Nuclear Energy Advisory Committee
December 9, 2010
L'Enfant Plaza Hotel
Washington, D.C.

Committee Members Participating

John Ahearne
Ashok Bhatnagar
Dana Christensen
Thomas Cochran
Michael Corradini
Marvin Fertel
Donald Hintz
Raymond Juzaitis
William Martin, Chair
Carl Paperiello
Burton Richter
John Sackett
Allen Sessoms
Neil Todreas

Committee Members Absent

Brew Barron
Susan Ion

Other Participants:

Richard Black, Director, Office of Advanced Reactor Concepts, Office of Nuclear Energy, USDOE
Nancy Carder, Medical University of South Carolina, NEAC Support Staff
David Hill, Director, Institute for Nuclear Energy Science and Technology, Idaho National Laboratory
Shane Johnson, Chief Operating Officer, Office of Nuclear Energy, USDOE
Marsha Lambregts, Deputy Director, Institute for Nuclear Energy Science and Technology, Idaho National Laboratory
Alexander Larzelere, Deputy Assistant Secretary for Fuel Cycle Management, 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
Frederick O'Hara, Medical University of South Carolina, NEAC Recording Secretary
Carter "Buzz" Savage, Director, Office of Fuel-Cycle R&D, 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 committee members received their annual ethics briefing from a member of the Department of Energy (DOE) General Counsel's Office.

The meeting was called to order at 8:59 a.m. by the Chair, **William Martin**. **Kenneth Chuck Wade** made safety and convenience announcements and noted changes in the agenda.

Peter Lyons was asked to update the Committee on the activities of the Office of Nuclear Energy (NE). Assistant Secretary for NE Warren Pete Miller retired to San Jose; he left the Office in better shape than when he arrived. As a result of Miller's retirement, there have been substantial changes in the leadership: Lyons is now the Acting NE-1, Shane Johnson is the Acting NE-2, Dennis Miotla is the Acting Chief Operating Officer, Monica Regalbuto is the Acting Deputy Assistant Secretary for Fuel Cycle Technologies, John Herczeg is the Acting Associate Deputy Assistant Secretary for Fuel Cycle Technologies, John Kelly is the Deputy Assistant Secretary for Nuclear Reactor Technologies, and Robert Boudreau has been named Ed McGinnis's assistant.

The NE University Programs' funding in FY09 and FY10 was $110 million; this year's allocation has been awarded to 66 universities in 32 states. In FY11, the pre-application phase for R&D has been finished; the number of applications is going up. Infrastructure awards have been started to rebuild infrastructure in universities and nuclear-engineering departments. There is a new element for FY11 Program-Directed Research for teams of universities in the areas of fuel cycles and reactors. This area has the largest program relevance. They are substantially larger, long-term research projects.

In FY11, integrated research projects (IRP) will be solicited on developing an advanced thermal reactor concept and experimental testing capabilities for accelerated aging of used nuclear fuel in storage (dry casks). This is an experiment; nothing is being cut.

In the international area, a trilateral memorandum of understanding (MOU) on developing fast reactors has been signed with France and Japan. It will allow U.S. engagement at Phenix in France and the fast reactor cycle technology development (FaCT) project in Japan, giving the United States access to research facilities in those countries, and it ties into a possible restart of the Transient Reactor Test Facility (TREAT) reactor at Idaho National Laboratory (INL). The International Framework for Nuclear Energy Cooperation (IFNEC) follows Global Nuclear Energy Partnership (GNEP) and is a substantial investment of resources. This is an opportunity to bring together countries interested in developing nuclear-energy capabilities. The U.S.–Russia Nuclear Energy and Nuclear Security Civil Nuclear Energy Working Sub-Group is defining agendas and working plans, and the Section 123 (of the Atomic Energy Act) agreement with Russia has recently been ratified.

A continuing resolution has been passed to provide funding. Part of INL's activities are funded by the Department of Defense (DoD); a continuing resolution provides $769 million for the coming year. This would be a decrease of $55 million from the request. There is also a reduction in the $18 billion loan program. $8.3 billion went to the Vogel plant in Georgia, leaving $10 billion; a continuing resolution would increase that authorization by $7 billion. New starts are not allowed except as specifically approved by Congress [e.g., small modular reactors (SMRs)]. Corradini asked if the Department had to go back to each committee. Lyons did not know if it would be on the basis of the Department or the Office; the prior approval in the House and Senate marks may suffice.

The Nuclear Energy Summit was held on December 7, 2010. It was cohosted by Senators Voinovich and Carper and organized by Third Way. Secretary Chu, Carol Browner, and Nuclear Regulatory Commission (NRC) Chairman Jaczko were among the speakers.

Cochran asked where the infrastructure funding was. Lyons replied that it is 20% of the R&D budget.

Richard Black was asked to review activities in SMRs. DOE has been working on SMRs for 2.5 years because the Air Force asked for SMRs to power air force bases.

A white paper was written to potential SMR vendors, who pointed out that such reactors would be attractive to utilities. A range of designs surfaced. The light-water reactor (LWR) SMRs are defined as 300-MWe or less (by the Atomic Energy Act). Westinghouse, mPower, and Nuscale are working on near-term LWR designs. It is a well-understood technology and has garnered commercial interest. The South Koreans may beat the United States to market, but the NRC's stamp of approval is the gold standard. DoD is partnering with DOE to advance SMR deployment at DoD sites.

Richter pointed out that DoD has all sorts of naval reactors, and asked why they did not have any highly enriched uranium (HEU) reactors for DoD land installations. Black replied that there are good reasons (e.g., proliferation) for them to be ruled out of land deployment. There is R&D funding in the budget. It will be focused on the SMR advanced reactor concept (fast and gas reactors). This work will be informed by the recommendations of the President's Blue Ribbon Commission on America's Nuclear Future.

The plant design will be based on 12 modules acting independently. It is a simpler, safer design that should bring some regulatory relief (e.g., the need for a fire brigade). The NRC is putting on a workshop on this topic during the week following this meeting. There is a working one-third-scale test system at Ohio State University.

Corradini commented that this is the equivalent of NP2010; policy decisions would need to be worked out, requiring funding. Black replied that vendors had been talked to. They did not have a long list of needed R&D. The regulatory issues are huge; resources will go to that. Lyons added that some decisions will have to be left to the NRC. Some decisions will have a technical nexus that DOE may be able to help inform. Sackett asked if there were any potential for DoD partnering in prototyping. Black answer, yes; there is interest in the Defense Advanced Research Projects Agency (DARPA). DOE is working with them. DARPA has put out a request for information (RFI) and has set up a committee to look at the design concepts that RFI elicits. Richter asked if there had been talks to see if DoD will be a customer for SMRs. Black responded that there has been a DoD–DOE working group looking at deployment of SMRs at Air Force bases and at a Tennessee Valley Authority (TVA) site on the Clinch River in Oak Ridge, Tennessee. They are open to working with industry to produce deployments. A number of mechanisms for partnering are being put in place.

One design being considered is the Babcock & Wilcox (B&W) mPower's 125-MWe plant with a 60-year plant life that accommodates air-cooled condensers as well as water-cooled condensers. Design certification will be sought in the fourth quarter of 2012.

The drivers for SMRs are a carbon-free energy source, domestic manufacturing jobs, and global competitiveness. Utilities are looking at SMRs because they have aging fossil plants that need to be replaced with non-emitting baseload electricity. DOE has a mandate to reduce emissions 28% by 2020 and 83% by 2050; that cannot be done simply with biofuels.

NE has been talking with manufacturers. They see nuclear energy as a growing industry. Assembly line replication optimizes cost, schedule, and quality through greater standardization of components and processes. The "skill of the craft" is there, also. If DOE and DoD projects produced a backlog of orders, manufacturers could ramp up their supply chains. Several activities are underway to do just that. "Plug and play" economies include prefabrication; optimizing on-site construction schedules and quality; and NRC inspection at the factory (ITAAC: Inspections, Tests, Analyzes, and Acceptance Criteria), reducing on-site inspection. (The latter constitutes a manufacturing license.) The hope is to get construction time down to 2 to 3 years.

Corradini asked who the competition was for SMRs. Black replied that it is natural gas. DOE commissioned Argonne National Laboratory (ANL) and the University of Chicago to look at SMR economics to assess SMRs on a $/kW basis and on levelized construction over time. Martin asked how real this was from a utility perspective. Hintz replied that all utilities would love small reactors. One bets the utility every time one builds a big reactor, and transmission losses for centralized big nuclear plants are large. Gas is a problem right now; its price is uncertain.

If one believes the forecasts of the price of natural gas, one has to defend nuclear energy some other way (e.g., as non-emitting). A lot of costs would be lower with smaller units. Martin pointed out that U.S. natural gas prices are lower than European natural gas prices. The United States may even become an exporter, although Congress may bar such exports. Fertel stated that DOE needs to go forward with these studies. The date being talked about is 2020. No one can get gas prices right for 2012, let alone for 2020. Studying the economics of SMRs, one needs to have the design done; without the design, one cannot get the production costs right. Richter pointed out that this situation involves the Office of Management and Budget (OMB), NRC, and DOE. One will not know actual costs until a few of these reactors are built. One needs to get the policy issues settled now and to set up a working group to get over them.

Paperiello pointed out that operations and maintenance (O&M) costs, such as testing, surveillance, and safety, need to be factored in. One has to account for NRC regulations and licensing procedures. Black said that these cost comparisons are made easier by the simplicity of design. What he was talking about was a comparative study of the options. Lyons added that the Office was regarding its role as making the cost projections acceptable to industry.

Cochran said that one cannot do enough cost studies to get capital costs down. The government's role here is the same as in the NP2010 program. A different approach is needed: assessing the long-term purchase-power price. One has to put some risk back on the developer and to take it off the government.

There is a large international market, and it is in the government's purview to enhance export trade. DOE's SMR program will support financial assistance partnerships with industry with a goal of certifying, licensing, and deploying at least two LWR-based SMRs; a research, development, and demonstration (RD&D) program that supports the licensing and deployment of both near- and long-term SMR designs; and a domestic fleet manufacturing capability.

Cochran asked why DOE should pay the licensing costs. Black replied that, if one is going to meet the greenhouse-gas reduction goals, there has to be some government role and assumption of risk and cost sharing in licensing.

There are five areas of technical focus:

- Instrumentation and control/human machine interface;
- Assessment methods;
- Materials, fuels, and fabrication technologies;
- Regulatory technology support; and
- SMR advanced concept evaluation with an early focus on co-generation and load-following capability.

There is significant interest in SMRs on the Hill: DOE asked for $40 million for FY11, and the House bumped that up to $55 million and the Senate to $50 million.

The technology push by NE consists of support for a public–private partnership program that will accelerate commercialization of at least two LWR SMR designs through cost-share first-of-a-kind (FOAK) development and licensing activities. The technology pull by DOE and DoD consists of the agencies' entering into power purchase agreements (PPAs) for low-greenhouse-gas electricity produced by SMRs (with seed money paid back over 11.5 years). For a $350 million investment, the return on investment over 30 years would be more than $1 billion, a good proposition. TVA wants to go forward with deployment by 2020 under Part 50 with government cost-sharing.

Korea is moving quickly on its Smart reactor. They will get regulatory approval by 2012 and deployment by 2013. This is a huge market; the United States does not want to lose the lead to that market.

Ahearne said that there have been a lot of discussions of DOE's inability to maintain a long-term project. Working with DoD mitigates this concern.

A break was declared at 10:37 a.m. The meeting was called back into session at 10:50 a.m. Martin asked the Committee for comments on the morning's presentations.

Christensen's concern about SMRs was that there are a lot of unknowns: costs, licensing issues, DOE's programmatic endurance, and FOAK costs being borne by overseas agencies. The agency needs to work more quickly.

Paperiello said that his concerns about deployment had been satisfied. A real design that the NRC can deal with is needed, and what licensing procedures are going to be used needs to be clarified. No matter how much experience there is, a new design can fail. He cautioned that this process will take time.

Bhatnagar said that the issue on policies is topped by the security requirements. The choice of using Part 50 versus Part 52 is not a concern now; the regulations will all be met; the difference between the two parts is *when* they are met. The focus on standardization will not change.

Corradini said that there are other issues: staffing and energy planning. The Nuclear Energy Institute (NEI) is talking with the NRC about these issues. Anything with a 10-year horizon has to have government involvement. If it is desirable for the United States to have a technical lead, the government has to be involved, especially at the nexus of science and policy. Seismic issues will dominate at such a small footprint as an SMR has; base isolation is needed. Cross-cutting technologies may lead to better investments.

Richter said that SMRs present an exciting opportunity for DOE. DOE should pull together a multi-agency group to see how to get from here to there (i.e., to the point where someone lays down money to buy one). DOE, OMB, NRC, and DoD (inter alia) need to work together. FOAKs have a tradition of

huge cost overruns that make industries skittish; the government is concerned with economic competitiveness and national security. DOE has to go beyond DoD and get other players involved.

Fertel said that the reorganization, staffing, and budgeting of the Office are well received. The job right now is not economics but getting enough information about the energy market and the value of SMRs.

Todreas commented on the international sodium fast reactor. The French and Japanese are moving to oxide fuels. The United States is interested in metal fuels; the nation will need to reorient DOE and the national laboratories to have an impact. The inclusion of blue-sky R&D in the budget is very important. The conduct of reviews has been the focus of concerns from universities for many years; those concerns are being addressed by the Office, as will be described later in the meeting. He worried about the endurance of the nuclear re-emergence. Parents of students believe in nuclear energy, but SMRs need to be done in a smart fashion to justify that belief. The number of plants ordered and their timing is the essence of the economics of production. That fact needs to be reflected in the economic report.

Sessoms said that economic studies are nice, but the ultimate costs are never known. Policy has to be the driver. The players in the U.S. Government have to be pulled together to compete with South Korea. Congress should free up some money in response to policy drivers. One has to sell stuff to make jobs.

Juzaitis said that academia needs a nuclear program to attract good students into the field, ones who hold the promise of the country's future. Nonproliferation, real or perceived, is the most important issue for the development of nuclear energy. If the National Nuclear Security Administration (NNSA) is allowed to dominate nonproliferation discussions, there will be great security costs. A framework should be established for the scientific assessment of proliferation risk. This issue permeates international dealings and SMRs.

Cochran stated that the Office's priorities are badly out of whack. The nuclear economy will be based on LWRs for hundreds of years, but DOE's R&D is heavily weighted on fuels. One needs to focus on capital costs. Others besides the government have to be willing to put up money. The costs cited for SMRs are 13 cents per kilowatt in a 5-cent-per-kilowatt market, killing the SMR concept. The United States should look for international partners and long-term power-purchase agreements, which would ameliorate the unit costs but not address the capital costs, which may be driven down by replication.

Sackett was encouraged by the change in direction brought about by the new leadership. Technical leadership in government has made DOE of more interest to other agencies. A consistent direction must be established. If NE can make the case for a given direction for an extended term, that is the right thing to do. University support is essential. Energy is central to the major challenges of this century. SMRs fit well with the United States' technical capabilities that are left, it offers a leap forward. SMRs are not your grandmother's reactor, and they gain public support. They can follow the load and make energy when the sun does not shine.

Hintz said that the presentation on SMRs was very good. He supported the view that they offer a window of opportunity that should be exploited in concert with other government agencies. It is all about safety in economics.

Lyons stated that DOE is trying hard to build coalitions with other government agencies. Within DOE, NE has built bridges with other offices. There are many siting opportunities for energy parks; Hanford may be one. Finland did not have a final design or regulatory approval when it launched its program. The focus of the NRC on a complete design would help avoid the Finnish situation. Nonproliferation should be and will be a central focus of the Office and of the Department. The SMRs offer the United States an opportunity for substantial progress in nuclear energy leadership and are the most exciting opportunity, both domestic and international. The United States must stay where it has a strong knowledge base for SMRs. Its best chance is to stay with the LWR concept. There are still uncertainties in security and operational costs. The companies understand that they have an opportunity to start anew in security design (e.g., underground siting). Industry should start with the point that the

design-basis threat can be met and transient upsets can be controlled. DOE could research material properties, instrumentation and controls, etc. The vendor has to convince the NRC that there is not a common-mode failure possibility so these installations can be regarded as individual plants. The majority of regulatory questions will be a blend of policy and technical issues. DOE should help NRC on a technical basis and let NRC translate that into a regulatory basis. A lot of groups worked together to make NP2010 a tremendous success and an enduring program.

Martin stated that some upside to nuclear power has to be able to be offered to the world. He pointed out that Daniel Poneman had written the NEAC policy report that called for steadiness; it is an issue of national security, economy, and environment. NE's role is important to other agencies and to the world.

Marsha Lambregts was asked to review NE's University Programs (NEUP).

Under the NE University programs, there were 128 R&D proposals submitted in FY10, of which 42 were awarded. 29 awards went to first-time principal investigators, and 20 to junior faculty. Awards were made to 26 universities, 20 had laboratory partners, and 8 of those universities were receiving awards for the first time. Four awards for a total of $3.75 million were made for major reactors; 12 awards for $1.95 million were made for minor reactors. 33 awards totaling $7.47 million were made for general scientific infrastructure.

Scholarships were awarded to 85 students for a total of $425,000. Fellowships were awarded to 32 students for a total of $4.6 million. The NE fellowship program is compared with similar programs run by the NRC and NNSA to look for synergies. $76 million plus $5 million for scholarships is anticipated in FY11.

The program-supporting component is about 50% of the funding. Review weighting is 35% relevance and 65% technical quality. The mission-supporting (blue-sky) component is approximately 30% of the program. Review weighting is 20% relevance and 80% technical quality. The blue-sky R&D is conducted in nuclear physics, health physics, radiochemistry, and nuclear chemistry.

There are some improvements in 2011:

- Expansion of blue-sky for R&D
- Integrated research projects
- Expansion and improvement of the peer review data base (reviewers now have to be certified)
- Enhancements to fellowship and scholarship criteria
- Adoption of the NRC and NNSA metrics, as appropriate to NEUP
- Peer review at the pre-application stage for R&D

Corradini asked whether conflict-of-interest concerns with the review certification process would shrink the reviewer pool. Lambregts replied, no. A group of peers looks at potential reviewers' competencies in the fields that they will review.

The FY11 NEUP review process includes request-for-pre-application (RPA) 3-pagers that go through a relevancy panel and a peer-review panel. The scored proposals will go to recommendation panels, whose recommendations go to the source selection official. Proposals selected by that official are invited to submit a full proposal; those who are not invited may submit a full proposal, if they wish.

Richter commented that peer-review processes are highly risk averse; they limit innovation.

Corradini asked whether a basic goal had been set for how many of the 800 pre-proposals would be invited to submit a full proposal. Lambregts said that 2 to 3 times the number of proposals that are expected to be funded will be invited.

Juzaitis stated that the comments that come back from the peer reviewers have to be clear why the proposal was rejected. Corradini added that, if more review information were provided, there would not be a flood of submissions of rejected proposals.

Lambregts pointed out that scholarships and fellowships have a long panel-review process.

In summary, NEUP engages universities to conduct program-directed, program-supporting, and mission-supporting R&D; infrastructure improvements; and scholarships and fellowships. Through NEUP, DOE-NE has competed $110 million of funding in 32 states at 66 universities since 2009. There

were several important changes for FY11 (review structure, reviewer database, and IRPs). A new solicitation to support program-directed work (integrated research projects) will be issued in FY11.

Todreas said that the move to a blind review process frustrated proposers by not allowing reference to prior work.

Lyons said that this is an outstanding program. There *is* a built-in bias that favors risk aversion.

Richter noted that a prior review of the program had recommended that fellowships be allowed to extend to 4 years on a special-case basis. Lambregts responded that that issue has been discussed. The application has been limited to first- or second-year graduate students. They have to express their research interests (which have to be mission-oriented). They are also asked to do a one-year internship at a national laboratory or at NE. Richter pointed out that the recommendation said that, "in exceptional cases," the fellowship should be extended to 4 years. He asked whether that recommendation should be accepted or rejected Lambregts responded that other sources of funding will likely be available to fellows for long-term research. Juzaitis noted that the fellowship programs are not predicated on mission relevance.

Lyons stated that the program did a terrific job and contributed greatly to the Office's work. A break for lunch was declared at 12:23 p.m.

Afternoon Session

The meeting was called back into session at 1:13 p.m. John Ahearne explained where the Committee's subcommittee structure and operations stood. Richter's Fuel Cycle Subcommittee is continuing. There are three new subcommittees: one on reactor technology (mandated by Congress), one on international efforts, and one on facilities.

Michael Corradini was asked to report on the Next-Generation Nuclear Plant (NGNP) Phase I Review conducted by the NEAC Reactor Technology Subcommittee.

Under Subsection (b)(1) of the Energy Policy Act (EPAct), the Secretary was to request NEAC to conduct a comprehensive review of the NGNP Project and to report to the Secretary the recommendations of NEAC concerning whether the Project is ready to proceed to the second project phase.

The first phase is to

- Select and validate the appropriate technology under subsection (a)(1);
- Carry out enabling research, development, and demonstration activities on technologies and components under paragraphs (2) through (4) of subsection (a);
- Determine whether it is appropriate to combine electricity generation and hydrogen production in a single prototype nuclear reactor and plant; and
- See if the project is ready to move on.

The scope of work for the review is to report on the market case and public–private partnership, status of NGNP licensing activities, status of industrial infrastructure for NGNP, and status of the R&D program and international efforts; review the conceptual design reports; and assess readiness to move into Phase II.

Two 2-day meetings were held. The first reviewed the charge, the draft review criteria, and the project requirements to successfully proceed to Phase II. It also reviewed the background of the NGNP project since its inception; considered the project from the perspective of potential customers and commitment; looked at the market case for the NGNP project; and studied the current design specifications for the NGNP project.

The second meeting looked at the NGNP program plan, which includes all Phase II activities, decision points, time schedule, cost estimates, and needed products. It also looked at the NGNP licensing strategy with input from NRC. The program plan is the key element to provide a clear understanding that should encompass all Phase II activities.

Two parts of Phase I work are to select and validate the appropriate hydrogen-production technology and to determine if it is appropriate to combine electricity and hydrogen production in a single prototype nuclear reactor and plant. After much discussion, the Subcommittee found that the NGNP role to produce hydrogen has been expanded by a broader role to produce process heat for a variety of applications (including hydrogen production). It also found that process-heat applications are more general in scope and can significantly expand the market and improve the business case.

Richter noted that the original NGNP had a 950° C. temperature requirement and that new hydrogen-production processes are more energy-efficient. He asked if that aspect had been discussed. Corradini replied, no. The design point is flexible. Hill said that the iodine salt process required 952° C, but high-temperature electrolysis is scalable to a lower temperature. A 750 °C design point lowers the technical risk.

The third part of Phase I activities was to carry out enabling RD&D activities on technologies and components. The Subcommittee will review this aspect in early 2011. On the basis of an overview, the Subcommittee sees no impediments to the project.

The fourth part of Phase I activities is to carry out initial design activities for a prototype nuclear reactor and plant, including development of design methods and safety analytical methods and studies. The Subcommittee found that Phase I design activities were unfinished, and the NEAC Subcommittee is still to review the remaining design in early 2011.

The EPAct specified that the prototype nuclear reactor and associated plant were to be sited at INL. However, the business case to optimize NGNP use for process heat applications and electricity indicates that a site in proximity to a wide range of industrial uses is more appropriate. A site at INL will not support a partnership agreement with industry as required by EPAct. This situation would require a change in the law. DOE was to develop a licensing strategy to use the 10CFR52 process and submit a combined operating license (COL). This process is well under way. The Subcommittee believes that such an approach requires a sufficiently detailed design so that the COL can be submitted to the NRC in a timely fashion. However, given the limited scope and duration of the current conceptual design activities, it seems unlikely that any vendor could complete a sufficiently detailed design to obtain a license for an NGNP without a partnership in place with the vendors as part of that team. The partner needs to be working up front with DOE early on.

EPAct-2005 directed the DOE to have INL organize a consortium of appropriate industrial partners that will carry out cost-shared research, development, design, and construction activities and operate facilities on a 50/50 cost-shared basis. Currently, there is no public–private partnership in place to carry this project forward. Also, no potential customer has indicated a willingness to commit to share in the cost of construction of a FOAK NGNP at the currently requested 50/50 cost share on an annual basis (as interpreted by OMB).

The DOE has developed a project plan for the Phase II activities. The plan would issue a call for a public-private partnership to be formed by the end of FY12. This approach would mean that any additional detailed design activities would occur after the partnership is formed and a cost-share is determined. A couple of years will pass with no design activities. Given the absence of a partnership and the limited amount of conceptual design work that will be completed, it does not appear that a COL can be submitted by September 2014 or construction completed by 2021.

At this time, the project is not ready for a decision to proceed to authorization of the complete set of Phase II activities. However, the Subcommittee considers that it would be practical to proceed with a portion of the Phase II activities. The Subcommittee believes that NE should continue supporting the development of the NGNP at an appropriate level. It does not see a credible path forward within the constraints imposed by the 2005 EPAct and the current lack of potential vendors and customers. DOE-NE should:

- Revise the NGNP program plan to reflect the current situation,
- Accelerate the formation of a public–private partnership as soon as practicable to obtain end-user input into design activities and fund additional design activities to support this effort, and

- Continue to engage the NRC for necessary licensing activities to ensure that the regulatory framework for this new reactor technology is ready to support commercialization.

Martin noted that this is an intermediate report that needed no approval at this time.

Paperiello said that what was reported is just a process, not the nitty gritty review. American National Standards Institute (ANSI) standards are written into the regulations; there are no ANSI standards for a reactor operating at this reactor's temperature. There is a lot of work to be done.

Richter asked if there were a big overlap in the application of process heat between this reactor system and SMRs. Corradini said that it is still not clear what the design size of this machine is. Technically, there should be a big overlap.

Fertel asked what the Office was going to do about changing the program plan, given that the path that is being followed is no longer possible and that goals cannot be met. Lyons responded that this review is dictated by the EPAct. However, how the Office will respond to these findings is not known, yet.

Allen Sessoms was asked to review the activities of the NEAC International Subcommittee.

At meetings of the Subcommittee, the Department of State (Alex Burkhart) stated that NE-6 participation in State-led negotiations were an essential carrot that advanced U.S. interests. NNSA (Mark Whitney) stated that, in order to set a positive tone for nonproliferation discussions, cooperation in the peaceful uses of nuclear energy were a prerequisite and thus NE-6 participation as a "door opener" was necessary. The Department of Commerce (Sarah Lopp) stated that the absence of NE-6 from the table during discussions put U.S. companies at a significant competitive disadvantage when compared to other potential suppliers (who might bring their presidents to negotiations).

The problem is that NE-6 is not at the table because they are not funded to engage in these activities. The federal agencies have to bring a lot of others (e.g., universities) with them to the table. The extent of NE-6 international engagement without adequate funding is substantial but not nearly as effective as should be the case if they are to support President Obama's goals with respect to national security and domestic job creation. This has been a problem for more than a decade.

Overall, NE has international engagement with a huge number of countries. It has international arrangements with many countries and has bilateral working groups and action plans with about a dozen countries. International Nuclear Energy Research Initiative (I-NERI) projects can cost millions of dollars apiece. The United States has R&D agreements with several countries. Coordination with the Nuclear Energy Agency/Organization for Economic Cooperation and Development is very productive. The Generation IV Nuclear Energy Systems Initiative (Gen-IV) International Forum is still useful. IFNEC was launched at the President's Nuclear Summit. There is a lot of overlap among these forms of international cooperation and engagement.

DOE needs to know what it costs to do these types of engagement well. NE-6 staff are preparing estimates of reasonable costs per type of engagement as a function of time in order to be credible and effective in the international arena. Fertel has put together a list of "products" that industry would find helpful for DOE to present with them as a package and that would represent the U.S. Government's commitment to supporting industry export efforts (USA, Inc., or Team USA). The costs of these engagements will have to be estimated. To develop a foreign country's nuclear infrastructure, the United States has to train foreign nationals to run that infrastructure.

The Subcommittee, working with NE staff, will analyze which current engagements are important to promote and what type of additional commitments are likely to emerge in the near to medium term. One has to prioritize and cost this stuff. Based on this analysis, the Subcommittee will recommend in January that NEAC send a letter to Secretary Chu by the end of January requesting that he work with the other relevant cabinet officers to press OMB and the President to fund this activity at the appropriate level. In addition, the Subcommittee will seek to informally convene a meeting of senior-level U.S. Government officials [from, for example, the NRC, National Security Council (NSC), Commerce, State, Export–Import Bank, Treasury, and Office of Science and Technology Policy (OSTP)] and industry, or to inject itself into currently ongoing discussions, to consider how collectively they might more aggressively

support the President's goals of enhancing domestic job creation while improving the nonproliferation regime. NE has a central role in getting this done.

Lyons stated that the Office and Committee greatly appreciate the role that Carter Buzz Savage has played in shaping DOE's fuel-cycle work. [Round of applause.] Savage is retiring at the end of 2010.

Christensen asked if the Subcommittee had talked about how to save funds by exploiting the overlap of these different international committees. Sessoms replied that one first has to get different agencies to agree on the real priorities.

Juzaitis said that universities should not provide training; training should be by local people. Universities should be involved in research projects in other countries. NE should not become a promotive agency but should focus on concrete science and technical objectives. The United States and Russia would place vastly different costs and values on nonproliferation devices and processes. Sessoms observed that the United States produces people with bachelor's, master's, and doctoral degrees who are not job ready. Education is not training. The United States should help foreign countries *train* their people for industrial positions. The United States has to be out there marketing nuclear technology. These activities have to be funded, and they are important to long-term U.S. goals. DOE should promote these activities government-wide. Lyons pointed out that the Office is now trying to fund international activities. The Team USA approach would be very important. The extent to which the Subcommittee comes up a year from now with ways to catalyze the Team USA approach would be very important. Martin asked where NE can contribute to the Team USA approach. Fertel suggested that it could increase transparency in the government, apply the 123 Agreement openly, and put more emphasis on risky investments.

John Ahearne was asked to report on the Facilities Subcommittee. The Subcommittee met at Oak Ridge National Laboratory (ORNL) and INL to find out the facility requirements and availability. It will visit other laboratories and industrial sites.

At INL, the missions include

- Performing neutron-irradiation materials research with the Advanced Test Reactor (ATR)
- Deploying fuel-fabrication research and development capabilities
- Putting a world-leading post-irradiation examination capability in place
- Meeting transient testing needs for the United States and international research with TREAT
- Conducting advanced separations/waste-form research at laboratory scale
- Actualizing the hub-and-node approach

The ATR National Scientific User Facility was offered as a prototype for a facility where world-class research is conducted in partnership with the university community to further DOE-NE programmatic missions.

More than a half-dozen facilities were toured at INL, among which were:

- The Center for Advanced Energy Studies (CAES), a public/private partnership between INL and the State of Idaho that is affiliated with three Idaho universities, is a 55,000-ft^2, light-duty laboratory in the process of being equipped. This facility appears to be an excellent project for INL and will represent a face to the university public for research across multiple energy topics.
- The Advanced Test Reactor (ATR) is used for (1) materials testing and development of new naval reactor fuels, (2) development of alternative low-enriched-uranium (LEU) fuels for conversion of U.S. and foreign HEU-fueled reactors under the Global Threat Reduction Initiative (GTRI), (3) material testing and development of new fuels for civilian power reactors, and (4) limited isotope production. The material testing is primarily focused on nuclear energy systems to include structural material testing and nuclear fuel development. The reactor is an important asset for the Department, and the staff at INL is properly managing and maintaining the facility.
- The Materials and Fuels Complex is a large hot-cell suite within which work is performed on reactor fuel development, power source system assembly, pyrochemical separation chemistry research, and hot fuel examination. The hot-cells appeared to be in good working order, and the

complex was well maintained. This complex is a national asset. It appears to be managed as such and the work being performed appears to be appropriate for the laboratory and the NE program. The Subcommittee was not able to assess whether the volume of work fills the capacity for the complex.

The Subcommittee concluded that it should endorse the overarching objective of building and operating a suite of world-class nuclear-user facilities for fuel-cycle R&D at INL. The facilities that were visited appear to be well maintained and upgrades appear to be consistent with authorization-basis requirements. Some of the facilities (e.g., the ATR), appear to be fully subscribed, or nearly so, while other facilities (e.g., the hot-cell facilities) are clearly underutilized. The ATR appeared to be in excellent working order, and the life-extension program appears to be addressing aging challenges within the facility. This facility is a national asset for materials research and will be essential to the development of next-generation reactor fuels and materials. Every effort should be taken to assure that the ATR is maintained in fully working order for the long term. In summary, INL seems well on its way to becoming a world-class facility.

At ORNL, top leadership pointed out that, of the Laboratory's $1.5 billion per year funding, about one-half comes from SC. The other half comes from other energy-technology funders and NNSA . ORNL is the technology provider for USEC. Facilities are needed to get real data to validate the many codes now in use. ORNL is down from 13 nuclear facilities to 4 [plus the High Flux Isotope Reactor (HFIR)]; hot cells have been reduced from 10 to 4. The current funding for the remaining hot cells is inadequate and is not sustainable. They have used the Navy's nuclear program as a feeder for new people, but they are having trouble getting and retaining those individuals. The NRC provides $15 million, and about 8% of the budget comes from industry. ORNL's capabilities and infrastructure support major DOE/NE programs.

The Subcommittee toured a variety of facilities, including the

- Fluoride Salt Reactor Loop and Salt Melt Demonstration
- Irradiation Fuel Examination Laboratory (IFEL)
- Low Activation Materials Design and Analysis (LAMDA) Laboratory
- Tri-Isotropic (TRISO) Fuel Fabrication Laboratory
- Irradiated Materials Examination and Testing Laboratory (IMET)
- HFIR
- Radiochemical Engineering Development Center (REDC).

They use a fluoride salt as coolant and have looked at the pebble bed reactor and the high-temperature gas-cooled reactor as salt reactors. They have 700 °C output and aim at 1000° C. The Irradiated Fuel Examination Laboratory is able to examine full-length fuel rods; they do post-irradiation examination and have looked at the metal oxide fuel rods from Catawba. The capacity is currently under-utilized and has a problem in disposing of the residuals from examining commercial fuel. At the LAMDA, the criterion for materials is <60 mr/hr at 1 ft. This lab is fully utilized and customers include Naval Reactors (NR), NE, the Office of Fusion Energy (FE), SC, the International Thermonuclear Experimental Reactor (ITER) project, and Japan. The staff includes about 20 researchers and has workers from the United Kingdom, Russia, and Japan. HFIR provides a flux of $3–4 \times 10^{15}$ n/cm^2 and has four tubes for loading experiments. It is one of the last U.S. research reactors that use HEU; a plan would convert HFIR to LEU in 2019. The reactor is well-funded for the next 7 years.

These facilities together with hot cell facilities at INL are adequate to fulfill those basic research and development missions of DOE-NE that require hot cells. ORNL exhibits a good safety culture relative to that at some other facilities. HFIR appears to be fully utilized and well run.

NE's financial stake into ORNL is small (less than $50 million) compared to the $1.5 billion ORNL budget and is thus highly leveraged.

Managed collaboration/competition should be encouraged among the national laboratories (especially INL and ORNL for NE). The concept of a DOE-laboratory-wide National User Facility (NUF) complex (beyond just INL) should be investigated.

Richter said that he did not have a good feeling that the needed facilities are extant. Ahearne replied that the report 2 years ago showed a lack and degradation of facilities. The two laboratories visited this year show great progress in maintaining their facilities.

Sessoms warned that bringing TREAT back would not be trivial. Ahearne added that it would not be trivial from a regulatory sense as well as from a funding perspective. It would be critical in participating in international cooperative research. Five or six years ago, INL's being an NE laboratory was not too comforting. Today, however, there is a more positive feeling about NE support. Lyons said that it is a big challenge to help the national laboratories, especially INL. INL has done a great job upgrading its capabilities. TREAT would be a world-class facility, and a post-irradiation test facility would be very important. ORNL and Argonne National Laboratory (ANL) have cut back in their nuclear-power-related facilities. However, NE is not their landlord; how to get world-class facilities there for NE is a difficult problem. The Office is seeking to establish a basic suite of specialized facilities. No country has a full suite. Ahearne pointed out that the United States has to be able to cooperate; it has to offer facilities to others so it can use theirs.

Cochran asked why TREAT was more significant than the ATR. ATR is running well. TREAT has been well maintained and would be a great addition to the United States' capabilities.

Sessoms said that DOE's offices have to learn to share. Pulling the complex together would provide an impressive capability. Fertel added that that should be a recommendation of the Subcommittee's report.

A break was declared at 2:32 p.m. The meeting was called back into session at 2:47 p.m.

Burton Richter was asked to report on the Fuel Cycle Subcommittee. The program has gotten into a good mode in the five-dimensional phase-space of nuclear reactors:

- Cost,
- Health and safety,
- Proliferation risk,
- Sustainability, and
- Used-fuel disposal.

The questions arise, what is it worth to move in one of these directions, and who should pay? The answers to these questions have never been determined.

NEAC has Four Subcommittees

- Fuel Cycle
- Reactor
- Infrastructure
- International

Their missions overlap to a degree; NEAC needs to develop a coordination mechanism for its subcommittees.

Used-nuclear-fuel disposition is new to NE and the Subcommittee. One can now have a rational discussion of Yucca Mountain. Budget information will be available soon. The report of the President's Blue Ribbon Commission on America's Nuclear Future is being awaited; the preliminary report is due in a few months. Other countries (Finland, Sweden, and France) are doing something about used fuel. Sweden did a bottom-up process and had a bidding war between two finalists for the jobs, tax revenues, etc. The United States had a top-down approach that produced a lot of resentment.

There are three fuel-cycle options: once-through, modified open cycle (with two sub-options, the first of which is breed and burn and the second fuel fabrication), and full recycle. With once-through, one is left with the used fuel. With breed and burn, one is left with spent fuel. With fuel fabrication, one is left with spent fuel, waste, and process losses. With full recycle, one is left with waste and process losses.

There are two basic fuel options; thorium/uranium options can have different waste attributes as compared to uranium/plutonium options. The differences do not appear to be significantly large. The thorium/fissile-based and uranium-based options appear to have similar proliferation risks. Cochran said

that, if one mixes uranium-238 with uranium-233, separation can be avoided. Richter said that the NNSA says that there is no attractiveness to uranium-233. Todreas asked if a big thorium program were envisioned. Richter replied that the technical papers say that the thorium fuel cycle warrants more analysis but does not solve all the problems. Both uranium-based and thorium/fissile-based fuels have similar resource requirements for the same fuel-cycle implementation.

Differences in the estimate of the mean costs of the once-through versus recycle processes are small compared to the uncertainties in overall costs.

In FY10, novel concepts were solicited from national laboratories; 21 white papers were received. Each concept was presented to a review panel. Feasibility studies for three concepts were started. Feasibility-demonstration plans are being written for others.

The Red Book [*Uranium – Resources, Production, and Demand*, published by the International Atomic Energy Agency and the Nuclear Energy Agency] says that 16,000,000 tonnes at $130 per kilogram would allow 1300 LWR GWe capacity for 60 years. There is a lot more uranium available at $130 per kilogram. With any metal, one starts with the highest-grade ores and works one's way down to poorer ones. However, the cost of production never changes. France believes in a uranium shortage and has opted for breeder reactors. Seawater has a huge amount of uranium, although it is very dilute; Japan is now leading in this technology, and the cost is now estimated at $900 per kilogram. However, Cornell has proposed a new, cheaper method of extracting uranium from seawater. At $250 per kilogram, electricity costs go up by 0.5 cents per kilowatt hour.

Martin pointed out that the IAEA has determined that there are 19 important elements (e.g., safety, regulatory, security, and nonproliferation) in building a safe and secure civilian nuclear program [*Milestones in the Development of a National Infrastructure for Nuclear Power*, NG-G-3.1, http://www-pub.iaea.org/MTCD/publications/PDF/Pub1305_web.pdf]. Meeting those requirements takes a long time. The community seems to constantly overestimate nuclear development. Richter answered that all 400 of today's reactors will be shut down in 2050. It does not make much sense to do R&D on advanced concepts.

[Cochran left at 3:15 PM]

Martin pointed out that people say that the United States would need 300 new reactors by 2050; at the same time, economists say that 13 will be built. Hintz said that the 300 number is definitely optimistic.

Todreas pointed out that France and Japan have no indigenous uranium resources and are subject to the world uranium market.

Bhatnagar agreed that one needs to get capital costs down. Once a design is standardized, costs will be driven by construction management.

Corradini said that his Subcommittee is meeting at the end of February to look at the conceptual design plan. He did not have any issues with Richter's Subcommittee's recommendations. Once it gets past the NGNP, the Subcommittee is open to new charges. Lyons said that, by the next NEAC meeting, the IRP selections will have been made, and one of them will be a reactor. The Subcommittee's advice might be helpful at that point.

An anti-proliferation program involves NNSA in the front and back ends of the fuel cycle. Once-through was compared with MOX by an international group, and no proliferation difference was found. Another report stated that the thorium fuel cycle was attractive to proliferation. Some standards for conducting such comparisons would be useful.

Lyons pointed out that the Office is taking this report seriously; it is paying for it. NEAC may be asked to review it. Ahearne pointed out that the National Academy of Sciences (NAS) has been asked to do a study. Richter complained that NAS reports take forever. The question is if DOE approves its own reports; they need peer review.

The Consortium for Advanced Simulation of Light-Water-Reactors (CASL) was selected to manage the Energy Innovation Hub for Modeling and Simulation to create a multi-physics computational environment to be used by a wide range of practitioners to conduct predictive calculations of the performance of reactors for both normal and off-normal conditions. This consortium will dramatically

advance modeling and simulation and high-performance computing to create a virtual model of an operating reactor.

The Subcommittee's recommendations are that DOE maintain an effective experimental program to run parallel with the modeling and simulation effort to verify its predictions. The Advanced Simulation and Computing Initiative (ASCI) program had such an experimental base from 1000 nuclear tests. This has not received the attention it deserves, nor is there a budget line to allow the necessary experiments to be done. Input from NNSA and the Office of Science (SC) should be included from the start.

Todreas noted that there is a focus on experiment and the Subcommittee's push for a budget for that experimentation is right on target. Larzelere said that experiments are being done by TVA, Westinghouse, and the Electric Power Research Institute as part of the cost match. Juzaitis said that the budget is too low. Richter replied that the Subcommittee said to start low and to build up. Sackett stated that there is a rich amount of data available from around the DOE complex that could be leveraged. Lyons said that he had pushed validation hard at the NRC and used the laser fusion as an example in which the models were way off.

The Subcommittee is very worried about availability of facilities. There are other models of international collaboration, as in the offices of High Energy Physics and Basic Energy Sciences, where facilities around the world are used by all as long as everyone contributes something. There are two models: share operating costs or pay for one's own experiments.

[Bhatnagar and Corradini left at 3:25 p.m.]

Richter moved acceptance of the report; Sessoms seconded.

Sessoms said that the MOX study is out of date. Blending down makes the fuel better. Richter said that everyone agrees that some set of metrics is needed. Fertel asked if the Committee were accepting all of the recommendations as stated in the report with this vote. Ahearne stated that it would and should.

Todreas suggested changing "this has not received the attention it deserves" to "it needs continuing review and a budget line." Richter accepted this friendly amendment.

Todreas raised the question about Lambregts' strategy for funding graduate students. Lyons replied that Lambregts had explained during lunch that, when students are chosen, they get $150,000 that can be spread over as many years as they want. Richter said that something can go wrong and delay the completion of an experiment.

Returning to the motion, Sackett suggested the rewording: "Maintain an effective experimental program to run parallel with the modeling and simulation effort in order to verify its predictions. This needs continuous attention and a budget line." The friendly amendment was accepted, and the motion passed unanimously.

There was no public comment offered.

Lyons summarized his views on the meeting:

- Richter's Subcommittee report is very good, and NE will take the recommendations to heart. It would not have ignored those recommendations even if the report were not accepted.
- The subcommittees are making strong contributions.
- Continuing focus areas will be convening a larger governmental presence and addressing the fact that facilities will be a constant challenge.
- The Office will move forward with TREAT and a postirradiation examination facility.
- The Fuel Cycle Subcommittee will have oversight of seawater extraction and the reports from the President's Blue Ribbon Commission on America's Nuclear Future; the Office will likely respond to the BRC recommendations.
- The Massachusetts Institute of Technology report is being reviewed.
- The Office's guidance on Yucca Mountain is highly uncertain.
- The issues around the NGNP need to be evaluated.
- The Office will continue to monitor SMRs.
- NEAC should be involved in the IRPs in the University Program.

The next meeting will be sometime in the beginning of May. He thanked the Committee for its valuable time and guidance.

Shane Johnson was asked to comment. He said that the staff values this Committee's guidance. In the fellowship issue, there is $8 million; no one will be turned out on the street. The budget will be flat or will go down; as a result, expenditures will need to be prioritized.

Martin said that the partnership of NEAC with the staff is appreciated. In 2 years, the Committee should pull together the subcommittee reports into a single planning document.

The meeting was adjourned at 3:58 p.m.

Respectfully submitted,
Frederick M. O'Hara, Jr.
Recording Secretary
Jan. 3, 2011

Corrected by
John F. Ahearne
Jan. 6, 2011

Corrected by
William F. Martin
Jan. 10, 2011