Minutes
Nuclear Energy Advisory Meeting
December 18, 2009
L'Enfant Plaza Hotel
Washington, D.C.

Committee Members Participating

John Ahearne
Ashok Bhatnagar
Dana Christensen
Thomas Cochran
Michael Corradini
Marvin Fertel
Susan Ion (by telephone)
Raymond Juzaitis
William Martin, Chair
Carl Paperiello
Burton Richter
John Sackett
Allen Sessoms

Committee Members Absent

Brew Barron
Donald Hintz
Neil Todreas

Other Participants:

Nancy Carder, Medical University of South Carolina, NEAC Support Staff
Shane Johnson, Chief Operating Officer, Office of Nuclear Energy, USDOE
Peter Lyons, Principal Deputy Assistant Secretary, Office of Nuclear Energy, USDOE
Edward McGinnis, Deputy Assistant Secretary, Corporate and Global Partnership Development, Office of Nuclear Energy, USDOE
Warren Pete Miller, Assistant Secretary, Office of Nuclear Energy, USDOE
Thomas O'Connor, Director, Office of Gas-Cooled Reactor Technologies, Office of Nuclear Energy, USDOE
Frederick O'Hara, Medical University of South Carolina, NEAC Recording Secretary
Buzz Savage, Director, Office of Fuel-Cycle R&D, Office of Nuclear Energy, USDOE
Rebecca Smith-Kevern, Director, Office of Light Water Reactor Deployment, Office of Nuclear Energy, USDOE
Kenneth Chuck Wade, Designated Federal Officer, Office of Nuclear Energy, USDOE

About 30 others were in attendance.

Morning Session

Before the meeting, the new members of the Committee were sworn in as special government employees by a member of the DOE Human Resource Office and they received ethics training by a member of DOE's Office of the General Counsel.

Chairman **William Martin** called the meeting to order at 8:59 a.m. He asked for approval of the agenda. Approval was unanimous.

Chuck Wade made convenience and safety announcements. Sue Ion joined the meeting by telephone from London.

John Ahearne was introduced as a cochair of the subcommittee that produced the report *Nuclear Energy Policies and Technology for the 21st Century*. That report contained recommendations and would be discussed later in the meeting.

Pete Miller was asked to introduce the new Committee members and the Office of Nuclear Energy (NE) staff members. A strategic direction and roadmap have been drawn up and are being reviewed before submission to Congress. A reorganization is also pending congressional approval. Relationships with the Office of Management and Budget (OMB) and congressional staffs have been continued.

Pete Miller was introduced to present the first section of a discussion of the future of nuclear energy.

The Office has the support of President Obama and Secretary Chu.

The United States is among the countries highest in electricity use and CO_2 emissions, and DOE aims to reduce CO_2 emissions 80% by 2050. This decision drives the activities of several DOE offices, including NE. Nuclear power produces 20% of the nation's total electricity and more than 70% of its nongreenhouse-gas-emitting electricity. When one looks at various scenarios, it is seen that, to meet DOE's ambitious CO_2-reduction goals, approximately 30% of the country's electricity generation must be derived from nuclear power by 2030. In 2007, electricity generation accounted for 40%, transportation accounted for 33%, and process heat accounted for 16% of the United States' total CO_2 emissions. A major question is how NE can contribute to the lowering of the transportation and industrial production carbon footprints.

NE has been moved more into science, discovery, and innovation, and it now has a modeling and simulation hub. NE needs (1) to ensure the production of clean, secure energy, providing at least 70% of the U.S. noncarbon-generated electricity; (2) to contribute to national security by reducing the risk of nuclear proliferation and reducing petroleum imports; (3) to enhance economic prosperity by moving toward a new reactor; and (4) to lower greenhouse-gas emissions.

Richter noted that if one takes out big hydro, nuclear energy produces 90% of the non-emitting electricity.

The primary mission of the Office of Nuclear Energy is to advance nuclear power as a resource capable of making major contributions in meeting the nation's energy, environmental, and energy-security needs by resolving technical, cost, safety, security, and regulatory issues. All of these determine the Office's research, development, and demonstration programs.

In addition, NE performs several mission-related functions, such as international engagement in support of the safe, secure, and peaceful use of nuclear energy and the international use of civilian nuclear energy; the delivery of nuclear power systems for use in national security and space exploration missions; oversight of the United States Enrichment Company's (USEC's) front-end fuel-cycle responsibilities; and stewardship of the DOE Idaho site.

In the FY 2010 budget, the big money is in Generation-IV and Fuel Cycle R&D.

Five key imperatives for NE have been identified and are to be described in detail later in this meeting. Those imperatives are to extend the life, improve performance, and sustain health and safety of the current fleet of nuclear-power reactors; enable new-plant

builds and improve the affordability of nuclear energy; enable transitioning away from fossil fuels in the transportation and industrial sectors; enable sustainable fuel cycles; and understand and minimize proliferation risk.

The nuclear energy hub is a Bell-Lab-ette designed to focus the activities of the Office. It is to model and simulate a reactor from end to end. A workshop has been held, and the funding opportunity announcement will be released soon. The community is self organizing to develop this hub. The development of this hub is moving more quickly than that for the other two hubs in DOE.

Juzaitis noted that a lot of discussion has been devoted to the responsibility for producing medical isotopes. Miller said that SC is responsible for supplying research isotopes; medical isotopes are seen as a commercial product. The National Nuclear Security Administration (NNSA) has been involved in converting highly enriched uranium (HEU) processes to use low-enriched uranium (LEU) in the production of medical isotopes. Juzaitis asked who owned the process for producing technetium-99. Miller responded, SC.

Peter Lyons was asked to continue the discussion on the future of nuclear energy and to describe the key imperatives of the Office.

The first imperative mentioned by Miller is the life extension of the current fleet of nuclear reactors. The goal is to safely extend plant life beyond 60 years with improved performance. The challenges facing the current fleet include aging and degradation of system structures and components, including pressure-vessel embrittlement. How to divide responsibilities between DOE and industry is a major question. A joint program may be appropriate. Several workshops are anticipated.

Imperative 2 encompasses new builds and extends from NP2010 to Gen-III+ reactors. DOE can assist in how to close ITAACs [inspection, testing, analysis, and acceptance criteria]. This topic will probably be explored in workshops. How small modular reactors (SMRs) can be used will be looked at to prove the costing, establish cost goals, be able to apply the technology in small generation increments, and revitalize the domestic nuclear industry. The United States' ability to construct large plants is lacking today. The capability to produce SMRs may be available or developable. SMRs may simplify siting and licensing. Reducing the material requirements, security footprint, and licensing requirements are possible activities.

The third imperative is to transition away from fossil fuels. Electricity generation produces 40 % of the U.S. carbon emissions. Increased electricity demand for electric cars etc. will increase the opportunity for nuclear power to contribute to the electricity supply. A funding opportunity announcement (FOA) has been issued, and the responses are now being evaluated.

NEAC plays a large role in the next-generation-reactor program.

A number of opportunities are seen for nuclear energy to produce process heat, and an ongoing study is investigating such opportunities.

Imperative 4 is the development of sustainable fuel cycles. The administration has strongly stated that it will not go forward with Yucca Mountain. An effort is being made to encourage innovation in the sustainable development of nuclear-fuel cycles. Spent fuel is being stored in dry-cask storage. A better understanding of the uranium-resource situation is needed. Repository space and conditions is another issue to be dealt with. All of this has to be done with an eye toward minimizing environmental impacts. Currently,

there is a lot of enriched uranium and storage space. The once-through and full-recycle strategies are the extremes of a vast range of a continuous spectrum of fuel-cycle designs. The modified open cycle may be a possibility for the efficient use of the uranium resource with a small required repository space.

Three potential fuel-cycle options are (1) optimized once-through, which probably has large requirements for geologic disposal of used fuel (several Yucca Mountains); (2) modified open, which would use fuel treatment to reduce the need for geologic disposal of spent fuel; and (3) full recycle, which would use separation techniques to remove fission products for geologic disposal and allow the reuse of the unburned fuel.

Imperative 5 is to understand and minimize proliferation risk. Limiting proliferation and security threats requires protecting materials, facilities, sensitive technologies, and expertise. It would require the development of proliferation risk-assessment methodologies and tools and the minimization of the potential for misuse of the technology and materials, leading to control regimes to ensure the mitigation of proliferation risk. R&D and strong guidance from NEAC would be needed.

Most NE programs have international components. There is an agreement to move ahead with the Global Nuclear Energy Partnership (GNEP) for cradle-to-grave nuclear-fuel services. Daniel Poneman's goal is a comprehensive approach to managing the nuclear-fuel cycle, which could vastly reduce proliferation concerns.

Proliferation concerns need to be seriously considered because, as the World Bank's World Governance Indicators show, there is a huge difference between the existing nuclear-power states and the aspiring nuclear-power states in the control of corruption, political stability, government effectiveness, regulatory quality, and democracy scores.

NE has laboratory operations at INL and at some buildings at Oak Ridge National Laboratory (ORNL) and Los Alamos National Laboratory (LANL). The extremely successful Advanced Test Reactor (ATR) National Scientific User Facility is part of the program.

Big challenges for nuclear power include the public perception of nuclear energy, capital cost of new plants, solving the nuclear-waste problem, and nonproliferation. The job of the NE programs is to provide a complete understanding of the range of policy options associated with nuclear-energy solutions to the nation's energy needs. Industry will make the final choice. NE's job is to make sure the options are understood.

Each Committee member was afforded the opportunity to comment on and ask questions about the Office's activities.

Ahearne was glad to see the degree to which the Office is responding to the recommendations of the 21st Century report. One area of concern is facility conditions and need for upgrades.

Sessoms said that a key study of INL showed it to be decrepit. It needs to be brought up to snuff. DOE needs a world-class option for doing the needed R&D. The hydrogen-production research has dropped to zero.

Corradini noted that this was the first time in 10 years that the office leadership has cared about the Committee. He asked who the customers were that the cited imperatives serve. Imperative 1 and Imperative 2 are aimed at the industry, and they serve as models for identifying the customer. Imperative 3 identifies process heat but does not identify a customer. The customer of Imperative 4 is not known.

Paperiello noted that multiple-use technologies are making weapons control difficult. The electronics are now available in Wal-Mart and are manufactured overseas. This situation may extend to materials. He was skeptical about modeling and simulation. All technology is based on experientialism. Substituting modeling and simulation will be a challenge. In GNEP, simulation of sodium-cooled reactors encountered pushback. DOE's infrastructure that is available to other agencies (e.g., for the NRC's fuel-irradiation studies) is waning and disappearing.

Cochran stated that the goals for the number of reactors to be built by 2030 are unrealistic. The imperatives should have divided issues into (1) existing fleet and (2) new reactors. For the existing fleet, life extension is good. Fuels apply to future reactors. The light water reactor (LWR) fuel costs have gone down and will continue to go down; capital costs have gone up. No advanced enrichment concepts are being looked at. The new-build issue has two challenges: capital costs and the fact that the cost/kilowatt is not competitive. SMRs may solve one of those issues, but first the proposed cost reductions must be carefully examined. He agreed that proliferation is a central issue. Also, the landlord issues have to be addressed.

Bhatnagar said that demonstration would strengthen confidence in commercialization. Capital costs will be improved by regulatory stabilization and engineering. Manufacturing and construction will entail 75% of the costs. Manufacturing efficiency has improved, but construction inefficiency has not and needs to be addressed. A design basis for nonproliferation is needed. In SMRs, the regulatory framework needs to be established up front as well as demonstration.

Richter stated that the predictions about nuclear power growth are unrealistic by a factor of two and need a serious review by NE. Starting up new builds is not an R&D problem; it is a financing and regulation problem. If the first few reactors get built on time and on budget, then the costs and technology will be known better. Japan and France have kept costs down by continuing to build same-design reactors. The availability of uranium is a major concern. The once- through strategy has its nonproliferation benefits. A 50-year core that does not produce a lot of actinides is needed for an ideal reactor.

Juzaitis noted that few visions are realistic upon visualization. The higher levels of the education ladder are not involved in the nuclear industry. Simulation produced a transformation in the nuclear-weapons business, although this problem is much harder than the nuclear-weapons work was. The computational program should not be separated from the experimentalists who are going to validate the simulation results. Integrated codes should have within them the physics case for nonproliferation, safety, etc. Technologists must recognize that they can affect nonproliferation through engineering design. The technical capability is one part of the equation; a complementary risk program can measure and control the risk associated with the technology

Christensen said that a key weakness is a lack of communication with the legislature, OMB, and other agencies. There has been a lack of clarity about why the government needs to do nuclear R&D. The goal for 2030 is a very ambitious program; one needs to be careful not to overstep one's capabilities. The problems of materials need to be wrestled with and made clear. Modeling and simulation is an important new opportunity, allowing study of materials at the atomic and molecular scale. The problem of decaying infrastructure goes well beyond the national laboratories.

Sackett stated that what was presented was an excellent plan for going forward. The goals and technology for domestic issues are different from those for international issues. Foreign countries are going forward with ill-suited technologies. While the United States has exercised substantial leadership in the past, it is losing ground. In the fuel cycle and in advanced-reactor development, the United States' leadership role must be rethought. How to gain a return on investments in R&D already performed needs to be considered. Modeling and simulation can link small- and large-scale experimentation done in the past. Lots of information can be gained from legacy materials (e.g., those used in earlier operating reactors). The huge impediment is regulatory risk.

Fertel pointed out that 40% of the 2010 budget goes to the laboratories' infrastructure (and should be more). The human capital has to be supported, also. Sustainable programs that will transcend administrations need to be established; that has never been done. One should not simultaneously run down 100 roads and not reach any destination. The DOE program needs to put more emphasis on keeping current plants online. On modular reactors, a shakedown of the regulatory process is needed. The customer of nuclear fuel cycle research is the U.S. government, which has the responsibility of dealing with the by-products of nuclear power production. The decision of whether or not to close the fuel cycle will be made internationally.

Ion said that, when the United States looks at future challenges for the energy sector, it's plans are similar to those of the United Kingdom and the European Union. If the United States is serious about pursuing these goals for nuclear power's contribution to the energy supply, the pursuit of high-temperature reactors will be necessary. Companies like Dow Chemical are interested in using reactors for process heat. The United States will need to provide financial leadership as well as policy leadership. The need to investigate the effects of material aging is self-evident; industry will have to deal with that issue. What is happening in India and China on fuel-cycle closure is important. The United States must decide what to do about thorium. Once one gets to 1200 reactors, uranium availability becomes a problem; one cannot rely on the availability of cheap uranium. One cannot leave the materials development to the industrial sector. The United Kingdom has a new initiative on nuclear proliferation and is developing a technical basis for that initiative.

A break was declared at 11:06 a.m. The meeting was called back into session at 11:22 a.m.

Martin said that, if one is to reduce carbon releases to the atmosphere, keep electricity use to what it is today, and reduce petroleum dependence, then nuclear technologies are incredibly important to the nation and the world. The scientific community's methodologies for developing scenarios and modeling those scenarios are currently not up to the need. Miller noted that the United States has engaged the applied-technology arenas to study how to meet the greenhouse-gas goals. The 30% scenario is one of the resulting scenarios.

Buzz Savage was introduced to describe the NE R&D roadmap.
He showed a chart with milestones for the programs.
The purpose of the Nuclear Energy roadmap is to provide guideposts to help ensure that nuclear energy remains a compelling and viable energy option for the United States. The nuclear energy imperatives cited by Miller and Lyons were developed to focus resources on national objectives for clean energy, economic prosperity, and national security. The

contribution of nuclear power to the U.S. energy mix must increase significantly if the country is to meet these aggressive objectives, especially the greenhouse-gas- and petroleum-reduction goals. The NE roadmap outlines an integrated approach to meet objectives and was developed in cooperation with the national laboratories. The roadmap also addresses the Secretary's challenge to transform NE's research, development, and demonstration (RD&D) programs to a more science-based approach.

The roadmap was structured to address the key imperatives and to adopt a demonstration approach. This science-based approach to nuclear-energy development supplements decades-long experiments with integrated theory and new tools (modeling and simulation) and it introduces demonstrations. The R&D program is goal-oriented. Rushing into commercial development without proving new technologies was a mistake.

Major milestones have been developed for each of the five key imperatives. For the first imperative, milestones have been set for (1) nuclear material aging and degradation R&D; (2) the development of advanced monitoring and nondestructive-examination technologies and the development of a plant instrumentation-and-controls modernization strategy; (3) the development of a high-performance, long-lived LWR fuel; (4) the development of next-generation safety-analysis tools; and (5) the development of technologies for power uprates.

For Imperative 2, which includes SMRs and other concepts in addition to Gen-III+ reactors, milestones have been set for (1) exercising the Part 52 licensing process on the first Generation-III+ plant; (2) completing the ITAAC process for the first Gen-III+ plant; (3) accelerating the licensing and construction of the first LWR-based SMR design and possibly several other designs; (4) developing advanced reactor concepts, technologies, and licensing tools for high-performance plants; (5) initially demonstrating advanced modeling and simulation tools for plant design, safety assessment, and validation; and (6) demonstrating advanced manufacturing and construction technologies.

For Imperative 3, milestones have been set for (1) fuel, materials, methods, and system development and testing to support the design and licensing for the next-generation nuclear plant (NGNP), a showcase technology for which Congress has shown strong support, and (2) R&D to integrate nuclear technology with fossil and renewable sources to supply heat for industrial uses. This is not just displacing natural gas but is also involves working with other offices and with industry.

For Imperative 4, milestones have been set for (1) the development of a high-burnup fuel for the once-through cycle; (2) the development of technologies for a modified open cycle, which is still not fully defined but would minimize the treatment of used fuel from once-through reactors; and (3) the development of technologies for full recycle. Only 1% of uranium is used in today's fuel cycle. The 1% includes U-238 because the fertile materinal in the fuel is considered part of the total that could be transferred into energy. New fuel forms and types need to be investigated. For full-recycle operations, the most promising technologies need to be identified by 2040 with an eye to commercialization by 2050. A new R&D facility is needed sooner rather than later. There is no fast-spectrum test facility in the United States.

For Imperative 5 (nonproliferation), milestones have been set for (1) defining proliferation risks and developing a complete initial demonstration of an advanced proliferation risk-assessment tool; (2) performing the relevant proliferation risk assessments required to inform fuel-cycle down-selections; (3) demonstrating the fully

integrated advanced nuclear-material-measurement and information-analysis systems that are developed; (4) continuing to develop and demonstrate safeguards technologies informed by advances in fuel cycle and reactor technology; (5) demonstrating real-time continuous material accountancy and control capability in the engineering-scale fuel-cycle test facility, which needs to be done before commercialization; and (6) developing the capabilities to incorporate material measurement and data analysis systems into the design of commercial-scale fuel-cycle facilities so cradle-to-grave fuel services could be offered to developing countries.

These milestones have been integrated. Some activities have been integrated with those of the Office of Environmental Management and the Office of Civilian Radioactive Waste Management. These options will be reviewed and will be used to inform a blue-ribbon panel that might study this subject.

The enabling technologies for developing structural materials, nuclear fuels, reactor and fuel-cycle systems, instrumentation and controls, power-conversion systems, process-heat-transport systems, dry-heat rejection, separation processes, waste forms, risk-assessment methods, uranium and thorium fuel resources, manufacturing science and technology, and computational modeling and simulation are being pursued by major programs in a matrix manner.

These efforts require interfacing with many other DOE offices and federal agencies. Stovepipes need to be eliminated. NE is working with SC, NRC, Department of State, Department of Transportation, and industry. Such engagement is very rewarding. Universities continue to be engaged in NE's R&D programs. U.S. leadership is being challenged around the world. Since GNEP was started, new partnerships have been formed (e.g., with Russia and India).

The next steps for the roadmap include a submission to Congress, a detailed description of the research program, an upgrading of the schedule of milestones, and a program-management plan for each of the imperatives. Implementation plans will be drafted in mid-January and will probably not affect the FY11 budget. The President's budget goes to Congress in February.

Martin noted that, 10 years ago, the President"s Committee of Advisors on Science and Technology (PCAST) talked about a resurgence of nuclear power. Ahearne pointed out that funding of such R&D had gone to zero. The view then was that many current plants would be decommissioned early. It was his hope that this team will move the nation forward.

Lyons reported that the Modeling and Simulation for Nuclear Reactors Hub is to be applied to an operating reactor. The state of the infrastructure requires a look at international cooperation. PHENIX is closed and is no longer available for testing. The Office intends to give serious consideration to the once-through, full-recycle, and modified-open-cycle fuel cycles in order to maintain a seat at the table in international discussions.

Miller restated that the hub is to use data from a reactor that has operated.

A break for lunch was declared at 12:15 p.m.

Afternoon Session

The meeting was called back into session at 1 p.m. A discussion of Savage's presentation was initiated.

Cochran stated that the milestones were cited (and may need to be adjusted), but the criteria for down-selecting have been overlooked. The timelines for the study of material aging were good, but other timelines seem to call for decisions before the completion of the R&D programs that are to inform those decisions.

Sessoms said that there is a lack of a sense of urgency in the timelines and milestones. Infrastructure needs to be addressed before the FY12 budget kicks in. International collaborations need to be established now because, clearly, there will not be a world-class laboratory in Idaho. Successful international collaborations are being carried out at the Large Hadron Collider (LHC) and at the International Thermonuclear Experimental Reactor (ITER). Nuclear R&D needs to happen.

Martin asked Edward McGinnis what the international community thought about the United States. He responded that the United States is behind and that other countries are waiting for it to step up. This is an international issue. The United Arab Emirates is going to set the model. It will be the first to deploy a new reactor, and how they structure the construction, operations, and fuel supply is important.

Ion pointed out that one issue that has to be factored in is the absence of the United States from recycling technology during the past 20 years, with India, France, and China stepping in. Once one gets to the pilot scale, one needs the infrastructure. One needs to decide what one wants to do and to recognize what everybody else is going to do.

Martin noted that an international nonproliferation summit is going to be held in April.

Sessoms said that the United States needs to work with other countries so that it knows when those other countries have crossed the line. Even without the United States, they are going to cross that line. The United States needs to build up the policy side by building up the technology side.

Juzaitis agreed. Nobody will do the technology; it belongs to the United States.

Richter noted that the last administration started the GNEP. The discussions are still going on. U.S. technology is missing, but the United States has not dropped out of the nonproliferation discussions. It is not a complete vacuum.

Paperiello commented that the roadmap is a good beginning. Detail needs to be supplied in the management plan. In addition, one needs budget recommendations and one needs to spell out to Congress and the public what is needed. Success needs to be defined to tell when a program is complete. It is difficult to define the literature and to move that information into industry.

Corradini said that he would suggest moving up the timetable so some results and indicators are seen before the next administration takes office. There will be some talk about how ITAACs are done. Industry expects others to pay; they need to pay to play.

Ahearne stated that a decade-long program is laid out, but work needs to be done on the milestones for the next few years because that is what will be driving the budget. The Office also needs to identify what topics NEAC can provide help on. The five imperatives can be interpreted many ways, so they are fine. A set of milestones for the next few years is needed.

Richter said that the major thing is how to get loan guarantees and how to get changes through the NRC. That is what will hold up the next generation of reactors. The milestones need to build the knowledge needed for the reactors of 20 years from now.

Fertel called attention to the fact that industry is talking with the loan-guarantee office. Industry's relations with NRC are fine. Standardization is the way to go. What DOE has done so far is a good model for SMRs.

Lyons pointed out that international collaborations, industry financing, taking an informed position on fuel cycles, budget estimates, near-term milestones, and a regulatory framework are needed. DOE can make a substantial contribution to these issues.

Fertel stated that this roadmap will take the Office in the direction it wants to go. One needs a sustainable program, which requires justification and success criteria. Contingency plans for budget cuts and an infrastructure roadmap (that recognizes what is going on internationally) are also needed. The Electric Power Research Institute (EPRI) and industry need to be considered. The National Security Council (NSC) is driving the nonproliferation summit that is coming up.

Ion urged the Office to pay attention to what is really important and to fund those programs properly. The international community will cooperate.

Sackett pointed out that the U.S. government has the responsibility for nuclear waste, and that responsibility is spread across many agencies. The stovepipes need to be broken down. The timeline for fuel-cycle development is very long. The international community has more anxiety about this issue than is reflected in the timeline. Even in the international arena, there is a lack of capability in fast-spectrum testing. Modeling and simulation must be done; the new-reactor bill would allow instrumenting a reactor to produce the data needed for the modeling and simulation.

Christensen said that the road mapping process was very good. It is very optimistic and needs some early milestones. In the roadmap, fuel qualification begins in 2021 without modeling and simulation. To be knowledgeable about fuels, the community needs a new facility. The nation needs to move on this issue and not wait for any blue-ribbon panel. The next steps need to be connected to the rest of the information.

Juzaitis believed that this was a well-populated list of milestones. It needs to be resource-loaded. The milestones need to be hooked to other agencies and issues. Proliferation resistance and physical protection need to be connected. Communication with the weapons community will shed light on the protections needed in the post-9/11 era.

Richter pointed out that both greenhouse-gas emissions and petroleum imports can be lessened by nuclear technology. He wanted to know what DOE's view of a broad energy-supply portfolio would look like, including wind backup. That portfolio building transcends NE.

Thomas O'Connor was asked to brief the Committee on the NE activities related to the NGNP, the one program that NE has a congressional mandate to do.

The goal is to expand the role of nuclear power into more than just electricity (e.g., to high-temperature process heat).

The NGNP is a rector that is helium cooled with a high outlet temperature of about 700 to 950°C. Two designs are under consideration, the pebble-bed reactor and the prismatic-core reactor.

NGNP appropriations have increased in the past few years (with a slight decrease in FY07 because of an appropriations delay). The appropriations for FY09 and FY10 were $178 million and $169 million, respectively.

The NGNP R&D focus areas are fuel development and qualification, graphite-materials qualification, high-temperature-material qualification, and design and safety methods and validation. The first fuel test samples were pulled out of the ATR this past year. These fuel samples had been subjected to the equivalent of 21% burnup. They will be allowed to cool for a couple of months before postirradiation examination and high-temperature testing (to failure).

In graphite-materials qualification, six grades of graphite are to be subjected to compression stress tests, and 300 specimens will represent 10 grades of graphite.

High-temperature materials for reactor vessels, heat exchangers, and code casework will be tested under a helium environment.

In 2009, the hydrogen initiative was completed. The different technologies were evaluated. Based on R&D, the best technology to pursue is high-pressure steam electrolysis.

Design and safety methods use modeling, simulation, and scale models of flow characteristics, air ingress, and tritium migration.

Cochran asked why more data are not available on these materials. O'Connor replied that there is a lot of experience with these designs and materials from the United States, Japan, France, and China. Currently, there are no regulations for high-temperature gas-cooled reactors. This R&D supports not only high-temperature gas-cooled designs but also high-temperature gas-cooled regulation.

Richter asked whether the inclusion of the pebble-bed concept meant that DOE has given up on reprocessing. O'Connor answered, no, but very little work has been done on the back end of that cycle. There are no more problems than with the prismatic block.

NGNP licensing activities include DOE and NRC collaboration on R&D needs, DOE's preparation of several white papers to initiate regulatory review of gas-reactor issues, and a formal pre-application licensing review scheduled to commence in FY11. DOE is cooperating with the NRC to ensure that there is no duplication and to quantify the integrity of the data.

An FOA was issued on September 18, and proposals were received November 16. Federal assistance is for conceptual design, cost and schedule estimates, and business-plan preparation. The agreement requires a cost-share from industry. The FOA supports more than one design. Conceptual design reports are due in August 2010.

A future NEAC task will be to respond to a congressionally required review. It will review the status of R&D, review the status of licensing activities, and review conceptual designs (including designs, management plans, and cost and schedule estimates). NEAC will forward recommendations to the Assistant Secretary for Nuclear Energy about whether the accomplishments in the areas of R&D, licensing activities, and conceptual design of the NGNP have been sufficient to support initiating Phase II for the development of a final design and, ultimately, construction of a demonstration reactor.

Under the terms of the FOA, detailed conceptual design reports are due to DOE by 08/31/10; NEAC's recommendation to the Secretary of Energy on proceeding to Phase 2 is due by 11/15/10; the NEAC report is to be submitted to Congress by 12/15/10; the Secretary is to make an announcement on the path forward to Phase 2 by 01/11/11; if

authorized, the procurement process for the Phase 2 award will occur between 01/15/11 and 09/30/11; and the cooperative agreement for final design and licensing will be awarded by 09/30/11.

A break was declared at 2:25 p.m. The meeting was called back into session at 2:40 p.m.

Rebecca Smith-Kevern was asked to describe the NE University Program. Dr. Ahearne requested that Ms. Smith-Kevern briefly summarize her presentation as some members departed early as a result of inclement weather.

NE University Programs have two components. The University Research and Education component has a direct link to the NE program. It supports research and development, infrastructure improvements, and human-capital development through research participation. The Integrated University Program supports basic nuclear science and engineering scholarships and fellowships.

The University Programs' goals are to support outstanding, cutting-edge, and innovative research at U.S. universities by funding creative research ideas that can potentially produce breakthroughs in nuclear reactor technology; attracting the brightest students to the nuclear professions and supporting the nation's intellectual capital in nuclear engineering and relevant nuclear science, such as health physics, radiochemistry, and applied nuclear physics; integrating R&D at universities, national laboratories, and industry to revitalize nuclear education; improving university and college tools for conducting R&D and educating students; and facilitating the transfer of knowledge from the aging nuclear workforce to the next generation of workers.

The total FY09 appropriation for NE's university support was $75.7 million. Of that, $64.7 million went to funding university research and education programs, about $6 million went to university infrastructure, and $5.0 million went to the Integrated University Program. Sixty-two 2- or 3-year, mission-specific R&D projects were awarded $39.5 million; seventy-six 1-year, $5000 undergraduate scholarships totaled $375, 000; thirty 1-year infrastructure grants were awarded $6.25 million; nine 3-year, mission-relevant R&D projects up to $600,000 were awarded; and fifteen 3-year, $150,000 fellowships totaled $2.7 million.

The NE University Programs (NEUP) followed a three-step selection process: (1) semi-blind merit review with the goal to achieve a mix of reviewers for each application, (2) proposal selection based on merit-review scores and available funding in task, and (3) a balancing review to ensure participation by minority institutions, geographic distribution, and funding limits per proposal. In the semi-blind merit review process, the reviewers were initially provided project narrative that excluded identifying information and then given information on team capabilities and budget available. The final two questions of the review were based on detailed capabilities and budget files. The initial evaluation responses could not be modified once detailed information was revealed.

In FY10, about 70% of the funding will be devoted to NE mission-related R&D, about 30% to infrastructure, and $5 million to scholarships and fellowships. Gen-IV is the big winner with $35.09 million.

For the FY10 R&D solicitation, a request for pre-applications was published Oct. 9, 2009; pre-applications were due Nov. 10, 2009 (600 were received); the request for full proposals was published in December 2009; full proposals are due in January 2010; 43 to 45 R&D selections will be announced in April 2010; and a NEUP workshop for

university feedback will be held in July or August 2010. For the scholarships and fellowships solicitation, a request for applications will be published in early January 2010; the FOA for universities and colleges to administer NEUP scholarships and fellowships will be published in January 2010; student applications are due in February 2010; and scholarship and fellowship selections will be announced in April 2010. For the infrastructure solicitation, the FOA will be published in January 2010; applications are due in March 2010; the review process will be completed in April 2010; and selections will be announced in May 2010.

NE expects to do more of the same in FY11 and will seek R&D on light water reactor sustainability, modernize classrooms and laboratories and support curriculum development, and provide $5 million for scholarships and fellowships.

In summary, NE strongly supports university programs by supporting mission-related R&D that emphasizes integration between universities and the national laboratories; by continuing to support university scholarship, fellowship, and infrastructure needs; and by collaborating with NRC and NNSA to promote basic nuclear science and engineering education and R&D for the nation's needs. The bottom line is that universities are playing a significant role in supporting NE program goals.

Juzaitis stated that faculty members are concerned that the research program makes them subcontractors to the national laboratories for applied technology. They need research that they can publish for tenure. Corradini said that the Department has done a great job rolling this program out. Such a large resource has to be carefully watched over, requiring some deliverables. The faculty members have to be careful what they propose. The work they do will be what they propose. Smith-Kevern said that the Office has heard that comment before and is now seeking mission-relevant topics as well as mission-specific topics. Miller said that the Office had tried to use these new terms but did not have enough time to provide good guidelines for the faculty members. This effort is a work in progress. DOE is not the National Science Foundation (NSF); there are appropriate restraints on what DOE can fund.

Martin pointed out that the Policy Subcommittee finished its work last year. He asked John Ahearne to address the Technology Subcommittee's work.

Ahearne said that he was pleased to see so many of the topics identified by the Technology Subcommittee reflected in the activities of NE. The infrastructure investments seem to have gotten postponed, however. Four subcommittees have been proposed. The subcommittee subjects and the chairs are

Nuclear reactors	Corradini
Fuel cycles	Richter
International	Sessoms
Infrastructure	Ahearne

Chuck Wade noted that task statements would have to be developed and approved and that he would take the lead on getting them prepared.

Miller pointed out that, relatively soon, a task force is needed to conduct the NGNP review. Ahearne pointed out that this is a report to DOE that needs to be approved by NEAC. O'Connor said that that is correct; DOE will forward it to Congress.

Corradini asked if the subcommittees will see the proposals before or after selection. O'Connor said that they will see them after the selections; therefore, there will be no secrecy concerns.

Cochran requested that the meetings of these subcommittees be publicized ahead of time and that all members of NEAC be cordially invited.

Paperiello asked about the gas-cooled reactor and whether all radioisotopes were looked at or just some. O'Connor replied that the post-irradiation tests are just now being designed. Paperiello said that he was concerned about carbon-14 production. He asked if only NE funds universities or whether other offices also support universities. Miller replied that NNSA supports universities, and the Office of Science (SC) has a huge program for universities. Paperiello pointed out that there are few nuclear engineers, health physicists, and radiochemists being produced

Corradini said that the radiochemistry program of DOE is now being handled by NRC. Smith-Kevern agreed. Corradini said that universities have no interest in these topics and the disciplines are disappearing.

Juzaitis stated that Texas A&M is moving its health physics program to the medical school. Paperiello pointed out that physicists in medicine are the highest-paid group of physicists in the United States.

Sackett asked if there has been much discussion of a strategy for licensing in the development of high-temperature, gas-cooled reactors and said that he sensed and appreciated a new spirit with the new leadership.

Ion said that the university interaction is fascinating. It took the United Kingdom 10 years to recover from the shutdown of modules in nuclear topics. Students are now re-engaging universally. With the attention given to Copenhagen, everyone is going to be looking seriously at nuclear power.

Fertel commented that good leadership had been seen at NE for the past four months, and the staff is engaged and spirited.

The floor was opened for public comment. **Edwin Lyman** of the Union of Concerned Scientists stated that reactors that use natural uranium or LEU (e.g., the traveling-wave reactor) should be developed, reducing the global need for enrichment-facility expansion. The advocates of reprocessing have had a long opportunity for achieving it and have failed. Resource utilization needs to be pursued in different ways, such as considering the efficiency of fuel utilization. Increased burnup makes possible reactors with high internal conversion and long-lived cores. Given the absence of a long-term repository, the safety and security issues associated with extended storage of spent fuel at reactor sites should be investigated. Despite years of preparation, DOE cancelled a research program at Sandia National Laboratories to address the source term of a sabotaged cask before that program could accomplish its objective; such a test should be completed. Quantification of proliferation resistance of fuel cycles is a pointless task. In developing metrics of nonproliferation with probabilistic risk assessment, the weakest part is always human-reliability analysis and the ability to model operator actions. Most probabilities derived are suggested by and based upon reactions to crises or upon deliberative actions (e.g., theft or diversion), neither of which is capable of having a probability assigned.

Lyman requested that a full formal statement from the Union of Concerned Scientists be included in the minutes of the meeting, and it is attached hereto as Appendix A.

In conclusion, Martin noted that there is an excitement in the Department. The job is astoundingly difficult, and the staff members are stressed. He complimented the efforts of the designated federal official (DFO, Chuck Wade). Miller echoed the appreciation of the DFO and added that NEAC is spirited, also. The Secretary has also expressed his respect for the Committee.

There being no further business or public comment, the meeting was adjourned at 3:41 p.m.

Mindful of an impending snowstorm that eventually shut down the city and the airport for two days, several Committee members excused themselves from the meeting early: Bhatnagar left at 12:00 p.m., Sessoms at 1:22 p.m., Christensen and Richter at 2:25 p.m., and Juzaitis at 3:30 p.m.

Respectfully submitted,
Frederick M. O'Hara, Jr.
Recording Secretary
Jan. 12, 2010

Appendix A

Union of Concerned Scientists Statement for Public Comment Period
DOE Nuclear Energy Advisory Committee Meeting
December 18, 2009

Edwin S. Lyman, PhD
Senior Staff Scientist

The Department of Energy needs to restore balance to its nuclear energy research and development program. Over the last ten years, the program (with the exception of the Next Generation Nuclear Plant, which has its own separate Congressional authorization) has focused almost exclusively on closed fuel cycle systems, and has essentially ignored the development of technologies that could improve the once-through cycle. These include:

a) *Reducing the need for uranium enrichment*

Uranium enrichment is one of the most proliferation-prone stages of the nuclear fuel cycle. Although the most commonly deployed nuclear reactors – light-water reactors – require enriched uranium, it is possible to use natural (unenriched) uranium in other types of reactors. Such reactors actually utilize uranium more efficiently than those that use LEU. However, the currently available designs, such as the CANDU, have other features that are undesirable, such as generation of a relatively large volume of spent fuel and positive moderator void coefficients. Unfortunately, there has not been a significant government-sponsored effort to improve the designs of natural uranium-fueled reactors or reactors that use very low levels of enrichment. For example, the traveling-wave reactor shows promise, yet it is being developed only by a private venture. This is an area of research with a potentially very large payoff --- the ability to advance nuclear power without also requiring a large expansion of enrichment capacity around the world. Part of this effort should also include studies to increase the feasibility and safety of extracting uranium from more exotic sources, such as seawater.

b) *Improving fuel design to achieve high burnups*

Current fuel types for light-water reactors have run into difficulties when irradiated to high burnups. The materials for both fuel and cladding undergo degradation that can have a negative effect on reactor safety. This is unfortunate, because increasing fuel burnup can have significant advantages. In particular, if burnups can be increased, then high internal conversion reactors with long-lived cores become more feasible. (Increasing burnups for existing light-water reactor designs, however, is of limited benefit in increasing uranium utilization efficiency.) However, the R&D needed to solve these problems is time-consuming and expensive. There are currently severe limitations in the ability of both industry and the national labs to carry out the safety testing needed to

improve these fuels. Capital investments in new hot-cell facilities and a renewed effort to identify innovative materials and designs are badly needed.

c) *Sabotage testing for environmental studies*

In the absence of a geologic repository in the near term, spent fuel may have to be stored at reactor sites for a longer period of time than anyone originally anticipated. In order to provide the necessary level of public protection over this period, additional research into the safety and security of on-site dry storage is needed. For example, the potential release of radioactive material ("source term") from terrorist attacks on spent nuclear storage casks has never been experimentally validated. A research program at Sandia National Laboratories to address this very question was cancelled by DOE before it could complete its work. This project deserves a restoration of funding so that technical resolution of these questions can be accomplished.

d) *Common-sense appraisals of proliferation resistance*

One area where more R&D funding is **not** needed is the effort to quantify and rank the "proliferation resistance" of various fuel cycle systems. DOE and other organizations have spent years on this fruitless task but have not come up with a useful methodology. (One exception is the Los Alamos-led study of the "attractiveness" of the materials separated by various reprocessing techniques, a determination based on a set of intrinsic material properties.)

DOE's proposal to use probabilistic risk assessment (PRA) in proliferation resistance analysis is a step in the wrong direction. The weakest part of any safety PRA is the human reliability analysis, which attempts to create mathematical models of intrinsically uncertain operator behavior and response under crisis. PRA-type analyses of diversion and theft scenarios would be even less credible because of the impossibility of quantifying the likelihood of intentional, malevolent actions. The difficulty of this task would be compounded by the fact that these actions can be modified to adjust to the evolution of a particular scenario, introducing complex feedback mechanisms.

Instead of trying to create more and more complex quantitative models, DOE should simply acknowledge the common-sense truth that the once-through cycle is by far the most proliferation-resistant system, and refocus its R&D effort on programs to make once-through as safe, secure, efficient, and cost-effective as possible.