ANS ANNUAL MEETING

It's all about the people

ART STALL, senior vice president and chief nuclear officer of Florida Power & Light Company (FPL), wasted no time in addressing the theme of the ANS Annual Meeting, held June 24–28 in Boston, Mass., which was "It's All About the People: The Future of Nuclear." In his role as a general cochair of the meeting, Stall introduced the opening plenary session by noting that his company has filed a zoning request with the Miami-Dade County government for more nuclear capacity at Turkey Point, and while the public climate is generally favorable, he said, gathering the people to work on any new nuclear project would pose bigger challenges than any of the technical issues. He observed that FPL already has difficulties lining up tradespeople for outages at its existing power reactors, and he sees a five-year retirement horizon for large numbers of salaried workers.

Stall said that U.S. universities are now issuing about 400 bachelor's degrees in nuclear engineering per year, about four times as many as in the late 1990s, but that there is vigorous competition for the graduates from all sectors of the industry. He mentioned some of the approaches FPL uses to improve the quality of life for employees in the hope of retaining them—such as flexible schedules, arranged to allow for alternate Fridays off. (FPL plans to apply for a combined construction and operating license [COL] for at least one new reactor in 2009, with Turkey Point a potential site, but the reactor type has not yet been chosen, and the company has made no commitment to build any new reactors.)

Dana G. Mead, chair of MIT Corporation, said that the rise in nuclear engineering enrollments began before what he perceives as an apparent change in the public mood toward nuclear power. Around 2002, he said, polls showed nuclear as the least-liked energy option, but now the popularity of nuclear is about even with that of natural gas. Also noting the prospect of workforce retirements, Mead recalled his shipbuilding experience in which an aircraft carrier had to be built every six years to earn enough to retain all personnel, but if necessary, submarines could be built between carrier assignments. The civilian power reactor realm, he observed, lacks that option, so if new reactors are not ordered, there is nothing else with which to keep personnel gainfully occupied.

Mead observed that the Department of Energy's loan guarantee program for new energy facilities allowed by the Energy Pol-

Mead

Meeting session coverage:

- *The growing need for new nuclear professionals and tradespeople*
- *The quest for a nuclear cooperation agreement between the United States and India*
- *The effort to bolster the nuclear supply chain*
- *Fuel cycle and waste management innovations*
- *Preparations for license applications for new reactors*

icy Act of 2005 had not yet been established in regulations. Still, he said, he saw a possibility that investors would go ahead on new reactors anyway. Returning to polling data (from tracking by MIT), Mead said that 39 percent want less nuclear power, and 35 percent want more. His expectation, he noted, is that support would increase if the high-level waste issue were to be resolved.

John Ritch, director general of the World Nuclear Association (WNA), asserted his position bluntly, calling climate change "nothing less than a global emergency" and stating that in the minds of world leaders, nuclear power is "nothing less than indispensable." He said that in less than 10 years, greenhouse gas emissions from the developing world would equal and then exceed those from the developed world. He called for a consensus on an increase in nuclear power for electricity, and also for vehicle batteries and desalination.

Ritch

He advocated an approach to greenhouse gas emissions that would move beyond the Kyoto Protocol to a "contraction and convergence" system, a 60 percent reduction in greenhouse gases and equal emission rights per person, worldwide. Getting to that point with nuclear power, however, could be impeded by what he called the "fundamental failing" of the United Nations and other international organizations, which is that they are influenced by "old-school antinuclear environmentalism."

Ritch said that while a WNA report on fuel supply assurances showed widespread support for nonproliferation, there is a desire for access to full fuel cycle development. In his view, the expansion of nuclear power should not be held back until greater nonproliferation safeguards are put into effect. He projected that at least 8 TWe of new nuclear capacity must be added by 2100 to avert environmental disaster.

The next speaker was someone involved in the area of nuclear personnel from a different perspective than the other speakers: Edward Sullivan, president of the Building and Construction Trades Department of the AFL-CIO. He said that the federal Bureau of Labor Statistics predicts a need for more than 2 million new construction craft workers by 2014. The training required for a skilled tradesperson these days, he said, is roughly equivalent to an associate's degree, and another new impediment to attracting and keeping the workforce is the growth of drug and alcohol testing nationwide. He observed that in recent years the pay scales for craft workers has stagnated, which he attributed to the availability of illegal aliens. Sullivan also showed his standpoint on organized labor by decrying the poor quality of work done in open-shop (nonunionized) situations.

Climate change [is] "nothing less than a global emergency" and in the minds of world leaders, nuclear power is "nothing less than indispensable."

Shannon Bragg-Sitton, a Los Alamos National Laboratory technical staffer on assignment to the National Aeronautics and Space Administration's Marshall Space Flight Center, filled several roles in Boston, including as technical program cochair for the Space Nuclear Conference. During the main meeting's plenary session, however, she spoke as a cofounder of the North American Young Generation in Nuclear (NA-YGN), an organization set up to attract and assist younger nuclear professionals, technical and otherwise. Based on her experience in NA-YGN, she suggested that the way to attract new people to nuclear fields is to emphasize viable career paths, not just jobs. She said she has found that opportunities are more likely to keep young people in nuclear than compensation alone will.

Bragg-Sitton

After Bragg-Sitton spoke, the session was suspended for about 15 minutes because the final scheduled speaker, Energy Secretary Samuel Bodman, had not yet arrived. He had a previous engagement and media event that morning at the office of Massachusetts Gov. Deval Patrick. Once he arrived, he delivered a speech on nuclear energy in general, not stressing the aspect of the demand for more personnel.

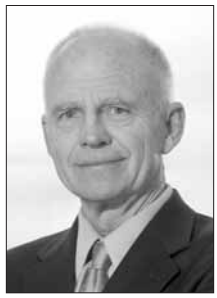
Bodman noted that the demand for electricity in the United States will increase by about 50 percent through 2030, requiring an extra 285 GWe—about as much as the current coal-fired capacity. He stated that nuclear power is the only large-scale emission-free electricity supply technology that can be added in large amounts right away. He also pointed out that U.S. civilian nuclear power is no longer self-sufficient in uranium enrichment.

Bodman

He listed the Bush administration's initiatives in nuclear energy, including the meeting with officials from China, France, Japan, and Russia on the Global Nuclear Energy Partnership (GNEP). He called the House of Representatives' markup of the DOE's fiscal year 2008 budget request "quite distressing," with a 70 percent cut for GNEP, a reduction for Nuclear Power 2010 (NP2010) , and nothing for loan guarantees for new energy projects, including power reactors. He called upon meeting attendees, and the industry in general, to make the case to Congress for better funding.

President's Special Session

Having led a mission to India for the society in January, ANS President Harold McFarlane chose the topic "India-U.S. Nuclear Cooperation" for the President's Special Session at the annual meeting. The mission started, he said, with a call from the science counsellor at the U.S. Embassy in New Delhi, who asked if ANS, which had signed a memorandum of understanding for cooperation with the Indian Nuclear Society some years ago, would be interested in visiting India's nuclear establishments and people. The society's representatives were well received by government, industry, laboratories, and universities, McFarlane said.



McFarlane

The session's opening speaker, Srikumar Banerjee, director of the Bhabha Atomic Research Centre (BARC), explained India's nuclear strategy, which aims eventually for a fully closed fuel cycle. The country has developed its nuclear technology in virtual total isolation for nearly 40 years, Banerjee said. This situation, along with India's meager uranium resources but large deposits of thorium, has led India to follow a three-stage industrial development program: first, the construction of natural uranium–fueled pressurized heavy-water reactors (PHWR); second, a fast breeder reactor (FBR) program; and third, the development of the uranium-233–thorium-232 fuel cycle, which will greatly expand nuclear fuel resources. This strategy is viewed as essential if India

is to become truly energy independent beyond 2050.

The major advantage of the PHWR, Banerjee said, is its highly efficient utilization of uranium in terms of tonnes of mined ore. This is particularly important because India has been mining ores with a uranium content of less than 0.1 percent, which compares poorly with the 12–14 percent ores mined in some other countries. While heavy-water production is necessary, there is no need for enriching the uranium or constructing large pressure vessels, but a significant indigenous effort to develop fuel and structural materials was needed. Given its current heavy-water production capacity and existing uranium reserves, India can sustain only a 10 000-MWe nuclear program, he said.

Banerjee described some of the efforts needed to independently develop such things as reactor designs, fuels, special materials and components, and advanced computerized reactor control systems, and then transfer the technologies to the commercial sector. India has also developed nuclear plant construction, operation, maintenance, and life management capabilities. Improvements are continuing, for example, in heavy-water production and the fabrication and operation of pressure tubes, which are the most critical components in the reactor. Today, he said, the capital cost for the PHWR is $1300 per kW installed, and nuclear power is now competitive with coal-fired plants operating at the coal mines. Previously, nuclear was competitive only at distances more than 800 km from a coal pit–power plant. Many Indian states are now calling for nuclear plants to be built in their regions.

Today the country's nuclear plant operator, Nuclear Power Corporation of India Limited, operates 17 reactors at six sites, with another two PHWRs due to be operating within a year's time, and several more planned. To maintain its options, Banerjee said, India also chose to purchase reactors and fuel from another source: Russia. Two 1000-MWe VVER pressurized water reactors being built by AtomStroyExport should soon be in operation. There are plans to build more light-water reactors, but that will largely depend on the country's opening the door to the global market.

The second-stage FBRs will use the plutonium created in the PHWRs, and will also recycle the spent uranium to breed more plutonium. Later, thorium will be used as a blanket material to breed uranium-233 to fuel the third stage. The 40-MWt/13-MWe Fast Breeder Test Reactor (FBTR) has been operating at Kalpakkam since 1985, and a 500-MWe Prototype Fast Breeder Reactor is under construction nearby. The closed fuel cycle is also considered the best way to handle long-term disposal.

Banerjee also mentioned that mixed-carbide fuels used in the FBTR have exceeded 155 gigawatt days per tonne (GWd/t) of burnup with no failures. At the same time, India is developing metallic fuel to increase the rate of plutonium production, which is necessary for the ambitious fast breeder reactor program planned. He also noted that the jump to stage three (the thorium cycle) will require a "huge inventory of additional neutrons," and these can only come from the fast reactor.

India is also working on a 300-MWe advanced heavy-water reactor project that will be fueled by U-233–Th mixed-oxide and Pu–Th mixed-oxide fuels. Designed for a 100-year lifetime, the reactor will be used for power production and desalination. The entire heat removal for the reactor will be achieved through natural circulation, so there will be no primary pumps. Construction will start during the government's current five-year plan. BARC is also developing a high-temperature reactor intended for hydrogen production.

Trade between India and the United States, India's largest trading partner, has expanded significantly since 1990, and this year alone, growth has been more than 20 percent.

Vaidhyanathan Raghuraman, the principal advisor and chief coordinator for energy, environment, and natural resources of the Confederation of Indian Industry, was the second speaker. He has been involved in Indian-U.S. industry working groups concerned with how to take civil nuclear cooperation forward. India, he said, is not well endowed in energy resources, and only certain regions have useful coal and hydro resources. He noted that the Indian government has only recently devised a fully integrated energy policy and realizes that in the long term, only nuclear will be able to fill the gap. To develop greater nuclear capacity, India will have to be part of global initiatives, Raghuraman said. To do this, India is also going to have to finalize the India-U.S. nuclear cooperation agreement that is being negotiated with the intention of opening access worldwide to nuclear technology and fuel, which has been denied to the country for the last three decades. He said that India must also open its own nuclear market, which is heavily dominated by state-owned companies, to domestic and foreign fuel and technology suppliers, adding that this will require a change to the Indian Atomic Energy Act.


Raghuraman

Critical issues—particularly regarding reprocessing—are being negotiated now as well, Raghuraman said. He noted that India wants to deal with the Tarapur boiling water reactor's spent fuel, which General Electric supplied in the 1960s before restrictions were introduced (all of Tarapur's spent fuel is being stored on site). In addition, he said, India will not accept any disruption to fuel supply, even if a future U.S. administration changes its policy. Regarding India's nuclear weapons test program, he continued, although the United States wants India's current moratorium to be a legal obligation, India wants to continue its moratorium as a self-imposed unilateral action.

One outcome of the 2005 meeting between President Bush and Indian Prime Minister Manmohan Singh that kicked off the current negotiations for a cooperation agreement was a mandate for the U.S. Department of Commerce (DOC) to begin promoting business and commercial ties between India and the United States. The civilian nuclear business was likely to be one of the biggest commercial opportunities, with the possibility of many nuclear plants to be built in both countries. A U.S. perspective on this was given by Jamie Estrada, who manages competitiveness issues for U.S. manufacturing and service industries in the DOC's International Trade Administration (ITA). Trade between India and the United States, India's largest trading partner, has expanded significantly since 1990, he said, and this year alone, growth has been more than 20 percent, with U.S. exports up by 25 percent because of India's steps to liberalize its economy by lowering tariffs, reducing nontariff barriers, opening sectors such as telecommunications to foreign investment, and taking initial steps to protect intellectual property. These are the right environmental foundations, Estrada said, for a broader trade relationship upon which civil nuclear cooperation would sit nicely.

Several major things must happen, he said, starting with the completion of the bilateral agreement, which will allow U.S. companies to sell technology to India. Once

this has been done, India will have to negotiate a full-scope safeguards agreement with the International Atomic Energy Agency and then get the Nuclear Suppliers Group to waive its restrictions on India's taking part in international nuclear trade. Only then, he continued, will the U.S. Congress be in a position to approve the agreement, which will occur only after the president makes a determination that the conditions outlined in the Henry J. Hyde U.S.-India Peaceful Atomic Energy Cooperation Act have been satisfied.


Estrada

Regarding the opportunities foreseen, Estrada said India is expected to invest $100 billion in its nuclear energy sector over the next 20 years. In his opinion, given U.S. nuclear technology and services capabilities—combined with the ideals and vision the two democracies share—India will consider U.S. companies as natural partners. Estrada also noted that nuclear cooperation with India could provide an impetus to develop nuclear power in the United States.

Last year, the DOC and ITA led a business development mission to India that included 19 nuclear energy companies and nuclear associations. Estrada said that he expects further missions to be organized, bringing in more companies and having meetings in the United States, as well. At the government level, he said, various bilateral discussions will take place to further cement the relationship, covering issues such as partnership arrangements and high-technology cooperation. He noted that preparations are being made for a vendor conference at the end of this year to discuss issues such as supply chain, labor force, licensing, finance, and liability infrastructure.

Another issue that will need government involvement, Estrada said, is competition from foreign companies that are subsidized in one way or another by their governments. The DOC is working to ensure a

Bringing value to ANS

The panel session titled "Bringing Value to the American Nuclear Society" provided an overview of young professional membership recruitment and retention issues faced by ANS and sought solutions to those issues from panel members and the audience.

The session chair, Dena Belschner, of Bechtel Power Corporation, described recent membership trends. Between 2002 and 2006, membership in the 21–25 age group, consisting primarily of student members, increased by approximately 500, she said. Membership in the 26–30 age group, a mix of both student and professional members, increased by about 200. "I think that this really ties in to what was said in the plenary session Monday," Belschner said, "that enrollment in nuclear programs is up threefold, so you would expect to see an increase in ANS student members as well." However, membership in the 31–35 age group, which consists entirely of professional members, has decreased over the past four years, she said.

Belschner described a two-part challenge for ANS in the area of member retention. She first pointed out the importance of converting student members into full members upon graduation. She then touched on retaining current professional members, who, if they leave the society, tend to do so "in approximately the third year of their membership."

Belschner then introduced the rest of the panel: Nichole Ellis, of Ellis Nuclear Engineering; Jim Felty, of Science Applications International Corporation; Garry Harris, of HTS Enterprise; Don Hoffman, of Excel Services Corporation; Mike Houts, of the NASA Marshall Space Flight Center; Kathryn McCarthy, of Idaho National Laboratory; Keith Oliver, a graduate student working on the GNEP project; Mary Jane Ross-Lee, of the U.S. Nuclear Regulatory Commission; Fitz Trumble, of Washington Safety Management Solutions; and Art Wharton and Ralph Winiarski, both of Westinghouse.

The panelists were questioned on where they found value in ANS, how to help others see that value, how to nurture young professionals, and how to be more effective in recruiting and retaining ANS members.

Better communication with members and prospective members was an oft-repeated solution. Although there was discussion of the need to better educate people on the opportunities offered by ANS, the real focus was on listening. "We need to hear the voice of the customer," Harris said. "We've got to dialogue; we've got to record and take action." McCarthy emphasized responding to members' concerns, even if the requested action can't be taken. "We need to very carefully look at what the concerns are and evaluate how those concerns can be met," she said, "and get back to the group that expressed that concern with details, with either 'here's how we're going to do it' or 'we can't do it because of this reason, but we want to hear some ideas you have.'"

The importance and involvement of ANS's constituent units (professional divisions, working groups, local sections, and student sections) was another recurring theme in the panelists' answers and the audience's comments. One function of these groups, as Hoffman noted, is to give members an easily identifiable "home" within the society. The Young Members Group, which is designated a technical group, was set up specifically to fulfill that need for young members. They "will ultimately be engaged in their technical discipline of choice," Hoffman acknowledged, "but they need a place where they belong initially so they can learn the ropes, learn the activities, get engaged." Trumble described the idea as "shrinking the society down," and he indicated that it should start with the professional divisions. Hoffman mentioned ANS's ongoing initiatives relating to the enhancement and improvement of local sections, and Houts talked about strengthening the student sections. "You look at not only helping the student sections operate as student sections," he explained, "but also as helping get their members exposed to what the national organization does."

Emphasis was also placed on the importance of the organizations and corporations involved in the nuclear industry. According to the panelists, ANS needs to work to make organizations realize the benefits ANS brings to the entire industry and encourage those organizations to give back to the society, whether that is by becoming an organization member or just by supporting their employees in society activities. The panelists' suggestions on how to achieve this goal ranged from offering sessions on professional skills such as technical writing to asking board members to reach out individually to their corporations. Hoffman tied this in with an initiative being set up by new ANS President Donald Hintz. "We're forming a special committee at the end of this meeting whose sole function is going to be to go out and address the organization membership issue, not only related to utilities, but to anybody involved in the nuclear industry," Hoffman said.

Members were also encouraged to reach out as individuals. "Each one of us needs to be an active, aggressive participant in our 'each one, reach one' program," Harris said. "That's where each one of us is responsible for going out there and recruiting and also retaining ANS members." McCarthy also encouraged the personal approach, reminding those in attendance that "as individuals, a very small thing can have a very big impact . . . so don't underestimate what you can do."—*Sarah Ross*

level playing field through a number of different actions, he said. And then there are the Wall Street and "Main Street" issues: Wall Street will have to be convinced that these are profitable ventures, and Main Street, that they are safe.

Fuel cycle

The honorary chair's special session, titled "The Nuclear Fuel Cycle and Its Waste Management—Innovation is the Future," was dedicated to the memory of the late Manson Benedict, a nuclear pioneer and past president of ANS (1962–1963).

Benedict, who died in September 2006 at age 98, was the founder and first head of the Nuclear Engineering Department at the Massachusetts Institute of Technology (1958–1971) and was well known for his role in nuclear engineering, said Neil Todreas, a professor of nuclear engineering at MIT and the ANS meeting's honorary chair. Benedict developed the gaseous diffusion method for separating the isotopes of uranium and supervised the engineering and process development of the K-25 plant in Oak Ridge, Tenn., where fissionable material for the atomic bomb was produced.

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Todreas related that Benedict received many awards for his work on uranium enrichment technology as part of the Manhattan Project during World War II, and for his later career as a scientist, educator, and public servant, which focused on nuclear power and other peaceful uses of atomic energy.

Benedict in 1967

From 1958 to 1968, Benedict was a member and chair of the Advisory Committee of the Atomic Energy Commission, appointed by Presidents Eisenhower and Kennedy. Among the awards he won were the American Institute of Chemical Engineers' William H. Walker award in 1947, the Society of Chemical Industry's Perkin Research Medal in 1966, the American Institute of Chemical Engineers' Robert E. Wilson Award in 1968, the U.S. Atomic Energy Commission's Enrico Fermi Award in 1972, the National Medal of Science from President Gerald Ford in 1975, and ANS's Henry DeWolf Smyth Nuclear Statesman Award in 1979. The Wilson Award citation said of Benedict, "He has served education, industry, and government with quiet and unwavering dedication."

Mujid Kazimi, a nuclear engineering professor at MIT and director of the school's Center for Advanced Nuclear Energy Systems, remembered that it was Benedict who convinced him to do his thesis on thermal hydraulics while he was a graduate student at MIT.

Kazimi's talk during the session was on actinide burning in reactors. The United States currently produces about 2000 tons of spent fuel each year, and annual worldwide production is about 8000 tons. Total accumulation is about 58 000 tons in the United States and 130 000 tons worldwide. Most of the spent fuel—95 percent—is uranium, while plutonium and higher actinides comprise just over 1 percent. There also exists about 150 tons of discarded weapons plutonium from the United States and Russia, with more potentially coming. This amount of plutonium is "significant," Kazimi said, "and is something that people have to consider in asking whether or not we should burn this rather than accumulate it."

The United States, of course, has been following the once-through cycle, with spent fuel from reactors destined for disposal in a geologic repository. "Although we all know that the preparations for the repository have taken many turns over the years, we're not quite sure whether we will actually get there," he said. By contrast, France, Japan, and other countries have assumed policies of recycling the spent fuel at least once, processing it into mixed-oxide (MOX) fuel and holding it in storage until it is needed for future fast reactors. The French, he said, "look at it as a way of waste management, not necessarily as a resource extension."

There is the possibility that the United States could recycle transuranic (TRU) waste in light-water reactors such that there would be a "net TRU reduction," he said. To reach this goal, fuel-assembly designs such as the one known as CONFU—*CO*mbined *N*on-*F*ertile and UO_2—would have to be used. The CONFU assembly is composed of 80 percent uranium pins and 20 percent TRU in nonfertile pins. In use, the CONFU assembly would preserve the power peaking and safety characteristics of current reactors, according to Kazimi.

Kazimi said that the CONFU approach is superior to the recycling that produces MOX, and that it "is better than thorium-based TRU burning since it avoids the U-232/U-233 issues." If the United States were to start recycling in 2027 using the CONFU design, it would take seven burner reactors about 30 years to eliminate the spent-fuel quantities sitting in interim storage, he said.

Alan Hanson, executive vice president of Areva's Technology and Used-Fuel Management group, said he, too, was an MIT graduate and had met Benedict in 1969. Hanson noted that he had taken a course taught by Benedict and had the highest regard for him.

Hanson explained the reprocessing technique used at Areva's La Hague plant, in France. The plant, he said, uses an advanced version of aqueous processing, which is a technology that was invented in the United States. The spent fuel is received at La Hague, placed in a storage pool for a period of time, and then taken for processing. The fuel is sheared and dissolved in nitric acid and then is put through several separation streams to sort out useful components (uranium and plutonium) from the waste products. The material coming out in the waste stream is minimized and compacted. The fission products are vitrified in glass and put in canisters. By law, all the waste material must be returned to the country of origin.

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As of January 1, 2007, La Hague has processed more than 22 650 metric tons (t) of spent fuel: 12 619 t from France, 5381 t from Germany, 2944 t from Japan, 709 t from Switzerland, 672 t from Belgium, and 326 t from the Netherlands. "If you look at the current inventory of fuel in the U.S. to-

day, we've already run through [La Hague] almost half of what has been generated here in the United States," he said.

Hanson also noted that the 22 650 t of processed material has conserved the equivalent of four years of the entire oil production from the country of Kuwait. In addition, he said, the uranium in spent fuel has properties comparable to uranium mine concentrates, so that recycling it conserves the equivalent amount of natural uranium.

Another reason to recycle is the energy value of plutonium: 1 gram of plutonium equals 100 grams of uranium, which equals one t of oil. "A strategy that says that we should just leave the plutonium in the used fuel and just throw it away is not a strategy for getting rid of it because [plutonium] doesn't go away at all in reality," he said. "The decay time is so long. We need to be looking at a strategy that manages our inventories of plutonium for import and export. We have to do this in a way that reduces proliferation risks, and we should do it in as economical a fashion as possible."

Hanson questioned aloud whether reprocessing in the United States could start up, particularly for the spent fuel at decommissioned reactors. "I'm not going to answer that question other than to say that technically there is no reason why it could not be done," he said. "That does not mean that politically and economically it could be done effectively, but technically it could be done."

Advanced recycling processes and fast reactors are key to the sustainable development of nuclear power, said Frank Carrê, of the Commissariat à l'Energie Atomique's nuclear energy division. He pointed to France's successful 25 years of reprocessing as a model for the back end of the fuel cycle. The industrial experience of recycling, along with national plans for more advanced fuel cycle programs, are the "seeds for the international development of optimized recycling modes in fast neutron systems," he said.

In order for countries to accept recycling as a fuel cycle option, Carrê said, current-day national initiatives need to be promoted on a worldwide basis, and long-term research and development projects and demonstration programs need to become part of an international technology road map.

Revitalizing the supply chain

For the topic of the general cochairs' special session, Art Stall (FPL) and David Barry (Shaw Group) chose an issue that is seen as a major constraint to the nuclear renaissance: the supply chain. New nuclear plants are continuing to be built around the world, while some 15 companies and consortia are preparing applications to build as many as 33 reactors in the United States. The question then arises as to the capacity of the supply chain to meet the demand.

Stall noted that other industries are looking for many of the same components that although are not nuclear grade, involve the same manufacturers. Shaw, the largest pipe manufacturer in the United States, has a $500-million order backlog—and this does not include any nuclear orders. The company, however, is increasing capacity in all of its shops to prepare for a rising work load and is reserving design and fabrication time for future customers. While Shaw may be able to do that, many suppliers will need more certainty before making the required investment.

There is also a shortage of qualified manpower, Stall noted, not only to supply and build, but to operate, inspect, protect, and regulate the plants. Another concern he noted was site preparation. Before the first concrete is poured, sites must be made ready to handle heavy loads, including massive cranes and other lifting equipment. He also pointed to the development of modularization, the purpose of which is to move as many person-hours as possible off site.

Manufacturing capability

Craig Hansen, of BWX Technologies (BWXT), said that nuclear manufacturing capability in the United States is limited, but that this does not have to be the case. As the largest nuclear manufacturer in the United States, he said, BWXT believes the industry can move forward more quickly.

One indicator of the challenge, Hansen said, was an IAEA analysis showing that nuclear power is and will continue losing market share for quite some time. Hansen said, however, that he believes that the United States can achieve a strong nuclear renaissance and even gain market share, but that this will require building up the industrial infrastructure. One critical requirement, he said, is to ensure that Congress and other Washington decision-makers really know what the industry needs. In this regard, he suggested that companies wanting to get involved talk to the organizations represented by two of his copanelists, Carol Berrigan, director for industry infrastructure at the Nuclear Energy Institute (NEI), and Tom Sanders, one of the founders of the American Council on Global Nuclear Competitiveness. "They are doing great work for you already," Hansen said.

The United States can achieve a strong nuclear renaissance and even gain market share, but this will require building up the industrial infrastructure.

In his own dealings with politicians, Hansen said, he always mentions two numbers, 41 and 69, explaining that coal and nuclear energy represent 41 percent of the country's electricity capacity but produce 69 percent of its power. This, Hansen said, is what provides our national competitiveness across the board and what will sustain the U.S. economy in the future. The real competition, he said, is how much will be coal-fired and how much will be nuclear.

Hansen asked if the industry is really prepared for the renaissance and pointed to a number of weaknesses. Quality was a particular concern, as many companies discovered during the earlier period of nuclear construction, when large numbers of qualified materials and equipment had to be returned. "If we want to sustain a rebirth," he said, "we will have to fix that problem." Much greater cooperation will be required within the industry, and utilities and vendors must talk to their suppliers to make certain that they understand the standards required so that mistakes are not made in the first place.

Hansen also noted other drivers that may have a strong impact on the renaissance, such as public attitudes, government policies, market changes, perceptions of risk, predictability, regulations, liability issues, unfair competition, costs, and return on investment. What stopped the industry the first time around, he said, was a failure to deal with many of the challenges, such as the implementation of a proper fuel management program. The government must also recognize that it has a critical role in areas such as tax incentives, which are needed to help suppliers build up capacity, particularly for small and medium-sized companies.

Hansen also said that having a level playing field is critical, not only at home, but globally as well. If we cannot compete internationally, he said, we will not be able to compete domestically. If the cost of environmental impact is valued on a fair basis, he noted, nuclear will be competitive. Having to compete against state-owned, controlled, or subsidized companies is also a concern, he added, and if the United States does not get involved in sensitive areas such as reprocessing, other nations such as Russia and France will fill that void.

NEI's Carol Berrigan discussed the results of a survey and assessment of manufacturers' capacities that NEI had conducted. In the 1980s, she said, more than

500 companies holding N stamps were active in what was largely a domestic nuclear market. That market is now global and very competitive. Seeing how very thin the supply chain was, Berrigan said, led NEI to set up the physical infrastructure task force in 2005 to look at how this would affect a nuclear renaissance.

NEI recognized early on that a number of projects will begin at the same time, causing demand to go from very low to very high very quickly, bringing with it availability concerns. There were also concerns about the capability and *willingness* of foreign companies to provide nuclear-grade materials that were acceptable to the U.S. industry and regulators. The lack of production capability for heavy and ultra-heavy forgings is well known. At the next level, large component castings, there are a small number of domestic suppliers and a limited ability for supply to grow because of environmental controls, Berrigan explained.

The basic goal of the task force was to understand what was needed and when. This included consulting with those actively planning new projects, and with supply chain managers, vice presidents, and others who were sourcing for new build to understand where "pinch points" occur. The assessment, Berrigan said, showed few challenges for the first couple of plants. But with expansion, there will be some real pinch points emerging for heavy forgings and a number of special components, such as nuclear-grade pumps, valves, and heat exchangers, safety transformers, safety-grade batteries, and mechanical insulation. The supply of simulators could also be a problem.

Another problem area highlighted was construction bulk commodities, such as concrete, reinforcement steel, structural steel, large forged seamless steel piping (a plant will need more than 5 miles), small-bore piping, and cabling and conduits. A commodity assessment also found that there is a significant escalation in prices, particularly of seamless piping and high-alloy steel.

Manufacturers of components that would likely cause a bottleneck were asked what would prevent them from increasing capacity. The list included a lack of raw materials and subcomponents; qualified specialists such as shop supervisors, welders, and other technicians; N stamp–qualified suppliers; and forging capacity.

The task force developed a series of recommendations, which included the following:

- Plan for longer lead times to procure critical components.
- Support the industry-wide efforts to broaden the manufacturing base.
- Expand domestic suppliers' access to the international market.
- Develop an incentive package to spur manufacturing growth.

Most important, Berrigan said, is the need to increase outreach to manufacturers and potential manufacturers to keep them fully aware of the scope of each project and of what is expected of nuclear grade components. She added that many of the manufacturers who had let their N stamps go are still manufacturing the same equipment. "We will be reaching out to them over the next several months to see if we can get them back into the fold."

Codes and standards

John Koehr, of the American Society of Mechanical Engineers (ASME), discussed the codes and standards needed for nuclear fabrication and construction. ASME's standards are well known for items such as nuclear pressure vessels, containments, and other special components, as well as for its N stamp qualification and in-service inspection programs. He listed other areas, including cranes for nuclear facilities, risk management, air and gas treatment, quality assurance, and operations and maintenance.

ASME is becoming more international, Koehr said, as components are manufactured and shipped from anywhere in the world. Since the 1980s, he said, there has been a drop in the number of companies holding N stamp certification, mostly in the United States. There are now 178 companies holding 426 nuclear certificates, of which about half are outside the United States. ASME now has participants from many countries in its committees and activities and is actively working to increase international participation, including holding more committee meetings and workshops overseas. ASME also visits other standards organizations to monitor trends.

ASME now has participants from many countries in its committees and activities and is actively working to increase international participation.

Koehr assured the audience that ASME codes, standards, and certification programs are well maintained and that ASME is responding to developments in the industry, such as new builds, Generation IV designs, risk management, probabilistic safety assessment development, and globalization. "We are ready to work to help revitalize the supply chain," he said.

Manpower and economics

One of the key issues for manufacturers is a shortage of qualified people, stressed Don Bowers, director for sales and power products at Velan Valves with responsibility for the company's navy program. Bowers began his career working on the construction of the Millstone nuclear plant. Since those days, he said, the supply of people with experience to construct and manufacture plants and components has dried up. Nuclear manufacturers need experienced people, he said, not only for fabrication and assembly, but also for a range of other requirements such as inspection, testing, and all those activities required to reach nuclear quality goals. New and improved standards will require additional qualification testing, he noted, but the question of who will foot the bill for this is still unanswered.

On economics and availability, Bowers said that the costs of smaller carbon steel valve castings, as well as of large valves, have risen as the price of carbon steel has recently gone up by 25–50 percent, while stainless steel has more than doubled over the past three years. Some of the special alloys have also more than doubled. "I hope that people who have done the costing for new plants did it six months ago and not two years ago," he said. "Otherwise there are going to be some surprised people."

Bowers posed the question of what is driving the material costs and availability. One answer is China, which, he said, has cornered the market on scrap steel, along with the huge demand for these products along the Pacific Rim. Another is a shortage of mill capacity and of arc welders. Nuclear projects will have to compete for machine time, and there will be some suppliers with the capability, but not the desire, to undertake nuclear work. "We cannot control that," he added.

On the positive side, Bowers said he was quite pleased at how nuclear steam supply system vendors have been getting the message out to suppliers of the importance of the first couple of plants. "Everyone, particularly the financial community, will be watching, and the first few units will set the trend."

Global issues

Tom Sanders is manager of the global nuclear futures program at Sandia National Laboratories, but he spoke at this session as vice president of the American Council on Global Nuclear Competitiveness. He warned that the decline of the United States' nuclear supply infrastructure and its ability to be a major if not dominant force in the global nuclear enterprise is having a serious impact on the country's ability to

influence the next nuclear era in regard to its national security interests. Sanders noted that in the council's view, "Nuclear is not a domestic energy resource if everything but the concrete is imported."

Nuclear projects will have to compete for machine time, and there will be some suppliers with the capability, but not the desire, to undertake nuclear work.

Sanders also warned about the impact of the 2 billion people who do not now have electricity but will soon be climbing up the energy curve. China in particular now consumes annually more than one-quarter of the world's steel, one-third of its copper, and one-half of its cement, and is now the second largest importer of fossil fuel behind the United States. The United States must be prepared, he said, for the implications of that growth. To ensure a stable and prosperous world, a large expansion of nuclear power will be necessary, he said.

Sanders also expressed concern that while about 15 countries have developed nuclear fuel supply capabilities over the past three decades, the United States has remained dormant. He pointed to Russia's decision to build significant numbers of reactors to free up its gas reserves. This was a country decision, not a company decision.

The last time there was such a confluence of issues, he said, was 50 years ago, and it led to the Atoms for Peace program. It also led to the establishment of a great American enterprise that was soon able to supply nuclear plants around the world, while also promoting the U.S. approach to safety, security, and nonproliferation. It is in the national security interest of the United States, Sanders stressed, to ensure that the global expansion of nuclear energy occurs with the same ideals.

NP2010 update

In what has become a recurring feature at ANS's largest meetings, a session was held to report on progress with the DOE's NP2010 program and the larger effort by several organizations to apply for licenses for new power reactors in the United States. An indication of how this effort has moved beyond the original goals of NP2010—to prepare and submit a few applications for early site permits, design certifications, and COLs, with the DOE covering half of the cost—was provided in an opening statement by Marilyn Kray, vice president of special projects for Exelon and president of the NuStart consortium. She said that organizations such as NuStart are now looking beyond their original goals to areas such as the development of operator training for the Generation III+ reactors that would be built if the COL applicants use their licenses to produce new nuclear generating capacity.

Kray

Tom Miller, of the DOE's Office of Nuclear Energy, Science and Technology, summarized developments from the agency's side. While NP2010 will require more appropriations by Congress in the coming years to maintain the federal government's 50 percent share of the project, he said, the DOE remains committed to following through on

"complete certification and first-of-a-kind engineering for the ESBWR and AP1000 designs." He said that the conditional agreement on standby support (also known as risk insurance) was to have been issued by the DOE in June but had not yet been released. Contract language is to be issued during FY 2008, and the first agreements with industry are foreseen for December 2008. Miller's list of potential challenges to new reactors generally agrees with those of other observers: workforce, supply chain, the licensing process, and research to establish the basis for the operation of a plant for longer than 60 years.

David Matthews, director of the Division of New Reactor Licensing in the Nuclear Regulatory Commission's Office of New Reactors, said that he is convinced that COL applications will begin arriving, on schedule, in October. He asserted that within the NRC, safety and quality are still paramount and override all considerations of scheduling or urgency on the part of applicants. He added that he thinks safety-related concrete pouring will begin on at least two reactors by the end of 2009. He would not go so far as to predict which reactors those might be, but he noted that an early application will not necessarily lead to an early license. The NRC's application reviews will cover the applicant's qualifications. He mentioned that he heard from someone at the Institute of Nuclear Power Operations that "we don't want amateurs." In whatever order applications arrive, Matthews said, if an application needs extra review time, later applications that pass muster more quickly may be allowed to move ahead and not have to wait for issues on earlier applications to be cleared up.


Matthews

Adrian Heymer, senior director of new plant deployment for the Nuclear Energy Institute, said that not enough progress has been made toward the establishment of the loan guarantee program for new energy projects, including power reactors, mandated in the Energy Policy Act of 2005. Heymer said that the "current government proposals are unworkable," citing the provision for a federal interagency review of guarantee applications as a problem that, in his view, could deter investment bankers from getting involved. Heymer then covered a wide range of other topics, including his view of the issue of whether a reactor could be targeted by a terrorist attempting to crash an aircraft. He said he thinks that by 2015, all planes will be capable of being remotely overridden and landed harmlessly by law enforcement officials, despite any attempt on board to cause a crash.


Heymer

Eugene Grecheck, Dominion Generation's vice president of Nuclear Support Services, delivered an update on North Anna-3—emphasizing that this is the first time that his company's management has allowed the new reactor project to be referred to as a numbered unit at a plant. (Dominion has still not committed to building the reactor.) Grecheck, a veteran of these sessions, also said that this would be the last meeting in which all COL applications are still in the future. By the time of the ANS Winter Meeting, the first few will have been submitted to the NRC.


Grecheck

Whether reactors are more likely to be built in states with conventional rate regulation (and cost recovery through rates) or deregulation remains an open question, but Grecheck gave an indication of how the issue affects his project. This year, the Virginia legislature replaced its deregulated system with a partial re-regulation, and according to Grecheck, having the new system in place helped convince Dominion to go ahead with its recent procurement of large forgings for the ESBWR that would be North Anna-3.

Heymer said he thinks that by 2015, all planes will be capable of being remotely overridden and landed harmlessly by law enforcement officials, despite any attempt on board to cause a crash.

Spent fuel storage

A special powdered coating that is sprayed on test components has shown that it can be an effective criticality control material for storing spent fuel, according to Jor-Shan Choi, a researcher with the DOE's Lawrence Livermore National Laboratory (LLNL). Choi was the lead presenter during the "Improvements and Innovations in Spent-Fuel Storage" session.

The coating consists of corrosion-resistant, iron-based "structural amorphous metals" (or SAM) that is applied using an advanced thermal spray technology. One composition, SAM2X5, has a high boron content and can be applied to enhance criticality safety for spent fuel in baskets inside storage containers, transportation casks, and containers for repository disposal.

Choi explained that to demonstrate the SAM2X5 powder, LLNL fabricated two half-scale stainless steel basket modules. The coating was applied by using oxygen and a fuel gas as combustion media to shoot the melted powder at high speeds through a nozzle-and-torch gun, achieving a bond strength of about 8000 psi.

Also fabricated for criticality analysis was a disposal container designed to hold 21 spent fuel assemblies from a pressurized water reactor with 35 gigawatt days per tonne (GWd/t) of burnup and 10-year decay. In addition, the 21 assemblies, each containing 264 pins of spent UO_2 fuel, were modeled, along with void spaces previously occupied by 24 guide thimbles and one instrumentation tube. One-quarter-inch stainless steel baskets were modeled with zero or 0.12 wt percent boron, and with and without a 1-mm coating of SAM2X5.

A version of the Monte Carlo transport code was used to calculate the multiple critical configurations. Choi stated that results indicate that as a neutron poison, the 1-mm SAM2X5 coating is about twice as effective as the borated stainless steel with 0.12 wt percent boron.

Jun Li, a Ph.D. candidate in nuclear engineering at North Carolina State University, offered insights into the effects on capacity of nonuniform spent fuel loading into the Yucca Mountain repository.

The repository's capacity is limited by the decay heat inventory of the spent fuel in relation to the thermal design limits. Li investigated the following schemes for decay heat and spent fuel loading management:

- Age-based sequential loading (Scheme #1): Spent-fuel assemblies are loaded into the repository according to the cooling age (years since discharge), starting with the coldest ones. The spent-fuel assemblies are loaded first into the innermost drift location. Once the drift is full, the next adjacent drift starts receiving the second oldest batches of spent fuel. This continues until all of the spent fuel enters the repository.
- Age-based mixed loading (Scheme #2): The oldest and youngest batches of spent-

fuel assemblies are mixed together in the first center drift. Next, the second oldest and youngest batches enter the adjacent drift. This continues until all spent-fuel assemblies are loaded into the repository's 35 drifts.

■ Decay heat load–based mixed loading (Scheme #3): All of the spent-fuel assemblies are characterized in terms of their decay heat load. Based on this characterization, the hottest and coldest assemblies are mixed together and installed in the centermost drift. The next group of hottest and coldest assemblies is mixed together to enter the adjacent drifts. This pattern continues until all of the spent fuel enters the repository.

■ Age-based bisequential loading (Scheme #4): The oldest batch of spent-fuel assemblies is loaded into the innermost drift, followed by the youngest batch into the next adjacent drift, followed by the second-oldest batch into the next adjacent drift, followed by the second-youngest batch, and so on. The pattern continues until all spent fuel is stored.

■ Decay heat load–based bisequential loading (Scheme #5): Same as Scheme #4, except that the sequence follows the order of decay heat load.

Li said that results indicate that the use of different loading schemes could have a relatively large impact on rock temperatures in the repository. Overall, he noted, the mixed loading schemes (#2 and #3) were found to result in the lowest rock temperatures and the maximum loading benefits.

William Hurt, an Idaho National Laboratory (INL) scientist, detailed the lab's work on developing a welding program for waste packages. Hurt explained that nuclear criticality must be prevented in the event that a waste package is breached and water is introduced inside it. Criticality control could be implemented if a new, weldable, corrosion-resistant, neutron-absorbing material is used to fabricate the welded structural inserts (fuel baskets) that will be placed in the standardized canisters.

Results indicate that the use of different loading schemes could have a relatively large impact on rock temperatures in the [Yucca Mountain] repository.

Hurt explained that the new material is based on a nickel-chromium-molybdenum alloy with a gadolinium addition. Gadolinium was chosen as the neutron absorption alloying element because of its high thermal neutron absorption cross section, he said.

Test work has shown that the new alloy with the gadolinium addition is generally weldable, but that issues remain that are associated with solidification characteristics and the "heat-affected zone microstructure," he said. These issues can be addressed by using post-weld heat treatment, he noted–but this treatment also presents some engineering challenges. Hurt said that testing is continuing at INL to find answers to the challenges.

Because the placement of nuclear-quality concrete is not well understood, all of the procedures require practice before the actual pouring, curing, and other processes are carried out on the concrete for the nuclear plant itself.

Certainty in construction

As U.S. utilities draw ever closer to the point of deciding whether to build new power reactors, the issue of certainty in the licensing and construction process grows in importance. At a session on whether there can be such certainty, Ron Affolter, vice president of Areva, spoke on some of the approaches the reactor vendor is taking. He said that 90 percent of the detailed design for the U.S. EPR will be finished before construction begins.

Like the other vendors, Areva is pursuing modular construction techniques. It is also learning from the EPR already being built at Olkiluoto, in Finland. (Affolter reported that the liner rings were stacked in Olkiluoto-3 in June). Unlike the other vendors, however, Areva has the means to control most of its manufacturing schedule. Affolter noted that Japan Steel Works is the only facility in the world that can produce ultra-heavy forgings but that Areva's facility in France can produce all other forgings for the reactor, and the EPR needs only one ultra-heavy forging (with 43 more that are classed as only "heavy"), making the EPR potentially less subject to supply and schedule problems that might arise as more new reactors are ordered.

Edward Shyloski, vice president of Shaw Stone & Webster Nuclear Services, summarized the techniques that must be used, and refined, in order to make new reactor construction more predictable and controllable. He noted that a major consequence of modular design is the need for the lifting of extremely large loads when components are assembled at the construction site, and as a result, project personnel must learn new techniques for lifting these loads and work out their engineering in advance. He also said that because the placement of nuclear-quality concrete is not well understood, all of the procedures require practice before the actual pouring, curing, and other processes are carried out on the concrete for the nuclear plant itself.

Shyloski also likened modular reactor construction to similar developments in shipbuilding, and this was echoed by the next speaker, Jim Moody, who works for a company that has some involvement in the shipbuilding industry: General Dynamics Electric Boat. Moody said that some lessons from modularization in shipbuilding can be applied to reactor construction, but not all. He called attention to advanced construction technologies recommended for new power reactors in a 2004 DOE report (designated MPR-2610 Rev. 2), including robotic welding, global positioning system applications, open-top installation, pipe bends in place of welded elbows, and precision blasting and rock removal.

Kiewit Construction was heavily involved in the nuclear industry for many years, but like other firms, it saw what appeared to be dwindling opportunities for major work in nuclear power and shifted much of its emphasis elsewhere. Now, however, Kiewit is on its way back. Bob Taylor said that his company is looking to regain its NA, NPT, and NS stamps by the first quarter of 2008, and to make additional use of its facility in Corpus Christi, Tex.—now devoted mainly to the assembly and shipment of offshore oil-drilling platforms—for work on nuclear modules. Following up on a point in Shyloski's presentation, Taylor said that there is an "ample supply" of heavy lift capability. In keeping with the

meeting's emphasis on people issues, he said that managers of reactor construction sites will need to "instill a sense of urgency in the project."

While the utilities that would spend the money for new reactors are the ones that crave certainty the most, two utility representatives observed that they will have less control over new projects than they had before. Dale Lloyd, of Southern Nuclear Operating Company, and Randy Vigor, of Duke Energy, recalled their companies' close involvement in the engineering of the reactors that they now have in service, but they said that this time around, they have to leave the engineering work to the vendors and their partners because the utilities no longer have the in-house expertise to act as their own architect-engineers.

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ANS goes to Washington

In 2000, ANS sent its first Glenn Seaborg Congressional Fellow, Joe Green, to Washington, D.C. The panel of past fellows at the Boston meeting was led by Ruth Weiner, of Sandia National Laboratories, who was the first chair of the program, which was initiated to help bring badly needed physical science expertise to Congress, particularly on nuclear issues, where it simply did not exist.

Weiner

The ANS program is part of the Congressional Fellowship Program established by the American Association for the Advancement of Science (AAAS) in 1974 to provide scientific and technical expertise to congressional offices, which typically did not have the money to pay for this kind of advice. Under the program, a fellow spends one year working on the staff of a member of Congress (House or Senate) or a congressional committee. Over the years, the AAAS program has expanded to include about 35 societies and scientific organizations, which can choose and fund any number of fellows. The AAAS describes the fellowship program as a gift to Congress, and fellows must be nonpartisan. They cannot bring their society's agenda with them, and each fellow is a free agent.

Every year, a luncheon is held at AAAS headquarters in Washington, D.C., where representatives from each organization discuss matters of mutual interest. Attending her first meeting as the chair of the ANS Congressional Fellow Program Committee, Weiner said, she was welcomed with open arms by other scientific societies, notably the American Chemical Society, the American Physical Society, and the Geological Society of America. It is an invaluable experience for a fellow, she said, to bring knowledge about nuclear activities to members of Congress and knowledge of how Congress works to ANS.

Over the years, ANS's program has built up a good reputation and is now on solid financial footing, and so it should be able to continue. Judging by the comments from the audience, many ANS members would like it to be expanded.

Joe Green, of Shaw Stone & Webster Nuclear Services, was interviewed for the fellowship program at the 1999 ANS Annual Meeting in Boston. Upon arrival in Washington, he said, fellows attend an AAAS orientation that helps prepare them for the next big step—hunting out an office to work in. Following several interviews, Green chose the office of Joe Knollenberg, a Republican from Michigan who had been in the House since 1992. Among his appointments, Knollenberg was a member of the Appropriations Committee's Energy and Water Subcommittee. The congressman was very much behind nuclear power and worked closely with the Department of Energy on its cleanup program and supported its Nuclear Energy Research Initiative. It was a difficult time for nuclear, Green noted, and there was no sense of a renaissance. Congress was resistant to climate change actions, as demonstrated by the Senate's vote of 95–0 against the Kyoto Protocol in 1998.

Green

Green said that he found that staff members tended to be young, were good at political science, and knew how to work the system. But they did not know technical details. His work included writing speeches, helping to answer letters, and dealing with industry representatives. Each day, he saw a stream of people come into the office, wanting to get 10–15 minutes with the congressman to give him their point of view and to say how Congress should vote.

During congressional meetings, hearings, and other venues, Green said, the staff provided the congressman with information and explanations and "a little bit of ammunition to help him shoot back at the opposition." This meant a lot of preparation work and staying in tune with political happenings. Then there was work related to legislation. Green explained one of the unique features of the Appropriations Committee, besides doling out money. For good and bad reasons, most bills don't make it through the legislative process, he said. The few that do in general are not very substantive, or, like the Kyoto vote, may "indicate some sense of outrage." The 12–13 appropriations bills must get passed, however, because they fund the work of the government and are used as a catch-all to get a lot of things done—for example, to do the work of authorization bills that either failed or did not have as large a scope as desired. They also set priorities, for example, on how to spend the billions of dollars that the Department of Energy gets each year.

Green said that he soon realized that Capitol Hill really needs scientific and engineering input to help produce a good balance of policy and politics. To help move policies through required him to quickly merge the technical with a bit of spin and political savvy. As an example of political reality, he noted that in most of our minds, emissions-free nuclear power and climate change go together. As a congressman representing the suburbs of Detroit, however,

Green found that staff members tended to be young, were good at political science, and knew how to work the system. But they did not know technical details.

Knollenberg never wanted to see that link made.

While the fellowship was designed as a mid-career opportunity, there is no age restriction. For Howard Shafer (2001), the fellowship was his first post-retirement activity after having worked at Exelon's Dresden station. As 2001 was a presidential inauguration year, Shafer had the opportunity to attend the inauguration of George W. Bush. It was an interesting time to be on Capitol Hill, he said, as Congress was preparing to deal with some serious energy legislation. He found a position on a House subcommittee that was chaired by Rep. Roscoe Bartlett (R., Md.), but he mainly worked for the staff director, Harlan Watson, who is now an ambassador and the country's chief climate change negotiator.

Shafer

Shafer had some kind words for congressmen. Most, he said, want to contribute to the country and are doing it for their children, grandchildren, and great-grandchildren. The legislative process does work, he said, although it is very slow and can be messy. The fellowship program is important for ANS, he said. "There is a game going on," he noted, and it is important to show up, carrying the banner for nuclear power. He said that he soon realized that opponents tended to tone down their statements when he was there.

Shafer mentioned that the House had completed its work on the energy bill on schedule before going on recess. Before the Senate had dealt with it, however, the events of September 11 occurred. Nevertheless, the final energy bill in 2005 included most of what the House had achieved during that spring.

Shafer was involved in setting up committee hearings and arranging for expert witnesses. He was also in a position to suggest questions to congressmen and during the hearing to point out what may be wrong about some of the testimony. And he was able to provide good feedback to ANS.

As an illustration of how the system works, he described how Congress dealt with assessing the vulnerability of the country's critical infrastructure to terrorist attacks after 9/11. It did not get much play in the press, he said, probably because there was not enough of a scare story. It appeared that gas pipelines are not a major concern as there is substantial experience in dealing with pipe breaks caused by accidental digging into pipelines, which can easily be sectioned off and repaired, and ice storms did much more damage to electrical transmission lines than a terrorist could. Nobody asked about nuclear power, he said, because most congressmen knew how sturdy the plants are. Unprotected water reservoirs turned out to be the most critical element for which Congress took action.

Tim Valentine, of Oak Ridge National Laboratory, the 2003 fellow, spent two years in Washington after transferring from his first position with Sen. Jeff Bingaman (D., N.M.) to the office of Sen. Lamar Alexander (R., Tenn.). This occurred after the senator met Valentine and suggested that because he was from ORNL, in Tennessee, he should be working in his office. The two senators then worked out a deal for Valentine to switch offices.

In 2003 and 2004, he worked closely on the energy bill with Jonathan Epstein (who was working for Senator Bingaman), a mentor of his, along with Pete Lyons (then on the staff of Sen. Pete Domenici, [R., N.M.]), who is now an NRC commissioner. They worked on nuclear loan guarantees, which provided a priceless anecdote that Valentine related. He had written up some notes for Alexander to use during the energy bill debate. In giving his speech, Alexander started talking about dropping atom bombs on Japan, but Valentine—quite shaken—was sure he had not written that. Alexander continued by pointing out that here was a country that had been devastated by nuclear war, and yet it has embraced nuclear power. He then asked why we aren't doing the same.

The fellowship program is important for ANS, and it is important to show up, carrying the banner for nuclear power.

Valentine went to Washington to help see that the right policies were made. "I did not make [Alexander] a supporter of nuclear, but I gave him the technical information he needed and the justifications that he could use," he said.

Senate hearings are highly orchestrated, Valentine said. Preparing for a hearing on the Tennessee Valley Authority's restart of Browns Ferry-1, he put together questions, talking points, and even follow-up questions. In fact, he would ask witnesses what they were going to say and to provide some good follow-up questions. When the senator arrived, he would have a "recipe book" and seem to be on top of the subject. What that does, Valentine said, is allow needed information and comments to be put in the record, and that record is then used to develop policy.

On a more current question, Valentine noted that many nuclear people are concerned that with the Democrats in control of the House, nuclear will not be included in the loan guarantee bill. That is not going to happen, he said. There is plenty of support in the Senate, and it is going to move forward. And there is a general recognition that the country must have nuclear to combat global warming.

The 2004 fellow, Mario Robles, of U.S. Enrichment Corporation, worked on the staff of Rep. John E. Peterson (R., Pa.). Robles had actually run for Congress and lost. Fortunately, he retained a good sense of irony, and he explained some of the "ways of Congress":

- Congressional committees: The level of power and influence enjoyed by a committee is "based on the Golden Rule: Those with the gold make the rules." Therefore, the most powerful committees are Appropriations (it gives out the money), Ways and Means (it takes the money), and Rules (it sets the rules).
- The "80" part of the 80/20 budget rule: 80 percent of the budget is spoken for, mainly by mandatory programs plus defense.
- The DOE's nuclear energy budget: More than two-thirds of the DOE's mission has nothing to do with energy, and very little of what's left over is available for promoting nuclear energy.
- The president's budget: In February, the president sends his budget to Congress, showing his priorities. When the Republicans were in charge, the president's budget was mostly dead; with the Democrats in charge, it is just dead. This is mainly because Congress has its own priorities.
- Timing is everything: To get funding, it is necessary to understand the appropriations calendar. In March is the hearing process, where agency heads defend their budgets. April is for budget resolution, when the money is allocated among the appropriations bills. By late June, the two houses are working out their appropriations bills independently. This is followed by the big powwow where final deals are thrashed out.

Robles

Engineers simply do not understand what is going on in the politicians' arena, and vice-versa, Robles said. One of the purposes of the fellowship program is to try to understand the politician. To help, he dis-

cussed some of the differences between the two "cultures." For example, engineers solve problems; politicians address issues. The norm in the engineering profession is to write everything down and make it precise and see where the data lead; politicians do not want to write anything down because they can then be held accountable. They take a stand and then see what data support it. The artifacts of the engineering trade are data based; for the politician, they are story based.

The story will have to be that the industry is not doing right by the 150 million Americans living near spent fuel storage facilities, and the materials need to be buried at Yucca Mountain.

Robles also had a "heretical" idea about what to do about "Bucca" Mountain. Post 9/11, he said, the question of the safety of spent fuel stored at reactors was raised. The industry said the stores are safe, but questions remain: Is it safe enough? Is it as safe as we can make it? The answer is no, in that it can be made much safer by putting it into a remote location, say, buried deep in the ground where people don't live. But the industry, not wanting to have the "u" word—unsafe—associated with nuclear, said it is safe where it is. That show of "strength" means there is no imperative for dealing with Yucca Mountain, Robles said, and so if the industry truly wants to continue with a repository there, it must show some "vulnerability." The story will have to be that the industry is not doing right by the 150 million Americans living near spent fuel storage facilities, and the materials need to be buried at Yucca Mountain.

Eric Loewen, the 2005 fellow, worked for Sen. Chuck Hagel (R., Neb.), in part because someone on the senator's staff who was working on climate change was moving on, and it looked like a good job. The office had never had a fellow before, and Loewen was treated as one of the staff, which would not be the case in offices with a larger staff.

Loewen

Senator Hagel was the Republican part of the 1997 Byrd-Hagel resolution, in which the Senate voted unanimously not to participate in the Kyoto Protocol. However, Loewen said, Hagel did not want to be seen as the guy who killed climate change. For him it is a serious issue, but he considered the Kyoto Protocol a flawed treaty. The person Loewen replaced was developing climate legislation that based emission limits on a metric called greenhouse gas intensity, which measures the ratio of greenhouse gas emissions to economic output. Reading the section of the text on the use of advanced technologies to reduce emissions, Loewen found that the "n" word was not there and he asked why nuclear power wasn't on the list. The answer was, "Oh, we forgot." Because Senator Hagel has a favorable opinion of nuclear power, Loewen was told to write it in. "So I wrote it in."

A great deal of work was done on the legislation, and it was resubmitted a couple of times. When the energy bill came up, Hagel was asked to submit his resolution, which became the Hagel-Pryor amendment, as a counter to the McCain-Lieberman bill. The Hagel-Pryor amendment carried that day and was added on to the energy bill. The Hagel-Pryor provision (Title 16), Loewen said, actually provides a fairly sound climate policy, although newspaper reports always seem to make an assumption that the United States does not have a climate policy.

Loewen also gave advice for making oneself heard in Washington. As constituents, individuals have the right to see their congressional members. He advised, however, starting with the appropriate legislative assistant who is responsible for the relevant issue. "You want to introduce yourself, tell them who you are, and what you can do for them." Other tips Loewen gave: Don't forget to do your homework. Know what the senator or representative has done on your issue. Look at current events to see what he or she is currently working on to help provide an opening line when you meet the legislative assistant. Take along a one-page action plan on what you want done or how you stand on an issue. Have a second document to back it up, if only to show you are informed. Also, don't forget to seek advice from the ANS Washington office.

At the meeting, be ready, show that you know what is going on, and speak English—do not use acronyms. "I cannot emphasize that enough." Finally, he said, don't talk down, and do listen.—*E. Michael Blake, Dick Kovan, and Rick Michal* NN