

Draft Minutes
Nuclear Energy Advisory Committee Meeting
April 29, 2010
L'Enfant Plaza Hotel
Washington, D.C.

Committee Members Participating

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

Committee Members Absent

None

Other Participants:

Keith S. Bradley, NEAMS Program Manager, Lawrence Livermore National Laboratory

Nancy Carder, Medical University of South Carolina, NEAC Support Staff

Shane Johnson, Chief Operating Officer, Office of Nuclear Energy, USDOE

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

Warren Pete Miller, Assistant Secretary, Office of Nuclear Energy, USDOE

Dennis Miotla, Deputy Assistant Secretary, 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

The meeting was called to order by Chairman **William Martin** at 8:59 a.m. He asked **Chuck Wade** (DFO) to make administrative and convenience announcements. Ahearne moved to approve the agenda, and Juzaitis seconded. The motion passed unanimously.

Martin announced that each Committee member will be asked for comments after each presentation during the morning and afternoon sessions.

Pete Miller was given the floor. He introduced and welcomed the new members and presented an update on the activities of the Office of Nuclear Energy (NE).

The roadmap for NE was finished and delivered to Congress. The Office now has four objectives:

1. For light water reactors (LWRs), to develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors
2. For new reactors, to develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration's energy-security and climate-change goals
3. For sustainable fuel cycles, to develop and select a fuel cycle, taking into consideration security, safety, etc.
4. For international aspects, to understand and minimize the risks of nuclear proliferation and terrorism

An implementation plan for each objective is under development for internal use.

Since the previous NEAC meeting, nuclear power is back on the table, starting with President Obama's State of the Union Speech. The President's Blue Ribbon Commission was announced, and it has started its work, looking at all aspects of the back end of the fuel cycle. The group is sobered by the challenge. It has its own staff and is operating independently from the Department. The Obama administration announced that it would withdraw the Yucca Mountain license from the Nuclear Regulatory Commission (NRC) "with prejudice." That action went to the NRC, which has to accept that bequest or not; a board report is expected in June. President Obama announced the first loan guarantee for new nuclear plant construction of two AP 1000 reactors in Vogtle, Georgia. The AP 1000 has a design certification; a modified design certification is under consideration by the NRC with a decision expected at the end of 2011. In April, there was the President's Nuclear Security Summit. Forty-seven nations participated to come to a common understanding of the threat posed by unsecured nuclear material, to agree to effective measures to secure nuclear material, and to prevent nuclear smuggling and terrorism. It is hoped that these materials will be locked down within 4 years. The Nuclear Energy Institute (NEI) hosted an industry meeting to advance these goals. NEI's international responsibility is growing rapidly and substantially. More than 20 bilateral meetings have been held with other nations, calling for control of highly enriched uranium (HEU) and civilian nuclear power cooperation.

Martin noted that one can only do well in safeguards if one provides the needed technical assistance to those other countries. Sessoms added that the challenge is that this need is not funded, and it is highly complicated because it involves so many departments and agencies.

Other activities of the Office include procurements, such as the \$40 million in awards for the Next Generation Nuclear Plant (NGNP) project for which two teams, Westinghouse and General Atomics, are submitting proposals. A downselect is to be made. NEAC will provide an analysis of the proposals to DOE, and the Secretary of Energy will decide whether to proceed to Phase 2.

Proposals were received for the funding opportunity announcement (FOA) for the new Modeling and Simulation Energy Innovation Hub. Site visits have been held with the finalists, and an announcement is just weeks away. The Nuclear Energy University Program R&D solicitation has been issued, and about \$35 million is to be awarded.

NE has received great support from the President of the United States and DOE leadership. It has been fighting the FY11 appropriations process, and the FY12 planning process has already begun. The next Blue Ribbon Commission meeting will be in May. They are may be more loan guarantee announcements in the near future. There are several bills in Congress on small modular reactors (SMRs). The Office needs to know what it should be emphasizing in its reactor program and to understand the balance between R&D for large plants and managing the enthusiasm for SMRs. The Office is being called upon for increased international collaboration and cooperation and is working with Congress and the Blue Ribbon Commission to chart a way forward on high-level waste and used nuclear fuel. A clear path forward is needed for infrastructure enhancements; the infrastructure part of the budget is staying static. The Office needs information about the best way to use those infrastructure funds.

Hintz noted that most international initiatives are focused on the fuel cycle, not on the safety of the plants in those countries. Miller replied that the community's interest is in infrastructure, and the Office is being requested to provide help to many countries. Funding for that technical assistance is needed. Lyons pointed out that the International Atomic Energy Agency (IAEA) provides a lot of that type of assistance.

Peter Lyons was asked to review the organization of NE and the FY11 budget request.

In the current official NE organization, HEU usage is under the Deputy Assistant Secretary for Corporate and Global Partnership Development and would fit more logically under "reactors." The Laboratory Facilities Management and the Radioisotope Power Systems components would be better elsewhere. And several cross-cutting issues are not represented by a mechanism to deal with them. A more-logical structure is being proposed for NE. A Deputy Assistant Secretary for New Facility Operations is being established and will include the Office of Integrated Safety and Program Assurance. A Deputy Assistant Secretary for Business and Technical Support is being established and will now have the Office of Uranium Management and Policy, which will cover the U.S. Enrichment Corporation, uranium bartering, uranium tails, and advanced centrifuge activities. Fuel-Cycle Technologies has been streamlined. Fast Reactors has been moved to the Office of Advanced Reactor Concepts. In FY11 Fuel-Cycle Technologies will take over the transportation, potential storage, and new geological repository R&D. Buzz Savage will be retiring, and his position of Deputy Assistant Secretary for Fuel-Cycle Technologies is being advertised.

The Office works closely with the National Nuclear Security Administration (NNSA) and other agencies.

Ahearne asked if the Office had any interest in laser isotope systems. Lyons replied that it has no interest in it per se but has funding for enrichment activities. General Electric is doing it with private funds. There are loans for the front-end. Ahearne asked if NE were out of the medical isotope business. Lyons replied, yes. NE has interactions with the Office of Science (SC), where that activity now rests.

Juzaitis asked where there was any funding of University Programs. Lyons responded that University Programs is integrated into all of the programs and is run through the Center for Advanced Energy Studies (CAES) in Idaho. Juzaitis suggested that maybe the organizational structure prevents it from getting better. Lyons replied that that is a big discussion topic. An entire meeting of the Committee may be devoted to it. Richter noted that his Fuel Cycle Subcommittee has recommended that a review of University Programs be held. Lyons answered that there is substantial involvement by the program managers in the university programs.

Todreas said that the fundamental point is that money is being taken out of R&D funding and being called University Programs. NE does not have a base-technology program. University researchers are assigned to technology needs, and the innovative ideas are not being allowed to surface.

Corradini commented that, given the current format, there is little innovative research. Out-of-the-box thinking should be funded. He himself had a grant with a manager at a national laboratory. A check should be made of how the universities are interacting with the national laboratories and responding to the national laboratories' needs. Miller suggested devoting a lot of time to this issue at the next Committee meeting. This is a small program. The Office has had to fight over it with Congress and the Office of Management and Budget to keep it as an identifiable budget line. At this point, the Office does not want to give it away. Also, the R&D has to be justified as mission-relevant or mission-supportive.

Cochran noted that the President has stated that there are nuclear terror threats. The new organization chart does not integrate and make a priority this threat and its reduction. That possibility should be rethought. Lyons noted that the Office of International Programs takes the lead in this area.

Sackett said that he was encouraged by the comments about cooperation with NNSA improving.

Lyons continued: in the FY11 budget request, the Generation-IV Nuclear Energy Systems had become a catchall, including the NGNP, boiling-water reactors, and the modeling and simulation hub. It has been zeroed out, and the funding distributed to more-appropriate line items, including a new International Nuclear Energy Cooperation line. A new manager of the Idaho Operations Office is in the offing. The \$36 billion in loan guarantees does not show up in NE's budget. There is a new line item on Nuclear Energy Enabling Technologies. The Hub is now there. This is an important move forward. There are new line items on Cost-Cutting Technology Development (\$43.3 million); Transformative Nuclear Concepts R&D (\$28.9 million), which is to consider the new ideas that are not surfacing now; and the Energy Innovation Hub for Modeling and Simulation, which will increase about \$3 million to \$24.3 million. As a result, the Office has a much better budget and budget lines.

Ion asked about advanced manufacturing techniques for life-extension of existing technologies. Lyons replied that one program is focused exactly on that; also, there is research on the characterization of existing materials and how they can be better used.

There are also new budget lines for SMRs, which are of great interest to Congress (\$38.9 million); NGNP Demonstration Project (\$103 million), for which Phase 1 reports are being received this year, which may lead to Phase 2 (\$1 billion in construction); Light Water Reactor Sustainability (\$25.8 million, which is cost-shared with industry); and

Advanced Reactor Concepts, which includes fast reactors and molten salt reactors (\$21.9 million). Phase 2 of the NGNP will be very complicated and slow; the funds will be used for R&D.

The budget request holds a very large growth in used nuclear fuel disposition, from \$9.1 million to \$45 million. \$25 million will be for repository science; this country needs expertise and geological storage. Records management from Yucca Mountain may end up here.

In addition, international nuclear-energy cooperation is increasing significantly, from \$0 to \$3 million.

A break was declared at 10:18 a.m. The meeting was called back into session at 10:35 a.m. Martin open the floor to Committee-member comments.

Corradini said that he was very positive about the activities of the Office and heartened by the Administration's approach to nuclear power. The Blue Ribbon Commission is dealing with a very important area. The charter of his Nuclear Reactors Subcommittee is very good.

Ion stated that the production of the roadmap is a good step forward; it garners support from the administration and allows the building of programs. The proposed organizational structure separates advanced reactors and the fuel cycle. The reactors will stand or fall by their fuel cycles. There needs to be coordination of these two mission lines. She noted that she had taken over the chair of Euratom's Science and Technology Program and is coordinating similar planning for a sodium-cooled reactor in France. Things need to get built. Components and systems need to be tested. Sessoms asked her if she would be interested in joining the International Subcommittee. Ion replied, yes.

Ahearne noted that a concern is always whether advisory committees' advice is heard. The issues raised by NE leadership gives this Committee a real challenge to focus on the issues raised.

Christiansen congratulated Miller and Lyons for the roadmap. Comparing it with the budget, one sees that the two are not aligned. The fuel-cycle activities need to be coordinated with the Blue Ribbon Commission. The roadmap needs to be flexible. The international part may be growing, and the roadmap may therefore need to be expanded. The Nuclear Engineering Enabling Technology does not show up in the roadmap or the organization chart. That is where University Programs should be.

Richter stated that a strategic plan had been produced, not a roadmap. It is terrific. A roadmap is what you plan to accomplish over, say, 10 years. The organization chart has to tie together the different fuel-cycle work. In University Programs, it is too easy for the funded projects to degenerate into an extension of the national-laboratory programs; University Programs needs a review. There is a question of who would buy SMRs. If DOE agreed to buy one upon licensing, industry would get interested in building SMRs. Now is the time to internalize nuclear-power programs.

Bhatnagar said that the four-step objective is a good way to proceed. If one did all of these steps, what would be the impact? It was a surprise that the Committee would not know what the implementation plans would be. Miller commented that the implementation plans cannot be published without interagency review and agreement, which limits flexibility.

Barron stated that the U.S. Government has the responsibility of managing spent nuclear fuel. He cautioned the Department against becoming enamored of a single global

solution. The problem is growing fast. All options need to be used to manage the growth of the spent-fuel inventory. He urged the Office to take a broader look at the inventory growth, mitigating strategies, etc.

Fertel agreed very strongly with Richter and Christensen. The Office needs take the next step in roadmapping. John Grossenbacher [Director, Idaho National Laboratory (INL)] had told Fertel that, if one looks at nuclear power in the long run, one will realize that it will play a role for hundreds of years. One does not need the optimum system right now. One can reach optimum solutions incrementally. Anything done on fuel cycles has international implications. NEAC needs to get its subcommittees active. Miller asked Fertel what the difference was today than before the Industry Summit. Fertel replied that that question and its answers were being analyzed right now. The Summit was focused on HEU and plutonium. The meeting with the Vice President went beyond that. Developing countries do not have the infrastructure to support reactors. Codes of conduct and other mechanisms are needed.

Martin pointed out that education and the needs for education go well beyond the borders of the United States.

Paperiello said that the question of waste is the NIMBY [not in my back yard] question. Waste is growing. In SMRs, one needs to consider security; they would be terrorist targets. Information transfer from R&D efforts needs to be addressed both for industrial use and for analytical purposes by this Committee.

Martin observed that he did not see the global growth of nuclear power to be anywhere near what current projections point to. If one overestimates nuclear-power growth, one might over-agitate governments that have to deal with the infrastructure and back-end issues. What is the growth likely to be? Hintz answered that the growth in China and Japan are impressive. In the United States, he was optimistic for nuclear power because of environmental and energy-security issues. He hoped that the new plants would be successful, that they would be on time and on budget, and that they would have safe operation. Industry does not have confidence that new plants will be so successful, and that would make them uneconomical. Major enablers would be necessary to keep people from stalling. The default position is building more gas-fired plants. With big plants, you are betting your company on the project. Loan guarantees are needed to bridge to 2020 when a lot of these units will be built. The utilities would love to have SMRs. Big plants produce transmission problems and capital-cost problems. To be economical, the SMRs must be built in factories and treated differently in the licensing procedures. Bigger is not necessarily better. One *does* get element-of-scale improvement in production costs, but other costs are the same between big and small reactors.

Todreas commented that the roadmap has come a long way. LWR sustainability is important and needs more action, such as coordination with the Electric Power Research Institute (EPRI) and the NRC. The reactors in the existing roadmap include LWR in Gen-3+, which is good. Those approaches have become modular. "Grid appropriate" should be used instead of limiting modularity to SMRs. He would like to see LWR used-fuel thermal recycle emphasized. It can be done incrementally. The fuel cycle and reactor designs need to be bolted together as nuclear-energy systems. The discussion of University Programs has to be raised in a sensitive manner. The subcommittees should receive overt questions from the Office in order to be effective. Words are important. In

the fuel cycle, one should define recycle, transmutation, fuel processing, etc. One should also define sustainability in the nuclear context.

Juzaitis commented that he loved the idea of U.S. leadership in international cooperation that was brought up at the Global Security Summit, but implementation plans are needed for messianic ideas. After the arsenals are gone, there will still be nuclear material. This society needs to think about what type of material it is producing. Policy, technology, and education pieces are needed. The technology program needs funding and support. In policy, the ideas are coming from other countries; the lack of compliance with agreements is killing us. Companies want training, not education, and everyone is looking for money. One should beware of programs that are driven from the top down.

Sackett said that, despite uncertainty about U.S. nuclear growth, such growth will occur internationally. The Nuclear Security Summit, the Blue Ribbon Commission, and inquiries from the international community are increasing the pressures on the Department and NE. Partnership with NNSA is important. NE has a central role that can *only* be fulfilled in cooperation with others. He complained that he did not see a roadmap for SMRs that would guide the licensing approach and manufacturing processes. There is a lot of legacy data, but the expertise and pedigree of those data are being lost. Support facilities and infrastructure are needed for irradiation testing etc. For any new systems, there has to be a demonstration prototype licensed and built. The University Programs' status poses the question whether the best and the brightest are being attracted to the profession. He asked what the true vision was that NE could put forward.

Cochran said that a lot of people have fallen in love with nuclear technology, and that clouds their vision. Large reactors cost too much and have unit costs that are too high. One cannot subsidize them out of that problem. Carbon-technology costs should be internalized. DOE should not buy an SMR and consider if SMRs will offset the economies of scale of large reactors. Fuel costs of LWRs have gone down for 50 years, and the strategy of nuclear-power development is based on the opposite assumption, that those costs will go up. At the summit for nongovernmental organizations [the NGO Summit], he had made the argument that the civilian HEU should be eliminated.

Sessoms stated that the roadmap document is excellent, a good starting point. The irrational exuberance in nuclear development needs to be managed. NEAC needs to figure out if NE can be relevant. Discussions need to be held with the Department of State, the White House, and the Hill; those discussions need to talk about "steering the ship" on international issues. It will cost a lot of money to do that. One needs to figure out how to get people to talk. A credible case can be made for international cooperation. It is important to understand where NE intends to go and to find out if that is doable. The international issues should be focused upon.

Miller said that these comments were thought-provoking. The answer to the issue of the separation of advanced reactor concepts from the fuel cycle is that both sides have to be involved. There is an Integration Council that could deal with this. The budget and organization processes are different, requiring cleverness in management schemes for cross-cutting issues. He admired and respected what the French and Japanese have done in closing the fuel cycle, but this problem needs to be thought through. He would not push for early deployment of a reprocessing facility in the United States. Nuclear technologists try to internalize all costs, and it is difficult to compete with \$4/million-Btu

gas. In Japan, they have to import 96% of their energy. In the United States, the glass is very full with wind, solar, gas, coal, oil, nuclear, etc.

Lyons agreed that these comments were very insightful. The \$3 million for international activities is the beginning of a new program with great growth potential. Better definitions are needed, especially for sustainability and its political aspects. Politically sustainable solutions are not in hand. The Blue Ribbon Commission will consider these issues. It has great leadership and membership. They are taking a broad approach (e.g., looking at management approaches in other countries). NEAC might want to provide comments to the Blue Ribbon Commission. The Office is sensitive to the need for successful university programs. Specificity was more apparent in the roadmap's earlier versions; that specificity was decreased during the interagency approval process. Implementation plans would suffer the same fate. The Office is trying to come up with documents that are as useful as possible.

A break for lunch was declared at 12:05 p.m.

Afternoon Session

The meeting was called back into session at 1:00 p.m. **John Ahearne** was asked to report on the progress of the four subcommittees.

The charters for the four subcommittees have been reviewed by Miller. The Facilities Subcommittee has a broad charter, and a prior review had considered the need for access to facilities by foreign partners. It is hoped to answer this question at a Subcommittee meeting during the following month in Idaho Falls. The other subcommittees have similarly broad charters. Fertel asked if the need for a foreign country's establishment of a safety regulator was included. Miller replied, yes and also expressed an interest in helping to identify overlaps in responsibilities. Cochran asked if there were a way to work in the fourth objective [understanding and minimizing the risks of nuclear proliferation and terrorism]. Miller responded, yes; at least in spirit and principal. Ahearne added that getting people together to discuss the topic is also a good idea.

Sessoms said that the International Issues Subcommittee was gathering dates for Subcommittee meetings and expected to set those meeting dates in the next few weeks.

Richter said that the whole fuel cycle is now included in the charter of the Fuel Cycle Subcommittee, not just the long-lived radionuclides. There is now the question of what to do with matrix fuels and molten salts. The Subcommittee needs to integrate its activities with NE's timetable. Ion noted that the United Kingdom had just established a Center on Proliferation-Resistant Fuel Cycles and that might help the Fuel Cycle Subcommittee.

Cochran stated that it needs to be determined if full-Committee members have access to subcommittee meetings and handouts. Miller pointed out that the charter states that subcommittees get to invite the meeting attendees. Also, any subcommittee documents are available to all Committee members.

Edward McGinnis was asked to describe the new proposed program in International Nuclear Energy Cooperation.

This field has a complex set of issues, technologies, and stakeholders. Today, the alignment of stakeholders is better than it has ever been. One cannot look at nuclear energy only within one's own borders.

NE has proposed a \$3 million program for supporting international engagement. Today, it supports R&D with other advanced-fuel-cycle countries to address long-term technical goals along with cooperation with other non-advanced-fuel-cycle countries (e.g., South Africa) to address nearer-term technical issues. It supports multilateral and bilateral policy engagement via international partnering; policies need to be interwoven with the R&D activities. And it supports international nuclear fuel management, exploring the possibility of comprehensive international commercially based nuclear fuel services without increasing proliferation risks. In addition, it is engaged in infrastructure development and support for U.S. trade.

Hintz asked how one can propose cradle-to-grave management when one cannot do it oneself. McGinnis replied that the nation is proposing to accept fuel back and would need to work out how to deal with it. The country has robust front-end fuel suppliers but lacks back-end services. It needs fully functional back-end services. Dry-cask interim storage is viable.

The types of mechanisms used to engage with 50 countries include bilateral working groups and action plans, memorandums of understanding (MOUs), International Nuclear Energy Research Initiatives (I-NERIs), trilateral agreements, and multilateral engagements. These need to be coordinated. Therefore, NE is proposing a new program on International Nuclear Energy Cooperation (INEC) to serve as the central coordinating program for international engagement.

Richter asked if this \$3 million was for coordination or for technical work. McInnis replied that this will be coordination to complement the technical work. Ion noted that Europe has similar groups. McGinnis replied that the Office works with them and must look forward to working even more extensively with them. Juzaitis asked where one goes to for money for international technical cooperation. Miller answered that this money is not available to solicitations by university programs. Anything of a technical nature would go through a program office.

Sackett asked how the program would relate with NNSA, the Department of State, etc. McGinnis replied that the program would take the lead in policy vetting and would do it with the program managers. The Department is tied closely to the administration's nuclear-policy leaders.

Cochran noted that there is considerable support for interim storage for shut-down reactors. One could set a limit of usage for such intermediate storage locations and charge the foreign countries for the takeback. McGinnis answered that other countries have looked at interim storage as a service. Cochran said that, politically, one would get better support for shut-down facilities *and* a nonproliferation objective.

McGinnis continued that, if funded, INEC would provide better coordination of the Office's international activities. This is an important first step to avoid taking piecemeal support from other programs, and it supports other administration priorities.

Sessoms noted that he and McGinnis were getting together the following week to see where they need to go. By the end of May, there should be a collective vision. Martin asked if there would be more international members of NEAC. Miller responded that NEAC will not be expanded.

Christensen noted that there are a lot of organizations and national laboratories that could contribute expertise.

Alexander Larzelere was asked to describe NE's advanced modeling and simulation activities and their relationship to the Energy Innovation Hub.

NE has a lot of responsibilities happening on a lot of different time frames, and modeling and simulation could influence all of them. Hubs have been around as a mode of organization for only a year, but there is a fierce sense of urgency of this Hub's impact on the U.S. use of nuclear energy. Modeling and simulation are being used to provide a new means of obtaining science-based insight and to go beyond the traditional "test-based" approach to understanding nuclear energy. Calls for modeling and simulation by the experts (e.g., in the MIT reports, the 2008 NEAC report, and the 2008 Robert Rosner article in the *Bulletin of Atomic Scientists*) are being responded to.

Nuclear Energy Advanced Modeling and Simulation (NEAMS) is not the first such effort; it builds on the success of the Advanced Simulation and Computing Initiative (ASCI) and of Scientific Discovery Through Advanced Computing (SciDAC). Important lessons learned from ASCI were

- to have a clear and compelling vision of the mission;
- that headquarters needs a "team of rivals" at the national laboratories for leadership of the program;
- success requires the partnership of universities, industry, and national laboratories; and
- the effort requires endurance (time and funding).

Additionally, science has relied on theory and experiment to gain science understanding. Today it uses theory, experiments, and modeling and simulation. Modeling and simulation are used because the subjects are too small, too hazardous, too far away, too expensive, too complex, or not allowed by policy. Modeling and simulation are not replacing but supplementing experiment and theory.

One example of discovery by simulation is the finding that wire wraps have a micro-effect on fuel tubes that aggregates into a macro-effect. Making the fuel "transparent" with simulation allows one to see what goes on in the fluid.

Modeling and simulation is prominent in the recent NE report to Congress.

The NEAMS program is designed to rapidly create and deploy "science-based" verified and validated modeling and simulation capabilities essential for the design, implementation, and operation of future nuclear-energy systems. It starts at the datum level and proceeds through verification, new tools, and computing platforms. Then it can be put in the hands of users through problem set up, analysis, and deployment. The program will collaborate with others to make it go as fast as it can.

The NEAMS program has great leadership and supporting elements: fundamental methods and models; verification, validation, and uncertainty quantification; capability transfer; and enabling computational technologies (computing technology).

Richter asked if there were an adequate base of experimental data for validation. Larzelere replied, yes and no. The program is talking with scientists to do experiments to fill in the gaps. Sackett asked if there were ties back to earlier codes. Bradley answered that the program will not start from scratch. It will integrate other programs to produce the needed data. Larzelere added that the codes are being built with the NRC.

NEAMS will deliver a continuously increasing capability for predictive simulation; flexible solutions that can be applied to different types of nuclear-energy technologies; and a comprehensive approach that ensures that new capabilities are fully developed and

“born” with appropriate verification, validation, and uncertainty quantification. NEAMS users will make discoveries and obtain insight into the physical behavior of nuclear-energy technologies, conduct design studies for new nuclear-energy technologies, and evaluate submitted designs and supporting analyses to determine if the technologies will meet the requirements to protect human health and the environment and to understand and optimize the operations of nuclear energy technologies. To accomplish all these objectives, NEAMS has assembled the “A” team of national laboratories, universities, and industry.

The NE Modeling and Simulation Energy Innovation Hub has held a workshop and issued an FOA. The Hub will be a multidisciplinary, highly collaborative team, ideally working under one roof to solve priority technology challenges.

Achieving the promise of the Hub requires a mission focus: an operating reactor that provides data for validation from an instrumented plant, leading to improved scientific understanding of important technology issues. NEAMS and the Hub will have mutually supportive roles. The Hub will be funded at \$25 million per year for 5 years; NEAMS has been funded for \$3.5 million in FY08, \$19 million in FY09, and \$24 million in FY10. Both are important, but neither is sufficient. NEAMS is focused on long-term R&D; the Hub is focusing on modeling and simulation for the next 5 years.

Shane Johnson was asked to describe the new proposal for Nuclear Energy Enabling Technologies.

The primary mission of NE is to advance nuclear power as a resource capable of making major contributions in meeting the nation’s energy-supply, environmental, and energy-security needs by resolving technical, cost, safety, security, and regulatory issues through research, development, and demonstration.

NE’s R&D objectives are to develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors; to develop improvements in the affordability of new reactors to enable nuclear energy to help meet the administration’s energy-security and climate-change goals; to develop sustainable nuclear-fuel cycles; and to understand and minimize the risks of nuclear proliferation and terrorism.

The Office went from zero dollars in 1998 to where it is today. Miller and Lyons have re-baselined the NE budget, including a new research, development, and demonstration (RD&D) agenda, consisting of reactor-concept RD&D (\$195 million), fuel-cycle R&D (\$201 million), and nuclear-energy-enabling technologies (\$99 million). Of the overall budget of \$912 million, 55% or \$495 million will go to research and development.

The *proposed* Nuclear Energy Enabling Technologies (NEET) program will consist of three complementary and integrated programs: Crosscutting Technology Development (\$43 million), Transformative Nuclear Concepts R&D (\$28 million), and the Energy Innovation Hub for Modeling and Simulation (\$24 million).

Crosscutting Technology Development would support R&D in Reactor Materials; Proliferation Risk Assessment; Advanced Methods for Manufacturing; and Advanced Sensors and Instrumentation, supporting the existing fleet, new reactors, and the fuel cycle.

Sessoms asked how one brings in the international perspective. Johnson replied that it would be done by bringing the right people to the table in workshops; workshops are planned to talk through the R&D scope.

Cochran noted that the risks will not be addressed by technology but by regulation and management. Miller replied that it will be a combination of both of those approaches.

Todreas asked where the NEAMS budget was. Johnson answered that it is invisible in FY 10 and FY 11; it is scattered across programs. Those activities will be gathered together under one manager in the FY12 budget.

NEET will support investigator-initiated projects that relate to any aspect of nuclear energy generation via an open, competitive solicitation process and encourage “outside-the-box” options for nuclear energy.

Richter stated that NEET sounds a lot like what ARPA-E [Advanced Research Projects Agency-Energy] is doing. Lyons responded that the NEET activities precede ARPA-E, which has industrial sponsors. These activities precede commercialization and may lead to ARPA-E projects.

The third element of NEET is the Energy Innovation Hub for Modeling and Simulation.

NEET will hold an R&D planning workshop. It is envisioned to have a one-day format with plenary and breakout sessions and is tentatively scheduled for the week of July 26th in the D.C. Metro area to coincide with the NE University Program Workshop.

A break was declared at 2:30 p.m. The meeting was called back into session at 2:45 p.m. Ahearne noted that Corradini has a large set of tasks on the table to provide advice on, and he has a short time to do it. The charter of the Subcommittee includes looking at the long-term and short-term goals for deployment here and abroad of LWRs, gas-cooled reactors, molten-salt reactors, and others. Corradini stated that the expectation is that the NGNP should be reported on this year so that a Secretarial decision could be made.

Bhatnagar noted that, with the success of Nuclear Power 2010 (NP2010), the licensing process will be understood, and the community can move on to construction and how to reduce the construction costs (which is where most of the money will be spent). The construction at Watts Bar is not very different than how it was done in the 1970s. The question is how to move forward to a different way of doing construction.

Hintz commented that this country is indebted to Miller and Lyons for bringing their expertise to these challenges that our nation faces.

Dennis Miotla was asked to review the progress of the Idaho National Laboratory (INL) toward being a world-class laboratory.

INL is closely coupled with NE, and its focus is on the NE mission. Good people are coming to INL because of the mission and the R&D leadership, and INL is working closely with the other DOE laboratories and with universities. In 2005, INL faced significant obstacles: an infrastructure run to failure, an R&D culture in decline, broken or nonexistent management systems, and \$1 billion in unfunded environmental liabilities. Today, INL is a far different institution from what it was in 2005.

The DOE vision for INL in 2004 was to establish the preeminent, internationally recognized nuclear-energy RD&D laboratory within 10 years. That laboratory would be a major center for national-security technology development and demonstration, a multiprogram national laboratory that would foster academic, industry, government, and international collaborations. The vision has not changed, but strategies and tactics to achieve the vision have evolved. Areas of policy emphasis have also evolved.

The NERAC recommendations were to

- Fund INL and build up facility and staff capabilities (significant funding has been appropriated for INL RD&D)
- Recognize and allow for contributions of other national laboratories (the laboratory is increasingly looking outward)
- Understand and agree on vision and mission (the original vision centered on the NGNP, four Gen-IV reactor concepts, and the Advanced Fuel Cycle Initiative (AFCI); it shifted to focus on the Global Nuclear Energy Partnership (GNEP) in 2006; it is back on track with a commonly agreed-upon R&D plan that should lend stability to the program and allow a look at facilities)
- Attract/retain the best and brightest scientists, engineers, and technical managers (INL has attracted and retained some of the best and brightest researchers and technical leaders with a lot of young people at the laboratory, leading to a bright future for the next 5 years; capabilities will be exploited wherever they are; the Advanced Test Reactor (ATR) is 100% utilized, so some work is contracted out to the MIT reactor)
- Create a culture where research and scholarship encouraged and rewarded [a culture is being created where research and scholarship in mission areas are encouraged and rewarded through CAES; the metrics (e.g., publications) are not there because this is an engineering laboratory]
- Develop and maintain high-quality, state-of-the-art research facilities (NE funding for Idaho Facilities Management has increased from \$91 million in FY05 to \$159 million in FY10; the effort during the first few years focused on stabilizing support infrastructure; the ATR National Scientific User Facility was launched in 2007; most if not all of the core R&D facilities at INL, including a unique capability for fuel studies, will be user facilities)
- Select a management and operating (M&O) contractor with superb qualifications and a credible plan to achieve the vision (Battelle Energy Alliance, LLC, was selected; it is comprised of Battelle, URS Corporation, Babcock and Wilcox, EPRI, and the MIT-led National University Consortia, bringing with it expertise in laboratory management, a proven track record in managing large projects, an ability to link INL with other national laboratories, experience with reactors and fuel cycles, and a 75-year history in RD&D)
- DOE should focus on managing the contract, not the contractor (the Performance Evaluation and Metric Plan is performance-based and fully aligned with NE priorities)
- INL should visit and benchmark world-class laboratories in NE and in other fields (in 2006, DOE hired Parametric Technology Corporation (PTC) to benchmark INL scientific and technical performance against several world-class laboratories; it recommended actions similar to the recommendations of NERAC; an annual review of the Nuclear Science and Technology Directorate is conducted by an INL-chartered independent peer review group; extensive surveying and benchmarking are conducted annually for support functions)

While INL is not precisely where it intended to be, it is in a better place than it could have imagined. The report of the peer review committee that evaluates NS&T progress annually (a senior group of internal representatives) was generally positive this year.

In summary, INL has made major progress, and the changing circumstances impact prospects for future success.

Martin asked Ahearne to comment on INL's progress. Ahearne said that the Laboratory was partially toward where the Committee wanted it to be. As pointed out, they started out way behind. They have to work harder to assume their rightful role in the national laboratories.

Carter (Buzz) Savage was asked to describe the new program proposal on a modified open cycle.

To determine how to dispose of nuclear waste, the Department looked at accelerators, fast reactors, thermal reactors, and the GNEP program (which postulated mixed oxide fuels). It was once felt that the best option was a closed fuel cycle with fast reactors. New options are now being looked at. In working with the Office of Civilian Radioactive Waste Management (RW), Yucca Mountain was a primary driver in what was done. Secondary repositories had to be looked for. But Yucca Mountain will be shut down this year with the responsibility for spent-fuel management transferred from RW to NE. All options are now being looked at, and it has to be decided what fuel cycles to consider, including a new one: a modified open cycle.

DOE will conduct R&D to investigate technical challenges involved with three potential strategies for used-fuel management:

1. Once-through
2. Modified open cycle
3. Full recycling

The modified open cycle handles everything between no treatment and full recycling. If there were some breakthroughs, they would alter the management strategy. There are many proposals being put forward, and all of them are being evaluated. The modified open cycle would involve looking at fuel forms and reactors that would increase fuel resource utilization and reduce (on a per-MWh basis) the quantity of long-lived radiotoxic elements in the used fuel to be disposed of, with limited separation steps using technologies that substantially lower proliferation risk.

Modified open cycles can provide the benefits of both open and full-recycle fuel cycles; can involve the reuse of fuel, which may require some form of treatment (as opposed to just producing spent fuel); and would involve modification of the used fuel. This modification could be as simple as heat treating the used fuel cladding or as complex as chemical processing and re-cladding the fuel or it could even be full recycling. Some separation processes employed for full recycle may be used for some of the modified-open-cycle concepts.

Some of those modified-open-cycle approaches are

- Breed and burn recycle reactor concepts (including the traveling-wave designs)
- Deep burn of recycled transuranics in high-temperature gas reactors (which requires fuel processing)
- Recycle of LWR fuel into Canadian Deuterium Uranium (CANDU) reactors with the DUPIC [Direct Use of spent PWR fuel In CANDU] process
- Fission–fusion systems
- Accelerator-driven systems for minor actinides (which will be reassessed)

Modified open cycles can be made possible by the design of systems that use novel physics concepts, the development of fuel forms that accommodate much higher

exposure, and the development of fuel-conditioning processes that avoid complex chemical operations. The deployment of a preferred fuel cycle option is being targeted at 2050, so the R&D discovery phase for modified open cycles must be completed in approximately 10 years.

The FY11 DOE budget request included \$40 million for research into modified open cycles as part of DOE's Fuel Cycle R&D Program. The modified open cycle has not been studied as thoroughly as the other two fuel-cycle-strategy options, and that is why it is being singled out as a new technical area for FY11. The tentative allocation of FY11 funding to specific modified open-cycle R&D areas includes 55% to fuels, 30% to separation and waste forms, and 20% to system studies (concept definition and analyses). Percentages may change in FY12.

Examples of modified-open-cycle R&D proposed for FY11 include (1) identifying novel fuel forms, ultra-high burnup fuels, thorium-based fuels, and deep burn of transuranic-bearing TRISO [tri-isotropic] fuels; (2) initiating the exploration of limited treatment of used fuel to add more fuel material to the used fuel, remove poisons from the fuel that inhibit the nuclear reactions, and repair or replace the cladding that contains the fuel; and (3) initiating a systems-engineering approach to define, establish requirements for, evaluate modified open-fuel-cycle options, and do some systems analyses to provide needed information on such topics as transuranic management, separation and partitioning efficiency, fission-product behavior, materials reuse, transmutation approaches of modified-open-fuel-cycle systems, and cost-benefit analyses. Many of these options have never been built, so economic analysis will be a challenge.

Richter noted that Savage is going back and looking at technologies that have been looked at chaotically in the past. A good hard look and systems studies will reveal the rotten ones and the ones with promise. The next meeting of the Fuel Cycle Subcommittee should get the catalog straight.

The floor was opened to public comment. There was none. The floor was opened to Committee comments.

Ion said that the engineering challenges to implementing the modified open cycle are more challenging than those of the traditional approaches on an industrial scale. Industrial engineers should be consulted. The prize of NGNP will be huge globally. Industry involvement will be tricky. There will not be large-scale deployment because the risk is too high. SMRs have advantages in their own right and should be on DOE's radar, and industry should be engaged. First-of-a-kind units must be built.

Christensen said that NE is getting more visibility on the international front. There have been other agencies that have been involved. DOE should reach out to them. There is no petascale computing in NE, so NE should reach out to the Office of Science and to the National Science Foundation. There are other programs that should have a home on the organization chart. He asked where else the NGNP might be built than INL. Solid safety and operating bases have to be established for INL. The \$40 million for the modified open cycle is a lot of money to shift at once.

Richter said that the Royal Society is looking at the relative proliferation risk of different fuel cycles. There should be coordination with them. He asked: What nuclear industry is there in the United States? The United States cannot build nuclear reactors. SMRs should be encouraged to bring reactor building back to the United States. The

main proliferation risk can best be managed with carrots and sticks. The NRC is concerned about the fly-by-wire operation of reactors.

Barron commented that there is a paradigm based on light water reactors and a huge infrastructure. That infrastructure resulted from Three Mile Island, Chernobyl, and Browns Ferry. An elegant SMR is really simple and safe. However, SMRs cannot have a huge infrastructure; that would kill them. Cost-sharing should be accompanied by benefit sharing. To get industry buy-in, the industrial players have to see a pro rata share of benefits without having all the benefits go to the common good.

Fertel noted that the Department of Defense has expressed interest in building an SMR. However, the costs have still not been gotten right on light water reactors. One cannot get accurate costs on fast reactors that have never been built. He was impressed with where the management team had gotten to at INL.

Paperiello pointed out that NE has a small budget. It must plan systematically. He was skeptical about modeling and simulation; all the examples given involve classical physics. Going from an atomistic basis up the chain is not convincing. An evolutionary process would be more interesting. There are PRAs [probability risk assessments] for these reactors, and it would be interesting to see how the models and simulations are related with them.

Ahearne observed that this Committee has more challenges than ever. His concern was whether it can produce useful products.

Sessoms said that he would like to request briefings from programs on what they are doing so a case could be made for an international policy. As many international activities as possible need to be incorporated into that policy. He asked how “world-class” was defined.

Cochran said that NE has a budget just under \$1 billion. He suggested taking 5% of that budget to figure out how to get HEU out of the commercial and naval fuel cycles, how to control uranium enrichment, understanding the economy of large and small reactors, how to get rid of unjustified subsidies, helping the Blue Ribbon Commission understand what went wrong with Yucca Mountain siting and what went right with the Swedish program, and figuring out how to design an international storage facility for spent fuel. Those are the most important problems to solve.

Sackett said that the presentations were very well done. The most important barriers in international policy will likely be internal. In modeling and simulation, one should take a close look at how it is done in aviation. One of their modeling and simulation programs is to figure out how to instrument their products to provide validating data. SMRs give us a chance to break the old paradigms. The back end of the fuel cycle offers an opportunity because the United States is not economically locked into a technology. It can step back and objectively determine how to manage this technology. Preserving the corporate knowledge is important.

Juzaitis said that the problems of nuclear power speak to the more competent students, but those students do not want just to work for a utility. The future industry will be constrained by nuclear terrorism. Iran was the United States' friend at one time, and the United States gave Iran a lot of nuclear technology. The infrastructure changes a lot more slowly than do political realities. Students are lining up to work for Terapower, not Westinghouse. The best students are going into nano/info/bio. On the NEAMS program, it worked in the weapons program because the weapons program was given money to

give up (one type of) testing. The integration of computing and engineering was forced by the designers themselves. Reactor designers have to be convinced to drive this transition, also.

Todreas said that this Committee has given NE advice to link reactors and the fuel cycle. Savage and Richter will sort out the fuel cycles, but the Reactor Subcommittee is focused on the NGNP. There is a lot more that needs to be done. SMRs are floating around on the Hill. He proposed that the Reactor Subcommittee consider the big picture at each meeting and hoped that NE does a strategic evaluation of how to line up the reactor work.

Corradini said that the reactor and fuel cycle subcommittees have to coordinate with each other. In focusing on NGNP, the Reactor Subcommittee cannot lose sight of the fuel cycle. There is a connection to regulation and certification. There are several processes going on for large reactors. One question is, how will DOE engage NRC on SMRs. That issue should be sorted out now.

Lyons said that the Committee's expertise and advice are appreciated. The Office is very aware of the need to coordinate with NRC and is having workshops with them. It is also acutely aware of the different missions of DOE and NRC, but there are many ways that the agencies can work together. The fuel cycle and reactors will be worked on by different offices but will be closely coordinated. As a nation, the United States is not locked into a waste strategy, and that will serve the country well. There is a law that says that the government cannot pay for all the NGNP; 50% has to be from the private sector, and it has to be in Idaho. A licensing case is for a desert in Idaho, nowhere else.

Miller said that Cochran's points are well taken. The economy of large and small reactors is important, and NE should take it on. On the backend of the fuel cycle, he was convinced that a nice hand has been dealt to the nation. There is time to think anew about this problem. This opportunity needs to be taken advantage of before the nation's hands are tied to a multi-decade decision. Proliferation reduction may have a technological component. This possibility should be explored to the best of our ability.

Wade announced that the next meeting will be held between the Thanksgiving and Christmas breaks.

Martin stated that this has been an extraordinary four months for nuclear power. He sensed stability in all its definitions. A long-term policy is being crafted for NE.

Richter said that the subcommittee leaders should think hard about their meeting structures. The subcommittees need to report, and the Committee's meeting schedule has to be coordinated with the subcommittee meetings.

The meeting was adjourned at 4:38 p.m.

Respectfully submitted,
Frederick M. O'Hara, Jr.
Recording Secretary
May 20, 2010