Minutes
Nuclear Energy Advisory Committee Meeting
June 9, 2009
L'Enfant Plaza Hotel
Washington, D.C.

Committee Members Participating

Thomas Cochran
Michael Corradini
Susan Ion (by telephone)
William Martin, Chair
Burton Richter
Allen Sessoms
Neil Todreas

Committee Members Absent

John Ahearne
Brew Barron
Marvin Fertel

Other Participants:

Alice Caponiti, Radioisotope Power Systems, Office of Nuclear Energy, USDOE
Nancy Carder, Medical University of South Carolina, NEAC Support Staff
Phillip Finck, Associate Laboratory Director for Nuclear Programs, Idaho National Laboratory
Timothy Frazier, Program Manager, Radioisotope Power Systems, Office of Nuclear Energy, USDOE
John Gilligan, Director, Nuclear Energy University Programs, North Carolina State University and Idaho National Laboratory
David Hill, Deputy Director for Science and Technology, Idaho National Laboratory
Kristina Johnson, Under Secretary of Energy, USDOE
Shane Johnson, Acting Assistant Secretary, Office of Nuclear Energy, USDOE
Steven Koonin, Under Secretary of Energy for Science, USDOE
Marsha Lambregts, Program Manager, Nuclear Energy University Programs, Idaho National Laboratory
Edward McGinnis, Deputy Assistant Secretary, Corporate and Global Partnership Development, 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
Kenneth Chuck Wade, Designated Federal Officer, Office of Nuclear Energy, USDOE

About 30 others were in attendance.

Chairman **William Martin** called the meeting to order at 9:03 a.m. He welcomed Kenneth Chuck Wade as the new Designated Federal Officer. He pointed out that this was a transitional period for the Federal Government. He referred the Committee to the President's reference to a new framework for civil nuclear cooperation during the prior week when he spoke in Prague. A former Committee member, Daniel Poneman, is now

the Deputy Secretary of Energy. Poneman was the manager of this Committee's policy statement that was issued this past year.

Martin asked for adoption of the agenda. Adoption was moved by Corradini and seconded by Todreas. The motion passed unanimously.

Martin asked each member to introduce himself or herself.

Shane Johnson was asked to review the budget and programs of the Office of Nuclear Energy (NE).

The Secretary's priorities are found in five areas:

- Science and discovery to move beyond incremental improvement of existing reactor and fuel-cyclic technologies to achieve transformational advances in knowledge and application
- Clean, secure energy; nuclear energy reliably provides 70% of the U.S. noncarbon-generated electricity
- Economic prosperity that advances U.S. technology leadership and global competitiveness and creates significant long-term employment and reliable and affordable electricity
- National security and legacy, where R&D is essential to reducing the risk of nuclear proliferation as nuclear-based electricity generation expands globally
- Climate change, where nuclear energy is recognized as essential to addressing global climate change

In a nutshell, the question is how to bring the nation's best science to bear on the energy and environmental needs of the nation.

The work of NE is divided into four areas:

- Delivering clean-energy products to market by maintaining existing, operating light-water reactors (LWRs); deploying advanced LWRs; and developing new advanced high-temperature gas-cooled reactors.
- Developing technical and policy options to the current fuel-cycle management strategy (the President will establish a blue-ribbon commission to look at the back end of the nuclear fuel cycle).
- Advancing U.S. international engagement to ensure safety and security by advancing policy and technology objectives and by maintaining a leadership role in international forums.
- Developing the U.S. nuclear-energy research infrastructure by building up the capabilities of Idaho National Laboratory (INL) and by supporting U.S. university nuclear-engineering programs.

These activities dovetail well with the current programs of the Office.

At this point, the Under Secretary of Energy, **Kristina Johnson**, joined the meeting. S. Johnson welcomed her and yielded the floor to her.

She ran a National Science Foundation (NSF) engineering research center, and the Federal Government is now standing up the Centers of the 21st Century (also called Energy Innovation Hubs or just "hubs"). Two are in NE: extreme materials and modeling and simulation. Requests for proposals (RFPs) to manage and operate the centers will come out in the fall if the initiative is funded.

A blue ribbon committee is to be established this summer to consider what to do about nuclear waste. Yucca Mountain is not an option. The Secretary and the President are excited about raising the prestige of R&D in this country from K–12 to undergraduate

schools to graduate research fellows, and postdocs. The Department will put together an energy-technology roadmap.

The Committee members were asked for their questions and comments.

Martin noted that, last year, this Committee issued a report on R&D and policy. Richter added that it was written because the United States had no plan for the future in nuclear energy. The national laboratories have decayed away, and educational programs were not supported. The President and Secretary give a general view of where the nation should be going. It is up to NE and its superiors in the Department to flesh that out. This Committee can help. A skeleton of a plan needs to be produced quickly. There is a lot to do.

K. Johnson agreed. The longer roadmap is inspired by the policy-recommendation report. The Committee will be asked for its help.

Todreas focused on the idea of transformational advances. The Gen-IV roadmap launched that program. The issue of LWRs is that light-water *coolant* should not be abandoned. The world will be using light-water-cooled reactors for 50 to 70 years. The first French sodium-cooled reactor will not come online until 2020 to 2040. Martin added that the developing countries want nuclear technology, and the Organisation for Economic Cooperation and Development (OECD) countries want safeguards.

Cochran said that the priority should be mitigating climate change. Nuclear plants will not make a difference in the near term. They are not economical. They will slow down climate-change mitigation. The Department of Energy should address economic issues in nuclear energy. K. Johnson noted that that is the purpose of the modeling and simulation hub.

Cochran stated that the effort to close the nuclear fuel cycle is doomed because it requires one-third of the reactors to be fast reactors. Fast reactors have failed in every country in which they have been tried. The Department will get a lot of requests to conduct advanced fuel-cycle R&D, but it will be worthless without fast reactors. The reliability and cost issues of fast reactors should be looked at.

Corradini said that the National Academy of Sciences (NAS) is about to publish *America's Energy Future*. The Department should read it seriously. It lays out a strategic timeline for energy development. The NP2010 program does not match the goals of the Repowering America initiative. One last reactor remains to be certified, and that certification should be focused on. Grid-appropriate reactors should be promoted for the export market.

Sessoms offered two observations: (1) DOE has to get back into the education business; (2) INL is not going anywhere, and the Department has to ramp up funding for it by a factor of 2 or 3 and treat it as a world-class facility. K. Johnson noted that $115 million a year will go toward education.

Ion urged the Department to stay abreast of what is happening internationally, especially in India and China and especially in fuel-cycle technology. The United States should take its rightful leadership place. The Department should upgrade its facilities to world-class status.

K. Johnson thanked the Committee members for their time and service and for a great report. Her job is a great challenge, and she was encouraged by the Committee's passion and advice.

A break was declared at 9:57 a.m. **S. Johnson** continued his presentation at 10:06 a.m.

The recommendations of the November 2008 NEAC report are very important to NE, the new leadership team in the administration, and the energy community as a whole in informing the development of the FY10 budget.

Richter asked who was setting up the blue ribbon committee. Cochran said that the Secretary is. S. Johnson said that the Office has been holding back on an NE R&D roadmap so the new Assistant Secretary for Nuclear Energy could approve it. The Under Secretary's call for an energy roadmap is an impetus for this Committee to structure a roadmap for NE. It is needed and overdue. Martin noted that the Under Secretary for Science may have input. Sessoms asked who will do it. S. Johnson said that that has not been decided. Corradini said that, when one looks up the chain of command, regulatory agencies will complicate matters

S. Johnson said that the human resources recommendation is being kicked off today with a multi-agency meeting. Richter noted that NE needs more staff. S. Johnson replied that some increase is expected but very little.

American Recovery and Reinvestment Act (ARRA) funds are driving a lot of other offices. NE got no ARRA funds. A lot of issues are hanging at this time. The FY10 budget will show whether the Office expands into new programs.

In supply-chain management, NE is not doing much; the federal role is unclear. No one is more sensitive to security than DOE and NE. The safeguards portion of the budget is significant. DOE does need to strive harder to improve Nuclear Regulatory Commission (NRC) processes, but the NRC is a very independent organization. Corradini noted that the certification process for boiling water reactors (BWRs) has dragged. There is a real problem there; the whole concept could be put at risk. S. Johnson said that scientifically grounded policy is needed.

The Office believes that there are many world-class capabilities at the facilities. A surge of improvement is needed as the facilities move forward incrementally. One of the hubs of excellence will be modeling and simulation. There has to be a fundamental change in how reactors are designed and licensed. It takes 7 years to license a new technology; that dampens investment. It is still taking 4 to 5 years to license an LWR.

Richter asked if the hubs will be outside the national laboratories. The big machines are at Oak Ridge National Laboratory (ORNL), the National Energy Research Scientific Computing Center (NERSC), and the weapon laboratories. S. Johnson replied that the hub concept calls for establishing research teams from a wide spectrum of disciplines to work in proximity to address issues related to nuclear energy. These centers will not live in perpetuity: they will be given 5 years of funding with an optional additional 5 years. In FY10, $35 million would be allocated per hub, $25 million for hub operations and $10 million for construction; in subsequent years, each hub would receive $25 million. The Department will issue a solicitation for such hubs, and the responses will determine the teams. Richter noted that the decision to locate the Rare Isotope Accelerator at Michigan State University weakened Argonne National Laboratory (ANL). DOE does not consider the long-term health of the national laboratories in its decisions. Corradini noted that the centers for bioenergy are all laboratory-university teams that bring in industry. That form of organization seems to be being used as a template for other centers in other offices and

agencies. Sessoms stated that INL is not on the list and that there has to be a serious decision to upgrade INL.

Todreas asked if teaming was to be accomplished by working elbow-to-elbow. S. Johnson replied that the researchers will be working at the same place. These are not virtual centers.

Hill noted that the bioenergy centers are each located at a physical site. The researchers are expected to spend a significant amount of time there. Richter agreed that the one in Berkeley works just that way. Ion asked how duplication was going to be dealt with. S. Johnson replied that the Secretary intends to be engaged and will establish a board to oversee the two NE hubs and the other hubs established across DOE.

S. Johnson noted that the policy portion of the NEAC report is getting a lot of attention. The LWR R&D budget item was not fully funded in the FY10 budget. R&D issues that cut across the current and future fleets will be looked at. Corradini asked if this were an LWR initiative or a Nuclear Power 2010 (NP2010) initiative. S. Johnson replied that it is a stand-alone program, not part of NP2010. Corradini asked if help were needed to reestablish NP2010 funding. S. Johnson replied that there is $20 million in the FY10 budget to close out NP2010.

In FY09, the Office is initiating a university program, program-specific R&D, investigator-initiated R&D, fellowships and scholarships, and enhancements to research capabilities. The NP2010 program is continuing to complete combined construction and operating license (COL) applications and continue first-of-a-kind engineering and design finalization activities for the AP1000 and economic, simplified boiling-water reactor (ESBWR) standardized designs. The high-temperature electrolysis experiments are being completed, down selecting to a single nuclear hydrogen-production technology and bringing the nuclear hydrogen initiative to a close.

Corradini asked if the hydrogen program was being brought to closure. S. Johnson replied, yes. Richter asked about the high-temperature sulfur-iodine process. S. Johnson answered that all of these technologies are being finished this year.

The Office will sponsor transformational research; create new Energy Innovation Hubs for extreme materials and for modeling and simulation; create a new production capability for plutonium-238; expand Gen-IV R&D; and redirect fuel-cycle R&D from a near-term technology-deployment program to a long-term, science-based R&D program.

Ion asked if the Department were assuming that more fossil and renewable energy will power the plug-in vehicles' needs. S. Johnson replied that it is hoped that nuclear will be expanded to meet plug-in vehicles' needs, but it may work out in fossil's favor.

Martin asked about the international aspect of NE's activities and where the international partners are. S. Johnson answered that the Secretary is committed to continuing DOE's international activities and staying engaged internationally. A major question is how to open the doors for U.S. companies overseas while limiting proliferation. DOE recognizes that there are foreign research facilities that the United States needs to use in order to move its program forward. The United States has little to offer in exchange. It was hoped that the Transient Reactor Test (TREAT) Facility would be restarted, but that did not appear in the FY10 budget. McGinnis added that S. Johnson had articulated the situation quite well. This is a globally integrated industry and R&D endeavor. Industry is carrying the bulk of the services needed. The international context must be factored in to maintain nuclear as a viable option in the United States. Sessoms

asserted that the NEAC report came out too late to influence the international community. There is a lot of confusion about where the United States is going.

Ion said that she realized that the United States is going back to R&D rather than to programs. Currently, industry is focused on LWR systems and not putting anything into next-generation systems. On the international front, the economic crisis has hit all countries, limiting work on advanced reactor systems, even in India and China. It would help if the United States would voice what is necessary here.

S. Johnson said that NE has been limited to R&D in high-temperature gas-cooled reactors and in sodium-cooled reactors. Other systems will be looked at in FY10. The question will be raised whether there are other technologies (even light-water-based) that should be looked at. Many international activities will continue, looking at the fuel supply and the back end of the fuel cycle.

Cochran noted that this Committee would serve a useful role if it stepped back and looked at the industry's real problems. The program does not address the real issues. Richter added that an R&D program should look at things that industry could do (e.g., in high-temperature materials).

Todreas reiterated that a whole area applicable to light-water cooling is missing.

Corradini stated that the Richter report called for NE to work with other DOE offices, and a lot of this has to do with the regulatory process. R&D should address licensing concerns and needs. Sessoms could not name anybody in the federal government that addresses R&D on manufacturing processes.

Marsha Lambregts and **John Gilligan** were asked to describe NE.'s university programs. Lambregts started the presentation.

The goals of the NE University Programs (NEUP) are to produce integrated, leading-edge R&D and an increased, high-quality workforce. Its purpose is to provide peer-reviewed funding to universities for R&D contracts and grants to universities for infrastructure, fellowships, and scholarships. It was formed between November 2008 and January 2009 and issued a solicitation in December 2008, awards from which were announced in May 2009. NE's R&D programs will allocate up to 20% of their appropriated funding to universities through NEUP. The Center for Advanced Energy Studies (CAES) administers NEUP. It will issue annual solicitations in following fiscal years, and contracts will replace grants and cooperative agreements for R&D. NEUP was based on the recommendations of the NEAC report.

For 2009, NEUP has a total funding of $64.7 million, of which $19.9 million went to Nuclear Energy Research Initiative (NERI) mortgages and $39.9 million went to R&D subcontracts. About $6 million went to infrastructure grants, and $2 to 3 million went to scholarships and fellowships, providing 70 $5,000 one-year scholarships and 16 $150,000 3-year fellowships. There are no mortgages. $2 million (39% of the overall budget) goes to administration.

In setting up the R&D solicitation, it was assumed that the program would have $13 million in new funding in six program areas; it is now at $43 million. Selections were based on a merit review. There were 433 pre-applications, 221 full proposals requested, and 216 submitted proposals. The NE Programs funding this R&D are Advanced Fuel Cycle Initiative (AFCI; $14.87 million), Gen-IV ($24.21 million), LWRs ($0.4 million), and Investigator-Initiated Research ($4.45 million).

Richter stated that this program is tied too tightly to the directions of the national laboratories and DOE. Martin asked if NE would be more open in the future. S. Johnson replied that, in the FY10 budget request, the Office sought a standalone $25 million budget item for university programs. This request was rejected by the Office of Management and Budget (OMB). They wanted a percentage of the program funds to go to university programs. Corradini said that what has evolved has worked out well. The discussions between national laboratories and universities to identify what would fit in was a good, productive strategy. Also, the 33% hit rate that the program achieved is very good. Todreas pointed out that, if one is completely coupled to the program, one does not get the best use of the university resources.

S. Johnson stated that Congress appropriated money by budget line, and it is illegal to spend that money for any other purpose. Thus, the amount of money available for university programs for any given program area is limited by the funding for that program area.

NEUP followed a three-step selection process. A semi-blind merit review achieved a mix of reviewers. The proposal selections were based on merit-review scores and available funding within a task. And a balancing review made sure that minority institutions participated, there was a balanced geographic distribution, and funding was limited to $1.5 million per proposal. During the merit reviews, four proposals had only one review because of a lack of qualified reviewers who had no conflict of interest. Most proposals had three reviews. Of the reviewers, 107 were from national laboratories, 120 were university professors, 32 were from industry, and 8 were from DOE and the NRC. Reviewers evaluated up to five proposals; 550 total evaluations were conducted.

The selection review board was comprised of laboratory and NE leads for each area. They considered the merit-review results for each application, addressing one work-scope at a time. Statistically significant deviations were given a detailed examination. Except for outliers, selections within a given work code were expected to parallel the numeric merit scores. Funding was given out starting at the highest merit score and going to the lowest as funding held out. The overall success rate was 33% of the submitted proposals.

The fellowship and scholarship solicitation was a collaborative effort between CAES and DOE-Idaho to allow awarding of grants. The solicitation was announced April 2, 2009. No administrative fees are allowed to universities; this allows in-state tuition waivers on the money. Applicants had to be U.S. citizens, beyond the first year in college, enrolled in an accepted to college or university, and pursuing a field of study of interest to NE.

Richter said that DOE should not choose the recipients; the universities should make that selection. They know the programs and the individuals.

For infrastructure funding, 54 submissions from universities in 32 states requested more than $12 million; 28 proposals were chosen by a panel review, and awards totaled a little more than $6 million.

Overall, NEUP seeks to implement an objective, fair, and transparent process and program.

Todreas stated that this information should be gotten out to the university community before the American Nuclear Society (ANS) meeting. Gilligan said that the information had been supplied to NEDO, but it is not known what they did with it.

Sessoms said that if anything could be done to expand the number of scholarships and fellowships, the Committee would be very happy.

The meeting was adjourned for lunch at 11:57 a.m. The meeting was called back into session at 12:42 p.m., and **Burton Richter** was asked to review the status of the Advanced Nuclear Transmutation Technology (ANTT) Subcommittee.

The Secretary asked that the ANTT program be changed from an early-development program to a science-based program. This being the case, the Committee should change the name of this Subcommittee to the Fuel Technology Subcommittee.

The Subcommittee has stated its major recommendation several times before: to improve the coupling of the NE program to the Office of Civilian Radioactive Waste Management (RW), Office of Environmental Management (EM), and Office of Science (SC) as well as to the National Nuclear Security Administration (NNSA). Now that new repository sites are being considered, a close collaboration with RW is particularly important.

A program has been started on safeguard monitoring of stored and reprocessed spent fuel. There is no Under Secretary of Science or associate director in any of the program offices. Now, Yucca Mountain is not going to be used. Fuels and their disposal must be coupled, so EM and NE should partner.

In its recommendations, this Subcommittee built on the NEAC report, which found that the facilities are in bad shape. This Subcommittee urged that the ACFI program review its facility needs. Although the program is not worked out in detail, enough is known to identify some of the important missing pieces: a neutron source and a transient test facility. Work could begin at the Los Alamos Neutron Science Center (LANSCE) and at the High-Flux isotope reactor (HFIR). There is not much time available on the Spallation Neutron Source (SNS). Internationally operated and funded fast-neutron sources should be explored. China, India, and Russia all have fast reactors.

ACFI seems to have been given the responsibility for keeping the sodium fast-reactor program going. The question arises whether this is a long-term assignment or just budgetary magic. This issue needs to be clarified. A broad Gen-IV review is a job for NEAC, not this Subcommittee.

This Subcommittee concluded that the accelerator-driven concept was not workable. The attention turned to reactors. The Japanese have determined that if plutonium does not need to be processed, the accelerator-based system may be promising for transmuting the long-lived, highly radioactive minor actinide fission products (neptunium, americium, and curium).

If electricity production and nuclear energy continue to expand, the amount of uranium required would be 16 million tons, and more would be needed by the second half of the century. DOE should be looking at other means of extracting uranium and ensuring a source of uranium into the future.

The new science-based orientation of the program gives the opportunity to take the time to see if new materials and processes can pay off. Today, the only way to make their reactor containment vessel is to forge a 500-ton billet of steel. New materials might offer other possibilities and should be investigated.

NE has turned over the university grants program and the fellowship program to CAES, a partnership of INL, its contractor, and the three Idaho public universities. There

are many potentials for conflict of interest in this program. It should have a serious performance review in about a year to see if it is functioning as it should.

Corradini asked if the Subcommittee were looking at small, fast reactors as test sites. Richter replied, yes. Either they are needed here or the operating costs should be shared with partners. The United States should be thinking of paying partners to build and operate such facilities. Corradini asked whether this might be 10 to 20% ownership of the next Phenix design. Sessoms asked whether they were talking about ownership or usership because the international organization owns it. Richter said that there are many models of use and ownership and data sharing, including contributing to construction costs, to operation costs, or to a combination thereof.

Todreas noted that the recommendations will be extracted and used, so the message from those recommendations should be clear. He agreed in principle with the recommendation on extracting uranium from seawater but believed that it was stated too narrowly. Richter agreed to reword the recommendation to say, "Investigate the potential of new sources of uranium (e.g., by extraction from sea water), perhaps in appropriate collaborations." Todreas said that the minor-actinide issue should focus on minor-actinide *targets* and open the possibility of using accelerators, neutrons, etc. for transmutation in the future. Richter offered a rewording of that recommendation: "DOE should re-evaluate separate treatment of the minor actinides in either accelerator-driven or reactor-based systems." This change allows for a future choice among various methods of effecting transmutation. Todreas said that the fast-neutron source is a start but is not a replacement for a fast-spectrum test reactor. Richter said that he thought that the report was clear about this, but would not be averse to including a footnote to the effect that "a larger-scale facility would be necessary in the future."

Cochran agreed that the Subcommittee's statement needs to be changed to include other fuel cycles. The makeup of the Subcommittee needs to be enhanced with people with broader views and experience. Richter agreed. He had suggested both of these before, but nothing happened. Cochran said that he believed that it is time that the Subcommittee operated with more transparency and be subject to the Federal Advisory Committee Act (FACA) rules. He also believed that the economic analysis of the cost of uranium is flawed and overlooks the historical fact that, in uranium mining, the cost of extraction goes down as the depletion of the resource increases. The cost of enrichment has a lot of room for efficiency improvements. In terms of separative work units (SWUs), the efficiency has increased from two SWUs to 200 SWUs. The issue of closing the fuel cycle has little to do with the cost of uranium. R&D should be focused on lowering the cost of new reactor systems. The closed fuel cycle is less safe than the open system, it will have more releases, it will require more management, and it will have more proliferation possibilities. Economical and reliable fast reactors should be focused on. Richter said that he and Cochran differed on details but not on fundamental principles.

The Under Secretary of Energy for Science **Steven Koonin** was introduced by Shane Johnson.

Ray Orbach was the first Under Secretary for Science and, at the same time, the Director of the Office of Science (SC). Those jobs have been split. The role of the Under Secretary for Science is now to back up the Director of SC and to serve as chief science officer across the Department.

He wants to break down the silos and increase communication across the offices. Matters nuclear extend across the Department and should share the expertise of the offices of SC. Other major issues include quality control of information coming out of the Department, the quality and morale of the scientific workforce, and policies that are well informed by technical matters.

Martin asked about his expectations for nuclear energy. Koonin replied that nuclear has to be a significant portion of the energy mix going forward. How to make nuclear plants safe, reliable, cost-effective, etc. has to be looked at. The deployability of the technology needs to be ensured.

Martin requested comments and questions from the Committee members.

Cochran noted that, the last time that he had met Koonin, he sued him. [Laughter.] He asked about inertial confinement and fusion. Koonin pointed out that the United States is a partner in the International Thermonuclear Experimental Reactor (ITER), and it just dedicated the National Ignition Facility (NIF), which will soon initiate an ignition campaign. We will see what comes of that. He would not count on any contribution from fusion in the next 15 years.

Corradini asked what practical actions could break down the silos. Koonin replied that the hubs will be a concrete way to foster multidisciplinarianism. Corradini asked at what level the hubs will be managed. Koonin answered that it depends on what you mean by management. The directors will be given great freedom. Corradini noted that there has been a lot of hubbub about fission-fusion fusion, and asked what Koonin thought about it. To save time, the answer was deferred to the end of the question period.

Sessoms asked how one infuses international cooperation into nuclear energy. Models for such cooperation are needed. DOE has to get back into the education business in an aggressive manner.

Todreas said that the United States has to be proactive in advanced reactors, especially light-water technology, which was downgraded by Gen-IV. But light-water technology fits into the transformational devices coming out in the next decades.

Richter stated that a roadmap for energy technology needs to be developed and needs to cover a long term (50 or 70 years). There is a lot of uncertainty on when the world will need to move away from LWRs. The U.S. research facilities are not in good shape. The nation's R&D is not world-class because the researchers do not have the tools they need. The roadmap should identify the tools needed.

Martin noted that Poneman believed that the United States should not be separated from the international community and that nuclear should not be isolated within NE. The Department could evaluate the nuclear technologies and integrate them into the roadmap. Where INL goes is a major question. Also, this Committee could use some guidance about where it is to go.

Koonin said that he was impressed with the advanced technology work being done in China. It is not going on in the United States. The nuclear community in the United States seems to be running in circles. Waste is high on the administration's agenda. A roadmap for nuclear energy should come out of NEAC. It should tell DOE how to structure a program, and it should tell DOE where to get the research done (at the national laboratories, universities, and/or industry). He had attended a recent workshop on fission-fusion hybrids. An engineering look at all of this issue would be enlightening. Some amount of fusion energy might be seen in the next decades; one question is how to

capitalize on it. A sober technical assessment is needed. Such hybrids might be worth a look. The Global Nuclear Energy Partnership (GNEP) was a way to engage international partners: it was the right idea but it took the wrong steps. LWRs will, indeed, be important in the next decades; DOE needs advice from this Committee on what to do. The facility situation needs assessment; stimulus money may be available for them.

Richter pointed out that the report that this Committee issued last year outlines how bad the national-laboratory facilities are.

Cochran asked when the administration was going to send a director of NE. Koonin replied, soon, he hoped.

A break was declared at 1:59 p.m. the meeting was called back into session at 2:12 p.m. Corradini moved, Sessoms seconded, that the ANTT report be accepted with the supplements added by the committee members' discussion. The motion carried with one abstention. A motion by Todreas, seconded by Sessoms, was to change the name of the Subcommittee to the Subcommittee on Fuel Technology. The motion passed unanimously.

Alice Caponiti was asked to review the recent developments in the Pu-238 supply.

DOE's FY10 congressional budget request includes $30 million to reestablish a domestic Pu-238 production capability. A Russian fuel shipment was received in December 2008; NE is continuing negotiations for the remaining shipments. A National Research Council (NRC) study was completed, and it concluded that the establishment of Pu-238 production is urgently needed. That study is entitled *Radioisotope Power Systems – An Imperative for Maintaining U.S. Leadership in Space Exploration*. The study was requested by Congress and the National Aeronautics and Space Administration (NASA) to support continued availability of radioisotope power systems for space exploration. The Pu-238 supply was the key focus of the report. The study committee meetings were held between September 2008 and January 2009; the report was completed in May 2009. Its key findings were that

- Radioactive power sources have been, are now, and will continue to be essential to U.S. space science and exploration.
- Pu-238 is the only isotope suitable as a radioactive power source fuel for long-duration space missions.
- An assured Pu-238 supply is required.
- NASA is already making mission-limiting decisions based on the short supply of Pu-238.
- Even if funding for reestablishing Pu-238 supply is provided in FY10, NASA's future demand will not be met; continued funding delays will increase the projected shortfall.

The major finding was that the FY10 budget should fund DOE to reestablish a Pu-238 production capability and that DOE and OMB should request (and Congress should provide) adequate funds to produce 5 kg of Pu-238 per year and that NASA should issue annual letters to DOE defining future demand for Pu-238. A letter was received from NASA in April 2008.

Cochran asked where the plutonium will be produced and if it would be used for any other purposes than space probes. Frazier replied that the Record of Decision allows it to be made in the HFIR at ORNL and at the Advanced Test Reactor (ATR) at INL. It will also be used for other purposes, as required.

Sessoms asked if it were possible to meet NASA's requirements. Frazier responded that NASA requires 5 kg per year. Sessoms asked if there were any other facilities where it could be produced. Frazier said that a commercial LWR could be used to make high-purity Pu-238, but it would also produce Pu-236, which produces a high gamma dose. Pu-238 could also be produced overseas at a neutron source.

Dennis Miotla was asked to review NE's operations and management of the ATR and to elicit advice from the Committee on those operations and management.

INL can make targets, irradiate them, and ship them off to other users. INL. is the only facility capable of handling large amounts of irradiated materials. It inherited the Materials and Fuels Complex (MFC) and the ATR in poor condition and has been attempting to restore the reactor to its original capability. It now faces a dilemma in that the ATR's national user facility is oversubscribed. INL is asking NEAC to look at the programs at the ATR to make sure they are effective and efficient so it can proceed with out-year funding planning.

INL has two ongoing ATR-improvement initiatives:

- The Life Extension Program (LEP), a maintenance program to return the ATR plant, supporting system, and documentation to the originally intended conditions
- The Safety Margin Improvement (SMI), which is intended to make the ATR more contemporary with commercial nuclear safety practices

The ATR is a critical nuclear R&D capability and needs to continue operating; but ATR is aging, and NE needs to be correctly focusing its resources on maintaining this capability. The customer base and demand for services is increasing and reaching capacity.

NEAC is being asked to assess and comment on the LEP and SMI programs, suggest additional needs or opportunities, develop a familiarity with the current state of the ATR, and produce recommendations for additional advisory reviews. An assessment on reconstituting the design basis was completed in March 2008.

Sessoms asked how much additional money would be needed for the LEP and SMI programs. Miotla replied that, in FY09, funding is at $108 million, up from $86 million in FY06. $200 million would be needed over 10 years. There is the option of shutting it down for the upgrade, but the Navy is worried about that loss of operating time.

Cochran asked if the reactor could be shifted to low-enriched-uranium (LEU) fuel. Miotla responded that it could be done but that he did not see the need. The Russians are not converting their reactors to LEU fuel. This reactor would be the last to be converted because operations with the new fuel would have to be recalibrated.

Todreas asked if NEAC could support all the new subcommittees being proposed. Martin said that that was something the Committee had to consider and decide.

Richter said that the question was not *whether* to do this upgrade. One *has* to do it. To upgrade the facility would cost $400 million; to replace it would cost $2 billion. He asked if the Committee had the technical expertise necessary to assess this problem. S. Johnson said that, if the Committee does not want to do this, it could suggest some technical experts who could guide the Department. Richter pointed out that, to maintain a project, about 2% of its replacement cost should be dedicated to maintenance each year to keep it in shape.

Corradini asked if the discussion were about one Committee member being supported by other experts. Todreas stated that it was difficult to discern any strategic questions

here. One could bring in a lot of management and operating (M&O) contractor people for technical oversight. Miotla said that an independent assessment is needed. Richter suggested that a DOE person could sit in on internal reviews. One cannot have advisory committees perform reviews of all internal reviews.

David Hill was asked to review the progress toward a world-class laboratory at INL.

DOE's vision is for INL to enhance the nation's energy security by becoming the preeminent, internationally recognized nuclear-energy research, development, and demonstration laboratory within 10 years of December 1, 2005. INL. will also establish itself as a major center for national-security technology development and demonstration. This goal requires that INL be a multi-program national laboratory with world-class nuclear capabilities. INL will foster new academic, industry, government, and international collaborations to produce the investment, programs, and expertise that will assure this vision is realized.

To fulfill its mission, INL needs to develop a world-class nuclear-energy capability; become a major center for national and homeland-security technology RD&D; become a leading clean-energy RD&D laboratory and a regional resource; and foster education, research, industry, government, and international collaborations to produce the needed investment, programs, and expertise. This nation needs a laboratory dedicated to nuclear energy. INL is not a science laboratory.

In addition to nuclear energy, INL has programs in national and homeland security and in environment and energy, advising regional states and provinces on energy use. It provides technical integration. What has been lacking is effectively leveraging capabilities across the national-laboratory system and with universities to build teams to get the job done. The available resources have to be used. The CAES administration of NEUP will further drive integration. In doing so, INL is serving the national interest; it has the right size, right talent, and affordable infrastructure. The four things that really matter are people, places, programs, and partnerships.

The U.S. nuclear-energy strategy has been fragmented. So, to influence the direction of policy and investment in capabilities, INL co-wrote with NE the *Facilities for the Future of Nuclear Energy Research* in November 2008. The INL–Electric Power Research Institute (EPRI) strategic plan for LWR R&D established a foundation for a new LWR sustainability program. And an EPRI-INL *Research Agenda* paper was issued in March 2009.

Delivering results to industry must be at the forefront of the NE/INL strategy. Industry needs solutions. The challenge for INL. is to bring the capabilities, expertise, and problems together to deliver those solutions. However, under law, a government facility cannot work under a fixed-price contract. As a result, industry tends not to trust DOE and INL. There are also issues with setting up a 501(c)3 organization as an intermediary. All of this R&D is for long-term issues.

A set of priorities has been identified. The goal is to identify a core set of high-value, long lead time to construct, currently operating facilities with the infrastructure to support nuclear energy R&D for 20 years. Major considerations are supporting infrastructure demands (e.g., providing security and safety) and exploiting the economy of collocation of capabilities. NE's research priorities are to improve the existing fleet of reactors, increase the deployment of advanced LWRs, deploy advanced reactor technologies, develop spent-fuel-technology options, and provide the infrastructure that underpins all

of these priorities. INL has to be seen as a national resource for national-laboratory, university, and industry researchers. A user's week was held June 1–5, 2009. It was wildly successful. A number of partnerships were established.

INL management is consolidating capabilities in town and is right-sizing the site facilities. RD&D capabilities are being consolidated at the INL research and education campus. Site facilities will be streamlined to support program missions. Existing facilities will be modernized and upgraded. And new facilities will be invested in. As a result, the INL real estate landscape is changing. Many of the 332 buildings managed by Battelle Energy Alliance will be modernized, demolished, or replaced with newer facilities.

In FY08, INL's business volume was $799 million, an 8% growth from FY07. DOE provided 65% of that business, the Department of Defense (DOD) and Department of Homeland Security (DHS) provided about 32%, and commercial entities provided about 3%. INL purchased more than $122 million worth of goods and services from Idaho large and small businesses in FY08. INL is eastern Idaho's largest employer and a nuclear-energy laboratory for the nation.

Todreas asked where INL was on the 10-year track. Hill answered that it was at or ahead of schedule overall. The people part is not there yet. New graduates are coming in. The laboratory needs good workers in "the engine room." He was optimistic in the long run and nervous for the short run.

Corradini asked if INL had benchmarked itself against its peers in attracting the "engine-room crowd." Hill responded that ANL has declined significantly. In the next few years, there will be two nonweapon laboratories working in civil nuclear energy: Oak Ridge and Idaho. There are people who would not live anywhere else than, say, Tennessee. But INL is being successful. The facilities need to be brought up so they are not a drag on the budget. If the facilities problem is solved, the people problem will be solved, too.

Sessoms asked how much additional funding would be needed. Hill replied, another $400 million for MFC and $400 million for ATR over the next 10 years.

Phillip Finck was asked to address the issue of science-based fuel-cycle R&D.

The former programmatic approach to improving existing technologies was to make incremental changes to allow for a short-term (about 20 years) deployment. In waste management, it was driven by the need for better utilization of Yucca Mountain. This approach was driven by a specific choice of technologies and an integrated system (dictated by the time frame and by the Yucca Mountain characteristics). The challenges were well identified, and engineering approaches were chosen to address those challenges. Fundamental challenges had also been identified, but were marginally acted upon (e.g., by modeling and simulation) with little money to invest. This industrial approach resulted in a very limited investment in the tools needed to develop a better understanding of the fundamentals.

The past definition of technical challenges was very limiting. The Yucca Mountain repository characteristics were the main driver for the system architecture and specific technologies. The *fundamental* elements are fuels and reactors. We need a new approach to the economics and a large, complicated integrated-waste strategy.

The proposed new approach looks at the long-term deployment of fuel-cycle technologies based on an initial analysis of a broad set of options and based on the use of

modern science tools and approaches designed to solve challenges and develop better-performing technologies.

We used a systematic approach, looking at new boundary conditions, system criteria, system options, technology criteria, technology options, technology risk, and resolution pathways. Under this system, policy decisions determine the grand challenges for R&D. What is wanted is a full "tree" of technological options and choices.

The old engineering approach relied on empirical and observational processes:

- Design a prototype based mostly on empirical knowledge
- Build and test a prototype
- Develop an engineering model to explain observations
- Define performance envelope
- Operate prototype
- Design and build actual system

The new "science-based" approach uses a predictive capability to

- Identify the governing phenomenology
- Develop a first-principle based model of the phenomena
- Develop mathematical model of the system
- Define and optimize
- Characterize systems performance
- Build a prototype and demonstrate performance
- Design and build the actual system

In transformational nuclear fuels with variable compositions, R&D is needed to understand and predict fuel behavior and performance and to reliably fabricate fuel with zero defects and with zero losses. The development path calls for developing a microstructural understanding of fuels and materials by the closure of combined transport and phase-field equations; by separate effect testing and properties measurement at the sub-grain scale; by the elucidation of the effect of nanoscale implantations; and by innovative, clean, and reliable fabrication techniques with tightly controlled microstructures tailored to desired performance. The transformational results of this process will be (1) a predictive capability for the fuel process and for the in-pile behavior of a variety of initial and boundary conditions and (2) novel fuel forms.

In waste storage and disposal, R&D is needed to understand how to store and dispose of spent fuel, high-level waste, greater than Class C, and low-level waste from a range of fuel cycles; to understand and predict geologic repository performance; and to develop a safe, secure, and cost-effective storage and disposal. To do this, we need to develop a predictive capability for the performance of storage and disposal options for a range of fuel cycles. Modeling and simulation tools can be used to do this.

In transmutation systems, R&D is needed because the fast reactors have not been commercially deployed and there is the perception that they result in a higher system cost of electricity. The licensing regime is based on LWR technology. What is needed is the ability to design and assess other systems. This ability can be gained through modeling and simulation for optimized design, performance, and safety assurance; advanced materials for performance, reliability, longevity, and safety; energy-conversion innovations for improved efficiency and component cost; and R&D facilities for validation of innovative features and for the exploration of options to produce revolutionary improvements in fast-spectrum system performance (and cost) to enable

transmutation and economic fuel-cycle closure and novel transmutation systems. The Brayton cycle would get rid of the second heat-exchange loop. The sodium reactors of today look like those of the 1970s. New tools would allow advances in design.

In separations and waste form, R&D is needed for recycling used nuclear fuel in a way that meets current air emission requirements, allows the economical recovery of transuranic elements for recycle/transmutation, and minimizes waste generation. Down the line, what is needed is a predictive capability for separation and waste-form performance over a broad range of operational conditions and novel separation technologies.

In materials protection, accounting, and control for transmutation, R&D is needed because large-throughput facilities currently require shutdown for periodic inventory, new reactor designs require a new nuclear-material-management approach, and the need to move from a reactive to a preventive systems approach. The goal here is to achieve real-time nuclear-materials management with continuous inventorying.

Modeling and simulation require tools that are based on a fundamental understanding of the physical processes and that are capable of predicting the performance of fuel-cycle technologies.

It being the appointed time, Martin opened the floor for a public comment; there was none.

Corradini noted that Finck had mentioned calculations to make the design process more efficient and asked if NE can work with SC to do that. Finck replied, yes. The models and simulations come from SC. They bring the capabilities needed to do the simulations. NE adopts and adapts their capabilities.

Richter noted that NE has moved away from rapid deployment of fuel recycling, fast reactors, and other projects. He did not know what review NEAC might want to do, but the options program will hit the table in fall 2009, too late to influence the next budget cycle. Ways need to be developed to deal with issues for the FY11 budget. NEAC does not need to review internal assessments; it needs to focus on the long-term questions. Because of the absence of policy opportunities, NE is behind schedule in developing the programs the Secretary wants. NE should be doing something on Gen-III^{++} [a play on the name of the programming language C^{++}]. The options for LWRs should be expanded upon.

Martin asked what should be changed in the facilities report.

Corradini asked how RW fits into NE, and how the national laboratories and others adapt the AFCI program to the needs of the radioactive-waste program.

Todreas said that the Committee should read this report, put it in the context of what it heard here, and write a note to the new Director of NE. The budget that is going in now should be set, and a roadmap for R&D should be initiated to inform the FY11 budget request. The options space to work in is well defined by the top level of DOE. The Committee knows what it is not involved in. The program has to be science-based. But that does not exclude real-life application. The Committee needs to offer its services for developing the FY11 budget request. It should consider ideas for the roadmap as developed or outlined on page 5 of Finck's presentation.

Cochran noted that, in the near term, this Department is struggling with building and selling economical reactors. This modeling approach should be used to dissect costs and find cost reductions that can be applied to near-term systems. In the long term, how far

can one go in burnup of LWR fuel with under 20% enrichment? That question should be explored with the models and simulations. Finck pointed out that burnup is only a small part of the reactor cost. The U.S. industry has gone up to 92% operating time by other methods. Cochran asserted that one will never get the costs for sodium-cooled reactors down to the costs of LWRs. Finck said that the core should be smaller and have a higher core power density.

Corradini said that the subcommittee structure should be looked at. Some subcommittees should be phased out, and others phased in. This is the only nuclear-energy advisory committee left. This Committee's structure needs to be mapped to what is going to be encountered.

Sessoms said that the Committee's report was correct on a number of things, especially fudging on the topic of Yucca Mountain; that was completely correct. The report was also correct on workforce development, INL, etc. Now the Committee needs to look at ATR and other facilities in the light of the new realities. The international approach on nuclear energy is important and can improve the international discourse. The Committee can explain to the international community what DOE is doing. That would be very useful. LWRs are the way of the future. Fast reactors are not going to happen. The Committee needs to help DOE focus on needed designs.

Richter said that the United States is behind in advanced reactors. Whether they are deployed is inconsequential; the United States should know what is going on. The reports last year were influential because they were written up and were responded to. The Committee should put out something like that once or twice a year. Sessoms added that these written reports are a big deal, as is frequent communication with the Secretary of Energy.

Todreas said that, in the Gen-IV debate, this Committee had a voice and defined issues and described options in parallel with DOE.

Martin asked S. Johnson to summarize the meeting. Johnson thanked the Committee for its spirited engagement. There are things that the Office wishes it could speak more freely about. There have been significant changes to DOE in the past 6 months and perturbations to all of the NE programs. The Office is moving forward, trying to understand the fundamental aspects of the spent fuel. Clear directions about the path forward have not yet been provided by this administration; the policy on a new framework for civil nuclear cooperation has not been finished up. Over the next few months, there is the opportunity to determine where the program is going in the long term. The Office will step back and look at the Gen-IV program and will focus on LWR technology. This Office could benefit from NEAC's assessing what this new framework for civil nuclear cooperation can and will be; the United States needs to lead with the technology with an emphasis on safety and nonproliferation. The United States needs to stop limiting engagement to those parties who have adopted a long list of requirements; one cannot lead with a negative. A major issue to be addressed is how to provide the infrastructure and human resources for this new framework for civil nuclear cooperation. Both under secretaries were pleased to be here today, and NEAC has been offered to them as a resource. The Office would like to get NEAC members' advice as the FY11 budget request is developed. Every time the budget in one program is increased, it has to be done at the expense of another program in the Office.

Martin thanked S. Johnson for his responsiveness.

Cochran asked what happened on molybdenum-99. S. Johnson replied that he did not know. The production of medical isotopes has been shifted to SC.

The meeting was adjourned at 4:36 p.m.

Respectfully submitted,
F. M. O'Hara, Jr.
Recording Secretary
June 22, 2009

Corrected,
John Ahearne and William Martin
July 7, 2009