotic spacecraft to perform complex scientific investigation of the planets, and in some point in the future to enable human explorers to live off the land of planetary bodies," he explained.

To help advance this goal, this year NASA developed the Nuclear Systems Initiative. The agency asked Congress for nearly a billion dollars over the next five years "as a down payment on long-term space nuclear power development effort," O'Keefe said.

The Nuclear Systems Initiative will focus on development of two major areas: radioisotope power systems and fission power propulsion research. "We believe that improved radioisotope power systems, which convert the heat generated from the decay of radioisotopes into electricity, will expand the capabilities of future planetary orbiters and landers," O'Keefe said. The fission power propulsion system of the Nuclear Systems Initiative has the ultimate goal of developing safe, highly efficient electrical propulsion systems for interplanetary spacecraft, powered by nuclear reactors. These systems are, O'Keefe said, "the best option for providing us vastly increased scientific return once our spacecraft reach the outer planets."

Meanwhile, NASA is not abandoning conventional power systems, such as solar power. Indeed, solar will continue to be the main power source for our earth-orbiting spacecraft, the International Space Station, and other future robotic missions, O'Keefe emphasized.

But when spacecraft travel to distant and extremely hostile places in the solar system—places farther and farther away from the sun—the more and more likely it is the lights will go out. "Therefore we do not generate power through the solar systems we've been using. As we've done with the *Galileo* mission to Jupiter, with the *Cassini* mission to Saturn, using nuclear power makes a lot of sense."

Currently, when utilizing conventional propulsion for spacecraft missions, the vehicles that NASA can send to the outer planets are limited in size, O'Keefe explained. Also, due to the gravitational dynamics, once the spacecraft approach their destinations on brief fly-bys, they can only do rewarding science for a few months, with the best imaging available for a few weeks or even days, he said.

"Let me give you a graphic understanding of exactly what the imperative for this is. Our friends at the National Academies of Sciences have determined that the number one, the absolute most imperative place in the solar system we must investigate, immediately, is Pluto," O'Keefe said. "If we got at it right now, with the conventional systems we have available, we would launch in the year 2006 at the very earliest, arrive there about 2017, and only have enough time—only a few weeks, maybe a couple of months—of fly-by to inform this great debate developed within the National Academy of Sciences in the year 2002. I certainly hope there are still folks available and around in the next 16–20 years who care about the results."

By using nuclear, or other exotic propulsion systems such as plasma bubble, NASA believes it can do much better, get there faster, and actually orbit the destination long enough to perform more meaningful science work. "We then could let our imagination dictate the terms and conditions under which we pursue exploration," O'Keefe offered. "Nuclear propulsion will enable exploration conditions that are inconceivable with current, conventional chemical propulsion."

As another example, O'Keefe explained that several months ago, as a consequence of triangulating data from the Hubble telescope, researchers have learned that there is "an equivalent, parallel solar system," referred to as 55 CANCRI. It has a Jupiter-like planet at its central core, a star that is roughly the equivalent in size of the Sun, as well as an array of planets that look to be roughly in the same configuration as the Earth's solar system. "If we got started on the task right now, and pursued a vigorous objective to explore that parallel-looking solar system, we'd get there, using the conventional technologies we have in our means today, in one billion years. That's where we are."

As Lewis and Clark redirected their voyage two centuries ago when it became clear there was no single water passage to the Pacific Ocean, NASA is looking at space missions that could, for the first time, be redirected to take advantage of circumstances as they unfold, O'Keefe said. "To pursue some of these other objectives, we could then utilize the capability, flexibility, and maneuverability that nuclear power can now afford to us, [giving] us the capability to examine the locations in multiple-, instead of in single-destination, format, and . . . redirect as necessary to the extent that we are informed."

For example, O'Keefe explained, by using nuclear propulsion technology, NASA could send a spacecraft to perform remote sensing duties around Neptune's moon, Triton. It could then be programmed to rendezvous and send a probe to land on a previously unknown satellite, should it present itself. "Nuclear fission will also allow us to send a spacecraft on a tour of Jupiter and all its moons, without being constrained by the gravitational pull of that planet." Similarly, nuclear technology may enable an orbiting spacecraft to send a probe to investigate Saturn's moon, Titan—the only moon in the solar system with a significant atmosphere—for a period of months rather than a few hours, such as presently expected in the *Cassini* mission, O'Keefe said.

Also, by comparison, nuclear power would allow investigators to return the equivalent of "hundreds of CD-ROMs of data, as compared to what we have today: a few floppy discs with our current spacecraft. That's it. The amount of information we can gather in the very brief time we have available for the multibillion-dollar missions is confined by, again, the basic laws

of physics we've been living with throughout time."

Where talk of nuclear technologies in space really gets interesting, however, is in the realm of human exploration.

"NASA wants to join with all of you in the next era of exploration of the cosmos, when we go to exciting places and do more than simply plant flags and leave footprints," O'Keefe said. "We can do a whole lot more than that. And it's restricted, as it was then, by our capacity to frequently return without a major undertaking. This would liberate us to pursue those kinds of exploration agendas. We're convinced that nuclear energy is the key to expanded human exploration of the solar system beyond the earth's orbit."

NASA "will no doubt rely on nuclear energy" for in situ manufacturing of consumable and propellant product, "which will enable our crews to do productive scientific research for an extended period of time and return crews safely to earth," O'Keefe said.

More notably, nuclear technologies will be needed to speed astronauts through space in order to prevent dangerous levels of radiation exposure from space.

Astronauts at the International Space Station, which is 250 to 300 miles above the earth's crust, receive the radiation equivalent of eight chest X-rays every day. "We're working with shielding and dealing with all of the physiological effects that go with that. But again . . . the problem is not exacerbated by the intensity of the exposure as much as it is by the duration of it. As a consequence, six-and-a-half months [the current American spaceflight endurance record, which was completed last June] is a long time to have that kind of duration of exposure.

"So, in so many ways, if we could reduce the amount of time of exposure, it enhances our capacity for exploration and discovery almost anywhere in the solar system and provides a greater probability on the part of survival of human beings to withstand the experience, which makes the possibility of human exploration conceivable.

"In part, this has great moment and import by virtue of the fact that if you take that stunning statistic of exposure that's achieved today on the Space Station, once [past] the Van Allen belt, the radiation effects intensify dramatically to the point where we're looking at at least a factor of three greater, beyond that stage. And, certainly around Mars, it is dramatically higher than that.

"There is no way that [astronauts] could withstand the experience. We therefore not only have to develop greater means by which we can shield them and provide the buffer and deterrent from physiological effects in this context, but also increase and improve the amount of speed and capacity necessary to achieve [passage to] this destination and get back as quickly as possible, maximizing the amount of time actually spent there and achieving the scientific research that is intended . . . in the first place.

"That's what our Nuclear Systems Initiative is all about," O'Keefe concluded. "We are about the business of translating from the Age of Sail to that of the Age of Steam in the course of this particular initiative."

## Nuclear's 60-year anniversary

On December 2, 1942, the first self-sustaining chain reaction was achieved by the Chicago Pile 1 nuclear reactor, located on a squash racquet court beneath Stagg Field at the University of Chicago (UC). Sixty years later, Alvin Weinberg, a Manhattan Project scientist who was working at UC on the historic date, provided comments about the next 60 years and beyond during the President's Special Session on the "Past, Present, and Future of Nuclear Power on the 60th Anniversary of the First Controlled Chain Reaction."

Weinberg, who later in his career was director of Oak Ridge National Laboratory, commented that the next generations of nuclear reactors should have longevity as a goal. "For the 21st century reactors, we should aim to design them to last a hundred years," he said (for an interview with Weinberg, see *NN*, Nov. 2002, p. 40).

Weinberg

When the 87-year-old Weinberg joined the Manhattan Project in 1941, he was 26 years old. His life expectancy then was 60-odd years. Today, his life expectancy, because of his having reached his age, is 90 years. So, he said to the laughter of audience members, his personal life expectancy has increased by about 30 years "without my doing much."

Nuclear reactors, he asserted, also seem to be lasting longer than their design lives. "There is no intrinsic benchmark for setting the licensing time" of 30 or 40 years for current reactors, he said. So why not, he asked, design future reactors for "immortal" (100 years plus) operating lives?

The economic advantage of long-lived reactors is obvious, because "time annihilates capital costs," Weinberg said. "Total production costs of a nuclear power plant should drastically diminish once the original debt is paid off."

*National security*

Adm. Frank Bowman, U.S. Navy–Naval Reactors, offered his personal view "that there is today a national security mandate for commercial nuclear power to greatly increase its role in meeting America's energy needs."

Bowman, who was selected to serve on nuclear-powered warships by Adm. Hyman Rickover (the "Father of the Nuclear Navy"), gave a history of Rickover's plan starting in 1946 to "study the nascent nuclear technology" as a possible contributor to national security. Rickover by 1948 had earned the support of key national leaders and was given a mandate to deliver a submarine that could travel at high speeds, continuously submerged, without recharging its batteries. By 1953, less than five years after receiving that mandate, the *Nautilus* prototype submarine began operating, "the first effective harnessing of nuclear power to do real work on a large and practical scale," Bowman said. In 1955—less than seven years from the mandate—the USS *Nautilus* sent her historic message: "Under way on nuclear power."

Bowman

Bowman explained that the *Nautilus* and her sister nuclear-powered ships would possess strategic and tactical superiority that would revolutionize warfare, deter conflicts through the Cold War era, and help ensure security of the United States—and the entire world—for more than 40 years.

Rickover also was given another mandate, to start up a commercial nuclear power industry. In 1957, less than five years after receiving this second mandate, the Shippingport Atomic Power Plant began producing electricity. The plant was the centerpiece of President Eisenhower's "Atoms for Peace" program, Bowman said.

Fundamental to the success of the Navy's nuclear program were the core values instilled by Rickover, Bowman explained. For example, the Navy program selects only "the best people," who are then rigorously trained and continually challenged. Also, the Navy's reactor designs and operating procedures must be "uncomplicated, battle-ready, and conservative," he said.

These core values are the foundation for the Navy's nuclear-powered ships having safely steamed more than 126 million miles, equivalent to 5000 trips around the world, without a reactor accident. Bowman called on the nuclear power industry to consider adopting these core values. "The only way to operate a nuclear power plant and indeed a nuclear industry—the only way to ensure safe operation, generation after generation, as we have—is to establish a system that ingrains in each person a total commitment to safety; a pervasive, enduring devotion to a culture of safety and environmental stewardship," he said.

Bowman observed that nuclear-powered ships, like nuclear power plants, continue to contribute to national security. "Our ships were there on 9/11," he said. "As presidents have done so often, President

Bush sent out a call for the nearest aircraft carriers, this time to directly defend the United States of America. USS *George Washington* and USS *John C. Stennis* got under way from Norfolk and San Diego to defend both coasts. *George Washington* sailed within view of New York harbor to make her reassuring presence known."

Navy ships also were called to patrol off the coast of Pakistan. President Bush didn't specifically call for nuclear-powered vessels, Bowman said, "yet 12 reactors got the first four warships on station—exploiting nuclear propulsion's endurance, flexibility, speed, and agility."

Bowman continued by suggesting that the nuclear power industry could "and should become involved in an equally crucial aspect of the future security of the United States" by providing energy independence. In 1958, he said, President Eisenhower instituted oil import limits of 9 percent, because excessive reliance on foreign oil jeopardized the nation's security. By 2001, however, the nation imported about 55 percent of its oil. "If we replaced our country's oil-fired electric plants with about 18 nuclear plants, we could stop importing over 200 million barrels of oil a year," said Bowman, "about the amount of oil that we imported from Iraq in 2000."

Bowman implored the industry to tell its story of how nuclear power can meet the civilian mandates for peace, prosperity, and security. "This is an unforgiving technology demanding our keenest attention to keep it safe," he said. "But it can be safe. Our Navy experience says so, and despite [Three Mile Island]—or maybe because of TMI—our practical experience says so. We need to tell the public and the concerned scientists the true story."

The true story, Bowman continued, is that nuclear power is already the nation's second largest source of electricity (behind coal) and that it doesn't cause acid rain, respiratory ailments, or the potential for global warming. "And we must tell the national security aspects of this story," he said.

Bowman concluded by calling for the nation to build 18 more nuclear power plants with a goal of ending oil imports from Iraq. "The President has taken on the terrorist threats with a policy of preemptive strike," he said. "We must take preemptive action for nuclear power to reduce our dependence on foreign oil. They're both about the collective security of our country."

*The need for nuclear*

Georges Vendryes, former director of nuclear industrial applications for the Atomic Energy Commission of France and a leader in the development of France's fast breeder program, commented that the optimistic expectations of Eisenhower's Atoms for Peace program have not been reached. This is because of the widespread lack of public acceptance of an energy source that, he said, "frightens people because it is tremendously powerful and somewhat mysterious."

The word "nuclear" still frightens people, Vendryes said, because democratic nations that use nuclear power have failed to convey the right answers to questioning citizens. "In that area like in many others, we need leaders endowed with vision, intellectual honesty, and courage," he said.


Vendryes

Vendryes pointed out that the failure to effectively convey nuclear's benefits to the general public has helped keep a wide gap in the quality of life between Americans/Europeans and much of the rest of the world, thus leading to the terrorist era that exists today. "How could our small planet possibly live in peace and harmony," he asked, "as long as the present unbearable disparities exist between men and nations as regards to basic needs such as food, clean drinking water, housing, medical care, education, etc.?"

That is why, he continued, it is urgent and mandatory to make vast quantities of energy available to developing countries, "not only to increase as soon as possible their standard of living, but also to foster world peace." Vendryes said that all available energy sources that are sufficiently inexpensive, safe, and clean will have to be used, and "nuclear energy is one of them."

Vendryes said he was convinced that sound logic would prevail in the public's acceptance of nuclear power. "I expect that the harsh economic and environmental realities will soon hit people with such a strength that a general awareness of the problems and solutions will override the current antinuclear moods," he said.

Vendryes also touched on nuclear technology's other beneficial uses (water desalination, hydrogen production, and space exploration) and its challenges (radioactive waste management, nonproliferation, and terrorist threats on nuclear power plants). In conclusion, he said, "the fate of nuclear energy is linked to the ability of man to master his own scientific conquests. If one does not believe in such an ability, the future of mankind is gloomy."

*Determined turtle*

Offering an Asian perspective on nuclear power was Chang Kun Lee, a commissioner on the Atomic Energy Commission of Korea and chairman of the International Nuclear Societies Council. Lee, using colorfully descriptive language throughout his talk, agreed that as the first 60 years of the nuclear era drew to a close, a dark cloud hung over nuclear's public image. "The perception among some circles is that nuclear belongs in the same company as 'axis of evil,'" he said. "It falls upon us, nuclear alchemists, in the next 60 years to correct this tarnished image and demonstrate to the world the true nature of 'nuclear'—a royal elixir to heal a planet afflicted with pollution" and in need of clean electrical power.

Lee explained that Asian nuclear experts are employing their efforts to develop next-generation reactors and optimal fuel cycles because of Asia's need for the clean power that nuclear can offer. Currently, 96 nuclear reactors are in operation in Asia, but these reactors supply only 2 percent of the total energy demand. Additional reactors are on the way, he said, with 17 units under construction and 19 others in various planning stages.


Lee

Regarding deployment of new plants, Lee described how Asia has bypassed the West in bringing new units into commercial operation. "The advanced nations bounded out of the starting line and hopped sprightly along at the pace of a rabbit while we Asian countries plodded along at the slow crawl of a turtle," he said colorfully. "At the moment, however, the Western nuclear rabbit is taking a nap under a roadside tree—hung with limp moratorium banners—while the Asian nuclear turtle is still toddling along on the road carrying the nuclear seed."

Lee observed that Asia was "keeping alive a nuclear technology shelter, keeping the flame burning, and know-how alive" for the forthcoming nuclear renaissance. "Surely," he concluded, "some day—when the rabbit finally awakes from its Rip Van Winkle–like snooze—these former students of nuclear technology in Asia will be ready to pay back their previous teachers in the West with state-of-the-art technical know-how and new or next-generation hardwares."

*Extinct dinosaurs*

Dinosaurs used to dominate their age, Mike Sellman said, but because they couldn't adapt to their changing environment, today they are gone. So must the nuclear industry change to survive, said Sellman, president and chief executive officer of Nuclear Management Company.


Sellman

Next-generation reactors, he explained, will have to achieve capacity factors that are better than the current industry average of 90 percent, for example.

"We must change the way we operate plants, but we must also change our thinking about how we are going to get to the next generation of nuclear plants," he said.

The road to the next generation will be paved by redefining the "fundamental purpose of nuclear power," he said. Nuclear power "is the green, clean, and renewable cornerstone of America's self-sufficient hydrogen economy."

That next generation of reactors won't happen, Sellman continued, without the support of both major political parties in the United States and without backing by environmental groups and investment bankers. He also repeated a belief held by many industry officials that a new reactor won't be built unless a consortium of nuclear utilities and others join together to support the project. "No investor can go it alone," he said, because "the economics are not there."

## New plant economics

Many nuclear professionals are unclear about the challenges that must be cleared in order to finance the construction of new nuclear power plants, observed Harold Ray, President of the American Nuclear Society and session chair/moderator. "We often wonder why it is that we're not seeing more progress on that front than we do," he said, in introducing the Thursday morning plenary session, "Economics of New Nuclear Power." The major reason, he summed up, is financing.

Ray, who is an executive vice president of Southern California Edison Company, explained that the industry will continue having difficulty financing new plants in the near term because "utilities are increasingly required to use markets to meet their obligations." This means that utilities must depend on power purchase agreements of, for example, five years in length for generating revenues, as opposed to the old days of guaranteed revenues under regulated environments. A "dramatic difference," Ray said.


Ray

He noted that all nuclear plants operating in the United States today were built in a regulated regime, under which utilities had a franchise for recovering their costs. Under deregulation, however, this increasingly is no longer the case, "particularly with regard to generation investment," he said. In addition, today's market prices for electricity are "very depressed," and it is anyone's guess how long these conditions will last, he noted.

Ray said that the initial cost for new nuclear capacity (in 2001 dollars) is "very high." A chart he displayed showed new nuclear in the $2000 to $2400/installed kW range, as opposed to $360/kW for a combustion turbine, $1400–$1500/kW for a combined cycle (coal and gas), and $480–$500/kW for a combined-cycle gas turbine.

Building a new plant with financing coming directly from a company's balance sheet was "unlikely," he said, and as a stand-alone project with financing from lenders, it would be "highly unlikely." So, a multi-stakeholder development will have to be initiated with participation from both private and public sectors.

But even under this public/private scenario, "there is more financial risk by far for the investor," Ray said. "Investors have a great desire for short-term recovery of investment because of this volatility and uncertainty." He said that reducing the risk for capital investment was "the most important thing" for the industry's financing of new construction.

*New plant needs*

James Asselstine, director of high-grade credit research for Lehman Brothers and a former NRC commissioner, listed the requirements for new plant construction. These include the assurance of predictable cost numbers and scheduling timetables, validation of new licensing processes, mitigation of construction completion and plant performance risk, continued low costs for fuel and enrichment services, and public acceptance with regard to safety and spent fuel disposal.

Asselstine said that builders of new nuclear plants would be from either of two categories: unregulated generation subsidiaries of large integrated holding companies, or independent power producer (IPP) merchant energy companies.

The successful new-plant builder, he continued, likely would use a strategy called generation corporate financing. "I think there is reasonable likelihood of being able to finance a new nuclear unit, particularly for a [generating company], that includes a combination of existing nuclear and non-nuclear assets that produces strong cash flows," he said. "I think we'll see a growing number of precedents for [generation corporate financing]."

Larry Scully, president of Scully Capital Services, Inc., detailed a business case report on the issue of building new plants that his company prepared for the Department of Energy. The report, Scully said, determined that new nuclear power plants could be competitive as long as plant costs were kept in the $1000/kWe range. Since capital costs likely would be too high to attract financers on their own, the first few plants "could require government assistance" that would address financers' risks but reduce potential costs to government, he said.


Scully

Although industry and the financial community are capable of "most new plant development business risks," Scully said, without the government's participation, some risks and costs of new plants may remain at unmanageable levels for potential financers.

To mitigate the risks, the report recommended the establishment of a new federal energy credit program, such as what is called a "standby facility," which would consist of interest maintenance, debt principal buydown, and equity options to support the financing in the event of regulatory and commissioning delays or judicial intervention.

"The DOE is very interested in the nuclear program and having the facilities move forward," Scully concluded. "[The DOE is] looking for their proper role. The next step is for DOE to analyze some of these mechanisms and continue to work with industry to try and fine-tune those."

*Utility input*

Louis Long, vice president of technical services for Southern Nuclear Operating Company, recounted his early days in the industry in the 1970s when Southern was building new nuclear power plants in a regulated market. "We had a generation expansion plan that went out for 10 years," he said. "The more money we spent, the more got into the rate base, and the more money we made for our stockholders."


Long

Contrast that with today, within the deregulated environment, where "the market is very short term, four to five years," he said. Long declared that he had never seen his management board "more risk averse than they are right now. We will not spend a dime unless there is certainty of that dime returning value to the shareholder."

The question asked at Southern and indeed throughout the industry, Long said, was "how would you finance such a plant where you spend $2 billion over a four- or five-year period and not earn anything back on it?"

Long said that Southern did not file with the Nuclear Regulatory Commission to participate in the Early Site Permit program because the company could see no business case for building a new nuclear plant under present deregulated market conditions. He added that he is hoping to see some sort of regulation allowed to reenter the market so that utilities could be more confident about making long-term commitments.

*Continued*

A bad news/good news story was delivered by David Christian, chief nuclear officer of Dominion. The bad news for the nuclear industry, he said, is that the country's economic downturn is real, and because electricity reserve margins are adequate, there is no market for nuclear's product.

The good news is that industry has done a good job of gaining and sustaining public confidence, there is a national security imperative to maintain a diverse energy supply, and the carbon issue is not going to go away. "But perhaps the best news is that we have a receptive administration, we have unified support of all the national labs, we've got a rational plan from the DOE, and we've got an excellent set of people thinking about how to finance future nuclear plants," he said.


Christian

Dominion is participating in the NRC's Early Site Permit process. Christian said the day would come when baseload generation would be needed, and that "federal protections" would be required to build new nuclear plants.

*Vendor comments*

There are four keys to initiating new construction projects, said David Torgerson, senior vice president of Atomic Energy of Canada Limited. The first is the cost and economics of nuclear power. If gas prices rise to $5/GJ as they were expected to this winter, according to Torgerson, then new nuclear will be "very competitive." There will always be the specter of cost overruns, but the industry has gained experience from past construction projects to downplay this risk, he said.


Torgerson

The second key is security. With gas supplies being a finite source, nuclear power is far more secure "perhaps even in ways we have not yet fully explored," he said. For example, the oil sands in western Canada have recoverable synthetic crude reserves that have the potential to displace a large fraction of offshore supplies. The in situ extraction of crude oil from these reserves is energy intensive, requiring large quantities of steam. "By supplying steam from nuclear power plants, we are effectively converting North American uranium to North American oil, thus enhancing energy security," Torgerson said.

The third key is the environment. A 700-MWe nuclear plant prevents the release of about 5 Mt of $CO_2$ per year if coal is displaced and about 3 Mt/year if gas is displaced, according to Torgerson. "If, in the future, $CO_2$ credits become real, then these credits will become another significant factor for nuclear power," Torgerson said.

The final key is hydrogen. "A single 700-MWe reactor can produce sufficient electricity for hydrogen production from electrolysis to power about 650 000 vehicles per year using fuel cells," said Torgerson. A hydrogen economy would require large-scale increases in electric power production if hydrogen is to be produced from electrolysis, which currently, Torgerson continued, is the only means to produce large quantities of hydrogen without producing $CO_2$, if the electricity does not come from fossil fuels.

James Fici, senior vice president of nuclear plant projects for Westinghouse, explained that his company's AP1000-designed units could cost "in the neighborhood of $1200/kWe, which would be competitive with natural gas units when natural gas prices are close to $4 per million Btus." By the third or fourth pair of AP1000s built, however, capital costs would be expected to be about $1000/kWe, "which would be competitive with natural gas prices just about $3 per million Btus and overall generating costs just below $35/MWh, which is the same as 3.5 cents/kWh," he said.


Fici

Fici noted that "the effort by reactor vendors such as Westinghouse to develop less expensive nuclear plant designs is only a part of the solution" for getting new plants on line. He said that industry and government would have to give greater efforts to achieve that goal. "Fortunately, DOE's Nuclear Power 2010 provides a good start."

## The real risks of RDDs

Chairman of the session on "Understanding Radiological Terrorism and Consequences" William G. Sutcliffe, of Lawrence Livermore National Laboratory (LLNL), remarked that one of the aims of the session was helping ANS members explain the real risks and consequences of radiological dispersal devices (RDDs).


Bolshov

The first speaker, Leonid Bolshov, of the Nuclear Safety Institute of the Russian Academy of Sciences, set out the actual risks and concerns of so-called "dirty bombs." Radiological terrorism, he said, involves not only the direct impact of radioactivity on health and the environment, but the indirect damages on society and the economy, which can be even greater.

As to availability of radioactive materials, one specific problem is "lost orphan sources," the number of which are rising year by year in Russia and in other countries, according to Bolshov. Terrorist targets are typically places where the public gathers, supplies of drinking water and food, agriculture, means of transportation and communication, and so forth.

The means of dispersion, Bolshov stressed, do not just include explosives. A source, he said, could be thrown from the roof of a building or left in a subway station or public park, as Chechen rebels did in Moscow in 1995, where it would radiate until discovered or the terrorists would make a public announcement. This would be enough to terrorize people, he commented, and the ease of detection and measurement could also promote fear.

Bolshov noted that public perception is crucial. He said that research in Russia shows a factor of 1000 to 10 000 difference between the actual consequences of exposure and the public's understanding of it. Therefore, even a small increase in background levels could have large consequences, notably if it involves infrastructure centers such as subway stations. Handling such an incident, Bolshov said, would be much more difficult than an accidental release at a licensed facility, adding to panic.

Of course, an incident would trigger fears well beyond the dangers—and, he observed, it is the exploitation of this that is the more important danger. Bolshov described a number of actions that the nuclear community can take, such as improving control of sources, providing more information and education about the risks, and promoting greater cooperation among the scientific community. He felt that it was important that there is general agreement on the risks in order to build public understanding and confidence, and that it would also help to perfect the international standards and legal basis of radiation safety.

Bolshov also remarked on when Chechen terrorists left a cesium source of a few curies in a Moscow park and later sent a message making further threats. Surprisingly, he said, another such incident has not occurred, and the only possible reason he and his colleagues could come up with is the fear that using radioactive materials intentionally like that might galvanize world opinion against the group.

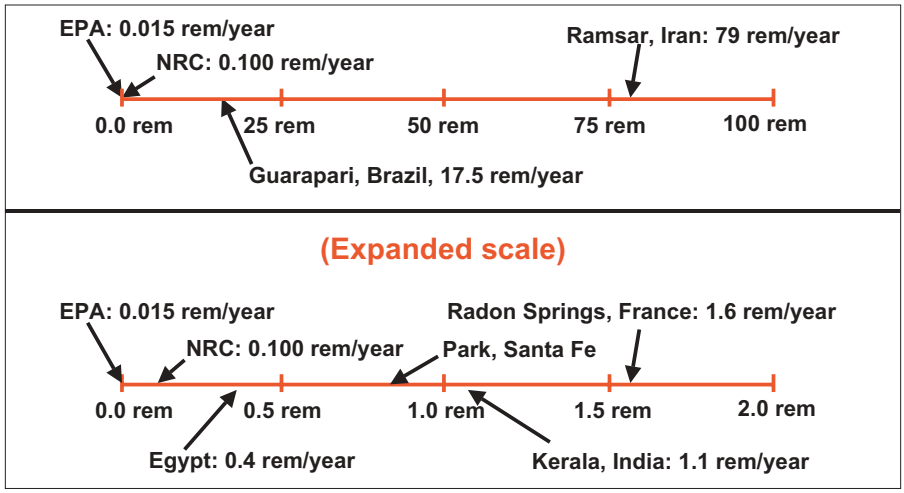
Chaim Braun, from the Stanford University Center for International Security and Cooperation, and vice president of Altos Management Partners, described actual attacks and threats to nuclear facilities. Previously, he said, the main threat of concern had been of a single person or a small group whose motivations might be opposition to nuclear

power, extortion, or personal grudge. The motivation of the new terrorists, however, is much stronger, he noted, involving a desire for revenge and retribution. They may come from other countries and be well trained and well equipped, with access to advanced technology, and their aim is to cause maximum damage to people and the economy. Nuclear remains a symbolic and high-priority target, Braun said. The impact of the terrorist threat on nuclear power is global, he reminded the audience, and the industry is hostage to the least-protected plants.

Nuclear plants are vulnerable to a variety of attacks, said Braun, besides those aimed at destroying the reactor and releasing large amounts of radioactivity or stealing radioactive material for an RDD. If the terrorist wants only to shut down the plant, which would have a large economic impact, he noted that there are a number of suitable targets, such as the step-up transformers or the external make-up water tanks. He also pointed to the visitor center as a vulnerable point of entry to a site, as they are usually not so well guarded.

Braun also pointed out that according to the NRC, the additional measures required after September 11 have added $5 million–$6 million to the operations and maintenance (O&M) costs of a nuclear plant. This compares to typical O&M costs of $80 million–$90 million. This, he said, is leading to the leveling out of costs, after their dropping continuously over the past decade. Plants must now learn to optimize their investments in security, as well as safety, he added. Braun thought that industry should also establish a coordinated security response program, similar to the O&M cost initiative of the 1990s. He indicated that an industry response plan will be essential for dealing with the newly established Homeland Security Department. Braun emphasized that before asking for assistance from the government, the industry had better show that it is doing something for itself.

Braun also described the Stanford University Database on Nuclear Smuggling, Theft and Orphan Radiation Sources, probably the largest such data source outside intelligence services. Besides the activities indicated in its title, the database includes cases of fraud; malevolent acts; illicit trafficking; material diverted from fuel processing plants, research reactors and research facilities; threats and actual attacks on nuclear power plants; and incidents and attempts of diversion.




Scales comparing EPA and NRC regulatory limits to natural background radiation environments

*Assessing impact*

The final three presentations were by specialists from the Lawrence Livermore National Laboratory, who brought substantial technical expertise to the question of prevention and consequences.

As an entry into the problems of dealing with the consequences of an RDD incident, Harry Vantine described experience in cleaning up after various accidents that occurred in U.S. weapons program. He and coauthor Tom Crites thought such a review would give an idea of the sort of impact to be expected, the measures that will be needed, and the costs.

**The impact of the terrorist threat on nuclear power is global, he reminded the audience, and the industry is hostage to the least-protected plants.**

Vantine covered two actual accidents involving nuclear weapons (there were a total of 32 major nuclear weapons accidents, nine of which released radioactive materials) and the cleanup of a weapons test site. In 1966 and 1968, high explosives contained in the nuclear weapons aboard military aircraft were detonated following crashes. The first occurred in Palomares, Spain and the second at Thule, Greenland. In the latter case, plutonium was further spread by the burning of 225 000 pounds of jet fuel. At Palomares, the cleanup criteria were based on returning the land to agricultural life. After these incidents, the air force stopped flying nuclear weapons on such alerts.

Vantine also described the cleanup of Enewetok Atoll, where atmospheric tests had been held. The cleanup, undertaken in the late 1970s, was concerned primarily with the removal of plutonium contamination, as cesium-137 and strontium-90 were considered too widespread and incorporated into vegetation to be effectively removed without severely damaging the ecological system. He also described the cleanup in Northern Canada in 1978 of a Soviet Cosmos satellite powered by a liquid metal–cooled, enriched-uranium, beryllium-reflected fast reactor, whose bits were scattered on reentry.

Vantine explained that it was fortunate that these incidents had not occurred in densely populated centers and that rather draconian cleanup measures (complete removal of contaminated structures and soil) could be carried out. A terrorist event, he noted, may be expected to occur in more populated areas.

Each of these incidents called for considerable debate as to the appropriate course of action, said Vantine. At that time there were few general cleanup standards to implement, and funding and political considerations were often the decision drivers.

*Changing public perception*

Perception is the key to terrorism's effectiveness, said LLNL's Mark Hart, who has examined factors important in developing the public's perception of the danger and what can be done to change it. Initially, he said, it was the growth in applications and use of radioactivity, rather than the actual health effects, that led to the setting of annual dose limits. But today, he continued, a significant justification for the low levels is that they are achievable, not the effects on health.

In the late 1920s, Hart explained, dose limits were set at 36 rem, based on experience with X rays. This was reduced to 15 rem in the late 1940s, due to the anticipated increase in the use of radioactive materials, and a decade later to 5 rem, driven by concern for latent genetic damage, particu-

larly to sailors in the nuclear navy, despite the lack of evidence of health effects.

In the 1950s, when there was growing concern of the effects of fallout from atmospheric weapons testing, the linear hypothesis and collective dose concepts were put forward. These are based on the conservative premise that any amount of radiation, no matter how small, is harmful. According to the collective dose concept, he explained, in a town of 15 000 people, 760 people would die due to background radiation. This, notes Hart, has not been observed.


Hart

Hart also gave examples of places of high activity where no impact on health has been found. Doses received at Ramsar in Iran measure 79 rem/year, compared to the NRC limit of 0.1 rem/year (see figure). He also made the point that Ramsar is not the desolate desert locale of popular imagination, but a thriving resort town where no increase in cancer compared with populations around the world has been found.

The idea that "any amount of radiation is harmful," started as an assumption and, contrary to popular impressions, has never been proven. Nevertheless, he said, this perception continues making people psychologically vulnerable to a radiological attack. He is particularly concerned that the effectiveness of RDDs as a terrorist weapon can be unintentionally enhanced by professionals and public officials. Under current regulatory standards, said Hart, "we are poised to unwittingly assist terrorists in their work." He explained that certain guides that will be employed in an RDD event would call for the evacuation and relocation of entire cities based on radiation fields that are today experienced flying in a passenger aircraft. While in theory, it is understood that accidents require other criteria to trigger extreme responses, such as evacuation, it is likely that the more familiar guidance will be used by cautious authorities. Hart urges going back and revising them to address the risk of an attack, because otherwise, there could be a credibility problem. There may have been a time, he said, when promoting the "absolute fear of radiation" was useful, such as during the Cold War. But this idea is now outdated, putting society in a vulnerable state when dealing with the use of an RDD. He believes that helping people obtain a basic understanding of where radiological protection concepts came from, and how and why they were developed, would be a good start in dispelling inappropriate fears surrounding lower levels of radioactivity. "In this way," Hart hopes, "the terrorist's ability to evoke fear in using a device will be greatly diminished, which could very likely rid us of the threat altogether."

This is not easy, of course, but as was noted by members of the audience during questions, Hart's presentation will help in doing just that.

*Biological agents versus RDDs*

In the last talk, B. W. Weinstein explained that biological and nuclear weapons of mass destruction were marked more by their contrasts than by what they have in common. Weinstein described differences in the processes needed to produce nuclear/radiological and biological materials and deploy them as a weapon, and how these affect the ability or options to deter weapons development, detect them, and defend against and respond to an attack. Understanding these differences, he says, will help in determining where to concentrate resources.

Production of nuclear materials requires a large, expensive infrastructure, while creating materials for a biological terror weapon requires relatively modest facilities that are widespread and have multiple uses: "think micro-brewery," he said. There are basically two difficult problems—how to make a powder that will disperse well, and how to disperse it effectively, he noted. Although the capability of producing an effective biological weapon would be confined to a relatively small cadre of experts, the knowledge and technical expertise needed to potentially create biological terror is widespread. It can be done with few people, and even a single person can do everything, he stressed.

**Production of nuclear materials requires a large, expensive infrastructure, while creating materials for a biological terror weapon requires relatively modest facilities that are widespread and have multiple uses.**

Weinstein described a number of relevant differences. On health effects, he explained that biological exposures are essentially bimodal—infected or not, dead or recovered. In many—if not most—scenarios, only prompt medical intervention can affect the outcome. There is also a large variation in personal health effects, unlike radiation. Also, the boundaries for biological exposures are much less certain, especially if a contagion is brought in. The decay rate of biological substances is uncertain, and is affected by what measures are taken; measurements have to be continually made to know what is still there. In some circumstances, biological agents can persist for decades. There are also animal reservoirs, which will not go away.

For nuclear threats the major focus is on detection and prevention: Detect the acquisition of technologies that signal an interest in nuclear materials and prevent terrorists from obtaining materials and technology that are available from only a limited number of sources. On the biological side, said Weinstein, it is almost the other way around. Attempts at detection of intent or prevention of acquisition have limited utility. The best leverage, he noted, is to convince people not to try this at all—that they will be caught and their action will not be effective.

## Inside the SNS

When it is completed, scheduled to occur in 2006, the Spallation Neutron Source (SNS) will provide the most intense pulsed neutron beams in the world for scientific research and industrial development. The accelerator-based neutron source is being built in Oak Ridge, Tenn., by the Department of Energy at a cost of $1.4 billion. SNS will essentially be a large microscope that allows researchers to examine the function and structure of organic and inorganic materials. It is expected to be vital in an array of applications in physics, chemistry, biology, and just about every other science.

The session, "The Spallation Neutron Source: Research and Development, Analysis, and Design," provided an update on progress of the facility's construction, as well as details on several of the facility's engineering aspects.

*"Best-in-class"*

Neutron scattering is, in some sense, a benchtop experiment carried out on a very large scale, noted R. Kent Crawford, head of the instrument development team for SNS, and who provided an overview of the facility's instrumentation. "It's benchtop in the sense that [the experiments are] typically very limited duration experiments. Users will come for a few days to a couple of weeks to do their experiments. Then it will be a different set of users." Crawford said they anticipate that when the facility is fully outfitted with its instruments, there will be on the order of 2000 separate users per year.

There are five neutron scattering instruments that are being constructed as part of the project, Crawford explained. Although each of the instruments is a distinct entity, there are many commonalities among the instruments. "There are a lot of components that are common to the instruments. And that's part of the infrastructure that we're developing."

Argonne National Laboratory has the lead responsibility for the instruments. Nonetheless, from the beginning the work group has included a significant number of staff from Oak Ridge National Laboratory—where the facility is being built—in addition to ANL staff, Crawford said. "The reason for that was that we wanted people who were going to be operating these instruments in the long-term to have, in a sense, grown up with them and have some intellectual ownership of the instruments, because we feel that makes for a much better facility in the long run."

The guiding philosophy for the instruments is that every instrument should be best-in-class, Crawford said. That means that if one took any of the SNS instruments and put them in any other pulse source in the world, "they would be better than the comparable instruments at that source. So, we get not only that increase in power associated with the SNS, but we get an additional increase associated with the instrumentation.

"That's possible because neutron scattering instrumentation has been a fairly dynamic area and there's been a lot of developments in components, which makes possible considerably more sophisticated instruments than could have been imagined a few years ago."

*Tour of accelerator systems*

Stuart Henderson, the SNS accelerator physics group leader, pointed out the design features that are unique to SNS as well as its unique technical challenges, and gave an update on construction schedules of the accelerator components.

From an accelerator standpoint, Henderson said the exciting part of SNS is its high-beam power. It is the highest beam power machine under construction. SNS is seven times as powerful as ISIS, the spallation source at Rutherford Appleton Laboratories in the United Kingdom, which at the moment is the highest power short-pulse source, Henderson said.

"There are a lot of complicated physics and engineering issues that have to be overcome to achieve this unprecedented beam power and control beam," Henderson said. "There's generating and handling high-intensity beams, the control and operation of pulse superconducting linacs, a lot of complicated beam dynamics issues related to high-intensity beams."

The job of the accelerator will be to generate a short-pulse proton beam of 1 GeV, about 700 nanoseconds long, and deliver it to the target at 60 Hz—giving a beam power on target of 1.44 megawatts, Henderson explained. The challenges that arise in generating this high beam power and delivering it to the target "really require unprecedented acceleration, transport, and accumulation efficiencies," he said. "We really have to understand in great detail the beam dynamics, beam quality, and beam transport in this facility. And there have been a number of design features to enable us to do that."

On the physics end, Henderson said, the high beam power brings up a number of challenges that fall in the realm of what are called collective effects. "This is a whole set of effects that arise from the fact that one has a lot of charge in a small area in phase space. Charges interact with one another. There are very large cell forces that, in fact, can become so large, unless something is done, that these forces can be larger than forces from the magnetic field whose job it is to contain the beam. So, there are a number of design features that have to be taken into account here to ensure that does not happen."

Ultimately, Henderson explained, the collective effects limit the performance of every accelerator, if the beam intensity is high enough. "This is a very important area of work where we've very carefully tried to estimate all of these collective effects that we can think of. We feel that these have been managed successfully up to this point."

**In the linear accelerator, each acceleration stage uses radiofrequency cavities that are optimized for the particle velocity. This essentially makes for a large number of separate types of accelerating structures, Henderson said.**

In the linear accelerator, each acceleration stage uses radiofrequency cavities that are optimized for the particle velocity. This essentially makes for a large number of separate types of accelerating structures, Henderson said.

In fact, there are five different types of accelerators that are required to get the beam up to 1 GeV with good efficiency and with low losses, he explained. The beam from the ion source is 65 kilovolts in energy, and it is accelerated and "bunched" in an object called a radiofrequency quadrupole—an RFQ—that brings the energy to 2.5 MeV. There is then a set of six drift-tube linac tanks that bring the beam to 87 MeV. The third distinct type of accelerating structure, the coupled cavity linac, then takes the beam from 87 MeV to 186 MeV. The fourth and fifth accelerating structures, both superconducting cavity linacs, take the beam from 186 MeV to 380 MeV and from 380 MeV up to 1 GeV, respectively.

"Within each of those types, of course, there are several structures that are repeating," Henderson said. "In the drift-tube linac there are six; [in the] coupled-cavity linac, there are four of these large modules; in the superconducting part of the linac, there are 33 individual accelerating cavities; and in the high-energy portion of the superconducting linac, there are then 48.

"So, there are many, many cavities driven by many, many RF-power sources driven by separate klystrons," which are high-frequency amplifiers for generating microwaves.

The front-end system of the SNS was designed, built, and commissioned by Lawrence Berkeley National Laboratory. It consists of an ion source that makes a 50-milliamp-peak pulse-current H-minus beam. The RFQ that accelerates the beam to 2.5 MeV also forms it into bunches about every 2.5 nanoseconds. "What emerges out the end are nicely defined bunches of charge every 2.5 nanoseconds," Henderson said.

The front-end succeeded in achieving the desired design parameters, Henderson said. For instance, the designed output current was 38 milliamps of peak pulse current; LBNL achieved 50 mA. For duty factor, LBNL met the 6 percent specification for repetition rate. Likewise, they met the 60-Hz repetition rate. "This was a resounding success and really proved out the design of this type of front end," Henderson said. "It's very satisfying to have the first part of the accelerator actually up there."

The 2.5-MeV beam from the front-end system is then delivered to the drift-tube linac, which, as mentioned earlier, consists of six individual accelerating cavities and brings the beam up to 87 MeV. "This is the old-fashioned type of accelerator you read about in your physics book and it still works very well," Henderson said. Production of the drift-tube linac is fully under way. "We will install and commission the first of these [drift-tube linac] tanks from April to June

of this spring and summer."

Installation of the coupled cavity linac, which takes the 87-MeV beam and accelerates it to 186 MeV, is expected to occur later this year. It is expected to be commissioned in spring of 2004, Henderson said.

**The NP2010 session was organized to provide an update on how the government and industry are following through on plans to have a new commercial power reactor up and on line by the end of the decade.**

The superconducting linac, however, is "really the thing that's unique in terms of a linear accelerator, unique to the SNS," Henderson said. It is a high-power, proton superconducting linear accelerator. There are six individual accelerating cells—six small resonating cavities made out of superconducting niobium—that are placed inside a helium vessel. Three of these assemblies are formed in a string that's then inserted into a cryomodule with heat shields, Henderson said. Full-scale cryomodule production is just starting, and commissioning of the superconducting linac is planned for 2004.

But why the excitement about superconducting cavities? In high-duty factor linacs, like the SNS, power dissipation in copper cavities ultimately becomes a limit, Henderson said. Accelerating gradients in copper cavities are generally limited to about 1 megavolt per meter in continuous wave operation. "On the other hand, superconducting materials offer a way around this, of reducing power dissipation and achieving much higher gradients because they have extremely low RF surface resistance. From niobium, for instance, surface resistance on the order of 10–20 nano-ohms are achieved routinely; it's about 5 orders of magnitude smaller than warm copper.

"So, the benefit here is obvious: The losses on the cavity walls are greatly reduced. You deliver RF power to this device and the power is free to go into the beam as opposed to heating up and then being taken away by cooling water, as opposed to heating up the accelerating structure itself. Large accelerating gradients can be achieved—about 10–15 megavolts per meter is expected in the SNS. The present state of the art is now a few times that, actually, for higher frequency electron superconducting linacs. So, there are real advantages here in terms of power and in terms of the much higher accelerating gradient."

Installation, testing, and commissioning of the different components is "going on all the time," Henderson said. "Basically, components are arriving in the direction the beam proceeds through the accelerator facility. So, we install one section, commission it, and while we're commissioning that section we're then installing components further along the beam line."

From the accelerator end, the hardware is in production and is in the measurement stage, Henderson said. "In fact, we're at full-scale production of almost all the accelerator components at this point."

## Nuclear Power 2010

Ted Quinn, vice president of Business America and a Past President of the American Nuclear Society, recalled during his opening remarks of the "NP2010: Status on Deployment" session the past testimony of a nuclear engineering college student who appeared before Congress. The student, according to Quinn, had said that in order for young people to be attracted to careers in nuclear power, three things would have to happen. First, Congress would have to support grants for university educations in nuclear energy; second, the nation would have to make an effort to strive for a healthy and robust nuclear research program that includes universities and national labs; and third, said Quinn in quoting the student, "we'd like you to build something."

In that vein, said Quinn, the NP2010 session was organized to provide an update on how the government and industry are following through on plans to have a new commercial power reactor up and on line by the end of the decade.

Tom Miller, acting associate director of the Department of Energy's Office of Nuclear Energy, Science and Technology, explained the parameters of the DOE's Nuclear Power 2010 program. The program was born out of Vice President Dick Cheney's national energy policy group, which recommended in May 2001 that the nation needs to depend on nuclear energy as a source of electrical power.

Miller observed that the DOE was optimistic about the program, and, in fact, "we want to see many new plants deployed."

The DOE has set a goal of 2005 for the industry to decide whether to deploy at least one new reactor by 2010. Miller noted that some next-generation designs could be deployed by 2010—General Electric's ABWR "could," Westinghouse's AP600 and AP1000 and Eskom's PBMR "probably" could, and Framatome's SWR-1000, GE's ESBWR, and General Atomics' GT-MHR "possibly" could.

In order to do that, though, the Nuclear Regulatory Commission's untested processes—such as the early site permit (ESP) and the combined construction and operating license (COL)—would have to be demonstrated, Miller said.

But progress has been made by the DOE and industry toward construction of a new reactor, according to Miller. A near-term deployment road map has been completed, a business case study (involving cost-sharing projects with Dominion and Exelon to look at commercial and federal sites as homes for new plants) has been accomplished, ESP demonstration projects have been initiated, and a gas reactor fuel qualification plan has been developed.

Providing insight into NRC activities under the agency's 10 CFR Part 52 licensing process was James Lyons, director of the NRC's new reactor licensing project office. Three utilities—Dominion, Exelon, and Entergy—have announced they will submit ESP applications to the NRC in 2003, with approval expected by 2006, according to Lyons. In addition, he said, the NRC's approval of the AP1000 design is expected by December 2005, and six other designs are now currently in the preapplication phase.

Lyons said the NRC was developing an ESP review standard, so that review of applications would be "rigorous and consistent."

### *The real crisis*

Richard Myers, senior director of business policy–Environmental Policy and Programs for the Nuclear Energy Institute, observed that there is no energy crisis in the United States, but instead an investment crisis. He observed, however, that "if we leave that investment crisis untreated for very much longer . . . we will have a very serious energy crisis."

Myers

The investment problem goes well beyond nuclear power, he said, and includes coal-fired power plants and electricity transmission infrastructure. Analysis done in 2001 revealed that the United States would have to invest about $56 billion into electric transmission just to maintain current levels of reliability throughout the nation. And by 2005, the nation's power plant fleet will be well aged, according to Myers. Regarding nuclear, the industry has about 800 000 MW of capacity installed on the grid, with almost

one-quarter of it—190 000 MW—40 years old or older and the rest 25 years old or older. For gas-fired steam plants, Myers said, more than 100 000 MW are "older and at risk" economically, as are more than 70 000 MW of coal-fired generation.

With projections from the Department of Energy indicating that 375 000—525 000 MW of new capacity will be needed by 2020, "this is a profile of a sector that is obviously having investment problems for an extended period of time," Myers said. "This is not technology problem. We know how to build and operate [power plants]. What we do not know how to do is finance them."

Myers said a reason for the crisis is that competitive markets, particularly dealing with electricity production, "do not necessarily produce optimal results." Sacrificed to electricity deregulation, he said, were reliability, fuel diversity, energy security, environmental values, and public "goods" such as regulatory process, integrated resource planning, and levelized cost analysis, even though these items are still public policy imperatives.

Thus, if the need is to build high-capital-cost technology in a low-capital-cost world, Myers said, the challenge is to create incentives for investment. Techniques that would stimulate investment, he said, include accelerated depreciation of new plants, investment tax credits, and, for early projects, protection against political/regulatory/licensing risk. Other incentives include direct R&D support, tax credits for clean-air production, renewal of the Price-Anderson Act, and changes to the tax treatment of decommissioning funds to allow deductibility of annual contributions. This all would make for an "ambitious legislative agenda," Myers said.

**The "extra costs" for the first units include first-of-a-kind engineering expenses, the long lead times needed for getting the first plants built and the expected high capital costs.**

*Shoreham-level risk*

In the 1970s to 1980s, the Shoreham nuclear power plant was built, and was ready to operate in New York state when community and political pressure forced it to stay closed forever. The utility that built it, Long Island Lighting Company, lost billions of dollars and eventually was taken over by the state's Long Island Power Authority. Today, Wall Street bankers still recall the Shoreham event when talk turns to financing of new nuclear plants.

Andy Patterson, of Scully Capital, said one way to convince bankers to lend on new nuclear construction is to provide them a government guarantee on their money. Scully Capital, an investment banking and financial services firm, in October presented a report to the DOE's Nuclear Energy Research Advisory Committee that summarized the difficulty in financing the first few new nuclear plants. The report, "Business Case for Nuclear Power Plants" (*NN*, Dec. 2002, p. 19) explained the need for government assistance in this matter.

Patterson

"One of the challenges is how to tackle the extra costs for the first new units," said Patterson, "because you have a first mover dilemma here. Everyone wants to be second, third, or fourth, but nobody wants to bear the cost of the first mover. And so government assistance is justified to handle this first mover penalty."

The "extra costs" for the first units include first-of-a-kind engineering expenses, the long lead times needed for getting the first plants built (because of untested regulatory processes, the Shoreham risk, etc.), and the expected high capital costs.

Patterson recommended the startup of what he called a standby credit facility. "This would be a government vehicle, a standby credit or insurance policy, whereby after a few months in the plant's commissioning if there's a delay the bankers would [have] their interest covered," he said. "So the standby credit facility would cover the bankers' portion on a new facility." The standby credit also would back up the utility's equity/debt in the project until three to five years after the plant's opening, when the utility would be able to start paying off its debt, he said.

Patterson said he was convinced the industry is moving toward new construction for a variety of reasons. "Clearly, the outlook for nuclear power has improved since 1990, and the message is starting to get out to Capitol Hill on this," he said. The existing low interest rates, the industry's "impressive" safety record, and the general public's support for nuclear all favor the building of new nuclear plants, he noted.

Another positive taken for granted by the industry is the steadiness of nuclear fuel prices, "given that [uranium is] from stable regimes in places like Australia and Canada," he said. "So that's a plus for the industry long term."

Patterson said that the Scully Capital report found three "key barriers that are standing in the way of new orders"—spent-fuel disposal (including its transportation), reauthorization of the Price-Anderson Act, and a clear NRC licensing process—but that these concerns are being addressed.

*Utility perspectives*

Eugene Grecheck, Dominion's vice president of nuclear support services, agreed that financial issues could hinder new plant deployment, but he emphasized the challenge that untested regulatory processes would offer.

The NRC's new plant licensing process has three parts: design certification, ESP, and COL. While design certification already has been demonstrated by the NRC and the ESP process is under way, the COL process "will need a similar initiative by industry and government," Grecheck said.

Grecheck also detailed Dominion's participation in the DOE's ESP business case study for evaluating sites for possible new plant construction. Selected for study were three DOE sites—the Idaho National Engineering and Environmental Laboratory, the Savannah River Site, in South Carolina, and Portsmouth, Ohio—and two Dominion plant sites—Surry and North Anna, in Virginia. Each site was evaluated using 45 criteria covering economic, engineering, environmental, and sociological factors. The evaluation work culminated in a Dominion report submitted to the DOE in September 2002.

The report recommended that the North Anna site be selected for the ESP demonstration effort, but it also determined that all five sites were "potentially suitable for deployment" of new nuclear power plants.

Dominion plans to submit an ESP application for the North Anna site in September, with the NRC's technical reviews expected to be completed in March 2005 and legal reviews by April 2005. The ESP and the final siting report are expected to be issued in May 2005, said Grecheck. (ESP approval would give a utility permission to locate a new plant at a site, but does not commit the utility to building a new plant.)

Marilyn Kray, vice president of project development for Exelon Generation, said the "driving force" behind any Exelon decision-making is to increase shareholder value. Thus, in a deregulated market, she said, it is "very difficult now to look at the capital expense" that is needed to build a new plant and then wait "10 years or 15 years before you can recover that and the impact it's going to have on your earnings."

Kray stressed that a utility shouldn't scramble now to build a new plant in hopes of making financial gain later. "That is not at all the behavior that we want to occur," she said. "So, the real driving force behind that at Exelon is that we need to view nuclear as a business and not as a cause."

But Kray agreed that the nuclear option should be maintained, and in that regard, Exelon is one of three utilities (along with Dominion and Entergy) that is planning to be an ESP applicant. Exelon plans to file the application for the Clinton plant site, in Illinois. (The Clinton plant is operated by AmerGen Energy Company, which is partially owned by Exelon. In an earlier meeting session devoted to ESP, Kray noted that if Exelon puts its interest in AmerGen on the market, as has been rumored, Exelon would hope that prospective buyers would view Clinton's ESP application as an asset.)

Dan Keuter, vice president of nuclear business development for Entergy, promoted the clean-air quality and energy security of nuclear power. He also said that oft-told tales of nuclear power's government oversubsidization are "a flat-out lie." For example, the tax credit of $17/MWh that the wind-power industry receives would pay "all costs of operating" a nuclear power plant, he said.

Keuter

Keuter said that Entergy is planning to submit an ESP application for its Grand Gulf plant in 2003.

## Nonproliferation and Clinton

The panel session, "Non-proliferation policy in the U.S.: Is it current with changing times?," brought together several people who had been government officials and advisors during the Clinton years, when important nuclear policies for the post-Soviet era were developed.

In introducing the panel members, Chairman David Rossin said he had asked them to describe how the policies were arrived at, something that outsiders rarely get an opportunity to hear. Rossin added some historical perspective, reminding the audience that although President Ronald Reagan rescinded many of President Jimmy Carter's nuclear policies, the latter's nuclear fuel cycle policy has largely remained intact. In Rossin's view, the reason for this is that the nuclear industry did not have the courage, the capital, or the need to risk investing in reprocessing. The possibility was revived only after the end of the Cold War, when the issue of excess military material had to be confronted. While this opened up discussion on the use of mixed-oxide fuel for the disposition of plutonium, President Clinton did not consider it a possible energy source.

Rossin first gave the floor to session cochair Roger Hagengruber, director of the Institute for Public Policy at the University of New Mexico, who noted that past decisions may have been understandable and the best choices at the time, but in retrospect they have not provided a sound pathway for accommodating the pragmatic reality of energy needs and nonproliferation. The United States now needs to lead, he said, not only in policy, but in technologies that lessen the likelihood of proliferation. One of the most promising developments, he said, is the new "coalition" with Russia.

Steven Black, acting director of the Office of Nonproliferation and International Security at the Department of Energy's National Nuclear Security Administration, noted that before the events of September 11, not enough attention was paid to the nexus of terrorism and weapons of mass destruction. He said that the United States had focused on rogue nations and weapons of mass destruction and not on terrorists and weapons of mass "disruption," such as radiological dispersal devices (RDDs). September 11 brought into the light a need to reevaluate perceptions and the risk of well-organized, financed, and committed nonstate actors and of nonconventional weapons.

Rossin

Black listed a number of measures, notably taken with Russia, including the disposition of weapons materials, controls on technology and weapons scientists, material security and border control, and others. The programs have also been expanded to involve other countries and the International Atomic Energy Agency, in areas such as physical protection and the location and control of radiological sources.

*The Clinton years*

The session then heard from three people who had taken part in developing the Clinton administration's nuclear policy: Fred McGoldrick (now with Bengelsdorf, McGoldrick and Assoc.), who worked at the State Department; Prof. Leon Feurth (George Washington University), who was Vice President Al Gore's national security advisor; and Dan Poneman (Scowcroft Group), who was with the National Security Council (NSC).

At the outset of Clinton's administration, McGoldrick noted, the NSC undertook a major review of nonproliferation policy. Following his own suggestion to the State Department, McGoldrick produced a short paper that set out what was needed in a nonproliferation policy. The paper stressed that large amounts of fissile material coming out of disarmament agreements had to be dealt with, and that the international community wanted assurances that the material was secure and would never be used again for military purposes.

In policy statements made in 1992–93, McGoldrick explained, Clinton proposed the purchase of excess weapons high-enriched uranium (HEU) from Russia and other countries, and its conversion for use in civil nuclear programs, which has already resulted in removing tons of material from possible weapons use. He also wanted to deal with excess weapons plutonium, which led to the 2000 agreement with Russia for the disposition by each country of 34 tonnes (t) of material. For this program, the United States adopted a dual-track policy of converting some plutonium to MOX fuel and immobilizing the rest. It also agreed for Russia to convert all of its material for power reactor use.

McGoldrick also mentioned the trilateral agreement signed with the IAEA on establishing verification procedures to ensure that excess material in each country was secure and not used for military purposes. The subsequent negotiations did make progress, notably on agreed technical inspection techniques, but stalled on Russia's refusal to include the Mayak storage facility under IAEA verification.

A move by the State Department was to encourage all countries to convert research reactors to operate with reduced enrichment uranium and to reinvigorate the U.S. program to take back research reactor spent fuel from other countries. It is also working with Russia to do the same for research reactors supplied by the Soviet Union.

Clinton also proposed an international convention to prohibit the production of fissile materials for nuclear explosive purposes or outside safeguards. The idea of a fissile material cutoff treaty, or FMCT, was aimed at stopping production by countries such as India, Israel, and Pakistan. No negotiations on this have taken place, however.

There were also proposals to limit the production of plutonium by maintaining a balance between production of plutonium and its use in MOX fuel. One related recommendation by the State Department is that all excess plutonium be placed under the temporary custody of the IAEA until it is released for peaceful uses. McGoldrick believes that this is an idea that should be considered and has published a detailed proposal on it.

While the Clinton administration rejected reprocessing and the use of plutonium in the United States, Clinton did not take a rigid ideological position on the use of plutonium outside the United States, said McGoldrick. He did not call for the end of reprocessing for civil programs, only the unsafeguarded production. In particular, Clinton did not stand in the way of reprocessing, granting long-term prior consent to Europe and Japan. McGoldrick also men-

tioned that Clinton resisted the considerable pressure from Congress and the environmental lobby to publicly oppose the startup of British Nuclear Fuel's Thorp reprocessing plant. This was probably because such opposition would have made it difficult to secure the cooperation of Britain and other European countries to pursue his other objectives. It struck McGoldrick that essentially all of Clinton's initiatives have been continued by the present administration.

Leon Feurth was an advisor to Al Gore during Gore's time in Congress and in the White House, where he was the Vice President's national security advisor during both terms. Feurth explained that the seeds of Clinton's policies were set during the campaign that brought him into office, such as advocating a comprehensive test ban treaty. It was also clear during the campaign that Clinton would engage global environmental issues in contrast to the previous administration that had to be dragged into them, he said. This included a desire to shift away from carbon-based fuels and nuclear energy in general. The Clinton administration did not undertake an ideological war against nuclear energy, he said, but it did not advocate it as a primary source of power. This led to some interesting problems, Feurth recalled, such as the Czech Republic's request for the administration's blessing for Westinghouse to complete the controversial Temelin plant. Feurth explained that following a due diligence exercise, the administration ruled that Westinghouse could proceed under certain assurances regarding safety.

As a Senator, noted Feurth, Al Gore became a leading figure on proliferation issues following the discovery of Iraq's nuclear activities. As Vice President, Gore was involved in completing the agreement on the exchange of weapons for fuel between Russia and Ukraine, and in pushing the final closure of Chernobyl.

The construction of a reactor at Bushehr in Iran remained a problem. Feurth claimed that the Clinton administration had reached some sort of agreement with Russia to hold off for the time being on Iranian ambitions. This understanding, which was at least slowing down the Iranian plans, broke down when Republican staffers leaked the arrangement to the press. Iran has caused a loss of time and momentum on other proliferation issues, Feurth said.

He noted that the advantage of the HEU deal was that it offered large enough financial benefit to Russia for Russia to agree to it. He believes the United States needs other such leverage to gain further Russian cooperation. He pointed to Minatom's desire that the U.S. agree to its offering spent fuel services to other countries.

As for North Korea, Feurth fears that "counterproliferation," which he defined as action designed to physically impede the acquisition of technologies that could lead to proliferation, rather than "nonproliferation," which focuses on diplomacy, would become America's dominant policy.

Dan Poneman, who joined the National Security Council during the first Bush administration, noted that the Clinton administration wanted to develop a "cradle-to-grave" approach to the removal of excess fissile material, not just to secure it. He said that the administration soon realized that the best approach was to work constructively with Russia, which led to the HEU and plutonium disposition agreements.

**The construction of a reactor at Bushehr in Iran remained a problem. Feurth claimed that the Clinton administration had reached some sort of agreement with Russia to hold off for the time being on Iranian ambitions.**

Civil reprocessing, he remarked, was a contentious issue, and many in the Clinton administration were interested in a more coercive approach as under the Carter administration. But Clinton understood that such an approach could backfire, so it was decided not to muscle Europe and Japan into accepting the U.S. position.

Poneman also mentioned that when the United States began to look at plutonium disposition, it did not have a clear policy and gave the National Academies of Science a chance to examine it. The NAS concluded that immobilization and burning as MOX were viable options, and the Clinton administration devised the dual-track approach, which was abandoned by the new (George W. Bush) administration. During the session's question-and-answer period, Feurth acknowledged that the reason for dropping the immobilization option was largely budgetary and did not indicate the desire to adopt reprocessing. "I do not think the Bush approach is any more or less ideological than the Clinton [approach]," he said.

*Taking account of September 11*

Alex Burkart, deputy director of the Office of Nuclear Energy Affairs at the Bureau of Nonproliferation Affairs at the State Department, discussed what is happening currently. In particular, policies are being adapted to take account of the events of September 11, 2001. For example, distinctions between state and nonstate actors have been blurred, as has the view of what a weapon of mass destruction is.

The Department has adopted five goals:

1. Curb the supply of materials, equipment, and technology for weapons of mass destruction and missiles to proliferators or terrorists. Priorities include preventing diversion and stopping specialized knowledge from leaving the Former Soviet Union, halting the supply to Iran of nuclear equipment and technology, and strengthening multinational export control regimes, such as the Nuclear Suppliers Group. Achievements already realized include:

- The setting up by the Russian and American Presidents of a working group to identify ways to increase the rate of safe disposition of fissile materials.
- The return to Russia of spent fuel from research reactors supplied by the Soviet Union.
- Setting radiological dispersion devices is a "front-burner" terrorist issue.
- The G-8 agreement to commit $20 billion to support cooperation projects on nonproliferation.
- Engaging India, Pakistan, and Israel in participation in export control training.

Burkart noted that Iran is one of the issues standing in the way of advanced technological cooperation with Russia. "It is more than a minor detail to the President," he said.

2. Get states seeking weapons of mass destruction to cease their efforts. Burkart explained that the United States approached each situation differently:

- On Iraq, the government pushed through the UN resolution, which President Bush called a final "disarm or be disarmed" demand.
- On North Korea's nuclear ambition, the United States is seeking to resolve this by diplomatic means with friends and allies in the region.
- On India and Pakistan, the United States has chosen dialog rather than a tongue-lashing to improve situations regarding control of weapons and materials. It is even seeking to work with their peaceful nuclear programs in ways that are consistent with existing commitments and obligations.

3. Strengthen the international systems of nonproliferation treaties, norms, and standards and their implementation.

4. Constrain the transfer of advanced conventional arms, as well as nuclear, chemical, and biological weapons.

*Continued*

5. Promote international nuclear cooperation under the highest nonproliferation and safety standards.

Finally, Burkart mentioned how very painful it was for some in the Clinton administration to include MOX as one of the options for plutonium disposition. The administration, however, found the Russian argument to burn MOX fuel quite compelling.

## Nonproliferation challenges

The Technical Program Chair's "Special Session: Nonproliferation Challenges for Nuclear Technologies in the 21st Century" was led by Tom Sanders, vice chair of the ANS Special Committee for Nuclear Nonproliferation and manager of nuclear initiatives at Sandia National Laboratories (SNL). This session is part of the committee's continuing effort to keep ANS members informed on proliferation issues.

At the start of the session, co-chair Scott Dam, of Jupiter Corp., acknowledged the work of two people: Buzz Savage, one of his assistant technical program chairs, and Mel Buckner, chair of the ANS Special Committee for Nuclear Nonproliferation.

In the opening talk, Robert Eagan, SNL, said he wanted to expand the discussion beyond policy issues to cover energy needs under the rubric "Power for Peace and Prosperity" to get across the idea that energy sources that are affordable, clean, and broadly available are critical for peace as are nonproliferation measures.

Eagan demonstrated the importance of energy by displaying a chart, produced by British Petroleum, that showed an almost one-to-one connection between availability of affordable energy and economic prosperity—"and all the things that that brings with it," he said. By 2020–2030, Eagan said, shortages in oil are pretty certain to develop and prices to rise. The same thing applies to some degree to natural gas. To assess the implications, he described the Global Energy Futures Model and the Global Nuclear Futures Model developed by Sandia economists. These are interactive tools that allow users to see the consequences of changes in various parameters—such as energy efficiencies, reactor types, alternative energy sources, etc.—on the economy, energy supply, pollution, and other environmental issues.

Eagan pointed to two particular global problems that will become more severe: carbon emissions from the developing world, and water shortages. He said that he had recently heard a figure from a U.N. source that 25 000 people die each day from a lack of clean water. Nuclear can contribute to the world's need for energy and water and reduce carbon emissions, but, he said, "it must be affordable, exportable, safe, and secure." Its use needs to be broad and international and take account of proliferation concerns, he added. For a large increase in use, there will be a need for advanced fuel cycles, otherwise the burden on waste repositories could be intractably high. He posed other questions that must be answered: Should plutonium be separated? If so, by whom? Is the thorium cycle better than plutonium? Should breeders and reprocessors be confined to a few countries?

Academician Evgeny Velikhov, president of the Kurchatov Institute, gave a perspective from a country fully committed to nuclear energy. For Russia, said Velikhov, proliferation concerns are a great obstacle to the economic development of nuclear power, although, he noted, it also provides some commercial opportunities.

Everyone at the meeting, noted Velikhov, knows that there is a need for nuclear power and that before the restart can happen on a large scale, proliferation issues need to be resolved. In his presentation, he concentrated on technological means rather than the politics of nonproliferation. Among the measures he discussed were the use of closed fuel cycles, with fuel and actinides returned to reactor, and the establishment of centers—under international controls—for spent fuel reprocessing. Such centers, he said, will help prevent access to fissile material and technology, and will provide physical protection and security. One radical option, which he described as a combination of technological and economical means, is to move to the leasing of nuclear reactors and fuel and applying "cradle-to-grave" supply contracts rather than simply selling the technology. What he particularly favored was the setting up of a limited number of large nuclear centers under international control, and, rather than supplying nuclear technology, it would deliver products—energy, water, and heat—under leasing arrangements.

Not surprisingly, Velikhov provided a Russian proposal based on the huge nuclear submarine construction facility, SEVMASH, the largest covered shipyard in the world, which could produce six submarines per year. Reactors could be constructed there, placed on barges, and shipped to the consumer under a leasing scheme. At the end of reactor lifetime—say, 50 years—it would be returned to the yard in the same way. Besides the advantages of factory manufacturing (reduction of construction time, lower doses for workers, etc.), he said, this could also simplify licensing. Velikhov noted that the AP600 reactor would be just the right size for the facility.

Another technology under development in Russia is floating reactors, particularly for remote or isolated areas where energy and fresh water are needed, he noted.

Velikhov sidestepped a question on his view of the possibility of gaining American support for Minatom's plan to offer spent fuel services in exchange for dropping the Iranian project. He did, however, put forward his belief that U.S. concerns could be resolved through other means.

Jacques Bouchard, head of the Nuclear Energy Division of France's Commisariat a l'Energie Atomique (CEA), focused on the back-end of the fuel cycle. France still considers recycling preferable to storing spent fuel in repositories that could become, he warned, "plutonium mines." France currently recycles plutonium as MOX fuel in 20 of its 58 pressurized water reactors, based on the principle "equality of plutonium flows," which means recycling all plutonium produced from reprocessing. France also plans to increase burnup of MOX fuel, which is now limited to three in-core cycles. Work to license a four-batch strategy, as for uranium oxide fuel, is under way under the MOX "parity project." Bouchard said that a stabilization of France's inventory of separated plutonium should be achieved around 2005.

Bouchard reminded the audience that light-water reactors will remain the dominant reactor system for quite some time, as new designs will not play an important commercial role until the middle of this century. He believes that the situation is such that plutonium must be used if its inventory it to be kept as low as possible. The first option for increasing burnup, he said, is to utilize full MOX cores, which is being studied in France for the EPR (European pressurized water reactor) and in Japan for the advanced boiling water reactor. Beyond that, France is also developing advanced fuels and fuel management strategies to burn more plutonium.

In the longer term, Generation IV designs being developed now will take account of sustainability issues (efficient use of natural resources and minimizing waste production), as well as proliferation-resistance. Bouchard particularly pointed to the "fast neutron, closed-cycle" family of reactors (including gas, sodium, and lead-bismuth–cooled systems), which are "top-ranked in sustainability," in terms of actinide management and conversion of fertile uranium, and rated good in areas of safety, economics, proliferation-resistance, and physical protection. The ideal system, he suggested, would be an integrated cycle involving a homogeneous fast core with nonseparated actinide recycling that takes in natural uranium and puts out only fission products as waste. Bouchard mentioned that several options have been investigated, the most well known being the electro-metallurgical process developed at Argonne National Laboratory in the United States for the Integrated Fast Reactor fuel


Bouchard

cycle. France, Japan, and Russia have also worked on schemes. CEA studies include a method based on conventional Pyrex reprocessing and another known as Ganex (Group ActiNides EXtraction).

*Nuclear's vital voices*

The final two speakers, explained Sanders, were vital voices in turning around the position of the U.S. Congress and the government on nuclear energy: Pete Lyons, who has served as science and technology advisor to Sen. Pete Domenici, of New Mexico, since January 1997, and Bill Magwood, director of the Department of Energy's Office of Nuclear Energy, Science and Technology.

Sen. Domenici, explained Lyons, kicked off the current round of interest in nuclear energy in a speech titled "A New Nuclear Paradigm," which he presented at Harvard University in October 1997. In that speech, he called on the United States to harness the nuclear genie. Lyons noted that Domenici has also provided leadership on most of the nonproliferation initiatives involving Russia. These include the Materials Protection, Control and Accounting Program; the high-enriched uranium (HEU) deal; plutonium disposition; and efforts to keep scientists occupied with valuable work in Russia and the Nuclear Cities Initiative.

In the past year, Domenici proposed the Nuclear Non-Proliferation Act, which seeks to recognize the global character of nonproliferation and terrorism challenges. While the bill was not carried through to law, most of its measures were included in the Defense Authorization bill, which did pass. The aim of the Act was to broaden most of the DOE's

# Saving millions

Operating nuclear utilities need to have a decommissioning "guru" on staff—to create and update a decommissioning plan, to keep track of decommissioning issues, to attend industry conferences and sessions on decommissioning technologies—even if they are not planning to decommission a plant any time soon. This was the major piece of advice proffered by the panelists at a session titled "Saving a Few Hundred Million Dollars: What Nuclear Power Plant Operators Should Be Learning from Plants in Decommissioning." The session was sponsored by the ANS Decommissioning, Decontamination and Reutilization Division and organized by Joseph Carignan, of TLG Services.

Ray Burke, of Maine Yankee, noted that he would have called the session "Pay Me Now, or Pay Me Later." His company made an abrupt decision to decommission the plant (located in Wiscasset, Maine)—a decision that it was not prepared for, Burke said. His presentation addressed the question of if the utility had it to live all over again, how would it better position itself for decommissioning?

First, Burke said, it would pay more attention to stakeholders. Build a relationship with opponents and engage in dialogues with the local community, creating a Community Advisory Board if there isn't one already, he declared. Also, he said, go back to company archives and see who owes what to whom. If the company has committed to returning a piece of land to the community or to remediating a portion of property to pre-plant condition, that needs to be known.

Second, he said, control contamination now. Prevent leaks and spills and clean them up quickly when they do happen.

Third, build a strong historical site assessment. Keep good records on both radiological and nonradiological spills. Take photos before and during construction and during any plant modifications. Include spill and event questions in employee out-processing forms. Burke said that Maine Yankee was fortunate to be able to hire a former employee who had helped build the plant and who knew where the photos were kept. These photos proved invaluable in showing regulators the condition of the site before construction started.

Avoid the legacy waste trap, he urged. If any waste is stored onsite, get rid of it ahead of time. This includes any contaminated soil, Burke said. Get rid of it now.

Finally, he said, develop a good decommissioning plan. Most plants are required to have a decommissioning fund and cost estimates, but a lot more is needed. The decommissioning guru may seem like a wasteful expense, but will prove to be invaluable, especially if there is a sudden shutdown decision, he observed. The guru needs to be a technical person, "not just an accountant," Burke concluded.

Einar Ronningen, from the Sacramento Municipal Utility District, which is decommissioning the Rancho Seco plant (located in Clay Station, Calif.), echoed some of Burke's comments. "Don't enter decommissioning with a large inventory of radwaste," he cautioned. In addition, minimize bulk chemical inventories before shutdown.

Also, he said, it would be wise to do a chemical decontamination of the major plant components immediately after shutdown. It may be expensive, but it is certainly cheaper than "sitting around for 10 years" waiting for the components to cool down.

On the topic of decommissioning planning, Ronningen reminded the audience that a decommissioning cost estimate is *not* the same as planning. The cost estimate will tell you *what*, not *how*, he said.

Elias Henna, of Southern California Edison (SCE), which is decommissioning San Onofre-1 in San Clemente, Calif., noted that his company is learning a great deal from the San Onofre-1 cleanup, since it has two operating units sharing the plant site. His major suggestion was one that he said might seem counterintuitive: If a utility already has decided on a decommissioning date sometime in the future, toward the end of life, it should switch to shorter refueling cycles and use lower burnup fuel. That way, fuel in the pool will have to be cooled for only five years, whereas high-burnup fuel has to cool for about 15 years. In this way, he said, a couple more refueling cycles will be added, but the decommissioning project can be shortened by some four years (assuming no technological breakthroughs in canister design and no change in NRC regulations). Some $191 million in fuel costs will be added, he noted, but $261 million in decommissioning costs will be saved.

He conceded, however, that this idea is more appropriate for a plant operating in a regulated market, not a free market. SCE is currently replanning the fuel cycles of Units 2 and 3 toward the end of plant life to incorporate this idea.

Mike Williams, balance-of-site supervisor at the decommissioning Saxton plant, in Saxton, Pa., suggested that plants keep GPS (global positioning system) coordinates for every spill. His other pieces of advice: "Plant operators are smart, but are not necessarily in very good shape!" Thus, he said, you may not be able to use operating staff as your demolition workers. Also, before you even *think* of a decommissioning cost estimate, do a historical site assessment. Finally, "Odds are," he said, "you don't know enough about your site's groundwater."

In the subsequent question-and-answer session, an attendee asked if a plant's decommissioning fund could be used to fund the "decommissioning guru." The panel suggested that there may be some regulatory resistance to that. One panelist noted that plants can use up to 3 percent of the fund for decommissioning planning, and so may be able to get cost recovery once decommissioning begins. However, Williams stated, regardless of whether a utility can recover the cost, it's a good investment.—*Nancy Zacha*

nonproliferation programs to include an international focus beyond just Russia. It encourages cooperation with the Russian Federation wherever possible, and recognizes the vital role played by the IAEA. Among its provisions is to create an expanded HEU blend-down program over and above the current HEU deal to enable faster stock reduction; it encourages blend-down to just below 20 percent, not to low-enriched levels, and restricts the entrance of low-enriched uranium to the United States to avoid disrupting the market.

Another bill introduced was for funding to set up international repositories working with the IAEA that would take orphan radioactive sources. It also would provide direct assistance to other countries to remove large sources and to replace them with alternative technologies. There was not enough time for it to go through in the last session, said Lyons, but it will be reintroduced. Most recently, Domenici has been working on the advanced fuel cycle initiative, which combines the study of advanced reactors, advanced reprocessing technologies, and reactor- or accelerator-based transmutation.


Magwood

After a brief description of the Bush administration's energy policy, Bill Magwood explained some of the rationale behind its support for nuclear energy. It is clear, said Magwood, that fossil fuels will remain the country's baseline for energy, but they all have question marks: supply disruptions and price fluctuations for oil and long-term concerns of stability of supply and price for natural gas; coal—an abundant resource—may, without important advances in technology, be unavailable because of pollution and greenhouse gas emissions. Renewables will be important, he said, but there are questions about their potential for meeting growing demand and their costs.

Nuclear, on the other hand, has proven itself, particularly over the past decade, he noted. Concerns about proliferation, however, simply will not go away. That is why the Gen IV program considers diversion and security threats, he said, adding that the Gen IV Roadmap project has been concluded and a report will be given to Congress by March.

Another important element is the advanced fuel cycle initiative, for which a program plan is being developed. Magwood explained that the near-term objectives focus on reducing the amount of high-level waste, the cost of geologic disposal of spent fuel, and the amount of actinides and plutonium in the spent fuel. In the longer term, it will look at advanced technologies to reduce the toxicity of HLW, to optimize the performance of the Yucca Mountain repository, and to develop other advanced nuclear technologies. Although there are no plans to move forward on commercial reprocessing, he said, its potential benefit for extending fuel resources for hundreds of years, as well as for managing spent fuel, must not be ignored.

At the moment, DOE and partner organizations are also studying the development of evaluation methodologies to find out how to measure proliferation-resistance. This is a long-term effort to make it possible to compare the capability of different systems. DOE is also working on instrumentation to provide measurement and control of materials in recycling facilities, and a task force is looking at the characteristics of proliferation-resistant recycle fuels for light-water reactors.

DOE sees Russia as an important partner for research and development, said Magwood, and following the last Bush-Putin summit, a plan for future work has been prepared with Minatom and given to the presidents.

Finally, Magwood highlighted a major nuclear energy mission for the Idaho National Engineering and Environmental Laboratory (INEEL). Over the past few years, there has been some decrease of work at INEEL and other national laboratories, Magwood said, and Energy Secretary Spencer Abraham decided to revive those missions and bring the labs back to their former glory. They will be the focus for Gen IV system development and advanced fuel cycles, and provide some support for the deployment of space nuclear power systems. His final slide was a job advertisement asking for senior management people to go to the great Northwest.

## Outside regulators for DOE?

External regulation of Department of Energy facilities is an idea that's been tossed around for a decade. In 1993, Hazel O'Leary, who was Energy Secretary at the time, announced the department's intention of seeking external regulation of DOE national laboratories and facilities, replacing the department's self-regulation. A few years later, an advisory committee recommended that the Occupational Safety and Health Administration, or OSHA, should regulate worker safety and the Nuclear Regulatory Commission should regulate nuclear facility safety at DOE sites. In the years since that time, however, despite several more studies, little in the way of concrete progress on the transition has been made.

In 2001, Congress directed the DOE to put together an implementation plan for transitioning to external regulation for its nondefense science laboratories, presuming the NRC's and OSHA's regulation. The next significant deadline on the issue is May 31, when four as-yet-unnamed laboratories are expected to submit accurate and detailed cost estimates of the transition.

The session "External Regulation of Operating U.S. Department of Energy Nuclear Facilities" addressed some of the concerns that remain as the May 31 deadline approaches. The audience heard perspectives from a government employee who worked on a report on external regulation, a deputy director at a national laboratory, and a skeptical industry veteran. The Department of Energy itself, though, was not represented.

"As far as I can tell, we're back where we were before when we first looked at this thing six or seven years ago," observed Gary Boss, of the General Accounting Office. "And this is an issue that's been gong on for a long time." Throughout the session, there were several other expressions of frustration both with the process and with the very idea of externally regulating the facilities.

Although the most immediate issue is whether the DOE should transfer 10 nonweapons laboratories to external regulation, there was a feeling that, despite the foot-dragging on the transition, it is only a matter of time before more DOE labs follow suit.

Boss likened that certainty to that of a particular, nationally known golf club admitting women members. "I think there's a general feeling among many that *eventually* that's going to happen—that eventually, at some point in time, there'll probably be a female member at Augusta National golf course.

"I think that eventually these laboratories will be regulated by someone other than DOE. And the question is, How do you get there? What's the best way to get there? What's the most careful way to get there, taking into account everything from a safety standpoint, security standpoint?

"You can get there if you want to. There's a way to do it to preserve national security, without it being overly costly. It's just a question of doing it carefully. I think eventually you'll see that. . . . To me, it's just a matter of time before we do that."

### *On with it, already*

Because of the differing interests of the parties involved in studying the possibilities of external regulation, the General Accounting Office was asked to put together a report on costs. Gary Boss, assistant director of natural resources and environment for GAO, was one of the coauthors of the report, and his dissatisfaction with the amount of progress on the matter was apparent.

After reading through one report on the matter early on in the process, Boss remembers not being able figure out why the issue was so complicated. "I thought, what's the big controversy here?" he said. "I thought it was real clear.

"And, it wasn't real clear. It was muddy. And quite frankly, I don't think the situation has changed much since then."

Where GAO has tried to make a contri-

bution, Boss said, is in determining how much money DOE is spending to regulate itself. "DOE is supposed to look at the compliance side of that. What would it really take to become compliant with NRC and OSHA regs? [That is] a very difficult question, not an easy question to answer. That's DOE's job. We were asked to look at the other side in terms of what it's costing DOE to regulate these facilities. Then we can compare that with what OSHA said they will charge DOE to externally regulate."

Boss said that he and his colleagues are in that process right now, working with DOE field offices and contractors. He said they expect to complete some of that work early this year.

"Right now I would say that the opportunities for savings really aren't that great," Boss admitted. "On the contractor side, there probably could be some differences. On the DOE side, I really don't know. What scares me a little bit is that these costs could actually go up. What would really make this work from an efficiency standpoint is if DOE changes the nature of how it relates to the contractors. Contracts have to be completely rewritten. . . . That's crucial for this thing to work if you're only interested in looking at the efficiency side of the equation."

On the other side of the fence—what it will cost to comply—Boss said he is also concerned because he doesn't think good information is available, nor will the DOE come up with any by the May 31 deadline using the current processes. "I think they ought to go to every one of those labs, get NRC and OSHA in there and come up with some kind of a number that everyone agrees to, and that's it. I'm worried now that we'll get something that will [require] me [to] come back in there to look at very carefully, asking, Are these numbers accurate? Are they reliable? Frankly, we're tired of doing that. We think we're well past that. This issue has been around a long time. I think it's really time for something to be done. We do this or we don't do this.

"There's enough information out there on the pros and cons for the issues to make some decisions. I think we'll have cost-related information to deal with that side of it. Insofar as all of the other kinds of policy issues, the complications that exist when you try to make this transition—and there are a lot of them—these have been discussed for years. This is not a new issue. The same kinds of things that we talk about now they talked about for almost 10 years. I don't think we need to get into that a lot more. The regulators, whoever they may be, and DOE and the contractors can get together and sit down and hammer out what has to be done."

*The costs of compliance*

Thomas Sheridan, deputy director for operations at Brookhaven National Laboratory, was a member of the group that submitted a plan to Congress last April on transitioning to external regulation. Having glimpsed the costs and implications that await such a transition, he can also be counted among the frustrated.

The group came up with "very, very rough" cost estimates from a number of DOE laboratories, held weekly meetings in Washington, D.C., and came up with a 98-page report that had times, schedules, and costs, Sheridan said. "But somehow between the time that we got finished with it and the time it appeared on the congressmen's desks, it had become 17 pages. An awful lot of details had disappeared out of it. I'm not sure exactly what caused that to happen."

For Brookhaven National Laboratory, the cost was $11.2 million, Sheridan said. About $1.6 million of that was for obtaining NRC licenses. And there was $9-plus million for OSHA compliance concerns. Sheridan sees several problems with the repairs that the money would be put toward.

"To take a place that has buildings that were built in the '50s and decide you're going to make it all OSHA-compliant next week or next year, a tremendous number of things that we found we needed to fix were [things such as] the ceiling's too low or the steps are not exactly all the same size. Those things are . . . very expensive to fix. And if you change the height of the steps, the guys who are used to them will probably fall down and hurt themselves because it would be such a surprise."

Sheridan said there are 618 eyewash stations at BNL that would be noncompliant with OSHA rules because they do not provide tepid water for a duration of 20 minutes. "How much do you suppose it would cost to fix each one of them? It's a thousand dollars each because you're going to have to put a tank in the ceiling somehow. A thousand dollars doesn't sound unreasonable to me . . . but I'm not sure there's a lot of value in that."

Sheridan

He said he has found the NRC and OSHA to be unsympathetic. "As hard as we have tried . . . to try to get them to say, 'Well, we'd grandfather that stuff,'—they can't say that. First of all, you've got to go pretty doggone high up in the organization for anyone to agree that they're going to give you permission. . . . But, secondly, they just don't do business like that. When somebody calls and says you have a problem, [OSHA] comes and knocks on your door. They look at whatever they're going to look at that day and fine you for whatever they find to be noncompliant. And then they go away until the next call comes."

Another question, Sheridan pointed out, is how DOE is going to fund the needed upgrades for compliance. "The only answer that we got was, you might have to stop doing some of that science for awhile. Well, the scientists leave when you do that."

As an example, in environmental management, if something happens that causes money to be diverted to something else, "you just don't make your milestones as fast as you were going to," Sheridan shrugged. In science, researchers are working on grants, "and every second that you take them away from that, whether it's with safety training or with other just 'crap' as far as they're concerned that is not productive, they are very, very jealous about that. . . . Every penny or fee that goes to the contractor [ticks] the scientists off. . . .

"So, the message of [taking] money from the scientific programs to spend it on upgrading the eyewash stations is going to really cause a lot of hate and discontent among the scientists."

Finally, Sheridan said he is worried about the unintended ripplings in BNL's public perception that may be caused by bringing BNL into full OSHA compliance. "If I say in the local newspaper it's going to cost us $12 million to come into compliance [with] OSHA, I'm afraid that the public is going to be pretty upset about that. Because that makes it sound like, 'Holy mackerel, they're even worse then we thought back in '97.' So there are certainly some political implications to that cost to come into compliance."

*The need has passed*

Until last May, Joseph J. DiNunno was a member of the Defense Nuclear Facilities Safety Board, on which he had served since 1992. As DiNunno, who began his career in 1942 at Westinghouse put it, "I've lived this, so I can talk here."

DiNunno outlined a history of the issue and then provided reasons why he feels external regulation of DOE facilities is not a good idea. "My basic thrust is that I don't think, given the life and the mission of the Department of Energy and where it is today, that this transition and the problems that this transition would cause is really worth the effort. This is my point of view."

There were two major reports that came out in the wake of O'Leary's announcement that DOE would seek external regulation. Congress looked at both of these reports, particularly the one from the external advisory committee, and "cautioned the secretary in 1996 to go slow—in particular, with respect to defense nuclear facilities," DiNunno explained. "They didn't think putting defense facilities under external regulation was a good idea."

This, however, was not a unanimous congressional opinion. "There were people up there [on Capitol Hill] that weren't satisfied that the action that was taken was an appropriate one. So, there's been continued

*Continued*

agitation in some form or other, by some committee or other up on the Hill, for pushing, still, for external regulation," DiNunno said. "This is where we are today."

There are 551 facilities that DOE staff have identified as eligible for this transition, he said. Seventy-six of those fall into the category of operational facilities that are part of the defense nuclear facilities, 375 of them are environmental management facilities, and 100 are facilities that fall under nuclear energy development and nonweapons laboratories.

"I looked at the case made to date for external regulation, and I find that the case made is more subjective than objective. I think that as engineers and scientists, if we're going to be advising Congress on what action they ought to take, we ought to make as objective a case as we possibly can. I don't think we've done that," DiNunno said.

There are three reasons that are commonly given as to why external regulation might be beneficial, he explained. One, there are those who say it will improve safety. Secondly, others say it will help improve the image of DOE and help make them more credible in the eyes of the public. The third reason is that it will save money.

"My examination of this thing has convinced me that just by conventional performance indicators, the department's ES&H [environment, safety, and health] record during the past decade, in particular, has been quite good and has shown continuous improvement," DiNunno said. "And the objective evidence that I've been able to find relative to radiation safety does not provide cause for any drastic change in regulatory regimes."

What about public image? "Public confidence is important for mission success. But instilling that kind of confidence is not a requisite or a criteria for external regulation," he argued "It's certainly not a cause for external regulation. It's a byproduct, perhaps. But you can't, in my view, argue that external regulation is required in order to improve the confidence of the public in the Department of Energy."

As to cost savings, DiNunno said, "The numbers that I have seen on this have been largely anecdotal and crude. So, I don't think a cost basis has been established."

DiNunno offered a few more reasons for his doubts about the benefit of external regulation. Maintaining stability in a safety program is extremely important to be effective, he said. "If you keep jerking people around by one program versus another, you're going to lose momentum with every change. We [DNFSB] already experienced some of this as a board. We experienced some of this change in momentum just with an administration change. . . . [T]here was always an inevitable slowdown as the administration changes. You hint that you're going to change the basic framework of regulating these facilities, and you're going to create a disruption of momentum that is well under way, is really moving in a very positive way."

In conclusion, DiNunno pointed out that he "can honestly say that external regulation is a proposed solution to a problem of yesteryear. One needs to deal with DOE as an entity today. What is it doing? Not just today, but how have they done over the last five years, or decade? And do they have something in place that's promising enough to give you confidence that it's likely to proceed along? I think that is extremely important to bear in mind.

"I'm not the only one who thought this. [A senator] sent a letter to Secretary O'Leary in 1996 warning her that if you proceed you're going to run into some problems up on the Hill. What he ended up telling her is that in his view . . . the need for another regulator may already have passed. It may come again, but not for now.

"That's where I've come out on all of this."

**License renewal is stable and predictable, said Kuo, and meets the agency's goals of reducing unnecessary regulatory burden, increasing efficiency and effectiveness, and raising public confidence.**

## License renewal in the U.S.

Looking around at the sparse attendance at the panel session, "License renewal in the United States," one of the speakers, Jim Lang, of the Electric Power Research Institute (EPRI), ventured the opinion that this showed how successful license renewal has been and how few technical issues remain. The panel was chaired by C. Thomas Snow, of Dominion Resources.

As program director for license renewal at the Nuclear Regulatory Commission, P. T. Kuo has played an important part in the impressive achievement of license renewal. Opening the panel session, Kuo provided a status report of license renewal, as well as an overview of the renewal rule and other guidance.

License renewal is stable and predictable, said Kuo, and meets the agency's goals of reducing unnecessary regulatory burden, increasing efficiency and effectiveness, and raising public confidence. "Whenever we have a meeting," he stressed, "it is a public meeting; everything is subject to public scrutiny. When we have workshops, the public interest groups are invited to attend and provide comments."

In just four years, said Kuo, the NRC staff has completed reviews of five applications (10 reactors), covering the designs of all the four main vendors—B&W, Combustion Engineering, General Electric, and Westinghouse. There are currently eight applications (16 units) under review. Of these, only the applications for McGuire and Catawba are being contested and will require public hearings, Kuo noted. NRC expects five applications in FY 2003, six in FY 2004, and five in FY 2005. Over the next three years, the staff will be reviewing 10–14 applications at any one time.

The NRC began to look into the feasibility of license renewal in the mid-1980s, focusing on aging phenomena, and in December 1991 issued the first license renewal rule. The industry then set up a demonstration project to see how this rule would work in practice. As a result, both the NRC staff and industry realized that the aging process begins at day one and that it is hard to set a dividing line based on aging for purposes of license renewal, said Kuo. The rule, as it now stands, concentrates on aging management, in particular of the long-lived passive structures and components.

Besides issuing a Regulatory Guide for renewal applications, NRC staff developed Guidance Documents for the safety review, including the Standard Review Plan for License Renewal (NUREG-1800) and the Generic Aging Lessons Learned (GALL) Report (NUREG- 1801). The GALL report was prepared following the demonstration project mentioned above, when the staff concluded that many existing plant programs could be used as aging management programs. They then assessed typical plant programs that seemed relevant. GALL is the collection of these assessments.

To deal with the National Environmental Policy Act (NEPA), the NRC staff also prepared a Generic Environmental Impact Statement (GEIS) and a Regulatory Guidance, "Environmental Standard Review Plan for License Renewal."

Kuo went through the review process, pointing out some of the major steps. If an application is contested, the NRC review should take 30 months to complete. Until recently, the time for completion of an uncontested review was set at 25 months. This target has now been reduced to 22 months after the Commission delegated the authority for the issuance of renewal licenses to the Office of Nuclear Reactor Regulation if the application is uncontested.

Alan Nelson, of the Nuclear Energy Institute, gave the industry perspective on how the process is working. He noted that half of the U.S. reactors are already committed to renewal, and NEI expects virtually every plant to go for it.

Nelson said that NEI has been leading the industry response, providing valuable assistance in developing a standard renewal procedure, accumulating experience, facilitating cooperation among applicants, resolving technical issues, arranging meetings with the NRC, and making other efforts to ensure that the process is kept on track and focused. NEI recently organized a workshop at NRC to allow staff reviewers to communicate lessons learned directly to the industry.

NEI gets particularly involved in the Interim Staff Guidance process, which is used to update existing guidance documents. One issue of particular concern is environmental-assisted fatigue, which has been on the table for more than a decade, Nelson said. NEI now plans to develop an Interim Staff Guidance for NRC staff to review, which Nelson hopes will lead to the issue's being resolved soon. Another hot topic for NEI is to develop an acceptable appeals process that allows NRC staff decisions or positions to be questioned. NEI's primary focus now is the development of a standard application format.

EPRI's Jim Lang discussed why there were so few technical issues still on the table. First, he said, from the day the plant starts operation, programs are put in place that are effectively aging management activities. These cover maintenance, in-service inspections, nondestructive evaluation, and others. "So we deal with the aging process from the very onset," he said. There are, however, some new technical questions and new twists on old questions that continue to come up. At the moment, these include cable aging, stress relaxation in pressurized water reactor internals, radiation-assisted stress-corrosion cracking of reactor internals, environmental fatigue of metal components, degradation of small-bore piping, stress-corrosion cracking of high-nickel alloys, and the environmental effects on fatigue.

Lang also explored how the issues evolved since the 1970s, when "plant life extension" programs began. Then, concern focused on issues such as fatigue and neutron embrittlement. The extensive investigations at that time concluded that really there were no technical showstoppers, he explained, and that extending the license term would not be a problem. Today, he noted, the processes in license renewal incorporate asset management concepts, since how plants are maintained is not only a liability issue, it is an economic issue.

*Avoiding environmental impact*

Karen Patterson, of Tetra Tech NUS, explained how NEPA relates to license renewal, stressing that "it is very different from what nuclear plant folk are usually exposed to in terms of regulations." NEPA seeks to avoid environmental degradation or risks to health and safety by identifying adverse impacts and the magnitude of those impacts, she said. However, "NEPA is not an environmental protection statute," she observed. "It requires that you evaluate a project and identify the impacts. Avoiding environmental impact is a goal of NEPA, not a requirement."

Patterson emphasized what it does not do:

- It does not prohibit development.
- It does not contain any environmental regulatory requirements.
- It does not amend nor preempt any other federal regulations.

She then explained how NRC, NEPA, and license renewal all fit together. The GEIS for license renewal identified and examined 92 environmental issues. For 69 of these, the NRC concluded that impacts would be the same and small and therefore plants did not have to look at them. Of the remaining 23, there were two issues, environmental justice and the chronic effects of EMF, that NRC decided could not be analyzed yet. However, the impact of the other 21 did have to be assessed.

For an analysis, Patterson said, NEPA is predicated on a sliding-scale analysis: the greater potential there is for impact, the more detailed the analysis needs to be. That would include mitigating measures and alternative measures, as well as the planned ones.

NEPA is most effective as an early planning tool, she said, which is what it was designed for. If used correctly, it identifies adverse impacts early enough so constructors can modify the design before the work is done, ultimately saving money as well as alleviating the impact.

NEPA is also the way that the public gets involved in the process. It provides the first opportunity for people to hear about a project and express their opinion. This is a really important component of NEPA, she believes, and it can help get public buy-in.

As a practical suggestion, Patterson advised putting together a permit book that includes all the plant's permits, licenses, and authorizations. "You will be amazed at how many you've got and how hard they are to find," she said. Also, she added, collect every single source that you used, looked at, or might use to write the environment report. And, if there might be a threatened or endangered species or critical habitat in the area, it would be worthwhile preparing a survey, just in case, she noted.

*Applicant experience of renewal*

Florida Power and Light (FPL) has two renewal applications, one completed (Turkey Point) and one nearly complete (St. Lucie). According to FPL's Steve Hale, the utility considers renewal as one of several alternative power sources to be considered in its strategy planning. Strictly speaking, he noted, the final decision will be based on economic considerations. The utility, however, is aware of the many advantages. Its plants have proven to be excellent performers, environmental benefits will become more important as concern about global warming grows, and employee morale has been boosted, Hale said. He also noted that the company is now attracting young people coming out of college to go into nuclear operations.

Hale emphasized the importance of FPL's aggressive community outreach program. The opposition movement did cause some problems, he observed, but the efforts to keep the press and public informed worked well. Plant employees were also very important for gaining community support. In fact, explained Hale, "we were very surprised that local people considered us such a good neighbor." The program also put together a team of professional people and community leaders from the area to provide comments on FPL's presentations and messages and to make sure the right facts were being given to people.

The next speaker, Bernie Van Sant, explained how his organization, Omaha Public Power District, used license renewal for Fort Calhoun as the cornerstone of an upgrade program involving the replacement of steam generators, an extended power uprate, dry cask storage, and other modifications and projects. The license renewal process provided the case for these projects, he explained. This meant, of course, that a positive renewal decision was needed before the board would approve spending the money, he added.

The final speaker, Garry Young, group manager for license renewal services for Entergy, warned that license renewal should be kept separate from the topic of life extension. "When you go to the public," said Young, "you do not want to leave them with the idea that you are extending the life of a dying patient, rather, that you are renewing a driver's license."

Entergy's Arkansas Nuclear One was the third application submitted. Although early on, said Young, Entergy got through the process in good time at a cost of only about $11 million, well below the $16 million to $17 million of the first two applications. And the costs trend continues downward.

Considering this success, the utility decided to do the same for all its plants. Four applications are now under way. Entergy is working to standardize the steps of the application process, learning as it goes along. One way is by reducing the number of "requests for additional information" (RAIs) issued by the NRC staff. By using the experience of the Calvert Cliffs

and Oconee applications, Entergy was already able to reduce the number of RAIs considerably.

Another successful measure was to "partner" Framatome ANP, whose role included assessing class 1 components (such as the pressure vessel and reactor coolant system). The success of this arrangement led to a teaming agreement for all projects.

Young said that Entergy also decided to maintain a dedicated team to handle the applications. A virtual office was set up so that team members do not have to move around. Entergy considers the team a highly valuable resource and expects business opportunities to come from it, he added.—*Dick Kovan, Rick Michal, and Patrick Sinco*

TOPICAL MEETING

# The technology of fusion energy

THE INTENSIVE EFFORT within the fusion community to decide the next steps to be taken in the field was capped last summer at 2002 Fusion Summer Study in Snowmass, Colo. There, consensus was reached that the United States should move forward with a burning plasma program. The results of the Snowmass program were submitted to the Department of Energy's Fusion Energy Sciences Advisory Committee, which will be guided by the results to formulate a national strategy on burning plasma physics.

"[The Snowmass conference] showed a degree of consensus in the fusion technical community that I don't think we've had in some time," Charles Baker, a fusion scientist at the University of California, San Diego, observed during the well-attended plenary session of the *Embedded Topical Meeting on the Technology of Fusion Energy* at the ANS Winter Meeting in Washington, D.C. "There might be a variety of reasons for that. But whatever the reasons are, it was a better sense of consensus than we've seen in the recent past."

Baker

The recent renewed emphasis in the United States on burning plasmas and magnetic fusion—which also takes into account several announcements by the Bush administration last year of support for exploring the possibilities of fusion energy—lent an additional degree of magnitude to the proceedings. As one speaker pointed out, history will one day tell if 2002 was, indeed, a watershed year for fusion. If nothing else, a window of opportunity has been opened—but exactly how wide remains to be determined.

The plenary session included several technical presentations on inertial fusion chamber technology, the technical challenges for Tokamak magnets, plasma facing components for fusion reactors, and structural materials research and development for fusion energy applications. The plenary session was highlighted by an overview of trends in technology development for magnetic fusion energy, and by the remarks of an Office of Science and Technology Policy administrator on the issues facing the next-step decisions for the national fusion energy program.

***Major themes of the plenary:***

- *Move forward with burning plasma*
- *But don't over-focus on burning plasma*
- *Technology, materials are key solutions*
- *Fusion power is doable in 35 years*
- *U.S. participation in ITER is possible*

*Technology activities*

Charles Baker, director of the DOE's Virtual Laboratory for Fusion Technology, provided an overview of activities in the fusion tools and technology portfolio. He also touched on the charge given by the DOE's Office of Science to a panel—on which Baker sits—to develop plans for a demonstration fusion power plant.

"The vision for fusion energy can only be developed by strong science and technology programs. In this room, I trust I'm preaching to the choir. But in a number of other audiences I often talk to, this point needs to be said again and again. Many of the concerns cited by critics really are technology issues," Baker said. "Doubts about the program? Well, when you get down to it, it's to a large degree technology and materials [that] are key to resolving those doubts."

During the last few years, Baker said, when the fusion program has emphasized the underlying science required to further develop both plasma physics and fusion, it has stressed that science and technology form a partnership. "Perhaps it's just a simple idea and is obvious, but it's been desirable, if not necessary, particularly with folks in the broader fusion community, to remind them of that feature."

An important dimension of this partnership, Baker said, is that "technology and materials are absolutely necessary to realizing our vision of attractive fusion energy." This tends to be a longer-term perspective, and that sometimes gets lost when tight budgets arise. "Some people want to use all of our resources to build the next widget for a confinement experiment. Others want to say, 'Let them pay for it themselves. We'll go off and do the long-range stuff.'"

The first element of the portfolio of activities in the technology program are the plasma technologies, which have historically played the main role in the fusion program, Baker said. "History says—it really demands—that kind of activity will go on."

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The current objectives of this part of the program, Baker outlined, are to develop enabling technologies to support the scientific program, including advanced methods for plasma heating and fueling; to develop plasma facing components; and to make ever better and more efficient—and cheaper—magnets that could result in cost reductions for fusion systems.

"Again, this notion, [of] the handshake between science and technology . . . reinforces this point about how important it is to provide the tools. The tools here really get at the longer term goals of turning fusion into a steady-state system, improving the performance, and trying to put in place a burning plasma," Baker said.

Another technology aspect of the fusion program is in chamber technologies, which handle the energy outflow of magnetic fusion devices. Researchers are trying to demonstrate the scientific feasibility of innovative plasma chamber technologies for magnetic fusion energy and assess the facility needs for the work, Baker said.

Closely associated with chamber technologies is the area of materials science, which has a mission to develop innovative materials to improve performance, safety, and overall systems cost for fusion. "We all know that fusion claims very attractive safety and environmental features," Baker said. "Some argue that it needs to realize those advantages to be a competitive energy source. Further development of materials is at the heart of the matter here."

The final element of the technology program is design, which includes studying next-step options to support the goals of the scientific program.

Actually bringing the elements of technology and science together to build a demonstration fusion power plant, however, is another matter. Baker is a member of the FESAC panel charged with developing a plan to start operation of such a facility within the next 35 years.

"As a first step, we've asked the hard question, is this doable in 35 years? And the short answer is, with certain qualifications—necessary funding and like—yes, we think one could do it."

At the time, the panel was just completing its preliminary report. By March they are to come up with more definitive information, such as linkages that will lead to this energy goal, the major milestones, and a cost estimate. "On those things, we are just beginning to scratch the surface and start," Baker said.

*Not a one-horse race*

The job of the Office of Science and Technology Policy is to advise the President and other executive offices on the scientific and technical dimension of any issue or policy matter that may arise, explained Patrick Looney, OSTP's assistant director for physical sciences and engineering. OSTP also works with members of the Executive Branch—most notably the Department of Energy—to coordinate government-wide activities and corresponding investment, and then to see that the objectives set by the administration are being met. Looney reviewed the current administration's thoughts on fusion energy—including possible U.S. participation in the burning plasma ITER project, a decision on which is expected early this year—and outlined the requisites for a healthy U.S. fusion program.

There will be in all likelihood, Looney noted, the need to expand electric generation capabilities. In the near term, this will be accomplished through traditional approaches—oil, coal, natural gas, and fission, which "is expected to play a greater role in our electricity generation as we go forth," he said.

**Researchers are trying to demonstrate the scientific feasibility of innovative plasma chamber technologies for magnetic fusion energy and assess the facility needs for the work, Baker said.**

The Bush administration, however, believes that long-term alternative solutions must also be investigated, Looney explained. "It's the responsible thing to do. Any solution that holds the promise of energy independence adds bonus to the problem. So, in a sense, the promise of fusion energy is simply too great to ignore. But we must also understand that we've heard that for about 50 years now.

"Within this administration, we must craft a very careful policy. We must very carefully articulate it to the lawmakers and others on the Hill."

The nation's long-term energy needs and environmental issues are not unlike those around the world. The European Union, as well as other countries such as Japan and Korea, are all seeking long-term solutions to energy demands, and are looking to do it in a clean and environmentally friendly manner, Looney said. "The National Energy Policy points this out and points to the potential for fusion to play a role in the long-term in our energy portfolio."

In addition, within the past year there have been several public, high-level announcements of support for fusion within the Bush administration, which Looney listed. At the Conference of G8 Energy Administrators in Detroit last May, Energy Secretary Spencer Abraham stated, "the President is anxious to accelerate fusion power as a realistic source of energy. We are now engaged in serious consultation here in the United States and around the world on how best to pursue a fusion program.

"President Bush is particularly interested in the potential for an international effort known as ITER, and has asked us to seriously consider American participation."

A few weeks later, President Bush and Russian President Vladimir Putin said in a joint statement, "We will promote further expansion of contacts in such areas of cooperation as information technology, the natural and social sciences, and areas of fundamental research, such as fusion energy and high-energy physics."

Last, Looney said, "We should probably also tell you that one of our closest allies, the U.K.—in particular [British Prime Minister] Tony Blair—is extremely bullish on fusion energy. And the President would like to be particularly supportive of one of our greatest allies.

"So, it seems that the administration looks upon fusion energy with great favor. But, we also have to recognize that we have a long way to go."

Looney called magnetic confinement fusion "essentially the fork in the road," and, paraphrasing Yogi Berra, said, "I think we need to take the fork in the road."

"The fusion community has made a compelling case that a burning plasma experiment is essential as the next step for fusion research," Looney offered. "I believe that fusion is a multidimensional problem, however, and that burning plasma is important, for there is no practical path to fusion energy today without a burning plasma experiment.

"But, to overfocus on burning plasma—in particular, [to] confuse burning plasma with the prospect of imminent energy production—is in my opinion potentially dangerous. Scientifically, the issue is much more complex than that, and you all are well aware of that."

U.S. fusion policy, Looney said, needs to reflect that complexity. The discussion of a timeframe for energy production needs to be decoupled from the debate, to the extent possible. "I say this because, in part, we've gotten out in front in the past, and we know what that'll buy us. We need to make sure that the statements are scientifically dri-

ven," Looney said. "As I see it, a healthy fusion energy science program should be multidimensional. It should be focused on the science as the next step, but retain as its fundamental long-term goal and vision the development of commercially viable fusion energy."

Based on these beliefs and this set of positions, the Bush administration has several decisions it needs to make within the next several months, Looney said.

First, does the United States enter the ITER negotiations as a formal partner?

Looney said he believes that the fusion community needs access to a burning plasma experiment, and that the time for the decision to enter into ITER is close. With the ITER parties on schedule to reach consensus on a preferred site, cost-sharing arrangements, and selection of a director general by April, if the administration decides to enter the project, "it would be desirable to have the U.S. enter sooner rather than later. So, a decision has to come pretty soon. We have to decide what we're going to do."

And what are the acceptable terms for U.S. participation?

Looney said the United States is currently discussing what terms it would find acceptable for participation. "We need to inform our process about the costs, the uncertainties in those costs, and the places where the U.S. can seek added value if it were to participate in the program. At this point, it's hard to know what exactly the costs are." He said to expect a decision by the early part of this year.

"But we must understand that such a decision cannot be made without consideration of the costs. Currently the budget outlook of fiscal-year '04 is rather tight. Revenues are, at this point, tanking. The stock market has not been doing well, as you are all aware. Deficits are growing. So, as this administration takes financial responsibility seriously, the question of who will pay is central to the discussions that have been ongoing.

"And that's a real concern for fusion energy in my opinion: How a burning plasma program will potentially shift the focus and direction of the fusion energy sciences program, and what aspects of the program will need to change, is important to this discussion.

"But I believe that we cannot enter into a burning plasma program at the cost of the long-term health of our domestic program. We cannot allow the U.S. fusion energy sciences program to become a one-horse race. If we cannot sustain the costs, we cannot have a program like ITER to envelop our total program. That would be a disaster.

"If this becomes a one-horse race, if that's what it looks like, then that price is simply too high to pay," Looney concluded. —*Patrick Sinco*

TOPICAL MEETING

# Integration of security and emergency preparedness

***Major themes of the plenary:***

- *There is no such thing as zero risk*
- *Instilling fear gives terrorists success*
- *Comprehensive security plan is in place*

THE UNITED STATES has changed since the terrorist attacks of September 11, 2001. The nation has had to reassess the strengths and vulnerabilities of its critical infrastructure and its law enforcement and emergency response elements. Much has been accomplished in this regard, "yet much remains to be done to decrease vulnerabilities and further develop our defenses to safeguard our people and our nation," said Nils Diaz during the joint plenary on "Integration of Security and Emergency Preparedness to Meet Homeland Security Initiatives." (This joint plenary was part of the embedded topical, *Eighth Emergency Preparedness and Response.*)

Diaz, a commissioner on the Nuclear Regulatory Commission, served as keynote speaker for the joint plenary because scheduled speaker Maj. Gen. Bruce Lawlor, of the Office of Homeland Security, was ill and not able to attend the meeting. As such, Diaz said he would fall back on a few of his favorite axioms to punctuate his deeply held beliefs regarding safety and security. For example, he said, "There is no such thing as zero risk. There is only one way to get zero: $0 = 10^{-\infty}$" and "The level of adequate protection need not, and almost certainly will not, be the level of zero risk." (This statement, Diaz said, was borrowed from a federal court while addressing NRC responsibilities.)

Diaz called the pursuit of zero risk "almost always foolish and wasteful," and he said that "public policy should not be based on worst-case scenarios." These types of scenarios, he said, are only good as vehicles to achieve the proper bounding of realistic assumptions. "Mother Nature and human actions take care of most worst cases and make them not so bad," he said. "Public policy, while necessarily conservative, should not be driven by nonphysical or unrealistic assumptions. Worst-case assumptions are often considered as a first step and are used because they are simple. But what I frequently see is that they continue propagating to become part of the established framework. Unrealistic conservatism always finds friends, [but] not me. Rather than using worst-case scenarios, I am for using realistic conservatism—based on the right science—so that the end product is still recognizable as a realistic scenario."

Diaz

Thus, he does not believe the doomsday scenarios being portrayed for nuclear facilities and spent fuel casks because, he emphasized, they do not take into account the limited health and safety consequences that realistically can be expected, nor do they consider the "decisive and powerful resources" that the

country would use to mitigate the consequences of terrorist attacks on any facilities that have hazardous materials.

Diaz said he frequently is asked whether a containment or other nuclear structure would be damaged by the impact of a 747 airplane loaded with fuel. His response was the "right answer to the wrong question," he said. "I firmly believe that there would not be significant health and safety consequences for the public from radiation in the very unlikely scenario of that type of attack, even if the containment is breached or other structures failed."

Diaz said it is reasonable to believe that the American system of protecting its citizens would not fail. "Make no mistake," he said, "America will deliver the necessary responses to protect public health and safety, and therefore, there will be no 'American Chernobyl.'"

*Fear factor*

Another variable is involved in perceived preparedness against terrorism. Andy Kadak, professor of the practice, nuclear engineering, at Massachusetts Institute of Technology, said that a successful terrorist act is measured not by facility destruction or damage but by the fear instilled in the general public, and thus the terrorists already have partially succeeded. For example, he said, "People living near plants believe that they are a target and are concerned."

Kadak, a Past President of the American Nuclear Society and former president of Yankee Atomic Electric Company, said this fear factor has made nuclear plants inviting targets, despite the fact that plants are hardened facilities and there would be difficulty in creating a major release of radioactive material.

Kadak also cautioned that existing emergency plans for nuclear facilities are tailored for in-plant initiated emergencies, not for terrorist attacks. He wondered how a nuclear plant would deal with the potential loss of key personnel, since existing emergency plans do not deal with this subject.

Kadak

Other terrorist-attack concerns mentioned by Kadak included the vulnerability of onsite structures that are not considered hardened; management of communications and lines of responsibility between local, state, and federal agencies in the event of attack; and dealing with the media in "terror management."

Regarding the last concern, Kadak recommended identifying and training key national spokespeople for dealing with the media in the event of a terrorist attack on a nuclear plant—much like Mayor Rudolph Giuliani was the lead for New York City following the September 11 attacks there, and the Nuclear Regulatory Commission's Harold Denton became key spokesperson for the Three Mile Island event in the 1970s. Also important, Kadak said, was "the work of psychiatrists and psychologists who would be needed to develop a public communications plan and strategy."

What could be "the hardest part," Kadak admitted, was convincing the media to downplay an attack on a nuclear facility, in an effort to minimize public terror. "The media and the antinuclear community can either promote the fear factor or moderate it," he said.

**Kadak ended his talk by revealing that he and Robert Long, a Past President of ANS and retired executive at GPU Nuclear, were working on developing a plan to upgrade nuclear plant terrorist-response capabilities.**

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*Government response*

On hand were government representatives to explain security initiatives under way by the NRC, Department of Energy, and Federal Emergency Management Agency (FEMA).

Roy Zimmerman, director of the NRC's Office of Nuclear Security and Incident Response (NSIR), described some activities that were undertaken by the agency, both pre- and post–September 11. Before the September 11 events, for example, the NRC already had a "comprehensive security plan in place" for nuclear facilities, Zimmerman said, including armed guards at plants, hardened facilities, and evacuation plans. Post–September 11, the agency created NSIR and issued more than 30 security advisories to licensees. The NRC also ordered security enhancements at nuclear facilities, many of which are considered confidential.

Zimmerman said the NRC would restart nuclear plant force-on-force exercises, which were suspended because of the September 11 attacks, perhaps as early as the first quarter of 2003.

Richard Arkin, acting director of emergency operations for the DOE's National Nuclear Security Administration, emphasized the need for development of improved radiation-detecting devices to be used to scan for materials entering the United States. He gave as an example the case of ocean-going ships coming into American ports carrying hundreds of sealed 40-ft containers. Detectors today need up to 15 minutes to give an accurate reading of contents, he said, an amount of time that "would paralyze commerce" if each container on each ship were scanned in this way before being allowed to enter the country.

The challenge for the nuclear industry and for the United States, Arkin said, is to develop a way to scan each container quickly (within seconds) so that no radioactive materials could be smuggled in. "Build me smarter, better, more robust detectors to give me a quick snapshot [while] working in an uninviting environment," he said. "That's what the country needs."

The director of FEMA's National Preparedness Division, Robert Welch, outlined the functions of the agency. Those functions, at their most basic, are "to provide federal leadership to assist state and local emergency management and response organizations with planning, training, equipment, and exercises for response to emergency or disaster."

Welch explained that FEMA's Radiological Emergency Preparedness program, which was established in December 1979 following the Three Mile Island accident, ensures that off-plant-site emergency plans and procedures are in place and that they would be implemented by state and local governments. Welch added that "evacuating for terrorism is the same as evacuating for a hurricane."

FEMA conducts what it calls consequence management scenarios (dealing with a radiological "dirty bomb," transportation of nuclear fuel, or nuclear plant security) to test the effectiveness of its programs. In a real-life emergency, Welch said, a federal response plan would be activated when the President declared an emergency. While FEMA would be considered the "lead federal agency" in most emergencies, for those dealing with a radiological event the NRC would assume the lead role.—*Rick Michal* NN