

Nuclear Energy Advisory Committee Meeting
June 12, 2012
L'Enfant Plaza Hotel
Washington, D.C.

Committee Members Participating

John Ahearne, Vice Chair
Ashok Bhatnagar (via telephone)
Matthew Bunn
Dana Christensen (via telephone)
Margaret Chu
Thomas Cochran
Susan Eisenhower
Marvin Fertel
Susan Ion
Raymond Juzaitis

Mujid Kazimi
William Martin, Chair
Regis Matzie
Richard Meserve
Carl Paperiello (via telephone)
Burton Richter
John Sackett
Alfred Sattelberger
Allen Sessoms

Committee Members Absent

Brew Barron
Michael Corradini

Donald Hintz
Neil Todreas

Other Participants:

William Boyle, Program Manager, Used Nuclear Fuel Disposition R&D, Office of Nuclear Energy, USDOE
Nancy Carder, NEAC Support Staff, Medical University of South Carolina
Peter Lyons, Assistant Secretary, Office of Nuclear Energy, USDOE
Frederick O'Hara, NEAC Recording Secretary, Medical University of South Carolina
Kenneth Chuck Wade, Designated Federal Officer, Office of Nuclear Energy, USDOE
Robert Rova, Office of Nuclear Energy, USDOE
Monica Regalbuto, Deputy Assistant Secretary for Fuel Cycle Technologies, Office of Nuclear Energy, USDOE
Rebecca Smith-Kevern, Director, Office of Light Water Reactor Technologies, Office of Nuclear Energy, USDOE
Frank Goldner, Associate Deputy Assistant Secretary for Fuel Cycle Technologies, Office of Nuclear Energy, USDOE
Michael Worley, Director, Office of Integrated Safety and Program Assurance, Office of Nuclear Energy, USDOE

About 30 others were in attendance in the course of the meeting.

Morning Session

The meeting was called to order by **Chairman William Martin** at 8:55 am. Ahearne moved to approve the agenda; Bunn seconded. The motion was adopted unanimously. Martin asked the members to introduce themselves. After the introductions, **Peter Lyons** welcomed and thanked the members of the Committee and asked the members of the audience, which was made up largely of Office of Nuclear Energy (NE) staffers, to introduce themselves.

Peter Lyons was asked to relate the current events affecting NE and to review the NE FY13 budget.

President Obama has made a number of encouraging comments about nuclear energy as part of a clean-energy initiative.

Secretary Chu visited the Vogtle nuclear power site and saw a job-creation engine: the total support workforce numbers are in the tens of thousands of workers.

NE is undergoing a significant reorganization. The realignment was precipitated by Shane Johnson's moving out of the front office. A model was developed that pulled together several cross-cutting areas that will report to a new Deputy Assistant Secretary for Science and Technology Innovation. Those cost-cutting areas will be the Office of Advanced Modeling and Simulation and the Office of Innovative Nuclear Research. The Nuclear Energy Enabling Technologies Program (NEET), National Scientific Users Facility (NSUF), Nuclear Energy University Programs (NEUP), Small Business Innovative Research Program (SBIR), and Renewable Fuels Module–Research Reactor Infrastructure (RFM-RRI) will move into the new Office of Innovative Nuclear Research. In addition, the Office of Gas-Cooled Reactor Technologies and the Office of Advanced Reactor Concepts will be combined to form the new Office of Advanced Reactor Technologies. Dennis Miotla will be the new Principal Deputy Assistant Secretary and Chief Operating Officer. All of these changes have to go through a formal approval process.

NEAC itself is transitioning to a model that will limit membership to 10 years. A plaque and a letter from the Secretary were given to each of the retiring members, who have served for 13 years on the Committee: Ahearne, Fertel, Cochrane, Sessoms, and Todreas [Round of applause.] The newest members joining the Committee were introduced: Bunn, Chu, Eisenhower, Kazimi, Matzie, Meserve, and Sattelberger. [Round of applause.] William Martin's retirement from the Committee's chairmanship was announced. He will remain as chair of the International Subcommittee. The new cochairs of NEAC will be Richard Meserve and Susan Eisenhower. The size of NEAC will change to 18 with the new membership. John Sackett has agreed to take on the chairmanship of the Facilities Subcommittee. Chuck Wade, the Committee's designated Federal Officer (DFO), is moving to another position. Robert Rova will be taking over as the Committee's DFO. [Round of applause.]

Two members of the Blue Ribbon Commission now sit on NEAC. The recommendations of the Blue Ribbon Commission are focused on consent-based siting. Congress has asked the administration to move forward on the Blue Ribbon Commission's recommendations by July 26, 2012. Ideas on how to do so are being pulled together from several departments (Department of Justice, Office of Science and Technology Policy, etc.). A strategy will be issued July 26 and will likely be a major topic of the December NEAC meeting. Four senators are working to form a legislative response to the Blue Ribbon Commission's recommendations: Alexander, Bingaman, Feinstein, and Murkowski. It is comforting to see that key congressional leaders are taking the Blue Ribbon Commission's recommendations seriously. Secretary Chu has been very complimentary to the Blue Ribbon Commission.

The leadership of the Office is very excited about small modular reactors (SMRs), a new paradigm for the construction of nuclear reactors. There are risks (e.g., they have unvalidated cost models). But they have several attractive potential benefits: They have enhanced safety from integral design. They offer significant job-creation opportunities. They have a shorter construction time, producing less financial risk. They have lower capital costs. They could be air-cooled. They have security advantages from being sited underground. And they could replace aging fossil plants. The Secretary of Energy Advisory Board (SEAB) has been asked to come up with a strategy for industrialization of SMRs.

After Fukushima, the Office has emphasized its program on advanced light water reactor (LWR) fuels with enhanced accident tolerance. Goals have been set up with plans for modeling and test components. This effort could develop a new class of nuclear fuels for the world.

About 20% of the Office's R&D funds go to universities in a peer-reviewed process under the NEUP program. This program will train future leaders and determine whether nuclear power grows or decreases. This is a highly successful program. In the past 4 years, NEUP has awarded \$218.1 million to 79 schools in 33 states and the District of Columbia. University programs should be closely coupled with national laboratories and industry. It is hoped that the effectiveness of the program will be increased.

The FY13 NE budget is currently before Congress. The adjusted FY12 budget was for \$858.7 million. The president's request for FY13 is \$100 million less at \$770.40. This reduction reflects decreases across the board in all program areas except in Idaho Sitewide Safeguards and Security and in International Nuclear Energy Cooperation, which got small increases. The Integrated University Program was zeroed out because of the feeling that these programs should be funded by industry. DOE's Office of Scientific and Technical Information (OSTI) compiled a slate on where NE PhDs went to work. Only 1% went to industry. The fellowships that were awarded in the past are forward-funded for 3 years.

The current House and Senate marks are very different. At \$785.4 million, the Senate has backed the Blue Ribbon Commission's recommendations. At \$883.7 million, the House has restored funding for the Integrated University Program, has focused on restarting Yucca Mountain, and has emphasized reactor concepts R&D.

In the interest of efficiency, Martin asked the Committee to go around the table after each speaker finished and to comment on the presentation, after which the speaker could respond to the questions and issues raised.

Richter said that the FY13 budget is a work in progress. A major question is what will happen with the Blue Ribbon Commission's recommendations; this Committee will only be able to respond to the developed strategy. In terms of fellowships, the Office of Management and Budget (OMB) is wrong; both the Office of Science and Technology Policy (OSTP) and DOE say that OMB is wrong.

Juzaitis supported the Integrated University Programs. Young technical leadership is needed by both the civilian and military sides of the nuclear industry. SMRs are exciting, but not that innovative. They are being approached with fresh eyes after 40 to 50 years. Nonproliferation afflicts this industry more than it does any other energy source.

Sessoms said that the funding of international efforts is a positive step.

Kazimi noted that there had been two decades of few nuclear engineering graduates. There is room to explore new applications of nuclear energy. He hoped that funding would be put into the new Office of Innovation. The universities' role is to bring in new ideas; industry should bring in practicality.

Sackett commended the NE leadership for a job well done in a difficult time. Needs should be identified, and a national vision for abundant, affordable energy needs to be set, as was advocated by Rick Smalley. DOE should push that idea of Rick Smalley's forward and look at the challenges of the future. This budget addresses some of the challenges but not all.

Bunn noted that the success of nuclear technology is based on R&D. Nuclear energy must be grown a lot if it is to make a contribution to dealing with climate change. The world will need 30 to 50 new reactors a year 20 to 30 years from now.

Ahearne stated that the Committee had advised many assistant secretaries for nuclear energy, and Peter Lyons is a breath of fresh air. His efforts will be beneficial for the country.

Meserve said that continuing attention should be paid to implementation of the Blue Ribbon Commission's recommendations and to SMRs.

Eisenhower commented that the organization chart seems simplified. The budget has a striking difference between the House and Senate versions. She asked what the Committee could do to champion the changes and influence the news media to educate the public about nuclear power. Lyons replied that one way would be to describe the difference: several House members are frustrated by the Yucca Mountain recommendations and consider them illegal. These questions are in the courts now. In the Senate, people have stepped forward to recognize the accomplishments of the Blue Ribbon Commission. The statutory limits on what can go in Yucca Mountain have already been exceeded. The Blue Ribbon Commission recommendations need to be given a chance to succeed. The courts will speak in the near future.

Fertel said that the budget will get harder and worse (across the whole budget) in future years. The money needs to be put where it will be most effective. Before the previous presidential election, NEAC

stepped back and did a policy and R&D assessment. That would be a good thing to do again. The Committee should send a letter to the Secretary and President saying that a country that emphasizes science, technology, engineering, and mathematics (STEM) education should be able to find \$5 million for nuclear engineering education. Some thought should be given to bringing in some young members of the community to tell the Committee what motivates them.

Matzie noted that he had been working with SMRs for 20 years. One can get cost-competitive construction, but operating costs have requirements that carry over too many overhead fixed costs. There are also barriers to international trade. The United States needs to overcome the backstopping that other countries practice.

Ion pointed out that, financially, licensing is not going to get any better. Getting SMRs off the ground is important. Advanced fuel concepts will influence both safety and nonproliferation. On the international side, Team USA should be seen in operation: universities, industry, and government need to be glued together.

Chu applauded the creation of the Office of Innovation. The Committee should have a strategic plan for this office. Scholarships and fellowships need a good internship program.

Sattelberger noted that there are internship and fellowship appointments, but they need to be expanded in certain areas. It has gotten easier to gain access to user facilities. There is a rumor that the Department of Defense is interested in SMRs; there should be a dialogue initiated.

Cochran reiterated that fellowships and scholarships should be funded. The United States did build about 50 small reactors like Shippingport and Vallecitos. Finally, the Committee and the Office should look out for Idaho National Laboratory; the boosterism for SMRs is coming from the Savannah River Site.

Bhatnagar praised the success of NE in following up on NP2010. There are issues on the LWR side; the cost of regulatory requirements takes up 20 to 30% of revenues of nuclear power. The next 10 years will be financially difficult. DOE should pursue near-term sustainability issues.

Christensen noted that its restructuring should move the Office forward. The Blue Ribbon Commission recommendations should be pursued.

Paperiello noted that fuel has to be disposable as well as non-proliferative. Safety goals include dealing with core-disruptive accidents. As the number of cores goes up, the chance of a core-disruptive accident increases. The public will tolerate only one core-disruptive accident in a generation.

Bunn said that, given the overall budget picture, the Committee should see this request as good, not terrible, even though it is less than the request of a year ago.

Lyons said that these comments were perceptive. The community is well aware that core-disruptive-accident designs complicate disposal, and it is dealing with that issue. The Office will go through the licensing process with several designs where all of these issues have to be dealt with. The Nuclear Regulatory Commission (NRC) has listed the regulatory issues that will be considered. The safety goals will likely be enhanced. Natural gas has hit a historic low price. How the country will wrestle with the problem of noncarbon energy sources is not clear. There have been interactions with the Department of Defense on SMRs; their interest is in the licensing process. A strategic plan for the Office of Innovation is important and should be developed. Also, the NE roadmap should be revisited. All of NE's fellowships include a national laboratory internship. Team USA is being worked on daily by Edward McGinnis. A position has been created in the White House to develop a Team USA concept. There are high costs for maintaining INL. There are new facilities being proposed for Idaho National Laboratory (INL), including restarting the Transient Reactor Test Facility (TREAT) and re-establishing an ability to analyze damaged fuel. An effort is being made to expand INL's capabilities. NE works with the National Nuclear Security Administration (NNSA) to understand international barriers. Safety and security issues have many players, especially on the international level; the Office needs to continue to coordinate with all of these

other players. It has been trying to advance new uses for nuclear power; there is going to be a joint workshop with the National Renewable Energy Laboratory (NREL) on that topic.

A break was declared at 10:39 a.m. The meeting was called back into session at 10:55 a.m.

Monica Regalbuto was asked to review R&D on used-fuel disposition.

The Office of Used Fuel Disposition covers uranium resources, fuel fabrication, interim storage, recycle, and disposal of nuclear fuels. It optimizes these processes through systems analysis, engineering, and integration. It balances near-term and long-term objectives. The near-term objectives are storage and disposal of high-level waste, accident-tolerant fuels, transportation and handling, long-term interim storage, and permanent geologic disposal. The long-term objectives are fuel-cycle options, advanced fuels, and processing and separation technologies.

The FY13 budget request for fuel-cycle technologies is about \$60 million. The Blue Ribbon Commission assessed the current used-fuel-disposition program and recommended the continuation of activities currently conducted: continuing to identify alternatives; conducting R&D on transportation, storage, and disposal; and coordinating with states and regional groups on transportation planning.

A strategy for complying with the Blue Ribbon Commission's recommendations is to be developed by July and is currently a work in progress. The Department acknowledges that "the specifics of a new strategy for managing our nation's used nuclear fuel will need to be addressed in partnership with Congress." The Department "will work in parallel to begin implementing the new strategy."

The Office's key objectives, which do not need congressional direction, are to

- Address the Blue Ribbon Commission's near-term recommendations
- Develop a technical and scientific basis for extended used-nuclear-fuel storage
- Partner with industry to develop and demonstrate integrated solutions for storage of used nuclear fuel
- Prepare for large-scale transport of used nuclear fuel, with an emphasis on decommissioned sites
- Develop the scientific basis for multiple disposal options for used nuclear fuel and high-level waste

To address these objectives, the Office is undertaking key activities in storage, transportation, and disposal. It is establishing formal collaborative R&D arrangements with three ongoing European programs: (1) Mont Terri, an international underground research laboratory in clay in Switzerland that will give DOE access to data and an opportunity to conduct new experiments; (2) the Colloid Formation and Migration Project in the Grimsel granite underground research laboratory in Switzerland; and (3) Development of Coupled Models and Their Validation Against Experiments (DECOVALEX), an international research organization focusing on mathematical modeling of geological systems. Another strategic activity is conducted through university R&D in storage and disposal. It is funding research projects to understand the behavior of high-burnup fuel during storage; the degradation of spent nuclear fuel canisters; and techniques for more-efficient packaging, cladding, concrete, and disposal. The final strategic activity is to update the transportation and storage system model with current data. Work has been initiated on standardized cask systems, which are multipurpose canisters for storage and transport.

In transportation, The Office has completed an implementation plan for the development and licensing of standardized transportation, aging, and disposal canisters and the feasibility of direct disposal of dual-purpose canisters. It also provided technical support for the ongoing development of a DOE strategy responding to the Blue Ribbon Commission recommendations; this effort will be continued and expanded. It will continue to provide technical support related to planning for consent-based siting efforts and addressing National Environmental Policy Act (NEPA) requirements. It plans to continue system architecture and valuations (e.g., developing costs for various operating scenarios).

In storage, the Office has focused on R&D on material testing to support modeling and simulation of used fuel and canister degradation; the identification and prioritization of data gaps to support license amendments beyond 40 years for dry storage; the definition of facilities needed to conduct the required

additional testing of irradiated nuclear fuel; and the initiation of planning for consolidated fuel storage, building on previous DOE work and industry storage licensing efforts, and evaluating design concepts for consolidated storage.

A Used Nuclear Fuel Storage and Transportation Research, Development, and Demonstration (RD&D) Plan has been developed. Phase 1 of the cladding ring compression tests has been completed. (The physical form of the test specimen is that of a ring, not a tube. The purpose is to determine the impact of hydride re-orientation in cladding on the long term performance of the clad). Cladding testing has begun at the High-Flux Isotope Reactor. A collaboration has been joined with the Electric Power Research Institute (EPRI), the NRC, and industry in the extended storage collaboration program. In the future, testing of pins and spent-fuel assemblies will be initiated, a full-scale demonstration program at the utility site will be conducted, technical support will be provided for the design of a consolidated storage facility, and materials to communicate with volunteers and stakeholders will be developed.

Transportation activities include developing the technical basis for transportation of high-burnup fuel following extended storage, supporting planning for eventual large-scale transport of used nuclear fuel and high-level waste to consolidated storage and disposal facilities, and focusing initially on shut-down reactor sites. The identification of transportation key data gaps has been completed. Evaluations of transportation from the decommissioned sites are starting to be conducted. The support of transport of high-burnup used fuel is being continued. The regional transportation groups are being re-engaged to understand stakeholder issues. The policies and procedures for providing technical assistance and funds to states and tribes for training local public safety officials are being finalized.

Disposal activities emphasize providing a sound technical basis for multiple, viable disposal options; identifying and researching the generic sources of uncertainty that will challenge the viability of disposal concepts; increasing confidence in the robustness of generic disposal concepts to reduce the impact of unavoidable site-specific complexity; and developing a near-term plan for demonstrating the borehole disposal concept. A disposal R&D roadmap has been completed. A salt R&D study plan has been completed. Work with our international partners for disposal in granite and clay rocks has been expanded. Efforts with industry have been initiated to develop an RD&D plan and roadmap for borehole disposal. A generic safety case for geologic disposal of nuclear waste will be developed. Generic engineered barrier system (EBS) design concepts will be evaluated. Coupled processes in a near-field clay environment will be modeled. EBS models will be integrated with generic disposal system models. Coupled models of thermal-hydrological-mechanical processes in salt will be developed. And thermal-load-management analyses will be updated.

This program is building the foundation to support the potential new waste-management organization. It will be a multiyear process.

Martin asked for questions and comments from the Committee.

Chu asked what the relative percentage of funding was for storage and transport R&D. Regalbuto replied that it changes every year with appropriations. Boyle added that funding was about equal between storage and technology, and 20% went for disposal R&D.

Cochran noted that DOE may end up with the industry's spent fuel. Putting it in concrete storage canisters requires repackaging for transport and additional repackaging for disposal. There should be a universal package. Richter said that this topic will be touched on in a subcommittee report during the afternoon session. Matzie pointed out that a lot of the early canisters were for storage only on sites with no repackaging capabilities. He asked what was going to be done with them. Bunn asked whether \$60 million was enough. That is less than what it costs to operate one site. He asked where the R&D ended up. There will need to be high level of linkage between NE and the organization started up for the disposal of spent fuel. Kazimi called attention to the fact that, in voluntary siting, significant R&D was to be associated with the siting. Juzaitis stated that NNSA was reconsidering safety and security and was grading risks to reduce storage and transportation costs. Meserve asked whether the different issues associated with spent fuel and high-burnup fuels would be considered.

Regalbuto responded to all of the questions: Local optimization is an operations-research issue to understand what each utility did. Will materials need to be repackaged to transport them? Yes, licensed transport casks will be needed. \$60 billion *is* not enough. Some activities cannot be started because funding cannot be sustained. The Office works closely with NNSA and has a good relationship with them, thus arriving at a balanced approach. The Blue Ribbon Commission's recommendations are being addressed and will be shared with the Committee in the fall.

Lyons added that it is not known whether or not R&D will transition to a potential new organization until Congress provides direction. Any new entity that is formed will have to be the one to apply for the license.

Rebecca Smith-Kevern was asked to review technical support for SMR licensing.

DOE is interested in SMRs that produce up to 300 MWe and are able to have their components fabricated remotely and transported to the site for assembly by truck, rail, or barge at a cost of \$800 million to \$2 billion per unit. Such reactors offer enhanced safety and security, reduced capital costs, shorter construction schedules, and improved quality because of replication in a factory setting. They could meet electricity-demand growth incrementally, reestablish U.S. technical leadership in nuclear energy, and create domestic jobs.

A significant investment, about \$500 million, would be needed to reach commercialization. However, the question is still open whether the plants could be built cheaply enough by exploiting the economies of replication and scale. A factory would be needed to make the price attractive enough to produce the orders needed to justify building the factory. One question is how simplified, "inherently safe" designs translate into smaller workforces and operating costs and still comply with regulatory requirements.

DOE commissioned a shallow and immature economic study of SMRs in 2011 that implied that SMRs can be competitive under certain conditions. The study is being followed up with a harder look at the economies of mass production.

Such reactors should have more siting flexibility than do traditional nuclear plants, requiring lower land and water usage. Also, they should produce a better match to power needs, be able to replace fossil-fueled plants, and use existing infrastructure. Nearly all 500 of the current U.S. coal plants that are more than 50 years old are less than 300 MWe; these may be shuttered in the next 5 years. With the small scale, multiple modules can match load growth and provide financing for future additional units.

To jumpstart the SMR industry, DOE is attempting to facilitate and accelerate commercial development and deployment of U.S.-based SMR designs at domestic locations by soliciting applications to a program from vendor/utility teams that have plans to construct SMRs at a domestic site. It is a 5-year/\$452 million program requiring a 50% cost share. DOE will support up to two SMR designs for design, certification, and licensing (no construction). This year, \$65 million was requested: the House mark is \$115 million, and the Senate mark is \$68 million.

DOE is soliciting applications from teams composed of SMR vendors and utilities or consortia willing to be first movers in constructing and operating mature SMR designs. It is supporting site permitting, design development, certification, operating-license applications, and NRC review processes. The solicitation will be open to LWR and advanced SMRs that can be deployed "expeditiously" (by 2022). The larger focus is on promoting the development of a fleet of SMRs.

To this end, the Office released a draft funding opportunity announcement (FOA) in January 2012, issued a final FOA in March, held an industry day in April, received applications in May, is conducting a merit review, and will announce selections in September with the hope to complete cooperative agreements and release funding in November or December. It is expected to prepare the design certification application and pre-application interactions from 2010 to 2014; submit the design certification in 2014; conduct the NRC design-certification review from 2014 through 2017; submit the combined operating licensing application in 2015; have the designs certified by the NRC by the end of 2017; have the combined operating license approved in 2018; conduct long-lead procurement from 2015 to 2018; conduct manufacturing from 2016 to 2019; receive limited work authorization in 2018; and

construct the plant and complete the NRC's inspections, tests, analyses, and acceptance criteria (ITAAC) from 2018 through 2021.

A vibrant industry with multiple dedicated SMR factories in the United States to meet domestic needs and produce exports is envisioned. The Secretary of Energy's Advisory Board (SEAB) is informing a long-term vision that would evolve through anticipated deployment phases. In Phase 1, licensing and risk sharing would be addressed. In Phase 2 first movers would be encouraged to invest. In Phase 3, clean-energy early adopters would receive tax credits and other incentives. And in Phase 4, full-scale factory production would deploy SMRs as a source of sustainable clean energy.

NE has the full support of the administration to aggressively promote SMRs, and DOE funding should have a significant impact on accelerating the first movers and building the momentum for the subsequent builds.

Martin asked if this were economically viable and compatible with industry interests. Matzie stated that industry believes that it can be competitive with large nuclear units on a dollar-per-kilowatt basis. The first unit has to be cost competitive. Incentives are problematic for industry to deal with. Meserve asked whether there were three or four applicants. Smith-Kevern said that she could not answer that question because the proposals are currently being evaluated. Ahearne asked if the study of competitiveness were available. Ion asked if the funding will be split evenly among the successful proposers. Cochran said that the plan for long-lead procurement and construction in 2018 was absurd. The strategy needs to be rethought. The economic analysis is available (*The Economic Future of Nuclear Power*, prepared by the University of Chicago in 2004). It would dispute the economic viability given the cost of natural gas. Bunn stated that the tight schedule limits what technologies can be considered. Eisenhower asked what the timelines were of the United States' international competitors. Fertel agreed with Cochran on the Chicago study and stated that the nation's competitors do not have to go through long financial analyses, giving them a head start.

Smith-Kevern responded that the University of Chicago could not get current information from reactor manufacturers. The budget is not necessarily a 50-50 split. SEAB will be advising NE about the strategy. Designers are in pre-certification application, and Congress told DOE to focus on expeditiously supplied reactors. The Koreans are about to submit a design for certification; the Chinese are copying others' designs; the Russians already have a barge reactor.

Matzie pointed out that one has to have a signed contract before doing any long-lead procurement.

Lyons noted that there was plenty of momentum on the part of several vendors to move forward. Advanced concepts will continue to be considered.

A break for lunch was declared at 12:02 p.m.

Afternoon Session

The meeting was called back into session at 12:58 p.m., and **Frank Goldner** was asked to describe the development strategy for advanced LWR fuels with enhanced accident tolerance.

The fuels campaign mission has three legs: capabilities development for a science-based approach to fuel development; metallic transmutation fuels with enhanced proliferation resistance and resource utilization; and next-generation LWR fuels with enhanced performance and safety and reduced waste generation. The vision is an LWR fleet using fuels with enhanced accident tolerance to provide a substantial fraction of the nation's clean energy.

A call for ideas was put out in 2009; three of these ideas were funded. Some industry interest groups were set up. Fukushima changed the effort from a performance track to an accident-tolerance track. An early working group was made up of Shaw/Westinghouse, AREVA, Energy Solutions, and Enercon. A new task order was set up to pursue high enrichment with Shaw/Westinghouse, AREVA, and GE-Hitachi. At the same time, INL constituted an advisory group and extended the network to other players.

The Senate provided some guidance regarding accident-tolerant fuel in which DOE was directed "to give priority to developing enhanced fuels and cladding for light water reactors to improve safety in the event of accidents in the reactor or spent fuel pools." A report will be presented to the Senate in July.

An enhanced accident-tolerant fuel is one that can tolerate a loss of active cooling in the reactor core for a considerably long time while maintaining or improving the fuel performance during normal operations, operational transients, as well as design-basis and beyond-design-basis events. The attributes of such a fuel are approved reaction kinetics with steam, improved fuel properties, slower hydrogen generation rate, improved cladding properties, and enhanced retention of fission products. There will be national and international meetings to develop a consensus on metrics. This program needs to coordinate within DOE and with national laboratories, universities, the NRC, industry, and international organizations and agencies.

An FOA has been issued for the development of LWR fuels with enhanced accident tolerance; it will fund up to three 2-year projects for a total of \$10 million. There is also a NEUP integrated research project on advanced nuclear cladding and fuel materials with enhanced accident tolerance.

The R&D strategy calls for three phases. In Phase 1, feasibility studies on fuel/cladding concepts will be needed to gain enough information for downselecting. Industry will have to be on board with significant cost sharing. To put an assembly in a reactor, the NRC will have to be involved. In Phase 2, there will be testing. In Phase 3, the systems will be lead test assembly (LTA) ready.

During a loss-of-coolant accident, zircaloy gets exothermic. One possible solution is to employ fuels with additional barriers to fission-product release and less-reactive cladding (e.g., silicon carbide).

Some testing has been done that found that there are impurities that migrate to the surface and cause surface reactions. It is likely that fuel and cladding designs can be found that can serve two purposes: increased performance and accident tolerance.

In summary, a three-phase approach is being taken for commercialization of LWR fuels with enhanced accident tolerance: (1) feasibility, (2) development and qualification, and (3) commercialization. The scope is focused on operating reactors and reactors with design certifications (GEN II thru GEN III+). The technologies developed during the process can be applicable to more advanced designs.

Juzaitis said that this is a burning-platform problem that needs to be addressed by the new Office of Innovation. Kazimi stated that licenses for higher enrichment are a big barrier and asked if there were a DOE program to investigate higher-enrichment fuels. Matzie asked about the downselection process: whether it would reduce the field to one concept and how all the players would be marshaled behind that one concept.

Goldner replied that his office has already been talking to the DOE personnel who will be in the new Office of Innovation. Loss-of-cooling-analysis (LOCA) types of tests, TREAT, and materials testing will be needed. There is a program to increase enrichment to 7 or 8% [19% in tristructural-isotropic (TRISO) fuel). It is hoped that the government could help fund the transition to higher-enrichment fuels. The down select is expected to be to one or two proposals. Paperiello said that there is nothing in the NRC rules that would be a barrier to this R&D. This is an ambitious project because zircaloy has been so well optimized. Fertel said that one needs to look at this with a systems approach. Changing a fuel supply is good, but changing the cladding may be unneeded. The question of the probability of a zircaloy fire should be revisited.

Lyons pointed out that the Office is also looking at nanostructured materials. They may have enhanced conductivity and strength, but at this point it is not known.

Ahearne introduced the subcommittee reports, starting with **Allen Sessoms** and the International Subcommittee.

The first draft of the Subcommittee's report was circulated on the day before this meeting. A letter from Assistant Secretary Lyons had asked how to best use program funds to support R&D and the Team USA approach. The Subcommittee had a conference call and several other meetings to discuss these issues. NE-6 (International Nuclear Energy Policy and Cooperation) does not have a mission statement. It is doing historical or ad hoc research. There is a need to establish priorities by the U.S. Government in international nuclear policy:

1. Prevent nuclear weapons development.
2. Prevent Fukushima-type incidents.

3. Promote safe and secure nuclear energy.

The NNSA is in the lead in the first of these policies. There is not enough being done by the United States on the second, and there is no clear indication of whose responsibility it is. Universities have international contacts to forge an international network on safety and security. One could set up an international nuclear technology school. NE-6 could have a central role in establishing such a school. The third policy area is complicated. The U.S. Government seems to know what Team USA means, but industry does not. A list of potential international markets for nuclear power is needed. A significant opportunity is open for universities and national laboratories to introduce the U.S. approach to nuclear power to countries inclined to install nuclear infrastructure. There could be joint meetings between NEAC and the Civil Nuclear Trade Advisory Committee (CINTAC) of the U.S. Department of Commerce. Foreign countries want to see trade shows inside the United States. They need to know more about nuclear technology and its possibilities and requirements.

Bunn emphasized that “no more Fukushimas” includes both accidents and terror attacks. No one is doing any research on resistance to sabotage. The cradle-to-grave approach is not certain to succeed but would have a high payoff if it did succeed.

Martin pointed out that the de facto repository of expertise in nuclear power is NE. These international activities entail much travel and talking, requiring funding.

Sackett pointed out that there already are nuclear education institutions (e.g., in London).

Ion said that the United Kingdom wants its electricity delivered by the private sector. Deregulation and privatization are being promoted. There are three utilities pushing forward on private nuclear power. Germany has closed down eight of its existing nuclear power plants, wrecking the balance sheet of one of the utilities. Offshore wind and nuclear are expensive technologies. The market must be rigged for these technologies become competitive. The United Kingdom has a big study under way on the government strategy and an R&D roadmap. Most of the existing fleet will expire about 2025 and will need to be replaced. The new fleet may be fueled with MOX. By 2015, the UK nuclear industry must have a permanent repository plan. Volunteer communities have been solicited, one proposal has been received, and an additional expression of interest has been offered. Europe is not unanimous. Germany is ratcheting back. Austria is pathologically opposed to nuclear power. Bilateral arrangements rule. Because of power shortages, Russia may build two new reactors near Poland and Germany to export power.

Lyons said that NNSA could be asked to speak about international issues at the next NEAC meeting. Centers of excellence on safety and nonproliferation could be established. NE has worked hard to work with NNSA. There is a joint modeling and simulation effort on designing new fuels under way with the NRC. Japan has reached out to regulators around the globe. Discussions are centered on safety, and they are making headway. NE is trying to work on the Team USA concept. There will always be multiple private organizations. The target countries list does exist, and industry knows where their potential markets are. Universities should look at ways to craft policies that promote international partnerships. It is not obvious that CINTAC and NEAC have a lot in common.

Burton Richter was asked to report on the Fuel Cycle Research and Development Subcommittee.

There is increased pressure for added fault tolerance for reactor systems. The response to the Blue Ribbon Commission is being developed. Systems studies and separation and waste form have been reviewed by the Subcommittee. Some proposals for accident-tolerant fuels include

- gas gettering and lower pressure in rods,
- metallic fuels with higher thermal conductivity, and
- micro-encapsulated fuel particles operating at higher temperatures.

The balance of plant (BOP) and regulatory capture were the problems at Fukushima. That was also the problem at the Deepwater Horizon. There are many years of testing required. Most of the reactors in the world are old. Better batteries, control instruments, cooling systems, etc. can significantly improve the accident tolerance of reactors. An R&D program is called for in such balance-of-plant issues.

The Blue Ribbon Commission said that deep disposal in salt, granite, or alkaline should be investigated and that a call for proposals should be issued to probe interest. A bottom-up approach may be working. Site-screening requirements should be developed by DOE. (The International Atomic Energy

Agency's requirements would be a good place to begin.) It is time to move on from Yucca Mountain. The new chairwoman of the NRC thinks Yucca Mountain is fatally flawed.

In used-fuel disposition, the Blue Ribbon Commission recommends consolidated interim storage. Dry casks are licensed for only 5 years. The Subcommittee recommends R&D on validating casks for long-term storage and on integrating storage and transport casks for cost effectiveness

NEAC should recommend that NE do a comprehensive review of national and international experiences to identify critical issues in places where advances in science and technology may address such issues.

System studies were started by DOE last year to weight a long list of criteria. How one weights these criteria (a political process) changes the results. NE and NNSA should try once more to agree on how to evaluate relative proliferation resistance. It is important when reactors are going to be built in countries with poor regulatory capabilities.

Separation and waste form campaigns will be launched.

In summary, the Subcommittee made six specific recommendations:

1. In accident-tolerant-fuels work, there is overlap with the LWR Sustainability Program (LWRS), and NE management should review roles and responsibilities to minimize duplication of effort.
2. Because older nuclear power plants may not benefit from more accident-tolerant fuels, NE should adopt an R&D approach that includes fuel, nuclear steam supply system, and BOP improvements to enhance accident tolerance.
3. Because a repository for used fuel will be needed, DOE should develop a preliminary set of generic site-screening requirements that incorporate domestic and international experiences.
4. In the waste disposal arena, a comprehensive review of the national and international experiences is needed to identify critical technical issues and areas where advances in science and technology may resolve such issues.
5. Because development of a new repository is a long-term project, storage of used fuel for periods longer than originally anticipated is necessary. DOE should continue efforts to determine how to validate casks for long-term storage and how to integrate storage and transport casks for cost effectiveness.
6. Progress in the advanced systems study program is good, but NE and NNSA have not come to agreement on evaluating relative proliferation resistance and should try once again.

[A seventh recommendation was withdrawn.]

Sattelberger asked whether the National Academy of Sciences has put together a panel. Richter replied that it has; they can *recommend* but they have no *responsibilities*. The study will take 2 years. NE has the responsibility.

Cochran pointed out that there is an additional issue in that radioactivity is a unique pollutant over which the states have no control. The Atomic Energy Act should be changed to give states authority over radioactive pollution. The Nuclear Waste Policy Act called for a consent process that has been since undermined. The site-selection criteria were to be developed by the Environmental Protection Agency (EPA), but they did not do it on time.

Bunn said that most countries do not have an interest in enrichment and recycling. The near-term problem is pyroprocessing in South Korea. It is not true that fuels that cannot be reprocessed can be developed.

Matzie noted that one hurdle is that owner operators do not appreciate best practices, probabilistic risk assessments, and safety cultures. They do not understand the risks, making them adopt barriers that can hinder deployment of reactors.

Kazimi asked if the Subcommittee had talked with borehole researchers and stated that the criteria's robustness to weighting should be considered.

Chu commented that the FY13 budget request is not seen to be well-balanced among the various needs and topics.

Sessoms asked who would have the best credibility in putting together such a panel. Richter pointed to DOE.

Paperiello asked why the transition-cask agreement has a 5-year limit. Boyle said that it came from the International Atomic Energy Agency (IAEA).

Richter responded to the questions and comments: The Institute of Nuclear Power Operations (INPO) has done a good job in training in the United States. The borehole issue was just an editorializing comment and is informed by research on fracking. Casings on wells have leaked, the cracks can be fixed, and the gas could be shut off. The budget was not out at the time of Subcommittee's meeting, so the Subcommittee could not address balance.

Lyons said that the Office has a lot of ideas on accident-tolerant fuels and systems that are in line with the Subcommittee's recommendations. Prototype site-screening criteria are being developed. Cask-challenges work is being tied in with that of Electric Power Research Institute (EPRI). There is no known way to accelerate cask testing. The cask issues are very important. There is a lot that we can learn from the international community of disposal in granite and clay. We do not know how Congress will move on the Blue Ribbon Commission recommendations. There would have to be significant additional funding increases to implement the recommendations.

Richter said that if Sen. Feinstein sees the government getting serious about waste disposal, she will increase the NE budget.

Ahearne moved for the approval of the Subcommittee's report with the exception of recommendation seven. Sackett seconded the motion. It was unanimously adopted.

Raymond Juzaitis was asked to report on the Modeling and Simulation Subcommittee.

The Subcommittee has had two meetings focusing on vision, strategy, and program management. The Subcommittee may soon recommend ending its term because of the reorganization of the Office. A full report will be forthcoming at the next NEAC meeting. The resources needed to meet the modeling and simulation vision are largely lacking. The Energy Innovation Hub and the Nuclear Energy Enabling Technologies program are redundant rather than complementary. The funding changes are going in the wrong direction (\$100 million to \$26 million). The project is now looking at a modeling tool kit. The mission has been reduced to just fuels and reactors. The technical approach is totally valid and consistent with others' efforts. The team has done a marvelous job. The technical direction, however, is uncertain. It is still a 4 π program. It needs technical direction and leadership. The National Technical Director is excluded from a direction role. The Nuclear Test Ban Treaty produced urgency for modeling and simulation for NNSA. Such a focusing urgency does not exist in the NE modeling and simulation program. Goals and timetables (a true value proposition) are needed. The Subcommittee will report its recommendations at the next meeting.

Matzie applauded the modular toolkit approach. There is not enough end-user involvement with flow down of requirements. One also needs to benchmark the codes, and there is no money built in for such scientific validation.

Lyons said that that will be an important report. The comments seem to be right on. Each point made needs to be taken as a challenge. Many integral experiments have been done in the past that make it difficult to study a particular variable. University research may allow teasing out such variable-specific data.

Michael Worley was asked to report on the 2012 activities of the Nuclear Energy University Programs (NEUP).

Funding for NEUP in FY12 totals \$62 million: \$15.9 million for integrated research projects, \$37.1 million for program/mission-supporting R&D, \$6.0 million for university research infrastructure (reactor upgrades), and \$5 million for Integrated University Program (IUP) fellowships and scholarships.

In FY 12, 648 pre-applications for R&D awards were received, and 150 of these were invited to submit full proposals. 202 full proposals were received, a 10 to 20% reduction from the previous year. Principal investigators (PIs) were limited to three proposals; members of collaborations were limited to six proposals. Of those 202 full proposals, 48 were approved for award: 33 lead universities and 23 collaboration organizations (eight universities, eight national laboratories, six industrial partners, and one foreign entity). Funding levels were \$450,000 or \$900,000.

Sattelberger asked what had been done with the 55 rogue proposals. Worley replied that they got additional relevancy reviews, and two got awards.

Among the award recipients were seven new schools. An attempt was made to integrate proposing universities with national laboratory user facilities, and additional awards resulted from this process.

For FY13, a pre-solicitation workshop and webcast was held in Washington, D.C., on May 2, 2012. Interested potential partners from the United Kingdom and the Czech Republic participated. A solicitation for three topics was issued on May 25, and proposals are due July 9. An award announcement is anticipated by the end of FY12. The percentage of project funds provided by the government to non-university participants was increased to more than 20%. Cost sharing is encouraged but not required.

The first topic to be considered is advanced LWR fuels with enhanced accident tolerance. It will deal with improvements to the nuclear fuel and cladding system by many possible methods, including design, materials, or combinations of the two to achieve lower fuel operating temperatures, higher temperature capability, higher strength capability, and increased resistance to oxidation. The second topic is used nuclear fuel storage. It focuses on areas of canister hardware not covered in the FY11 Integrated Research Program (IRP). And the third topic is inherently safe LWRs. It seeks to improve the safety goal from “passively safe” (GEN III+) to “inherently safe,” which means a reduced likelihood of severe accident consequences.

A planning conference for the FY13 NEUP is being held August 7-8, 2012, at the Marriott Metro Center in Washington, D.C. It will seek to engage the university community to identify the expected focus of FY13 NEUP R&D solicitations; to review the general NEUP objectives/emphasis areas (improved integration with NE R&D Programs, increased emphasis and process improvements for oversight and monitoring of ongoing projects, and clearly defined roles and responsibilities); and to solicit feedback. Some of the major improvements for FY13 are to limit the total number of projects for a principal investigator; to improve the application and project-execution processes; to preclude a new project award if there is an existing no-cost extension; to improve communication with and among reviewers; and to employ social media as a performance metric to allow students to communicate with each other, find mentors, etc.

Martin called for comments and questions. Richter and Cochran thanked Lyons for his outstanding work. Sattelberger asked how all these proposals were processed. Chu asked what actually got funded and what the distribution was among the topics. Ion was impressed with (1) the focus of funding for international leadership (i.e., for SMRs and accident-tolerant fuels in systems) and (2) the recognition of the need for a consent-based approach. Matzie asked what the process was for sharing information among the Office’s programs and their awardees. Eisenhower questioned the use of the term “accident tolerant” and noted that it should refer to disruptions, not just accidents. Also, it is passive, as though accidents *can* be tolerated. A “nuclear waste dump” could be rephrased as a “used-fuel repository.” The Committee can be influential on what things are called and how they are perceived. Meserve noted that a large number of activities were going on in response to Fukushima in all the countries that have nuclear reactors. They are conducting stress tests, consolidating reactor operations, rethinking testing programs, etc. The trick for NE is to see how it can augment and control this process of accident analysis and play an important role. There is a perception that there is a long-term problem in the United States because of the low cost of natural gas. This low cost will not continue forever. There will be changes in the future. The natural gas situation in the United States is an anomaly. Natural gas costs \$2 in the United States and \$16 in Japan. The United States will start exporting, and foreign markets will drive prices up. Some natural gas will be used to make other products (like diesel fuel). Natural gas prices will go up, and nuclear will be competitive. Juzaitis asked what the Office was trying to do with NEUP, incentivize nuclear engineering education or produce scientific information. The number of states participating in a program is not a good metric. The National Science Foundation (NSF) will not fund anything with “nuclear” in its title. DOE has to think strategically. In proliferation resistance, a dedicated approach is needed. The National Academy of Sciences is not penetrating the deep secrets of NNSA. NNSA’s efforts to study policy on improvised explosive devices (including nuclear) should be exploited. Sessoms asked how the NEUP nexus with the United Kingdom was set up and how it could be broadened. Lessons learned have to be

captured and broadly accepted; the United States should have a leadership role. Congress is interested in funding issues to address national interests (such as trade and energy production). Kazimi was impressed with NE's direction and refocusing on LWRs. These are the reactors that will be used for many years. More time should be granted between the issuance of a funding opportunity announcement and the delivery date of the proposal. Sackett noted that a sense of urgency about nuclear is needed. It will emerge first in the international arena. Natural gas is the bridge to nuclear; nuclear needs to be gotten on board, and NE should position itself well. Bunn commented that, while there are a lot of national regulations, it is not clear that the needed regulations are present in the international community. In NUEP, an added weight could be given to international partnerships, especially in countries whose policies the United States wants to see upgraded. Paperiello said that the NE program is focused on the next 10 years, which is good. The report on modeling and simulation is fascinating. Bhatnagar looked forward to working with the other Committee members. Ahearne thanked the staff of NE, the support staff from the Medical University of South Carolina, and particularly William Martin for his leadership.

Worley responded that funding favors collaboration and innovation. Independent reviewers are used; they are identified by a certified peer-review process that vets the reviewers to avoid conflict of interest. Awards are selected primarily on the basis of peer and analytic reviews as reviewed by senior management. The U.K.–U.S. nexus cannot be expanded because of restrictions in the United Kingdom; the programs are equally open to any international entities. For example, the Czech Republic has been made aware of the United Kingdom's actions. The Office issues funding opportunity announcements as soon as possible; the key information is put out in the preliminary solicitation. Respondents get added points for partnering, particularly with foreign partners.

Lyons said that this had been a highly productive day, and he thanked the members for their hard work. The outgoing members should feel that their legacy is in good hands. He thanked the past leadership. The values and roles of NE vis-à-vis the international community are very complex, and the specific international activities of NE should be made known to the International Subcommittee. The Office and staff appreciate all the comments and efforts.

No one had signed up to make a public comment, and the meeting was adjourned at 3:58 p.m.

Respectfully submitted,
Frederick M. O'Hara, Jr.
Recording Secretary
June 27, 2012