2006 ANS WINTER MEETING

Changing times for the nuclear industry

THE PLANETS ARE aligning for the nuclear industry, declared J. Bennett Johnston, the former Democratic senator from Louisiana, who spoke during the opening plenary session of the American Nuclear Society's Winter Meeting, held November 12–16 in Albuquerque, N.M. The meeting, with the theme *Ensuring the Future in Times of Change: Nonproliferation and Security,* attracted an attendance of more than 1700 to New Mexico, home to two Department of Energy national labs—Sandia and Los Alamos. After years of stagnancy, Johnston said, the industry is poised for unprecedented activity.

Keith Arterburn, ANS Chair, Public Information Committee

Johnston

Johnston, who served four terms in the Senate from 1972 to 1997 and played a large role in authoring the Energy Policy Act of 1992, recalled the 1970s as "a heady time" for the industry, thanks to the boom in construction of new nuclear plants. Then something happened—the supply of cheap natural gas, the accident at Three Mile Island, President Jimmy Carter's prediction that 20 percent of the nation's electricity would come from solar by the year 2000, the intrigue of a hydrogen economy just around the corner—and the boom went bust. The industry was allowed to atrophy for three decades, Johnston said.

Johnston noted that there are four "planets" aligning for the industry: the worldwide concern over global warming; the public's greater desire for clean air; the higher prices of competing fuels; and the realization that renewables won't produce as much electricity as once imagined.

Despite this positive alignment, Johnston said that he is concerned about how the nuclear renaissance is taking shape. For instance, he said, the industry's stagnant state has allowed the domestic manufacturing base to dwindle, which is why he has become involved with the American Council on Global Nuclear Competitiveness. The council's mission is to alert political and business leaders to the nation's decline in nuclear manufacturing and to promote opportunities for restoring global leadership. "We believe that nuclear energy represents a multibillion-dollar business opportunity that the United States can either seize or squander," he said.

Johnston predicted that a rebirth of a robust nuclear construction and manufacturing industry could result in the creation of more than 1 million jobs in the United States. "This figure could, and indeed almost certainly would, be higher as we secure contracts to supply American-made nuclear products across the globe," he said.

The construction value of a new fleet of reactors in the United States would be more than $150 billion. "It would result in total economic activity of well over a quarter of a trillion dollars," he said. "The retail value of the electricity produced by the new reactors would be more than $50 billion per year, and the electricity would avoid the emission of millions of tons of air pollutants and billions of tons of greenhouse gases."

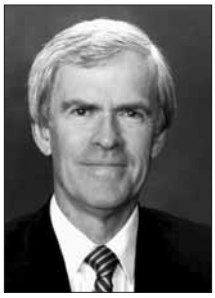
The nation's security would benefit from a nuclear renaissance, too, he said, in that America's ability to influence the nonproliferation behavior of other countries depends in part on U.S. firms' participating in the commercial nuclear fuel cycle, especially in the uranium enrichment and recycling businesses. For example, he said, nuclear fuel provided by the United States to plant operators in other countries would come with certain end-use restrictions, such that the enriched uranium in the fuel could not be used to "speed start" a nuclear weapons program and could not be reprocessed without the permission of the United States.

President George W. Bush had been scheduled to appear at the meeting by way of a taped video, but political events of the day (the results of the November midterm elections) had him occupied with other matters. Joining the conference by live video teleconference from Washington, D.C., however, were New Mexico Sens. Pete Domenici (R.) and Jeff Bingaman (D). Both senators had worked hard to pass the Energy Policy Act of 2005, which in part favors nuclear by providing provisions such

Major themes of the plenary:

- *The "planets" are aligning for nuclear power.*
- *The Yucca Mountain Project needs to get back on track, but GNEP may need further defining.*
- *A system of advanced safeguards and quarantine measures for proliferation risk reduction is needed.*
- *Communicating and exchanging best practices are important tools for the world's nuclear regulators.*

Domenici



Bingaman

as a federally backed insurance program during the licensing of the first few new reactors.

The senators commented on several issues regarding the technology, from the benefits of clean and reliable nuclear power to the math and science education needed to develop the workforce for the industry's expansion.

Domenici remarked that he would strive to get the DOE's proposed Yucca Mountain repository back on track, but he was realistic. With Sen. Harry Reid (D., Nev.), an avowed opponent of the repository, now holding the position of Senate majority leader, the going will be tough. "He won't be running around saying, 'Now that I have a little more power, I'm giving up,'" Domenici joked. Reid used to be a boxer, according to Domenici, "and he'll have both fists out on this one. We'll just have to see how it comes out."

To an audience member's question about the Global Nuclear Energy Partnership (GNEP), Domenici responded that he thought the Senate would provide the program with about $270 million in its fiscal year 2007 appropriations bill. The House is not as generous, he said, funding GNEP at about $120 million for FY 2007. The actual funding for the program is yet to be seen, since the Congress has not passed an appropriations bill for FY 2007.

GNEP is the DOE's program to expand the use of nuclear power on a worldwide basis through international consensus. It would include facilities such as a consolidated fuel treatment center, an advanced burner reactor, and an advanced fuel cycle facility.

Commenting on GNEP, Bingaman remarked that he thinks Congress needs to understand it better "before we go too far down the road." Congressional hearings on the program should be held so that lawmakers can better understand the scientific work that needs to be done before construction begins on GNEP facilities. "I don't think most members of Congress have any real concept of what GNEP entails or the implications of it," he said.

Domenici replied that while Bingaman's observation was "pretty astute," the truth of the matter is that "Congress has not understood many programs that we've proceeded with."

Tom Hunter, director of Sandia National Laboratories and a cochair of the Winter Meeting, said that science has set the course for the last half century and is likely to do the same for the next 50 years. The world, he said, is undergoing a major transition: a growing population, the emergence of new economies, the growth of radical terrorism, a global energy dependence, a threatened environment, and a radical change in the competitive position of the United States in science and engineering. Hunter stressed that nuclear technology must play a leading role in the development of this rapidly changing world. "The future of nuclear energy—whether it is in strategic deterrence, global proliferation, or power generation—is the one arena where the course could be set now," he said.

Hunter

The meeting's other cochair, Michael Anastasio, director of Los Alamos National Laboratory, agreed that times are changing and that three elements are driving the changes. The first is the growth in demand for nuclear energy as countries strive to deal with rising populations and to raise economic levels to improve their standard of living. The second is the proliferation of closeted weapons programs under the pretext of a nuclear energy capability. The third is the development of nuclear-weapons states. All three of these elements are interrelated, according to Anastasio. "I believe that action taken in one area will have an impact on the others," he said.

Photo: LANL

Anastasio

This interrelation is why the nuclear path forward needs "a next-generation system of advanced safeguards and quantitative measures for proliferation risk reduction," Anastasio said. A defense-in-depth safeguards approach, which would help deter clandestine nuclear activity around the world, is going to be be developed by the United States in cooperation with its allies and the International Atomic Energy Agency, he said.

Dale Klein, chairman of the Nuclear Regulatory Commission, remarked that there could be no nuclear renaissance without addressing safety and nonproliferation concerns. The best guarantee of a safe and orderly deployment of nuclear plants is "strong and fully independent" regulators from around the world communicating and exchanging best practices with each other, he said.

Klein

Klein noted that the regulators should work together to create a governance framework that will ensure that international safety and nonproliferation goals are achieved. In this regard, the NRC is planning to work with its domestic and international partners to create this framework, he said.

GNEP

During the *ANS President's Special Session: Perspectives on the Global Nuclear Energy Partnership* (GNEP), ANS President Harold McFarlane commented on his travels in the past year to five different continents, answering people's questions about GNEP and hearing what they had to say. McFarlane noted that in his talks abroad, he focuses on the vision and concept of GNEP. "I think it's an incredibly important concept," he said. "It's a very bold initiative, and one that I'm delighted to see."

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GNEP is the Department of Energy's program to develop worldwide consensus on enabling the expanded use of nuclear power to meet a growing electricity demand. Its goal is to use a fuel cycle that enhances energy security while promoting nonproliferation. This goal would be achieved by having nations with advanced nuclear capabilities provide fuel services—fresh fuel and recovery of spent fuel—to other nations that agree to use nuclear energy for power generation purposes only. The closed fuel cycle model envisioned by the DOE requires the development and deployment of technologies that enable recycling and consumption of long-lived radioactive waste.

Continued

GNEP, as currently envisioned, would include a consolidated fuel treatment center capable of separating the usable components contained in light-water spent fuel from the waste products, and an advanced burner reactor capable of consuming those usable products from the spent fuel while generating electricity. National laboratories in the United States would design and direct a third component, an advanced fuel cycle facility, which would be a state-of-the-art lab designed to serve fuel research needs for decades.

Dennis Spurgeon, the DOE's assistant secretary for nuclear energy, who also serves as the GNEP program manager, said that much of the international interest in GNEP is predicated on the United States' getting back into the commercial nuclear business and assuming an active role. Over the past 30 years, the nuclear capability of the United States has atrophied. "We no longer have the capability, for example, to forge the heavy ingots needed to fabricate major nuclear reactor components," he said.

The United States has also slipped in its position as the world's leader in uranium enrichment services. Today it meets only a portion of its domestic uranium demand, using "outdated technology," Spurgeon said, who also noted that the United States is without a domestic commercial fuel recycling capability, an operating fast or gas-cooled reactor, or an operating high-level nuclear waste repository.

The DOE's task for the next two years, Spurgeon continued, is to collect technical, economic, and environmental information to make a convincing case for moving forward on building the GNEP facilities. The DOE's specific actions over this time frame include obtaining input from U.S. and international industries and governments; developing a detailed GNEP technology road map; adjusting the road map after receiving input from industry and international partners and the policy community; carrying out technology development; reusing existing international agreements and developing new bilateral or multilateral agreements, as appropriate; pursuing industry participation in the development of conceptual design and other engineering studies that support GNEP facilities; preparing environmental impact statements for locations that submit proposals to host the facilities; and, no later than June 2008, proceeding with a government/industry partnership to build some of GNEP's facilities, assuming that a credible technology pathway has been developed and satisfactory progress has been made in its implementation.


Spurgeon

Spurgeon echoed McFarlane when he said that the GNEP vision has been well received by the international community, but that much of the interest is predicated on the belief that the United States will follow its words with actual progress. "Prospective partners await congressional action on the GNEP budget and will, in part, gauge their responsiveness and their actions accordingly," he said.

As the program stands now, Spurgeon conceded that GNEP is still a "DOE proposal" because Congress has not yet funded the program. A fiscal year 2007 appropriations bill, which would fund GNEP, does not yet exist. "After the events of last Tuesday [Election Day, November 7], I don't have the foggiest idea of when we might actually get one," he said, "although I do hope it will be in the not-too-distant future."

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Craig Hansen, vice president of BWXT's Washington Operations, agreed with Spurgeon that the United States needs to get back into the manufacturing of nuclear components. "We increasingly risk playing second string," Hansen said, to the growing number of countries that are thinking about a global nuclear industry and that are making the infrastructure investments necessary to play leading roles in that effort.

Even before GNEP gets off the ground, the biggest challenge facing the reemergence of the nuclear industry in the United States is the availability of trained engineers, technicians, and laborers, according to Hansen. Currently, U.S. universities are turning out about 500 nuclear engineering graduates a year. Of that number, only about 200 actually decide to work in the power generation field. Meanwhile, projections for growth in the nuclear industry show that job availabilities will outpace the supply of workers, he said.


Hansen

Another challenge involves having enough resources available for manufacturing nuclear components. "With increasing demand for specialized materials, resource availability is a significant issue up and down the supply chain," he said. "Whether the resource is qualified personnel, stainless steel, nickel, or nickel alloys, they result in increased prices and longer lead time."

Hansen also listed other challenges for the industry, including finding the dollars to build new nuclear plants, foreign tariffs on U.S. products that make them less attractive to international buyers, and regulatory and security issues. "We are clearly at a critical juncture for the United States in the global nuclear industry," he said. "The decisions we make in the next three to five years may very well decide whether we will lead or follow, and whether the industry grows or withers."

Hiring problems may be a challenge for the National Enrichment Facility (NEF), said Marshall Cohen, vice president of communications and government affairs for Louisiana Energy Services (LES). That company is preparing to build the NEF, a $1.5-billion–$2-billion uranium enrichment plant in New Mexico. The NEF received its construction and operating license from the Nuclear Regulatory Commission in June 2006, and a groundbreaking ceremony was held in August in Hobbs, N.M.


Cohen

When NEF starts operating at near full capacity, 300 full-time employees will be needed. Before that, when construction of the facility gets under way, more than 1000 construction workers will be on site for a significant period of time. "We're working very hard to get the skilled labor that is necessary," Cohen said. "Craig [Hansen] mentioned it earlier, and we're already finding it an issue that is real today."

LES is recruiting workers from both around the region and across the United States. "There are a lot of different jobs we're trying to fill," he said.

Interest in 4S project grows

Interest continues to grow in the Galena 4S project, which was set up to construct a 10-MWe reactor to supply heat and electricity to Galena, a city of about 800 people in western Alaska. A panel session was organized by Chris Lapp, of Lapp Consulting Services, to provide a status report on the project.

The 4S is a liquid sodium–cooled battery-type reactor that has been under development by Toshiba since the late 1980s and is supported by Japan's Central Research Institute of Electric Power Industry (CRIEPI). The design came out of Toshiba's involvement in the PRISM project, an effort led by General Electric to develop a passive reactor in the 1980s and 1990s. The 4S abbreviation stands for *super safe, small,* and *simple*. It also boasts another *S* feature—*security*—in that it has a very low proliferation risk.

Toshiba has described the main technical features of the design at previous ANS conferences, concentrating on characteristics that make it suitable for a small, isolated community with little infrastructure such as Galena. This session provided an update of the project and the plans to get the design certified and a project licensed. It also looked at other uses for the reactor, notably in mining activities, where there is a growing interest.

Leading the panel was Philip Moor, director of project development at Burns and Roe, which put together a series of white papers, underwritten by the state of Alaska, to provide legal and technical analyses for a proposed plant. Moor introduced other members of the Galena team, including Marvin Yoder, the city manager of Galena and project manager of the 4S project, and Matias Travieso-Diaz, of the law firm Pillsbury Winthrop Shaw Pittman, which advises on regulatory and licensing matters for the project.

Toshiba was represented by Yoshiaki Sakoshita, who is responsible for developing a commercial 4S reactor, and Nobuyuki Ueda, a specialist in safety aspects of fast reactors at CRIEPI. Sakoshita noted some of the important features of the plant and explained why the Galena team is confident that the project will go ahead. He said that Japan has a policy to develop sodium-cooled reactor technology and continues to sponsor a great deal of research and development work. Substantial expertise already exists in the United States from the development of the EBR-2 reactor, which shares two main features with the 4S reactor—sodium coolant and a similar metallic fuel.

Moor set the scene for deploying the 4S reactor, which, he stressed, does not compete in the same market as large units but is aimed at remote applications, small-demand customers, and areas with weak or nonexistent electrical grids. He noted that Burns and Roe believes there will be significant opportunities for small reactors in electricity production, mining, desalination, hydrogen production, and industrial process applications over the next few decades.

Yoder, who has been driving the project, earlier this year testified on the merits of small reactors before a congressional committee in Washington, D.C. Galena and most of Alaska, Yoder said, had been looking for new sources of energy to fuel their future long before the current global energy problems. In August 2003, Toshiba made a presentation in Galena that impressed the city council, which agreed to explore the possibilities of the 4S.

Galena's electricity needs are now being met by diesel generators that depend on fuel shipped in during a three-month window each summer when the Yukon River is open. Yoder quickly went through the arguments that favor nuclear power for his and many other communities in Alaska, particularly using a small reactor like the 4S, which is ideal for very remote sites.

The reactor, he said, sits inside a steel tube and is set underground in a silo. It has a core lifespan of 30 years, so no refueling will be done. It also requires a minimal amount of operational management capability. Finding a site should be straightforward, he said, as a clear zone of about 800 meters is thought to be sufficient, and the construction period is about two years.

In 2004, Yoder explained, a study into energy possibilities for Galena was carried out under the sponsorship of the U.S. Department of Energy. The study, "Galena Electric Power—A Situational Analysis," found that nuclear power would cost less and have less environmental impact than other options. In December 2004, the city council passed a resolution to continue to pursue this possibility.

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As Galena now generates only about 2 MWe of power, even the 10-MWe 4S reactor is rather large. There are many other possible uses for the energy, however, such as providing district heat to the local airbase, building a small grid to supply nearby communities, and producing hydrogen. He added that the situational analysis predicted that in 20 years, the city will need the whole 10 MWe.

After the council's decision, Alaska's state legislature agreed to a grant of $500 000 for preparing a series of documents to further develop the proposal. Burns and Roe led the effort to produce the seven white papers, which covered the following topics: a general overview of the project, nuclear liability, physical security, emergency planning, decommissioning, seismic issues, and containment.

As for the economics of the project, in 2003, Galena consumers were paying about 28 cents per kW, which is well above the cost of the project. Consumers are now paying over 40 cents per kW—which is still one of the lowest rates in Alaska, Yoder said. Several other Alaskan communities, including the city of Nome, are studying the option. As to the ownership of the plant, Galena is considering the involvement of the state, as well as of private corporations.

Yoder concluded by noting a number of recent developments suggesting that "we are not just whistling in the wind." Mohamed ElBaradei, the 2005 Nobel Peace Prize winner and the director general of the International Atomic Energy Agency, has been speaking out in support of deploying reactors such as the 4S. In addition, a role for small reactors is included in the DOE's Global Nuclear Energy Partnership. "We are starting to see that what Toshiba presented to us in 2003 is getting some traction along with the rest of the nuclear renaissance," Yoder said.

While a small town like Galena does not need a lot of electricity, large mining operations could easily use 10 MWe and more. John O'Brien, managing partner of Shale and Sands Oil Recovery, Inc. (SASOR), put the mining and conversion of oil shale and tar sands into usable fossil fuels at the top of the list of possible uses of the electricity. SASOR was formed a few years ago by people with experience in various energy sources who thought that there must be a way to use nuclear energy to produce fossil fuels from these deposits.

Globally, O'Brien said, 85 million barrels of oil are consumed every day, with the United States accounting for about 20 million. With competition from countries like China and India growing quickly, the government is now pushing for shale oil development.

O'Brien described shale oil as immature oil. Given another few hundred years, it would start to turn into oil. The United States, he said, has some 1.5 trillion barrels of oil equivalent of shale, of which about 800 billion barrels are recoverable. This compares to oil reserves in Saudi Arabia of 239 billion barrels. Back in the 1970s and 1980s, considerable attention was given to this resource due to oil supply fears, but as

OPEC reopened the spigots, interest ebbed away. It is doubtful that in today's tight market this would happen again. He noted that one shale basin in America has about 2.5 billion barrels per acre. But these are in deep deposits, often 2000 feet down, and cannot be surface mined, making them very expensive using current techniques.

Many companies have been developing the technology for *in situ* processing of oil shales. This involves "cooking" or retorting the shale in the deposits and drawing up the produced oil. O'Brien's company developed a process for fracturing the deposits to better inject the heat to cook the shale. This is usually done hydraulically with steam. To be most effective, O'Brien said, high temperatures are needed, which is why a high-temperature nuclear reactor is of interest to SASOR.

Canada, where there are significant amounts of tar sands, is already producing over 1 million barrels of oil a day using an *in situ* process in which steam is injected into deposits. They are looking to double production in the next decade. The steam is produced by natural gas, which is why this activity, O'Brien said, is the largest greenhouse gas emitter in Canada, a Kyoto signatory.

It makes sense, he said, to use nuclear reactors to create the thermal drivers, electricity and hydrogen (which is needed to process large hydrocarbons). While a number of the main nuclear vendors are trying to promote their reactors for this application, they are too big, he said, due to the limitations on thermal energy transfer underground. "This is why the 4S looked so good to us. If you do the scaling, the 4S is a perfect reactor for putting in place in Canada to develop this." The concept would involve deploying a few reactors in the deposit that would produce electricity and hydrogen, as well as heat.

O'Brien believes that global warming is going to be the main driver for nuclear energy. He is confident that when a "reasonable" price is finally put on CO_2 emissions, this alone will pay for the reactor. He thinks that the first new reactor in North America will be a 4S unit in Canada.

Licensing and timing

Taking a lead from O'Brien's confidence, Travieso-Diaz said that it is conceivable, if things go right, that the first new reactor built in the United States will be at Galena. He described the licensing aspects for the Galena project and the possible timing.

If Toshiba starts working with the Nuclear Regulatory Commission early this year, Travieso-Diaz said, he believes that a combined construction/operating license (COL) could be issued in seven years. While this may sound somewhat aggressive, he said, there are reasons for that aggressiveness. He noted that the NRC is near to completing changes to the regulation for the certification and licensing of new reactors that will make the process quicker and more efficient. But the challenge, he said, is that with the nuclear renaissance that is occurring, he foresees the submission of a number of applications by the end of 2007 or the beginning of 2008. "Anyone who wants to catch NRC's attention [had] better start working very soon," he said.

Travieso-Diaz

Travieso-Diaz described four basic requirements for a nuclear project: an approved site, an approved design, an approved operator, and economic feasibility. He stressed two critical issues that could stop the project. First, if an NRC license requires a lot of people to operate the plant—for example, if there must be large numbers of security staff on site to repel a terrorist force—the plant will not be built. The white paper estimated that 10 to 15 security and operating staff will be required, with some people doing multiple tasks. "This is our view of the world and may not be that of the NRC."

A site [for the 4S reactor] must be chosen and an early site permit application submitted to find out if there are any fatal flaws in the plan.

It is also crucial that the license be granted in a reasonable amount of time. If it takes too long, "Somebody is going to give up," Travieso-Diaz said. "It has to happen soon, and the result has to be manageable."

The 4S is not an entirely new concept, he noted. It uses sodium coolant, which is familiar to the NRC, and he believes that the Galena area is an ideal location for this type of reactor. It is crucial, he said, that there is also a sincere desire on the part of the applicant to see this process through, and he expressed his belief that the design could be certified in three and a half years from the outset. From Toshiba's viewpoint, the risk is relatively low, because after the first year, when the pre-application review is completed, the company will know if there are any flashing red lights that will tell them that this is not going to work.

Meanwhile, a site must be chosen and an early site permit application submitted to find out if there are any fatal flaws in the plan. If everything plays out right, he said, a COL could be granted by 2012.

Asked about the attitude of the NRC, Travieso-Diaz said that some NRC staff have shown some pessimism because they foresee the submission of applications for many different reactors, leading to staff allocation problems. "This is why we do need to get moving on it." But he believes that the NRC, based on its experience and ability to grant exceptions, will be able to recognize that the rules do not have to be the same as for a big plant.

Nonproliferation and security

Iran had no interest in arming itself with weapons of mass destruction when the Ayatollah Khomeini came into power during the Islamic Revolution of 1979. WMDs, in fact, were against Islamic law. But when the world sat on its hands in the 1980s as Iran was subject to a chemical-weapons attack by Saddam Hussein's Iraq, the Iranians decided to protect themselves, according to Paula DeSutter, assistant secretary of verification, compliance, and implementation for the U.S. State Department.

The cost to the world of not coming to Iran's aid in the 1980s is coming due today, DeSutter noted during the *General Chair's Special Session: Nonproliferation and Security.* Iran's nuclear, chemical, and biological weapons programs "would be nonexistent had the international community responded aggressively and responsibly to the Iraqi chemical weapons," which were in violation of the Geneva Protocol, she said.

DeSutter explained that although Iran continues to assert that its nuclear development program is devoted solely to the peaceful and transparent pursuit of the nuclear fuel cycle, the International Atomic Energy Agency has confirmed that Iran has deliberately and repeatedly hidden its development activities for 20 years. These covert actions can lead to one conclusion, she said: Iran is operating an undercover nuclear weapons program, even as it is claiming its right to develop a peaceful program under the Non-Proliferation Treaty (NPT).

DeSutter

DeSutter stressed, however, that it is too early to throw in the towel on the NPT, which is the international agreement opened for signature in July 1968 to limit

the spread of nuclear weapons. Since the treaty's inception, 189 countries have agreed to abide by the NPT. Of those countries, "only Iran, North Korea, Libya, and Iraq violated their commitments by pursuing nuclear weapons programs," she said, "and only Iran and North Korea remain in violation of their NPT obligations." In this regard, she added, the United States remains actively engaged in correcting those violations and bringing both countries back into compliance with the NPT and with IAEA safeguards obligations.

As more countries seek to satisfy their growing energy needs through nuclear power, the nuclear industry needs to "remain beyond reproach," DeSutter said. This is because the peaceful deployment of nuclear power becomes increasingly intertwined with the fight against nuclear weapons proliferation. "We must continue to make it very difficult, if not impossible, for the Irans and North Koreas of the world to have access to nuclear technology while they retain their nuclear weapons intent," she said.

Export control laws must also be enforced and strengthened, DeSutter said, and shipments of weapons-related goods destined for countries with suspected clandestine nuclear weapons programs must be prevented. "We must continue to relay the message, probably best stated by a most unlikely source—Libya's Moammar Qadhafi—that acquisition of nuclear weapons and other types of WMDs brings not security but insecurity," she said. "Only through such efforts can future generations be assured of reaping the benefits of peaceful nuclear energy in a safer world."

Be assured, however, that the Iranians are shopping around for scientists capable of working in the country's nuclear program. Laura Schmidt-Williams, deputy executive director of the International Science and Technology Center (ISTC), deals with former Soviet scientists who are seeking civilian jobs before rogue states and terrorists come knocking on their doors.


Schmidt-Williams

Schmidt-Williams noted that on a recent visit to a former WMD research institute, she was approached by native scientists who said to her, "The Iranians were here a few months ago and they want to work with us. We want to be members of the international community in good standing, and we don't want to work with them." The problem, however, is that the paychecks these researchers receive from their own government are woefully small—for example, the head scientist of a research institute in Central Asia might receive less than $20 per month—so a well-paying nuclear job in Iran could be quite alluring.

Schmidt-Williams said that while some former Soviet scientists have done well in moving to civilian jobs, she worries about the forgotten researchers with WMD-relevant expertise from outside Russia, most notably Central Asia and the Caucasus. "I do think that there isn't sufficient attention in some parts of Washington being paid to those communities," she said. "ISTC is well positioned to continue addressing this threat, given adequate funding to do so."

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The ISTC was established in 1992 by the United States, the European Union, Japan, and Russia, and is funded primarily by taxpayer dollars from these and other governments around the world. Traditionally, the United States and U.S. partners have provided the largest share of funding to the ISTC, followed by the European Union and now Canada. More than 300 government agencies, nongovernmental organizations, and private sector companies participate as partners with the ISTC. Over its history, the organization has worked with 65 000 scientists on more than 2400 projects that have a combined worth of more than $700 million.

Agencies and companies that want to work with the ISTC can hire "world-class, former weapons scientists for very competitive rates," Schmidt-Williams said. The ISTC has access to about 30 000 nuclear researchers looking for work, and more are becoming available. For example, Russia's two largest nuclear educational centers are producing 2500 new nuclear scientists and engineers each year. In addition, Russia plans to significantly reduce the size of its nuclear weapons complex over the next few years, with the result being that up to 15 000 nuclear experts may be "downsized," she said.

Susan Eisenhower, president of the Eisenhower Group and a senior advisor to the National Academy of Sciences' Committee on International Security and Arms Control, remarked that President Dwight D. Eisenhower's "Atoms for Peace" speech to the United Nations in 1953 challenged the international community to harness the power of the atom to serve the peaceful pursuits of mankind. Susan Eisenhower is a granddaughter of the late president.

When President Eisenhower made his speech, he predicted that perhaps all countries would be able to develop an atomic bomb, she said. Yet, while the number of nuclear weapons countries is growing, "we have to be relieved by the fact that growth has been much slower than was anticipated."

At the same time, Eisenhower said, in order for a nuclear renaissance to flourish around the world, a number of reforms have to take place in the international community. One of them, public education, must take a high priority, especially in the United States, she said. "As in 1953, today when we talk about the future of nuclear energy, most people bring to mind the linkage between nuclear energy and nuclear weapons, whether we like that or not," she said. "Iran and North Korea remind us constantly of this linkage. So I would say it's time for the nuclear industry to stop hiding from the fact that this is the ultimate dual-use technology."


Eisenhower

Institutional reforms that are needed on a global basis include international standards for power plants, cross-national licensing, an effort to secure nuclear materials, and a control of the processing of weapons-usable materials, she said. There also will have to be development of proliferation-resistant reactors with built-in features that prevent their clandestine use or diversion of material to weapons production, and there will need to be multilateral approaches to the spent fuel question and radioactive waste. Eisenhower called these reforms part of "a huge international agenda."

Regarding the problem of long-term spent fuel storage in the United States, Eisenhower noted that the public's concern about waste security and personal safety would not go away "simply by assuring them that there is nothing to worry about." She emphasized again the need for a massive public education campaign. She wondered aloud why the people of Nevada could be so anti–Yucca Mountain, and yet so comfortable with the Nevada Test Site's being located in the state. She surmised that perhaps it is because Nevadans and others refer to Yucca Mountain as a "nuclear waste dump, and so the project carries a negative connotation." To provide a counterpoint, it would be better if the project's supporters started calling it "the next Fort

Knox," she said. Such a positive message about Yucca Mountain should in fact be put forth by all of the nuclear industry, which should consider the proposed repository a "strategic nuclear reserve."

Despite the slow progress of repository work at the Yucca Mountain site, Eisenhower pointed out how quickly things can change: In six years, from 1951 to 1957, the nuclear industry went from its first production of electricity from a reactor, to the launching of the first nuclear-powered submarine, to the commercial operation of Shippingport, the first power reactor. This was at a time when, in 1957, a Republican president had a Democratic Congress. And so, rapid movement on nuclear issues, such as Yucca Mountain, is possible, she said.

The nuclear industry needs to take other positive steps, Eisenhower noted. These include linking arms with other power generators such as coal, gas, and oil, because all forms will be needed to meet the electricity demand; underscoring that nuclear energy can actually ease nonproliferation concerns, as is the case with the "Megatons to Megawatts" program under which Russian weapons material is converted into fuel for commercial nuclear plants; providing jobs in nuclear energy for weapons scientists from Russia and other countries, which the ISTC is already doing; declaring that reprocessing works and is already being done in other countries such as France; and demanding political bipartisan consensus and leadership.

Eisenhower concluded with an endorsement of President George W. Bush's proposed Global Nuclear Energy Partnership, which she said could create a cradle-to-grave nuclear supply system that could dramatically reduce the threat of nuclear proliferation. "In particular, we can prevent the spread of sensitive enrichment and recycling technology and tie up weapons-usable materials in civilian nuclear fuel cycles," she said. "We are in desperate need for the continuation of a vision for nuclear energy and to see it articulated at the highest levels of the United States government."

Scott Campbell, president of the American Council on Global Nuclear Competitiveness, agreed that it is time for the domestic nuclear industry to get going again, for a number of reasons. "Nations that are engaged in the nuclear energy business sit at the nonproliferation table, have the technology to address global climate change, have the key to combating global poverty, and hold the catalyst to advances in science and technology," he said. "Having American companies competing in the global nuclear energy market will lead to more revenue, better-paying jobs, and will improve American competitiveness."


Campbell

Campbell noted that while the United States spent years arguing about its nuclear future, the rest of the world recognized the technology's benefits and moved aggressively forward. "The United States can't flounder in indecision and inaction anymore," he said. "The world is going nuclear and we must too, or fall sadly behind."

The United States is poised, Campbell said, to do three things that can revitalize the industry and transform the nuclear landscape by bringing safe, proliferation-resistant nuclear energy to the developing world. First, he said, new plants will be built in this country. Second, the United States will recycle again. Third, the United States can transform the market for reactor design and manufacturing by developing new technologies. "Today, this nation has a historic opportunity to address the gap on the global nuclear energy ladder," Campbell concluded.

U.S. reactor plans

Sessions on new power reactor projects in the United States have become a staple of ANS national meetings. In Albuquerque, the new-reactors session was held not in a large ballroom but in a fairly small meeting room, perhaps indicating that such sessions are believed to be losing their novelty. Nonetheless, several dozen people packed the room to hear, and respond to, reports by some of the key players in what might become a nuclear renaissance. Speakers from electricity providers continued to make it clear, however, that none of them has yet made a commitment to build anything.

"Having American companies competing in the global nuclear energy market will lead to more revenue, better-paying jobs, and will improve American competitiveness."

The issue of what would count as a commitment was addressed by Eugene Grecheck, vice president of nuclear support services for Dominion Generation. Even with an early site permit (ESP) review process for North Anna nearing completion at the NRC, and with considerable effort and expense having gone into adding plans for a cooling tower system at the site, Dominion officials have stated that the company would not decide whether to apply for a construction/operating license (COL) until just before the scheduled submission date in November.

Grecheck stated that he sees no reason at present why Dominion would not submit an application, but politics might alter the situation. He noted, however, that to be ready to build new nuclear capacity at North Anna, Dominion will have to order the large forgings necessary for the fabrication of ESBWR hardware before it decides whether to submit. These forgings would be generic enough that they could, if necessary, be resold later to someone else who might need them, so he said he does not see such an order as a firm commitment to build.


Grecheck

Grecheck said that the approach to new reactors has different paradigms from the ones that applied when the first wave of power reactors were built. At that time, signing a contract with a nuclear steam supply system vendor constituted a commitment to build and operate a reactor. Now, with memories of unfinished and canceled plants still sharp, and the switch to a licensing process that has yet to be tested, the approach to new reactors is more incremental, with the final commitment perhaps not taking place until a COL is issued. Grecheck's position is essentially the same as that voiced by Constellation Energy's Michael Wallace at the Utility Working Conference in August (*NN,* Oct. 2006, p. 65), and in fact may be shared by most of the dozen or so expected COL applicants.

The vagueness of the phrase "dozen or so" is unavoidable, because another aspect of new-reactor sessions is that there has yet to be complete agreement among all speakers on how many reactors are currently planned, at how many sites, or by how many potential licensees. Because it is the NRC that would process the COL requests, and the agency has requested that potential applicants provide advance notice of when they expect to submit, the NRC's figures probably give the clearest picture of how things stand now.

Bill Borchardt, director of the NRC's Office of New Reactors, told the session that as of early November, the NRC had been informed of 20 upcoming COL applications for at least 29 reactors. These figures in-

clude one prospective applicant who has requested that the NRC not reveal its identity and assume only one reactor in cases in which the applicant has not yet announced how many reactors are planned.

Borchardt restated the case that the NRC has frequently made in favor of standardization, not only of plant designs but also of license applications, so that the NRC can apply the decisions it makes on lead applications to subsequent applications for the same reactor type. He allowed that if he were the one spending the money, he'd want to be able to take his own approach and customize at least some of the plant to meet his company's needs, but he said that the only way that COL applications could be processed and approved quickly is for each plant to have as little site-specificity as possible.

As far as reducing regulatory uncertainty before submission, Borchardt reported that the information needed for the preparation of applications is nearly ready. The final revisions to 10 CFR Part 52 should be issued in January (they were sent to the commissioners for approval on October 31), along with the final regulatory guide that is currently designated DG-1145. The updated Standard Review Plan should be issued in March. Addressing some of the later regulatory uncertainty, Borchardt said that the procedures for NRC review of licensees' inspections, tests, analyses, and acceptance criteria are to be added to the agency's inspection program in January.

Steve Routh, manager of the ESP/COL Technology Group at Bechtel Corporation, provided a more detailed look at what a standardized COL application might contain. This involved a uniform organization and the extension of standardization (where possible) to specific chapters in a final safety analysis report. Because Bechtel would be involved in COLs from the standpoint of an architect-engineer, Routh indicated that his company would also be involved with state-level permits and COL issues that had not been fully resolved in reactor design certification. He said that Bechtel's approach would be to maximize standardization and minimize departure from a reactor's design control document.


Routh

Many of the audience's questions at the end of the session were fielded by Grecheck. Asked whether new reactor standardization would extend into plant operating procedures and components such as pumps and valves, he said that COL applicants are already looking at standardizing realms such as training. On component manufacture, however, he said he does not want to see competition stifled and hopes that different vendors would develop models that meet all of a reactor design's specifications.

In response to another question, Grecheck noted that some cable manufacturers have said that they are not yet ready to meet new reactor demand, but he still expects enough products to be on the market when they are needed. Asked whether the concentration of COL applicants in the Southeast might overload the region with new nuclear capacity, Grecheck said that even the capacity proposed so far might not be enough.

Risk issues in site cleanup

The panel session, "Current Risk Issues in Environmental Cleanup," was led by S. Y. Chen, of Argonne National Laboratory. Although no Nuclear Regulatory Commission official spoke, much was said about the commission's license termination process and its approach to assessing risk and determining the level of radioactivity cleanup needed at a site, which differs from that of the Environmental Protection Agency (EPA).

The EPA's Stuart Walker, who works in compliance and regulations, is the lead person preparing the radiation-related parts of the agency's cleanup policies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund. Under CERCLA, industry is taxed to provide funds to clean up hazardous waste sites. Walker provided an overview of CERCLA and the EPA's risk assessment approach to radionuclide contamination.

For CERCLA purposes, the EPA treats radiation basically the same as chemical contamination but takes into account some differences, such as in decay and growth.

For CERCLA purposes, Walker said, the EPA treats radiation basically the same as chemical contamination but takes into account some differences, such as in decay and growth. He noted that only one of 65 Superfund sites did not have chemical contamination along with radionuclides, which explains in part why the EPA wants consistency in assessing chemicals and radionuclides.

Cleanup assessments under CERCLA are largely based on applicable or relevant and appropriate requirements (ARAR), Walker said. The point about "relevant and appropriate requirements" is that they typically refer to similar site situations. For example, he noted, when considering the cleanup of groundwater that is a potential source of drinking water, the requirements of the Safe Drinking Water Act regarding maximum contaminant levels in groundwater have to be met.

Where ARARs are not available, he said, or do not provide sufficient protection for certain circumstances, risk-based assessments are applied. For carcinogens, such as radionuclides, the risk goal is 1 in 10^6 cancer incidents, although it can go down to 1 in 10^4. The EPA, he said, likes to be at the more protective end, which it calls the point of departure.

Walker explained that CERCLA cleanup levels are not dose-based as are those of the NRC (or the Department of Energy). In place of the dose conversion tables used by the NRC, the EPA uses "slope factors" from radiation health effects assessment tables, which give risk coefficients that are, nevertheless, based on recommendations of the International Commission for Radiological Protection (in ICRP 72).

Walker then discussed a number of guidance documents, starting with a general one for those familiar with CERCLA but not to its use with radiation. Another, "Soil Screening Guidance for Radionuclides," follows the approach of a chemical guidance document to determine what level of leaching from soil is acceptable, he said. It is designed to look at contamination levels and pathways from a site to determine whether the site is clean enough that no further analysis is needed, and it considers five different soil-to-groundwater models. This, he said, is a sophisticated method that ensures that the situation really is acceptable. Using a really simple model, he added, would likely require removing much more dirt.

Another guidance document Walker mentioned is the radionuclide preliminary remediation goal calculator, an online model that can be run from the Internet that is used to convert levels of contamination to levels of risk. If the concentrations correlate to the 10^{-4} to 10^{-6} risk range, he said, the EPA generally does not take action unless there are ecological concerns or if there is concern that a particular pathway is not being captured in the risk assessment.

Walker also described other risk tools under development for establishing risk-based concentration levels in particular situations, including the Building Preliminary Remediation Goals (PRG) calculator, for inside a contaminated building, and the Outside

Surfaces PRG calculator, for exterior walls, slabs, and pavements. He noted that this would help in carrying out a risk-based cleanup after a dirty bomb incident.

State regulations

Philip Egidi, who is with the Colorado Department of Public Health and Environment, gave a state regulator's perspective on environmental cleanup issues. Egidi is also heavily involved in the cleanup subcommittee of the Interagency Steering Committee on Radiation Standards, which is where the various state and federal agencies get together to try to develop consensus and consistency.

Egidi commented that most ANS members have dealt only with NRC staff, not state regulators. Under the NRC's Agreement State Program, however, the regulation of radioactive materials is mostly handled by the states, he said, including machines (e.g., X rays, mammograms) and naturally occurring radioactive materials (NORM).

The states' basic radiation statutes are all-encompassing, he said, regulating all types of radioactive material. State regulators tend to take a pragmatic approach, he said, using available methodologies and tools, including the CERCLA process and the NRC process, but tailored to the state's needs.

Egidi deals with a variety of situations, from radioactive bolts (one of which appeared on his desk one day) to a building with very high radium contamination in its foundation mortar. Some sites, he said, fall under NRC license, and others do not. He said that he has received applications from drinking-water utilities that want to send their sludge to the local landfill that takes technologically enhanced NORM. Typically, they will provide a risk assessment without first coming to his agency and have already paid consultants a lot of money. The quality of these applications, he said, varies widely.

Risk assessment is important, he said, as it gives a number that informs a decision. "But a lot of the time, we have very limited resources, as do the licensees." He further explained that often a site owner inherits active material without knowing it is there, and the cleanup programs that are developed generally correlate to the depth of the company's pocket.

Risk-informed, he said, is a nice way of framing and putting into words what he actually does. "We make informed decisions . . . collecting all the information, not just risk assessment."

One project he noted concerned a site next to an old vanadium mill from the World War II era. The site supposedly had been cleaned up, but actually, some very active material remained there. As much of the material as possible was removed until the owner's money ran out. This led Egidi's office to put an environmental covenant on the land, allowing the site to be released, but with legally enforceable institutional controls. Colorado and a few other states do this.

He also noted that Denver is seeing a lot of "gentrification" of old industrial sites where previous measures to clean up contamination are proving not good enough for this use. Throughout the state, remote mining towns are being turned into ski resorts, and old uranium mining roads into mountain-bike trails.

Another point Egidi made is that stakeholder concerns go well beyond just dose risks, mostly focused on property values and liability issues. He also pointed to concurrent jurisdiction, saying it is very common, particularly if groundwater is involved. Groundwater regulators tend to be very protective, he said. "Woe be the person to take on the groundwater regulator who is not prepared!" He added that a number of complex sites with uranium and thorium contamination cannot be completely unrestricted because of groundwater issues.

Stakeholder concerns go well beyond just dose risks, mostly focused on property values and liability issues.

NRC versus EPA

Daniel J. Strom, of the Pacific Northwest National Laboratory, was a member of the scientific committee (87-5) that put together NCRP Report No. 146, *Approaches to Risk Management in Remediation of Radioactively Contaminated Sites,* published by the National Council on Radiation Protection and Measurements (NCRP) on October 15, 2004. The report addresses concerns about the regulations and guidance on decommissioning and remediation developed by the NRC in its License Termination Rule (10 CFR Part 20 Subpart E), which seem to differ significantly from the requirements of the EPA. In particular, he said, there was the well-known disagreement over an NRC site release criterion set at 25 mrem (0.25 mSv) per year plus ALARA (as low as reasonably achievable). The EPA said that this did not provide a low enough level of risk by its own criteria and wanted the commission to use 15 mrem (0.15 mSv). There were concerns about state regulations that could be more restrictive, and even fears that there would not be a "sunset" on cleanup. Under CERCLA, Strom said, this could be the case.

The NRC asked the NCRP to identify and summarize the current guidance and practices used by the commission under its License Termination Rule and by the EPA under CERCLA. The report was to include a historical basis for their development, commonalities, and significant differences, and to also cover current and future implications as they relate to public perception, uncertainty, measurability, and radiation dose and risk estimates. The report was hoped to be a step toward developing consistent approaches to decision-making by the two agencies.

Early on, Strom said, the committee decided that the scope for the review set by the NRC was not complete enough to result in a good report, and so the NCRP added some topics, including laws, regulations, and models. Strom mentioned his surprise that the NRC did not even mention the role of the states, which, he said, the committee quickly realized was fundamental.

It was evident to the committee that the NRC and the EPA use profoundly different risk-management paradigms, Strom said. In simple terms, he said, the NRC's radiation paradigm sets a dose limit, which is then brought down using ALARA. The EPA's chemical paradigm starts with a goal for acceptable risk (for example, 1 in 10^6 incidents of cancer). This goal is relaxed toward some acceptable limit of contamination, usually based on cost-effectiveness and technical feasibility.

Strom also observed that the EPA's calculations commonly use a 30-year exposure to a "suburban resident" who does not drink the groundwater or primarily eat food produced on site, while the NRC commonly uses lifetime exposure to a resident farmer who does drink the groundwater and eat food produced on site.

Strom summarized the seven conclusions from the NCRP report as follows:

1. Criteria differ for acceptable levels of residual soil contamination. The EPA has a lifetime cancer incident risk criterion, whereas the dose limits that the NRC uses are based on cancer incidents, cancer mortality, and heritable ill health. "These are not strictly comparable but wind up being fairly close when the dust settles," he said.

During the report's preparation, Strom said, he realized that the EPA could not possibly use a dose criterion because it has a responsibility for all risks, chemical and radiation. He added the comment that both agencies are "dead sure" that there will be no medical progress made in the future in their risk assessments. The same is true, he said, about global warming.

2. Concurrent regulation is the rule, not the exception. The committee noted that

although it would be desirable to have harmonization, it is not necessary.
3. Meaningful stakeholder involvement is required. In Strom's opinion, the NRC (which he said was "a direct descendant of the Manhattan Project") has not quite caught up with the EPA in stakeholder involvement.
4. Either approach can protect public health with site-specific cleanup levels. Either the NRC's License Termination Rule and practices or the EPA's National Contingency Plan and practices can give fully satisfactory results. He does suggest, however, that further talks between the two would be useful.
5. There are many drivers for practical decision-making. While every situation has its own level of risk, it is primarily feasibility and costs of alternatives to remediation and the need to achieve negotiated agreements among regulators, site managers, and stakeholders rather than rigid adherence to dose or risk criteria in regulations that drive decision-making.
6. State involvement is vital. State governments have a vital role in determining acceptable remediation of radioactively contaminated sites, including sites licensed by the NRC. States should be taken into account in efforts to reconcile differences in NRC and EPA demands.
7. EPA involvement should not impede NRC license termination. Involvement of the EPA in remediation decisions at facilities licensed by the NRC need not be a significant impediment to remediation and license termination. This is more of a theoretical problem than a real problem. There are some sites where they will work together.

A new approach

The last speaker was the session chairman, S. Y. Chen, director of the Environmental Technology and Restoration Program and strategic area manager in risk and waste management for Argonne's Environmental Science Division, who introduced a new approach to calculating risk that he developed to take into account the recommendations now being put forward by the International Commission on Radiological Protection (ICRP). Chen said he was driven to develop his proposal following an ICRP forum where the commission presented plans to drop the use of the "critical group" in estimating dose and replace it with the "representative individual," which requires a probabilistic approach for estimating dose. This, Chen said, is a big shift.


Chen

While he had some concerns about this approach, Chen does expect this part of the new ICRP recommendations to be adopted. The challenge then will be how to implement it.

The "critical group," Chen explained, represents the highest-exposed population subgroup for a particular radioactivity condition. Basing cleanup criteria on the maximum dose that could be received by someone in this group should ensure ample protection to anyone, he said.

This approach, generally viewed as overly conservative, requires a simple deterministic calculation that comes up with a single (maximum) dose level. However, regulators now want their decisions as to what is a safe level of contamination to be risk-informed, which means taking a probabilistic approach.

Regulators now want their decisions as to what is a safe level of contamination to be risk-informed, which means taking a probabilistic approach.

Chen explained that in his view, in order to get practical and meaningful results from a risk analysis, it is necessary to include a distribution of all possible land-use scenarios by which the "representative individual" could receive a dose. At the more conservative end, for example, would be the "subsistence farmer," while at the more relaxed end would be the "suburban resident," who would receive a much lower dose than a farmer who lives on and feeds himself from the land. This, he said, does require some assumptions about future land-use patterns, whichever approach is taken, say for a period of 100 years.

Chen cautioned, however, that his proposal uses a number of assumptions and could be controversial. It is just at the "proof of concept" stage, he said, and although it will not be ready for regulatory use for some time, he still wanted to open it up for discussion.

Other sessions

At the session on emerging topics in nuclear safety technology, Steven Nowlen, of Sandia National Laboratories, reported on research into cable response to live fire (given the acronym CAROLFIRE), a project sponsored by the NRC's Office of Nuclear Regulatory Research that also involves the National Institute of Standards and Technology and the University of Maryland. Nowlen said that the work is focused on "Bin 2" cable fire scenarios. ("Bin 1" are those most likely to cause cable failure, and "Bin 3" are the least likely, so in between are the prospects that are uncertain and thus require more research.) These scenarios include intercable thermoset shorting, intercable shorting between thermoset and thermoplastic cables, failures affecting three or more cables, multiple spurious actuations in control circuits with properly sized control power transformers, and fire-induced hot shorts lasting longer than 20 minutes. Also in Bin 2, but outside the CAROLFIRE scope, are certain potential failures of cold shutdown circuits.

Nowlen said that the testing was finished but the results were not yet available; a draft report was expected by the end of 2006. Cables in different configurations were tested both with steady heat sources (which yielded clear data) and direct contact by fire (less controlled, but more realistic). Among other things, he noted that thermoplastic cables cannot be made "nuclear-grade." Asked whether cable manufacturers had actively participated in the tests, Nowlen said that after materials were ordered for the tests, Rockbestos offered samples of a new silicon-based cable intended to ceramify when burned and avert failure modes, but apart from that, none of the manufacturers sought to get involved with the testing.

At the same session, Marc Vial spoke on behalf of the consortium that is planning a mixed plutonium/uranium oxide (MOX) fuel fabrication plant in the United States. The group, which currently includes Cogema and Stone & Webster, submitted a license application to the NRC in September. The agency asked for more information, and the group was to submit further information on November 17. Vial said that a problem that could arise in the fabrication process is plutonium's tendency, in its tetravalent state, to polymerize, which can clog pipes and interfere with the fabrication process. He said that an alternative to increasing the concentration of nitric acid in the process stream—which can have undesirable effects of its own on the equipment—is the addition of hydroxylamine (NH_2OH), which reduces the plutonium from tetravalent to trivalent, a state in which the plutonium cannot polymerize if the hydroxylamine concentration is higher than that of the plutonium, permitting the use of a much lower acid concentration.—*E. Michael Blake, Dick Kovan, and Rick Michal*