Minutes for the
Nuclear Energy Research Advisory Committee Meeting
November 5-6, 2001, DoubleTree Hotel, Arlington, Virginia

NERAC members present:

John Ahearne
Joseph Comfort
Michael L. Corradini
Jose Luis Cortez
Allen Croff
James Duderstadt (Chair)
Marvin Fertel
Beverly Hartline
Andrew Klein
Dale Klein (Monday only)
Robert Long
Warren F. Miller, Jr.
Benjamin F. Montoya
Sekazi Mtingwa
Lura Powell
Richard Reba
Joy Rempe
John Taylor
Charles E. Till
Neil Todreas

NERAC members absent:

Thomas Cochran
Maureen S. Crandall
Steve Fetter
Leslie Hartz
J. Bennett Johnston
Linda C. Knight
Allen Sessoms
Daniel C. Sullivan
C. Bruce Tarter
Ashok Thadani (ad hoc)
Joan Woodard

Also present:

Robert Card, Under Secretary, USDOE
Nancy Carder, NERAC Staff
Charles Forsberg, Researcher, Oak Ridge National Laboratory
Norton Haberman, Senior Technical Advisor, NE, USDOE
William Halsey, Fission Energy and Systems Safety Program, Lawrence Livermore National Laboratory
John Herczeg, Lead Nuclear Engineer, Office of Technology and International Cooperation, NE, USDOE
Kenneth Hughey, Senior Manager, Entergy Nuclear, Inc.
R. Shane Johnson, Associate Director, Office of Technology and International Cooperation, NE, USDOE
Jerry Langford, Fission Project Manager, NASA Marshall Spaceflight Center
Louis Long, Vice President, Southern Company
William Magwood, Director, NE, DOE
Gail Marcus, Principal Deputy Director, NE, USDOE
Tony McConnell, Vice President, Special Projects, Duke Engineering & Services
Thomas Miller, Program Manager, Office of Technology and International Cooperation, NE, USDOE
Frederick O'Hara, Jr., NERAC Recording Secretary
Burton Richter, Professor of Physical Science, Stanford University (by telephone)
Robert Versluis, Office of Technology and International Cooperation, NE, USDOE
Jack Wheeler, Space and Defense Power Systems, NE, USDOE
Craig Williamson, NERAC Staff
Earl Wahlquist, Associate Director, Space and Defense Power Systems, NE, USDOE

About 50 others were in attendance during the course of the two-day meeting.

Monday, November 5, 2001

The meeting was called to order by Chairman **James Duderstadt** at 10:00 a.m. He reviewed and adjusted the agenda. The minutes of the previous meeting were approved unanimously. He introduced **Bill Halsey** to speak about nuclear-energy R&D at Lawrence Livermore National Laboratory (LLNL). Lawrence Livermore National Laboratory is managed by the University of California for the DOE. It has 7250 LLNL and 750 other employees. Its capital plant is valued at $4 billion, and its annual operating and capital funds total about $1.3 billion per year. He displayed the LLNL organization chart, calling attention to the Energy and Environment Division, headed by C. K. Chou.

The mission of LLNL is to ensure national security and to apply science and technology to the important problems of our time. The Laboratory is an applied-science national-security laboratory whose primary mission is to ensure that the nation's nuclear weapons remain safe, secure, and reliable and to prevent the spread and use of nuclear weapons worldwide. This mission enables its programs in advanced defense technologies, energy, environment, biosciences, and basic science to use its unique capabilities and to enhance the competencies needed for the national-security mission. In addition, the Laboratory serves as a resource to the U.S. government and as a partner with industry and academia.

The Bioscience and Healthcare and Energy and Environment divisions are collectively a significant portion of the laboratory's activities and are targeted to be at least one-third of the laboratory's funding in the long range. Funding for the entire laboratory is now down 10% from the historic peak, and the institution is looking forward to stability.

Duderstadt asked if the Health and Environment activities were imported from the National Institutes of Health (NIH) or were part of DOE activities. Halsey responded that some were imported but that much of the work is driven by the DOE mission.

Stockpile stewardship is the primary focus of LLNL and Los Alamos National Laboratory (LANL), ensuring safe, reliable nuclear weapons without testing, which involves accelerators, computational simulation, laboratory and large-scale experiments.

Mtingwa asked what accelerators he was referring to. Halsey showed a photograph of the Advanced Test Accelerator (ATA) and said that they had a number of applied accelerators to carry out the stockpile-stewardship responsibilities.

The National Ignition Facility (NIF) at LLNL is a combination of world-class science, technology, and engineering, designed to produce a controlled, sustained thermonuclear burn in the laboratory. Another capability is computation: ASCI (Accelerated Strategic Computing Initiative) White, the world's fastest computer, is now operating at 13 teraflops. The Laboratory has programming capabilities to go along with hardware, leading to multiscale simulations driven by the need to model nuclear weapons. This capability is now being extended to

- Computational biology
- Climate, weather, and ocean circulation
- Environmental issues, such as the movement of contaminated groundwater
- Design of new materials
- Modeling chemical reactions at the electron-physics level
- Many areas of physics

A possible application is the modeling of a virtual nuclear reactor from the nuclear to the plant scales.

Ahearne asked what would be possible with that capability. Halsey responded that virtual design, developing concepts in parallel, and focusing R&D on the most important areas would be possible. It is being looked at internally. Duderstadt commented that it would be important in education and training, too.

In addition to nuclear-weapons-stockpile stewardship, LLNL is advancing the nonproliferation of weapons of mass destruction by helping the Russians to secure their nuclear materials; developing advanced technologies for proliferation detection and response; and studying the prevention of and response to nuclear, biological, and chemical terrorism. The bottom line is that its unique capabilities and strengths allow LLNL to contribute to important national needs, such as nuclear energy, often in partnership with other laboratories.

LLNL has a history in nuclear energy. Reactor systems and concepts experimented with include:

- Pluto Program, producing the Tory-IA and Tory-IIC (a 500-MW nuclear ramjet flyable prototype) reactors
- several reactors onsite
- space propulsion designs

Fuel-cycle work included the development of unique, robust fuels (U/Be-O ceramic, U-solution, nitride, and alloy) and experience in spent-fuel disposal (e.g., the Spent Fuel Test - Climax and the granite disposal, retrieval, and analysis at Nevada Test Site). Comfort asked what the results were. Halsey said that most results were what was expected, although corrosion occurred in waste packages that was not anticipated.

Unique facilities and capabilities at LLNL include:

- SuperBlock Plutonium/Tritium Facility
- Site 300, a large experimental test site
- Seaborg Institute for Transactinium Science
- ASCI
- Center for Applied Scientific Computing (CASC)
- National Atmospheric Release Advisory Center (NARAC)
- Center for Global Security Research (CGSR)
- Center for Accelerator Mass Spectroscopy (CAMS)
- Laser Isotope Separation (LIS)
- NIF, which uses petawatt lasers to produce a high-energy, short pulse

The LIS and plutonium activities do not currently receive funding.

LLNL is currently a participant with DOE-NE in the Advanced Accelerator Application (AAA) [formerly the Accelerator Transmutation of Waste (ATW)], Gen-IV, and Nuclear Energy Research Initiative (NERI). In the past, it has cooperated with NE by coordinating the study, “Recommendations for a Nuclear R&D Agenda”; contributing to the NE Infrastructure Roadmap and the NERAC Long-Term R&D Plan; hosting the workshops “Proliferation-Resistant Nuclear Power Systems: A Workshop on New Ideas” and “Workshop on Technical Opportunities for Increasing the Proliferation Resistance of Global Civilian Nuclear Power Systems (TOPS)”; and contributing to TOPS in other ways.

The LLNL SuperBlock is ~25,000 square feet of Category-I Pu experimental space. It has an $80 million annual budget (split between programs and infrastructure) and represents the world’s premier capabilities in actinide science. It also has tritium-handling capability. The SuperBlock has end-to-end capabilities with Pu, U, minor actinide (MA), and tritium for program development, safety analysis, system analysis and design, demonstration, deployment, applied research, and performance analysis and iteration.

The Glenn T. Seaborg Institute for Transactinium Science was formed in 1991 with Lawrence Berkeley National Laboratory (LBNL), LANL joined it in 1997. Its mission is to maintain and enhance U.S. leadership in the critical technologies related to the chemistry, physics, and metallurgy of the transactinium elements. It places a special emphasis on the education and training of the future generation of scientists and engineers in heavy-element research to meet changing national and international needs in

- environmental protection and remediation
- nuclear waste isolation and disposition
- national security and policy
- nuclear energy
- transactinium physics, chemistry and metallurgy

It has a long list of programs in research, education, and industry and has created several postdocs.

A. Klien asked what background the postdocs come from. Halsey responded, chemistry, process chemistry, and nuclear chemistry. Duderstadt asked how LLNL's funding for the Seaborg Institute was. Halsey said that they would like to have the ability to do more, but have adequate funding to carry out a robust program. Their funding is a combination of programmatic and institute support.

NARAC is the national emergency response service for real-time assessment of incidents involving atmospheric release of nuclear, chemical, biological, and natural hazardous materials. Since 1979, NARAC has responded to more than 70 alerts, accidents, and disasters and has supported more than 800 events, including the Kuwaiti oil fires, the Tokai accident, and backcalculating the Chernobyl accident. All DOE and Department of Defense (DoD) sites have access to this center. Others are looking at it.

Much of what LLNL offers in nuclear-energy R&D is derived from the base of science and technology developed to support national security: nuclear-materials management, nonproliferation, nuclear-facility security and safety, enrichment and waste management for the nuclear fuel cycle, and advanced concepts.

An important activity has been managing the transparency of Russian highly enriched uranium (HEU). This program involves the conversion 500 metric tons of weapons-derived HEU to 15,000 metric tons of low-enriched uranium (LEU), which are then puchased by the USEC, Inc., at a price of approximately $12 billion over 20 years for use in light water reactors. The LLNL-led transparency program assures that the LEU received is, in fact, derived from HEU removed from dismantled Russian weapons. Through 2001, it is anticipated that about 141 metric tons will have been converted. The current rate of about 30 metric tons per year of HEU represents about 50% of the U.S. annual nuclear-fuel use.

Corradini asked if this fuel was for U.S. or foreign consumption. Halsey said that it was for the U.S. market, but some is sold abroad.

In the area of managing nuclear materials, LLNL is also involved in the disposition of excess plutonium. That portion of the plutonium that is not converted to mixed oxide (MOX) fuel can be put into a ceramic matrix and disposed of as high level nuclear waste. This project is on hold for a few years. The politics and the price tag are difficult issues to deal with. Ahearne asked if all the facilities in the Super Block are in working condition and staffed. Halsey responded affirmatively and noted that the facility is available for other R&D. It can make ceramic Pu pellets and powders for fuel research.

Miller asked what the National Nuclear Security Administration (NNSA) plan was for SuperBlock. Halsey said that it is a critical component of the stockpile-stewardship effort and that mission is expected to continue. Ahearne asked if the facility was sidelined for a couple of years. Halsey said, yes. It is built, qualified, and not yet contaminated. It can make metal fuels and oxide fuels.

In nonproliferation, arms control, and international security, LLNL conducts work in proliferation prevention and arms control, proliferation-detection and -defense systems, counterterrorism and incident response, and international assessments and hosts the Center for Global Security Research. The LLNL-developed Argus, a site-security system, is the standard security system for DOE and NNSA, specifically designed for high-security nuclear facilities. It provides real-time command and control of operations; personnel access control; alarms, sensors, and video monitors; and material monitoring customized for each facility; and an integrated emergency-response initiative is under way.

The Laboratory has provided technical support for the Nuclear Regulatory Commission (NRC), performing nuclear-materials safeguards and security (NMSS) investigating the service life of shipping packages, MOX-fuel transportation, the Shippingport-vessel-transport safety review, and shipping-package testing; operating a research office on seismic-hazard assessment and on digital instrumentation and control, and preparing safety analysis reports for the USEC, Inc., and Yucca Mountain.

LLNL led the development of the atomic vapor laser isotope separation (AVLIS) for the production of LEU. Parts of that system are currently on standby or mothballed, and the mission is being reevaluated. The laboratory has also conducted special isotope-separation studies for defense programs and evaluated specialty separations for specific missions, such as easy gadolinium enrichment for use in achieving higher-burnup reactor fuel. Corradini asked if he meant economically easy, and Halsey responded, the most economically feasible at a large scale.

For more than 20 years, LLNL has been the largest national laboratory contributor to the Yucca Mountain Project with lead responsibility in the near-field environment (thermal, hydrology, chemistry, and mechanics) and the engineered barrier system (EBS); waste-package materials, waste-form models, engineered materials, and EBS performance).

Ahearne asked if LLNL has a position on the high or low temperature designs for Yucca Mountain. Halsey replied that either one would work. It would be a tradeoff of intangible uncertainties. The higher-temperature repository would be more compact and, therefore, cheaper.

LLNL contributes to DOE-NE advanced nuclear-energy programs in a number of ways. It is a minor participant in the AAA, providing early program reviews and recommendations and contributing to the 1999 roadmap by looking at benefits, impacts, and nuclear data. It is a contributor to the systematic study of multi-tier options (repository impacts of transmutation, environmental impacts, and proliferation resistance) and a minor participant in the development of the Gen-IV Reactor Roadmap.

Hartline asked if he had any conclusions on the repository impacts and benefits of AAA. Halsey noted that a discussion of that topic appeared later on the Committee's agenda. If one is going to process fuel and change the waste forms, clear the waste streams, and eliminate most of the actinides, there are obvious benefits to the repository in terms of long-term dose potential, design flexibility, and other areas. Hartline asked if it made a difference between hot and cold. Halsey responded that, if one had a waste-stream future that was all transmuted and optimized into separate streams, one would want a different repository design and operational philosophy than for spent fuel. Either a cold or hot repository would handle those waste streams. There would be different waste packagings and loading scenarios. There would be cost impacts, but what they would be would depend on the mix going into the repository, how the repository would evolve, and how costs were assigned.

LLNL applies innovative scientific and engineering concepts to several DOE-NE NERI projects. It is studying monitoring and control technologies for the Secure Transportable Autonomous Reactor (STAR) with Argonne National Laboratory (ANL). It is working on an encapsulated nuclear heat source (a STAR reactor) with the University of California at Berkeley (UC-B), ANL, and Westinghouse. It is conducting isomer research with LANL. It is looking at new design equations for irradiation creep and swelling in Gen-IV reactor materials. It is using multiscale modeling to look at random grain-boundary-network connectivity as a predictive tool for intergranular stress-corrosion cracking. And it is using positron emission tomography to detect nuclear-pressure-vessel flaws. This latter effort is funded within the Nuclear Energy Plant Optimization (NEPO) program.

In education and training, LLNL has contributed to the Organisation for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA) Study "Nuclear Education and Training: Cause for Concern?" and it has set up many laboratory-university institutes. It cooperates with universities by hosting staff/faculty visits/sabbaticals and student programs for undergraduate, graduate, and postdoctoral students. The Livermore Science and Technology Education Program (STEP) teaches teachers about science and technology. There is a campus of UC-Davis at the LLNL site, and UC-Merced is setting up a new campus with LLNL as a partner.

Mtingwa asked if their programs had been around long enough to see a turnaround in the number of PhD radiochemists. Halsey responded that he was not sure.

With internal, exploratory money, LLNL supports advanced nuclear energy science and technology:

- In computational material science, they are taking an advanced computation approach to multiscale modeling of material performance.
- With the AVLIS, they are evaluating the technical capabilities and limitations for multiple LIS missions.
- In advanced fuel fabrication, they are assessing the potential of the plutonium ceramic facility to contribute to advanced-fuels development.
- In nuclear isomers, they are exploring the potential to store and control the release of energy in isomeric states of select nucleii.
- In the design of proliferation resistance for small liquid-metal reactors (LMRs), they are conducting a few reactor explorations jointly with UC-B, Central Research Institute of Electric Power Industry (CRIEPI), and the Japan Nuclear Cycle Development Institute (JNC).
- In the Virtual Reactor, they are applying ASCI capabilities to multiscale modeling to an entire reactor.

Hartline asked how much money was going into nuclear energy R&D at LLNL. Halsey responded, tens of millions of dollars. Corradini asked what the funding of the Energy and Environment Directorate was. Halsey said it had 430 full-time equivalents and more than $100 million per year.

Duderstadt asked about the interface between LLNL and the University of California research staff and whether LLNL plays a proactive role to make ties with other universities. Halsey responded that the Laboratory does not have a mission to work with universities and in academic outreach. That comes piecemeal. The institutes have an outreach component, but that has a narrow focus. Ahearne commented that, in ASCI, LLNL has offered opportunities to other institutions and its student programs are open to anyone. Halsey agreed and went on to say that they did a good job at it.

Powell said that her institution sees a need to bolster the education programs in nuclear science. Miller noted that the NNSA has done a good job of reaching out to the academic community but could do a lot more. Halsey commented that the capability of the ASCI hardware is impressive and there is interest in outreach, but access to the hardware has not been forthcoming. Miller said that there needs to be more money for basic research and training.

A. Klein stated that his university had de-emphasized nuclear chemistry over the years, so there are fewer teachers in the field and asked if this area should be picked up in nuclear engineering departments or forced into chemistry departments. Corradini responded that energy technology is of great interest to students, so this topic is part of a bigger problem. Chemistry and chemical engineering see very little interest. The most students want to go into the biological sciences. You have to allow radio- and nuclear chemistry to stay in the chemistry departments, otherwise the teachers lose their credentials. Todreas noted that Massachusetts Institute of Technology (MIT) has successfully brought an actinide chemist into the nuclear engineering department and commented that very few places are educating nuclear scientists.

Corradini said that academia is getting mixed messages from DOE. Some portions of DOE are encouraging academic cooperation, but others feel pressured to hew to the mission line. Powell noted that DOE used to have a lot more money for education than it does now. Because of the current focus on energy, there may be a window of opportunity to get more funding for education. Hartline stated that other agencies are funding education and there was no reason DOE could not fund radiochemistry. Reba pointed out that the National Academy of Sciences (NAS) had studied the role of radiochemistry in various fields. They noted the decline of academic positions in radiochemistry and made some recommendations. A statement from NERAC might bolster that NAS committee's recommendations.

Montoya said that there is a correlation between lack of capital investment by industry and student interest in the area. What should be done is to stress a National Energy Policy (NEP) that would induce private investment and, thereby, additional academic interest.

A break was declared at 11:35 a.m. to get food for a working lunch. The meeting was called back into session at 11:58 a.m. to hear **William Magwood**, Director of the Office of Nuclear Energy, Science, and Technology, give an overview of recent DOE nuclear energy program activities. He started by introducing the new staff members who were in attendance.

The U.S. NEP came out since the last NERAC meeting. It is a good plan for the future, but it does not have the high-level attention it did before September 11. A significant portion of the National Energy Plan (NEP) is devoted to nuclear power: The National Energy Plan Development Group recommended that "the president support the expansion of nuclear energy in the United States as a major component of our national energy policy" by

- supporting the expansion of nuclear energy in the United States
- developing advanced nuclear fuel cycles and next-generation technologies
- developing advanced reprocessing and fuel-treatment technologies

These recommendations represent a good idea of what projects NE should be doing in the future.

Ahearne noted that reprocessing was stopped several decades ago and asked what was intended in the NEP. Magwood said that it was referring to research in advanced concepts in nuclear reprocessing (e.g., pyroprocessing). The distinction between recycling and reprocessing was lost in the final editing of the document.

A few of the other recommendations offered in the NEP include some for the NRC, which is still a tough regulator but has become a reliable partner with industry: make safety and environmental protection high licensing priorities, safely uprate existing plants, relicense existing plants, and increase the available resources for nuclear-safety enforcement. A recommendation for DOE and the Environmental Protection Agency (EPA) was to assess the potential for nuclear energy to improve air quality and to accomplish this through with the advisory-committee process. A charge letter for NERAC to perform such an assessment will be in the offing; in the meantime, Magwood officially asked the Committee to work with EPA to assess the role of nuclear energy in improving air quality. Duderstadt accepted the charge on behalf of the Committee. Recommendations specifically aimed at DOE urged it to use the best science to provide a deep-geologic-repository capability; avoid taxation of qualified decommissioning funds; extend the Price-Anderson Act [this legislation had passed out of the House committee and was expected to pass the House during the week of the Committee meeting; there were issues dealing with subrogation of contractors and the security of commercial plants; a 15-year extension was expected]; conduct R&D on advanced nuclear fuel cycles and next-generation technologies; and collaborate internationally on cleaner, more efficient, less waste-intensive, and more proliferation-resistant technologies. The 2002 budget does not address these issues, but the 2003 budget will.

As part of the 2002 and 2003 appropriations, NE is pursuing the following nuclear-energy R&D activities:

- Nuclear Power 2010 (an effort designed to support the construction of the next U.S. nuclear power plant by 2010);

- Gas reactor activities (including improving fuel-manufacturing processes and inspection, conducting a gas turbine–modular helium reactor (GT-MHR) plant cost evaluation, cooperating with the NRC in developing a gas-reactor framework, and testing fuels);
- Advanced Light Water Reactor (ALWR) activities (providing money for the AP1000 Independent Review and Analysis, conducting a pilot demonstration, and preparing a regulatory guide on transient- and accident-analysis methods to assist NRC; and
- Generic activities [including early site permit (ESP), which allows a utility to evaluate a site and then "bank " that location and starting the verification and validation of analysis codes].

Ahearne asked if the applications for ESP are primarily at existing sites. Magwood replied that it is a mix of existing and new sites. Fertel commented that, in the foreseeable future, it is going to be largely existing sites.

Another current NE activity is Generation IV, a very successful effort to develop an international participation and R&D agenda to develop next-generation nuclear power plants. The Gen-IV Roadmap is being developed by more than 100 experts from a dozen countries. The Generation IV International Forum (GIF) is now formalized with an international agreement, and the OECD NEA has been established as the international R&D coordinator. A lot of NE's work will happen through the International-NERI. Agreements have been signed with South Korea and France, six projects have been awarded with South Korea and four with France. Agreements with Japan and South Africa [with a pebble-bed modular reactor (PBMR) focus] are expected next. Four meetings of the Gen-IV International Forum have been held: Washington, D.C., January 2000; Seoul, South Korea, August 2000; Paris, France, March 2001; and Miami, Florida, October 2001.

NERI is a long-term research and development effort to address issues affecting the future use of nuclear energy. Nine new projects were awarded in FY 2001. In total, $79 million has been allocated in R&D during the 3-year project duration. Several of the initial 3-year projects will have run out at the time of the next awards, so more funds should be available for new projects. The solicitation for that round is to be issued in November.

The NEPO program is a cooperative research effort with industry to improve the long-term reliability and efficiency of existing nuclear power plants. Ten projects are under way in aging management and nine projects in generation optimization. Since the start of this program in FY 2000, three generation-optimization projects have been completed.

The support of fellowships and scholarships has been increased, and the International Student Exchange Program is being revived. Hartline asked how many students apply to this program. Magwood replied that about a half dozen apply from France, Japan, and Germany; others are expected to apply this year.

Mtingwa asked if NE had considered where the NERI money is going. Magwood responded that about one-third has gone to universities, there has not been much money to spend.

Todreas commented that the International Nuclear Energy Research Initiative (I-NERI) be reviewed by one of the NERAC subcommittees. Ahearne noted that he would speak to that topic in his subcommittee report.

Magwood continued that a lot of positive interest and response (including that from the NERAC Subcommittee) has been shown for the idea of Centers of Excellence, but no actions have yet been taken, because NE is awaiting passage of the FY02 budget. The program is expected to start this fall. The FY02 budget will reflect this interest.

In the area of AAA, research in pyroprocessing will be pursued, a uranium-extraction (UREX) demonstration will be conducted this fiscal year at Savannah River, nonfertile-fuel development will be continued. With no funding for an accelerator, this work will be largely research. However, international partners are looking for a research facility.

In terms of the R&D budget, NE has reversed its fortunes. Corradini asked if the AAA was part of the long-term target R&D funding of $240.0 million. Magwood responded, no. Corradini asked what *does* go into this R&D funding level. Magwood responded, the items in the FY 2002 OMB (Office of Management and Budget) Budget: the Medical Isotope Program, University Program, NEPO, NERI, Nuclear Energy Technologies, and AAA, totaling $106 million. That budget also includes an offset from royalties paid by General Electric for an advanced light water reactor project in Japan. DOE management is now looking at the 2003 budget.

Ahearne noted that Congress put more FY02 money in NERI than requested and asked if Congress will be expected to fund that program again. Magwood replied negatively: DOE is expected to hold the line on the budget; the budget targets are very tight for the future.

Duderstadt observed that the good news was that R&D is $106 million and the bad news is that half of that comes from Congressional directives. DOE needs to support NERI etc. The Secretary has pointed out that basic research should be mission-directed. He asked Haberman to provide to the members of the Committee copies of the Secretary's speech, "The Mission and Priorities of the Department." According to that speech and the NEP, nuclear energy is a priority to this administration; we will have to wait and see if it is to Congress, too. Not only the DOE leadership, but the OMB also needs to be educated. The needed support will never be forthcoming if recommended funding levels are low-balled with the hope that Congress will bail out the program.

Rempe asked if there was enough money to expand the I-NERI. Magwood said, yes. Corradini asked where in the budget I-NERI is located. Magwood replied in the Gen-IV Roadmap, Advanced Reactor Technologies, the implementation of the Near-Term Deployment recommendations, and fuel testing for gas reactors.

Reba pointed out that two areas have suffered significant reductions: facilities and isotopes. He asked what the long-term implication was here. Magwood said that, in facilities, some facilities work [e.g., the decommissioning of the Experimental Breeder Reactor II (EBR-II)] had been completed, and further funding was not needed. The isotope appropriations face some problems. DOE has not been able to convince Congress why DOE should be in the isotopes business.

Ahearne said that NERI is the major investment in the long term and should be funded first and foremost. Magwood said that there is no fat to trim in the budget, just fingers and toes. NERI is suffering because of that.

Taylor asked what the thrust of the 2002-2003 budget will be. Magwood said that the primary theme will be reorganizing the budget to meet the recommendations of the NEP. Miller asked if the Office had been working in such a way as to make the NEP and the long-range plan coincide. Magwood said that they had been trying to achieve consistency. Some activities are not dealt with by the Long-Range Plan (LRP) but are covered by the other subcommittees.

Mtingwa asked if there was no money in the 2002-2003 budget for a dedicated isotope-production facility and pointed out that the State of New York had offered matching funds for such a facility and it would be a shame to lose those funds. Magwood replied that there are no funds in FY02, that Congress is not buying our argument.

A. Klein asked where the NERI projects that run their course of funding go for continuing funds. Magwood replied, the Gen-IV program, probably. The Office could use some guidance on this issue.

Hartline noted that there are 10 program elements listed in the budget and asked which ones are most aligned with the NEP. Magwood pointed to Nuclear Energy Technologies and said that several others will also be major players.

Fertel asked how NERAC can help NE grow its program to $240 million per year for R&D. Magwood responded, by interacting with people in the Department: the Secretary and the Under Secretary. Also, the Committee should make sure that what the Office is doing is in line with the NEP and the Strategic Plan. The question is, "How does the Department's $13 billion get allocated?"

Comfort questioned whether putting emphasis on the NEP puts the isotope program at greater peril. Magwood responded that it does; the emphasis is on energy security. Mtingwa noted that one has to be alive and healthy to enjoy energy independence.

Duderstadt asked Magwood to comment on the Fast Flux Test Facility (FFTF). Magwood said that former Secretary Richardson had signed a record of decision (ROD). However, Secretary Abraham decided to reexamine the issue, and the Department put forward solicitations for industrial use of the facility. One proposal is to use it for isotope production. That proposal is being analyzed.

Neil Todreas was introduced to present the report from the Gen-IV Subcommittee. The organization of the Subcommittee was reviewed. It is made up of seven members plus the chairman and reflects participation by UC-Berkeley, industry consultants, and utilities. Gen-IV is split into the near term (2000 to 2010) and the long term (2000 to 2030), and the presentation was likewise divided.

The Gen-IV Roadmap NERAC Subcommittee (GRNS) has produced a list of suggested goals and is now looking for feedback on those recommendation goals:

- To identify and develop one or more next-generation nuclear-energy systems that can be commercially deployed no later than 2030 and that offer significant advances in reliability and economics and
- To develop a technology roadmap for Gen-IV nuclear-energy-systems R&D that will identify the R&D required to advance the most promising system(s).

The goals have been established, the technology roadmap is to be completed in October 2002, the concepts will be selected in January through spring 2002, and the R&D program will be defined in summer 2002.

The Subcommittee has been discussing four key questions:

- In regard to the R&D roadmap, what is the proper degree of emphasis on more base technology versus more single-concept-specific technology needs? (The more creative approaches are less well defined.)
- What are the vulnerabilities and incentives in proceeding with a process of an early selection of concepts from a pool of incompletely and inconsistently detailed candidates?
- How should an evaluation methodology be proved out and validated?
- What are the implications of needing increased geological repositories for current and especially future growth of nuclear generation?

He introduced **Robert Versluis** to present the Gen-IV roadmap update and future plans. This project is about 50% completed. He showed an organization chart of the roadmap effort. The group developing the roadmap is considering complete systems, including the front and back ends. It has staffed the Evaluation Methodology Group, the technical working groups (Water-Cooled Reactors, Gas-Cooled Reactors, Liquid-Metal-Cooled Reactors, and Nonclassical Reactors), and the crosscutting groups (Fuel Cycle, Fuels and Materials, Risk and Safety, Economics, and Energy Products). Each of the groups has a U.S. industry cochair and an international cochair.

Mtingwa asked how one became a member. Versluis replied that a country finds an expert, who is proposed to the GIF, is accepted unanimously, and is sponsored. The Russians never put anyone forward. Till pointed out that a competing group included the Russians, and Versluis acknowledged that they were still operating.

Versluis showed the milestones on a 2-year timeline. In the first year, the goals were set, and the fuel-cycle evaluation group has identified energy-growth scenarios and compared them with the various fuel cycles. The technical working groups have screened about 100 concepts, described each briefly, analyzed the pros and cons, screened them for potential, and looked at gaps. Its report is due out later in the month. The next step will be quantitative screening of each concept by the Evaluation Methodology Group. The concepts include an extensive list of water-cooled, gas-cooled, liquid-metal-cooled, and nonclassical (liquid-core, gas-core, advanced-high-temperature, organic-cooled, nonconvectively cooled, and direct-energy-conversion) reactors.

Each crosscutting group will bring with it technical expertise and consistent scoring methods. They will work out the definitions of the R&D pathways and write the R&D scope report. During the next year, they will evaluate and document the most viable concepts and assemble a roadmap to develop a plan. They expect to select six to eight concepts. DOE is looking for innovative concepts; other countries are interested in funding more mature concepts. Combinations of reactor types need to be evaluated, also. The R&D plan will then be drawn up, organized around the selected concepts. Issues that are being dealt with include

- The roadmap should be organized around concepts.
- There should be consistency in scoring, and this is to be achieved through metrics.
- The resource and information limits need to be acknowledged and dealt with.
- Symbiotic combinations can achieve fuel-cycle benefits.

The active issues before the group are

- Innovative concepts promise significant advances toward goals.
- What selection criteria and processes should be used to select the six to eight concepts on the basis of limited data?

In summary, the effort is receiving excellent international support, the technical working groups have assembled comprehensive concept studies, the Evaluation Methodology Group has forged a working consensus on evaluation, and the crosscutting groups are being integrated.

Powell asked if it would be deleterious to safety considerations if countries with expertise are participating in other groups. Versluis said that the issues that have led to Russia's nonparticipation will soon disappear and that an international R&D plan will be agreed upon. Others can join as well. Powell asked how others could be brought into this effort without having to go back and retrospectively bring other systems up to minimum safety criteria. Todreas said that the focus to date has been getting the effort on track and that now the focus has to shift to what she was referring to.

Comfort asked how well the participants are connected to what else NE and NERAC are doing, specifically to NERI. Versluis answered that they are very well connected. Todreas pointed out that there is another phase that will identify gaps and needed research. He introduced **Charles Forsberg** to review the activity of the Fuel-Cycle Crosscut Group (FCCG).

The charter of the FCCG is to examine fuel resource inputs and waste outputs for the range of potential Gen-IV fuel cycles, consistent with projected energy-demand scenarios. The range of fuel cycles considered will include currently deployed and proposed fuel cycles based on uranium and/or thorium. The Group's responsibilities include defining energy-demand projections; projecting the ore resource base; surveying cycle types, identifying technology gaps, and recommending R&D; determining the range of energy supply achievable by Gen-IV concepts, within ore availability and waste-production constraints; and recommending fuel-cycle parameters for all Gen-IV activities.

The FCCG examined the implications of a global nuclear-energy enterprise; in particular, it identified baseline world-demand growth projections used for analysis of nuclear-energy futures (the midcase of a range of projections):

now: 350 GWe from nuclear power
2050: 2000 GWe
2100: about 6000 GWe

Ahearne did not believe that this choice could be defended as a midrange projection. Fertel said that a combination of population growth and an increase in the nuclear portion of energy supply drives these projections and choices. Corradini observed that the results will reflect the assumptions made in calculating them. In his opinion, it is not likely that demand will grow at anywhere near the cited rate. Till pointed out that one can also make rational errors by being too conservative.

Forsberg continued that mainline projections exclude other applications of nuclear power (hydrogen, heat, etc.). The time frame was to 2100 because Gen-IV considers reactors deployable by 2030 and a reactor lifetime was projected to be 60 years. Therefore, the fuel cycle must consider the lifetime fuel demand and waste generation out to 2100.

Considering the fuel cycle in the abstract, the resource-base options are conventional mining, secondary recovery, and seawater uranium. One must also consider capital and operating funds, which lead to the construction of technical facilities and the production of energy. Waste possibilities include spent nuclear fuel; high-level waste; and low-actinide, reduced-long-fission-product waste.

Four alternative fuel cycles have been defined:

1. The existing U.S. method: once through,
2. The current French system: partial recycle,
3. Full recycle of uranium and plutonium, and
4. All actinides destroyed.

Each produces various wastes and uses different resources.

The key fuel cycle issues are long-term sustainability concerns associated with uranium and thorium resources, waste management, and nonproliferation.

Cost and environmental impacts, not resource availability, limit uranium and thorium resources. Three components in current estimates of ore reserves are available: the Red Book, which lists known and speculative reserves; geologic estimates to crustal abundance; and the capture of the uranium that is present in seawater at the level of parts per billion. Harvesting ore of tenfold reduction in uranium concentration increases uranium reserves by a factor of 300 and increases the ore processed by a factor of 10 per kilogram of uranium. The future mining and milling costs and environmental impacts are determined by the economics of scale and by the nature of technological advances. Because of the distribution of uranium in the Earth's crust, if the grade of ore goes down by a factor of 10, the amount of ore mined and processed must go up a factor of 300; cost depends heavily on the technology of extraction. Ocean water is an attractive source of uranium because you do not have to grind rock; that is why it was chosen in this study as the "standard source."

Repository availability may be the major constraint to nuclear energy, and the choice of fuel cycle impacts the repository in terms of radiotoxicity, volume and waste form, and fissile mass. Consider the repository options for the conventional once-through fuel cycle vs partitioning and transmutation (P/T). In a conventional spent-nuclear-fuel repository, decay heat controls the repository size, high temperatures degrade repository performance, the temperature is limited by limiting the density of waste by using lots of waste packages and long runs of tunnels, and the repository size can be reduced by long-term waste storage in surface storage or a ventilated repository. In a P/T repository, the key is to reduce decay heat from ^{90}Sr, ^{137}Cs, and actinides; if the actinides are destroyed (P/T), long-term decay-heat eliminated, and many options for cesium and strontium management would be opened. It might be possible to reduce the amount of waste requiring storage to a few underground silos.

Three fuel cycles have been proposed to further nonproliferation:

- once-through fuel cycles with no processing,
- conventional recycle with no clean plutonium, and
- very low weapons-usable inventory (i.e., a $^{233}U/^{232}Th$ denatured fuel cycle).

A basis for comparing cycles is not well-established.

Nuclear-energy scenarios are being evaluated through modeling to understand the impacts of different fuel cycles. Dynamic scenarios from year 2000 to year 2100 are run for generic fuel-cycle types, and performance is evaluated against the three sustainability goals listed above.

Four classes of fuel cycles are being examined: once-through, partial recycle, conventional recycle, and recycle including higher actinides. The results of these modeling efforts indicate that

- With the LWR once-through case, known uranium resources are depleted by 2025, speculative uranium resources are depleted by 2050, new uranium resources must be discovered, and enrichment tails increase almost linearly.
- With a LWR/pebble bed modular reactor deployment with an ultimate 50/50 mixture of LWRs and PBMRs, PBMRs are phased in as demand increases, and mass flows look almost identical to those of the once-through LWR cycle; and
- With liquid-metal-cooled fast reactors being phased in (and LWRs being mostly phased out) in 2030 as demand increases, uranium usage for the next century stays within currently known and speculated reserves.
- When compared with the once-through LWR cycle, the fast-reactor fuel cycle produces a slow decrease in ore demand.

Corradini noted that these scenarios can probably best be used to answer policy questions, such as, how long can I run on one repository with LWR once-through? Forsberg said that that is an excellent observation.

The small impact of the fuel cycle on nuclear economics provides a degree of freedom for future nuclear systems. Today, the fuel cycle is a small portion (19%) of the full-system overall costs.

The Group found that there are generic (not reactor or fuel-cycle specific) areas requiring R&D: uranium resources and costs, metrics of proliferation resistance, a careful look at alternative waste-management strategies because of the potential impacts of alternative fuel cycles like P/T and the possibility of the need for repository options for alternative waste forms.

A draft report is being produced and is in the review cycle. Scenarios for alternative fuel cycles need to be completed. The needed front end, recycle, and repository integrated fuel cycle R&D needs to be defined. Key fuel-cycle uncertainties also need to be further addressed.

Corradini said that one has to go beyond the base-case growth scenario because it would affect the conclusions. Forsberg agreed, but the results could be restated in terms of the growth scenario.

Hartline asked if there were any experts on repositories in this group. Forsberg replied, yes, Halsey. Fertel noted that these are international considerations, but all the discussion has been related to the United States. A Yucca Mountain will not be built every year. Most of the growth will be in Asia. The demographics of where these systems are going to be sold makes a difference in the fuel-cycle considerations. Todreas agreed that markets are going to have to be taken into consideration.

Till asked what implications the NEP has on these considerations. Fertel said that the NEP was all natural gas and it only goes out to 2020.

Miller noted that, in the timeline, the first roadmap draft is due in January and asked what the review process of that document was. Versluis replied that draft is to be reviewed by the GRNS, GIF, and the policy-review committee. Miller asked if there should be another technical team looking at it. Todreas replied, it depends. This roadmap will not have a lot of specifics, just structure. In October 2002, it might go to the public for review. On the other hand, those putting it together cannot be silent and secretive. There will be presentations at the American Nuclear Society meeting and at other venues.

Hartline pointed out that the FY03 budget request going to Congress should also be implementing this roadmap. It is terribly important to get this crystallized by July 2002. Todreas said that he did not believe that all the R&D items will be identified by then. Miller commented that by the time the group has narrowed the field down to six or eight concepts, it will have made hundreds of enemies. How the field is going to be narrowed down to those six or eight should be explained early on. Versluis said that there would be presentations about the process the following week at the conference in Reno.

Till pointed out that the group needed to influence the implementation of the NEP. Hartline put it: the two must work in parallel toward an endgame. A break was declared at 2:55 p.m.

The meeting was called back into session at 3:12 p.m. **Neil Todreas** began the discussion of the near-term deployment (NTD) program (to 2010). Its goals are to identify technological and institutional gaps between the current state of the art and the necessary conditions to deploy new nuclear plants in the United States by 2010, prepare estimates of the resources, and recommend funding priorities. The key questions for discussion are

- How can the prospects for early exercise of the COL (combined construction and operating license) process be advanced?
- Will nuclear be able to reenter a deregulated power market that rewards short project schedules?
- Should incentives be provided?
- What are the steps to be taken to assure a smooth transition between the NTD and Gen-IV activities?
- What is the impact of security considerations on NTD plants?

Todreas called upon **Thomas Miller** to describe the progress of the group working on the Near-Term Deployment Roadmap. The mission of that group is to identify the technical, institutional, and regulatory barriers to the near-term deployment of new nuclear plants and to recommend actions that should be taken by DOE. The participants in the group come from utilities, vendors, national laboratories, academia, industry, and NERAC.

A request for information (RFI) was issued April 4, 2001, to reactor designers, architect-engineers, nuclear plant owners and operators, Gen-IV participants, and Nuclear Energy Institute New Plant Task Force members. A public notice was issued through *Commerce Business Daily* (*CBD*). The RFI solicits identification of design-specific, site-related, and generic barriers to the deployment of new nuclear plants by 2010. Responses were received from 12 organizations. The NTD Roadmap was completed by the target date of September 30, 2001.

The RFI requested information in two areas:

- specific deployment candidate designs that meet six criteria:
  1. Credible plan for gaining regulatory acceptance
  2. Existence of industrial infrastructure
  3. Credible plan for commercialization
  4. If R&D is needed, a plan for cost-sharing between industry and government
  5. A clear demonstration of the economic competitiveness of this plant
  6. A reliance on an existing fuel-cycle structure
- In generic and design-specific gaps, it asked if there were known gaps requiring ranking and possible solutions or other gaps.

Design-specific responses were received from Framatone, Exelon/PBMR, Westinghouse, and General Atomics. Other potential candidate designs exist, but information was not submitted for them.

Generic gaps that were identified by the responses are

- ESP demonstration,
- COL demonstration,
- Construction inspection and Inspections, Tests, Analyzes, and Acceptance Criteria (ITAAC), and
- Risk-informed regulation for future design certifications:
  - advanced fabrication, modularization, and construction technologies
  - standardized life-cycle information and configuration control systems

- high-level waste disposal solution
- risk-management tool
- public influences and acceptance
- appropriate resource and financial arrangements

Miller turned the podium over to **Tony McConnell**, Vice President, Special Projects, Duke Engineering and Services, to give a status report on the Near-Term Deployment Group's activities. The environment today is one of increasing awareness of the need for new baseload generating plants at a time of fossil fuel price volatility, clean air constraints, excellent existing nuclear plant performance, improving economics of new nuclear power plants (consolidation is producing large companies that are able to master the large capital investments needed), significant public and political support, greater certainty in the licensing process, and an NEP that is favorable to nuclear power.

The Group identified nine generic issues that could influence the viablility and timing of any nuclear plant project: economic competitiveness, implications of the deregulated electricity market, efficient implementation of 10CFR52 (standardized licensing process), the adequacy of the nuclear industry infrastructure, issues associated with the clear need for a National Nuclear Energy Strategy, nuclear safety, spent-fuel management, public acceptance of nuclear energy, and nonproliferation of nuclear material. The first five are considered "gaps" to near-term deployment for which specific recommendations are made. (Dealing with these would improve the prospects for near-term deployment.)

Montoya asked about the deliverability of the electricity. McConnell said that, if the transmission grid is not there, you will have to put it in for a large baseload plant. You might not for a small plant. Louis Long (Vice President of Technical Services, Southern Company) commented that they assumed the transmission system would respond to the marketplace. The need is no different from any large lump of power you put on the grid. Today, those plants needing the least transmission and distribution (T&D) are the least costly.

Mtingwa asked about someone being able to get hold of spent fuel. Taylor responded that those problems are being addressed across the board. They are not specific to NTD. The issue is being dealt with by the NRC. New plant designs have already considered enhancements in this area of sabotage protection.

Ahearne asked if the Group was forecasting an electricity price of 4 cents per kW hour. Louis Long replied that the experts say that nuclear can compete at that rate if the capital costs can be contained.

New nuclear power plants absolutely must be economically competitive in the deregulated marketplace. This is the most significant challenge the industry faces. Nuclear plants do have a significant long-term advantage because of their low production costs. An issue for deployment is whether nuclear's advantage is enough to offset its high capital costs. But there are challenges as well as opportunities in the deregulated electricity marketplace, which is a fundamentally different business environment. Today, the risk for new projects rests squarely on investors, and long lead times for nuclear plants make it difficult to respond to short-term electricity-market needs.

The efficient implementation of 10CFR52 is significant because the regulatory process is a source of business uncertainty. The Part 52 process has been improved with the ESP Design Certification (DC) and COL. Part 52 provides more opportunity for public input earlier in process; that translates into a greater certainty that projects conforming to approvals will operate. But ESP and COL have never been exercised, posing a risk to plant investors.

The nuclear construction hiatus has led to an aging workforce and an atrophied manufacturing and construction infrastructure. The current government backing for building new nuclear plants is not adequate for near-term deployment.

The Group concluded that

- New nuclear plants can be deployed in the United States in this decade if we have sufficient, timely, private-sector investment.
- To have new plants operating by 2010, owner/operators must commit to orders by 2003, which requires very near-term action.
- Economic competitiveness is the key area of uncertainty.
- Efficient implementation of Part 52 is most urgent.
- Some excellent candidates are available. Some certified designs are ready, and other candidates show promise for improved economic competitiveness.
- Achieving near-term deployment will require close collaboration between industry and government.
- Selections of new projects must be market-driven and primarily supported by private-sector investment, but government support is essential in the form of leadership and effective policy, efficient regulatory approvals, and cost sharing of generic and one-time costs (e.g., completion of designs and the demonstration of the ESP process).

Industry-government collaboration is essential to success to provide needed resource leveraging (industry-laboratory cooperation), to greatly enhance investor confidence, and to end up with better standardization of designs and processes.

The Group made several recommendations:

- Dual-track implementation should be pursued for both ALWR and gas-cooled reactors (both tracks are required to address different market scenarios).
- Market-driven initiatives will be needed with DOE cost-sharing of regulatory-related generic and first-time design-specific costs. DOE funds should be sought only for initiatives that obtain more than 50% private-sector funding. Those costs will include ESP and COL demonstrations, design certifications for the ALWRs and COLs without DC for the gas reactors, and first-time engineering completion costs.
- The development of the National Nuclear Energy Strategy is needed to complement the new NEP.
- A phased plan of action with three phases was proposed. The three phases are regulatory approvals, design completion, and construction and startup.

In the area of regulatory approvals, generic guidance needs to be developed for ESP, COL, and ITAAC (inspection); industry and DOE should cost-share ESP and COL applications to demonstrate the processes and should complete DC; Final Design Approvals (FDAs) for gas reactors for selected designs; and a risk-informed, performance-based regulatory framework should be developed.

In the area of design completion, detailed engineering should be completed for at least one design in each track (ALWR and gas-cooled) to allow deployment by 2010 and DOE and industry should cost-share these market-driven initiatives.

In the area of construction and startup, such activities should be privately funded but supported by appropriate government incentives

The focus of all these activities should be on minimizing the time to market. Efficient regulatory approvals by the applicants and NRC will advance the process. Projects should be expedited via parallel regulatory approvals and design completion (e.g., six utilities buy five reactors for six sites and share the licensing costs for the technology) and the early procurement of long-lead components.

Government incentives should be established to reduce business risk reduction by encouraging long-term power-purchase agreements, accelerated depreciation, tax credits for new investments, tax incentives for fuel-supply diversity and emission-free generation, access to tax-exempt state government financing, and ensuring that energy and environmental policies and regulations are adequately balanced.

Programs focused on most urgent personnel areas need to be expanded and accelerated. Those areas include construction, engineering, operations, and health physics. The Nuclear Energy Institute (NEI) survey will better define the needs. A DOE/industry matching grant program should be established; the American Nuclear Society (ANS) Task Force on the Nuclear Workforce is working on it. NERAC also has some recommendations on human infrastructure. It would be worthwhile for industry and government to cooperate on a study of fabrication, manufacturing, and construction infrastructure, both domestic and international.

Ahearne asked how increasing nuclear power would reduce foreign-oil demand. McConnell replied that there is a sense of current heavy dependency on foreign-oil imports, part of which is going to power generation and the same is true for natural gas. The portion going to satisfy the demand for power could be supplanted by nuclear energy. Ahearne noted that most oil is used for transportation, so a large fleet of electric vehicles will be needed before nuclear power will affect oil imports. Montoya commented that the issue of fuel security should be flagged as a separate comment.

The Subcommittee also recommended that a National Nuclear Energy Policy should be developed that would build on the support for nuclear power expressed in the NEP. That new policy should

- articulate national-security and environmental-quality imperatives
- commit the federal government to a specific new-plant goal similar to NEI's Vision 2020, which calls for 50,000 MWe new nuclear capacity
- commit the federal government to a nuclear-energy-supply R&D investment strategy that is in balance with the subsidies in other energy-supply options
- expedite regulatory approvals consistent with safety regulations
- commit to market-driven, public-private partnerships.

Broad support also needs to be sought from Congress.

Corradini asked what subsidies in other options he was referring to. McConnell stated that in the 13 years from 1985 to 1998, $1 billion was invested in ALWR research and development, of which only one-third (about $333 million) came from the government (DOE). In comparison, during just the past 5 years, $415 million was invested in fossil energy R&D, $343 million in solar and renewable, $521 million in energy efficiency, and $235 million in fusion. For direct comparison, only $26 million was invested in nuclear-energy R&D during that same period.

If all of these recommendations are to be achieved, industry and government must act together to enable new nuclear-plant construction, bearing in mind that (1) the technology options are safe, reliable, and economically competitive; (2) national security requires greater energy independence; and (3) environmental quality requires emission-free generation. Several aggressive, focused actions are urgently needed in 2002: the forming of consortia to provide industry leadership and innovation; a regulatory foundation needs to be established (NEI and the NRC have a key role here); a major increase needs to be made in the FY02 NTD budget; and DOE cooperation with industry needs to be increased. Building new nuclear-power plants in the United States is the single most important step toward revitalizing nuclear-energy R&D. Nuclear technology in the United States should be kept alive and vital; if the United States is not the leader in this field, someone else will step forward to be that leader.

Todreas resumed control of the discussion and went back to the key questions for consideration. Three reactors are design-certified but none of their vendors are putting them up for the next step in this country. Anyone going ahead with the COL process will test and validate that process. But we are not far along in achieving that step.

Taylor said that the most urgent issue is to address the regulatory barriers. Todreas said that DOE has to take this report and do something on COL with one of the candidates. Corradini asked if that is on DOE's plate or the utilities'. Fertel stated that the operative concept here is "market driven." Three companies will probably file ESPs. At least one will file for COL. When GE has buyers that are interested in going forward, that is real progress. DOE should make it clear to the market that it is interested in sharing the costs for a COL over several years by making multiyear funding available if a company wants to go forward with a COL.

McConnell noted that the Group did say that the market should drive it, but it did not pick a specific design. Todreas noted that there would be regulatory fallout from any individual action. McConnell observed that some of the licensing and design work would have to be carried out in parallel.

A telephone call was placed to **Burton Richter** to give the status report of the Subcommittee on Advanced Nuclear Transformation Technology (ANTT). The AAA program has been reorganized and is better focused. Four goals have been set

1. Enhance long-term public safety.
2. Benefit the repository program.
3. Reduce proliferation risk.
4. Improve the prospects for nuclear power.

The analysis of many approaches to transmutation is moving ahead. Facility needs have been looked at. The R&D program was reviewed, and Roadmap II has been discussed. The outline for a preliminary draft of the Roadmap has been drawn up for discussion and is organized around the four goals listed above. For each goal, objectives have been set, quantitative measures have been drawn up, and options for meeting the objectives have been identified.

For improving the long-term public safety, two objectives are possible: reducing the radiotoxicity and reducing the dose. Whether this is an “and” or an “or” is a government issue. How this problem is analyzed is critical. An integrated dose is probably the best way, as was suggested by Tom Cochran a year ago.

For benefitting the repository program, three objectives could be sought: reducing the heat load imposed by the materials disposed of, precluding future criticalities, and reducing the mass requiring disposal.

For reducing the proliferation risk from plutonium in commercial reactor spent fuel, three issues need to be considered: reducing the inventory of plutonium in the fuel cycle, minimizing the mass of plutonium transferred to the repository, and minimizing the potential for diversion. The long-term needs to be balanced against the short term.

For improving the prospects for nuclear power, two objectives might be to provide viable and economically feasible waste management options and to minimize the technical risk.

Analyzing the options for meeting the first three of these goals can be accomplished fairly quickly. The analysis of the options for the last goal would depend on externalities and would need to wait until a fair amount of R&D and effort are already invested.

A choice tree was developed that identified all the permutations of possible spent-fuel separations (plutonium or plutonium plus mixed actinides), reactors LWR or gas-cooled), fuels [MOX, nonfertile fuels, or TRISO (tri-isotropic)], and transmuter (accelerator or fast reactor). Nine possible combinations result from this classification scheme. All of the accelerator-based processes require recycling through the accelerator several times. The AAA people have set themselves too high a bar; a 99.5% or even 99.0% reduction might be acceptable.

Three ways of treating plutonium are possible: one can separate it completely, separate it partially, or separate only the americium. The Subcommittee’s recommendation is to keep all options open. Richter believes that the options can be narrowed down from the original nine to about a half dozen in about six months.

In assessing the readiness of the technology, it was assumed that the Accelerator Demonstration Test Facility (ADTF) with a 5- to 10-MW linac and target and materials test (TMT) station will be ready to turn on in 10 years and that a subcritical multiplier (SCM) at a maximum thermal power of 100 MW will be ready 3 years later. The results of the evaluation indicate that the fuel and separation technologies have the farthest to go, that the accelerator is in the best shape, and that the test facilities required along the road pose a real problem. Each area and subsystem was assessed, and the least-ready and most-ready options for each one were presented to display the range of readiness of each component:

Area and Subsystem	Technology	Readiness
Target	Liquid lead-bismuth eutectic (LBE) target	Conceptual development
	Water-cooled target	Late R&D stage
Fuel fabrication and performance	Nonfertile fuel	Conceptual development
	MOX, Integral Fast Reactor (IFR) ternary	Ready to go
Separations	Pyroprocess	Conceptual development
	UREX process	R&D stage
Blanket coupling	Spallation target with nonfertile-fuel blanket	Conceptual development
	Fertile fuel, DT source, low power	R&D stage
Blanket technology	LBE, gas-cooled	R&D stage
	Sodium-cooled	Ready to go
Accelerator	Superconducting, low-energy cavities	Early R&D stage
	Radiofrequency quadrupole, high-energy superconductor cavities	Late R&D stage

In assessing the test-facility needs, the subcommittee found that the United States' nuclear R&D infrastructure is marginal at best, that many facilities have been mothballed and there has been little enthusiasm for restarting them, that even the earliest stages of technology development will require the use of international facilities because we cannot do them on our own, and that much of what is needed is not presently available.

For separations and fuel fabrication, a new intermediate-scale separation and fuel-fabrication facility and a new pilot-scale separation and fuel fabrication facility (capable of processing 100 to 200 kg/year of transuranic waste (TRU), including the reprocessing of SCM spent fuel) are needed. Barnwell could be converted; the Fuels and Materials Examination Facility (FMEF) at Hanford was never started or contaminated and could be used, and GE Morris is a possibility. For fast-spectrum fuel development, we have nothing. The French and the Russians have facilities we could use. The Transient Reactor Facility (TREAT) could possibly be used for transient testing only, and the FFTF would be wonderful for fast irradiation.

The preliminary analysis of test-facility needs indicates that

- For the target, 1-MW beams are available at Paul Scherrer Institute (PSI) and Los Alamos Neutron Science Center (LANSCE); a 2-MW beam will be available in about 5 years at the SNS; and LANL's Low-Energy Demonstration Accelerator (LEDA) facility could us get to 5 to 10 MW, but an upgrade may be needed.
- For the fuel, thermal-spectrum testing is available at the INEEL ATR (Idaho National Engineering and Environmental Laboratory Advanced Test Reactor); fast-spectrum tests could be conducted at the PHENIX in France until 2006 and possibly at BOR60 in Russia; an FFTF restart would be a big help, but this program does not have enough money to carry that facility.
- Transient testing requires either a restart of the ANL-W TREAT facility or a new facility.

For target–SCM coupling, foreign facilities can be used for the next 3 to 5 years, but it is not clear what to do after that.

International collaboration is necessary to move this program ahead. Europe and Japan are at least as interested in transmutation as we are. In Europe, both the pronuclear and antinuclear forces are interested in transmutation. France has the best-developed program, and OECD's NEA is about to issue a detailed analysis of the potential and the issues of transmutation. Everyone faces the same need for facilities to carry out the R&D, although nobody has the complete suite needed. Therefore, it is to everyone's financial benefit to share the load. DOE is working on the problem; but for it to work, the United States will have to invest in some of the facilities.

Roadmap I was detailed and described a system of very large accelerators and very large SCMs connected to the power grid. The system took too long and cost too much. Roadmap II is aimed at the multitier approach. It is too early to describe all the details that Roadmap I did. Roadmap II should be a living document (it should be periodically updated) with realistic goals and milestones for the next 5 years and must necessarily be vague beyond that. DOE has made a good start at developing Roadmap II, and they will issue a report by the end of the year with real numbers supplied by next summer.

A final note: The AAA group has done an excellent job in the past 6 months, and the program is developing well. The AAA people at DOE and the labs need to look ahead and give a realistic analysis of the potential of the program and the cost of moving it to the point of an operating SCM or other fast system. That will take a while. The look ahead should include the international dimension. It will probably take 2 years to get that far if an international agreement can be put in place. There is sufficient support for the program until then. The FY 2002 budget is $50 million, Congress requires a report by May 1, 2002, that will have to be more an educated guess that a sturdy analysis. By May 2002, one cannot get anything but a handwaving estimate of the costs involved.

Todreas asked if the focus is still on legacy wastes. Richter said that it is aimed at the long-term production of nuclear power in the United States. It will have to interact with but not have a lot of leverage on the Gen-IV decisions. It will not lead the Gen-IV discussion.

Ahearne asked if the new monies can be used to build anything. Richter responded that he did not know, but building facilities is not an issue this year. Herczeg interjected that the markup said that no funds were available for construction. Our foreign partners have said that, if the United States was not interested in building something, they were not interested in partnering. Richter commented that R&D and preliminary design work are what is needed in the next year. Ahearne asked if $50 million can be used prudently in the next year. Richter responded, yes; design, system analysis, fuels, and separation processes could be funded. He was not sure the tritium program would have to be in that funding. Herczeg noted that DP would have to cough up the funds for the shutdown of the LEDA facility. Richter commented that LEDA would be imperative for the development of AAA.

A break was declared at 5:12 p.m. to await the arrival of Under Secretary Card. The meeting was called back to order at 5:39 p.m. as William Magwood introduced Undersecretary **Robert**

Card, the line manager over the NE Division. Each member of the Committee was introduced. The Chairman commented on the NEP and pointed out DOE's opportunities to contribute to that policy. He noted a concern with how resources are deployed in DOE to match that policy and asked to help find ways to increase NE's funding to the level of their importance to that policy.

Card said that DOE does not have any hood-ornament advisory committees and that the Committee's work is appreciated. The problem with the investment in nuclear energy is that it is very much smaller than for other energy sources. A key reason is that the industry structure does not lend itself to incremental improvements in funding. Coal does, and it enjoys a rich spectrum of support. Nuclear energy requires billions of dollars per plant, and the technology challenges do not fit into a research portfolio very well.

The United States invested in AP600 reactors, and no one made use of them. The Department should find something that can be built and get it built. To get the industry sustainable, the Department should pick up something and go with it. The industry needs to get a line going, and DOE stands ready to help.

Ahearne did not agree with the assessment of the research portfolio. The Committee put together a research portfolio last year that could provide critical elements for future design. That research has to be built back into the system; that effort requires faculty, students, and some research for them to work on.

Duderstadt pointed out that the research capabilities of NE can be compared to those of the Office of Fossil Energy (FE), but they can also be compared to those of High Energy Nuclear Physics (HENP), which does not even relate to the provision of energy. The investments the Committee is talking about are very modest in comparison.

Taylor said that, until nuclear power plants are being built, no new people are going to be attracted to the field. The United States should pursue a large light-water reactor and a small, modular, gas-cooled reactor. DOE should put up some money to get this program moving. Instead of asking for small, incremental additions, ask Congress for the full amount (in the 2003 budget) needed to get the industry moving again.

Card responded that a lot of players have to come together. Congress and DOE are not against nuclear energy, but there is not the spark to drive it home. We need major utility backing for funding of some research that the utilities cannot afford themselves.

Fertel said that he did not think building one reactor would do any good, and if it is done with government money, that is even worse. A number of companies are ready to take plans to the NRC , either as multiples of small modules or as a variety of large plants purchased by numerous utilities and sharing the licensing costs. DOE's support in progressing this way would be a great help.

Corradini suggested that perhaps DOE could pay the licensing fees. Card said that that would be in order, and he would be willing to run with that. Industry might, for example, want to put a commercial reactor at a DOE site. Considering control systems, industry needs digital controls for reactors, but one has to ask if that is something the government should be involved in.

Mtingwa pointed out that Richter had just said that the FFTF would be an ideal facility for performing tests on new fuels. Card said that the FFTF is either a ward or a crown jewel and pointed out that a group has expressed an interest in using it to produce isotopes. The Department is worried about the group's depth of knowledge about what would be required from an investor's standpoint. He would rather invest $36 million in starting a new power reactor than in restarting the FFTF. If a reactor technology could be found that could be used for the disposition of weapons in the near term, that would be interesting. Converting weapon materials to MOX fuel is very expensive (six times the thermal value of the material). If a reactor could use this plutonium fuel, it would bring down the cost of MOX fuel. Ahearne pointed out that the Russians want to fund the completion of their breeder reactor. Card responded that that is something for others to resolve. Considering LWRs, it is imperative for everyone to make weapons disposition cheap. There is a great philosophical alignment on this issue, but it is too expensive for a single country. For national security, we need to research how to decommission these weapons cheaply. Taylor asked why not contract to do it in Europe, and Card responded that the contract basis is the hangup but that may be solved.

Todreas said that the Committee has a goal of deploying a new reactor by 2010; therefore, an order must be placed by 2003. The Department is going to have to put some incentives in its 2003 budget. One cannot just wait until the industry steps forward.

Cortez asked Card if he considered university programs as an important issue because the amount given to universities now is very small and they are closing down their reactors. Last year's $11.5 million is going to $17 million this year, but it needs to be increased even more. It would be good if the FY 2003 budget was in the order of $23 million. Duderstadt said that the other side of that issue is that university leaders have said that, if DOE support was not forthcoming, they would shut down their research reactors. Card replied that political support will come with a tangible need. Duderstadt pointed out that the revitalization of the nuclear industry is key to the revitalization of nuclear-engineering departments at universities; but DP and other government offices are facing large numbers of retirements, and will need nuclear scientists that are not being produced now. Card encouraged the Committee to look for sustainable efforts that will be important to those who will succeed those in leadership positions today.

The meeting was adjourned for the day at 6:22 p.m.

Tuesday, November 6, 2001

The meeting was called to order at 8:32 a.m. by Chairman Duderstadt. Earl Wahlquist of Space and Defense Power Systems (NE) introduced **Jack Wheeler** to speak about space fission technology.

The responsibilities of the Office of Space and Defense Power Systems include system development and testing, safety analysis, maintenance of assembly and test infrastructure, and integration and launch support. These activities are performed for and with a budget from the National Aeronautics and Space Administration (NASA).

Possible applications for nuclear systems in outer-planetary missions include

- Surface power systems for robotic missions to conduct science, perform exploratory drilling, and prove resource utilization,
- Small in-space power systems for nuclear electric propulsion (NEP) for planetary rendezvous and increased power for science and observation upon arrival,
- Multimegawatt power systems for rapid interplanetary transport, and
- Nuclear thermal propulsion (NTP) for direct heating of hydrogen for propulsion and power for cargo and piloted missions.

Four teams looked at each of these applications, and the national laboratories were used to support these investigations. The DOE CTAP Team (coordination, technology, assessment, and planning) looked at what types of missions might be undertaken, what the system requirements might be for such missions, what the concepts look like, what the commonalities are, and what the technology would look like. They made up a table of requirements for different types of missions, which allowed the identification and assessment of some near-term concepts. They looked at in-space applications, Mars surface applications, the Hubble Telescope, and power loss (dust coverage) of the Sojourner Rover and Pathfinder Lander photovoltaic arrays. They also looked at two reactor concepts: heatpipes with Stirling engines and a SNAP-10A derivative. They considered the mass versus power produced and concluded that reactors are more attractive than radioisotopic systems for power outputs of 3 to 7 kW.

An attractive system was seen to be one with 3-kWe EOM (End-of Mission) power, a 5- to 10-year life, 2.1 m high by 2.0 m in outer diameter, and scalable to higher power. A cutaway of the system showed reactor control drives, radiator (dissipates excess heat), cooling heat exchanger, Stirling engine, heat exchanger, extended heat pipes, radiation shield, and reactor core.

It is desirable to use past investments in space nuclear systems to reduce the development cost. The technology work is to be focused on the nuclear subsystem and directed by work on guiding concept(s) and applications. Emphasis is placed on near-term systems that require a smaller level of effort than more advanced technologies. The technology plan will evolve over time. The fission-technology plan will look at focused technology for in-space application, common technologies, optional flight systems, focused technology for surface power, fuels development, and a low-specific-mass radiator. The focus on the nuclear subsystem will look at the shield, heat transport, and reactor.

A matrix of concepts was drawn up and showed a lot of commonality in design and the associated heat engine. For in-space applications, the study identified three promising combinations: a gas-cooled reactor and Brayton cycle, heatpipe and Brayton cycle, and liquid metal and Brayton cycle. For Mars-surface applications (3 kWe), it identified heatpipe and Stirling cycle and liquid metal and Stirling cycle.

The current standing of the study is: For Mars-surface applications, a concept-evaluation set has been developed, a concept for an entry-level system (3 kWe) has been defined, focused concept/independent assessment work on the combination of a heatpipe with a Stirling engine has been performed, a guiding concept set has been developed for and some initial studies performed on a small nuclear-electric-propulsion unit (the focus of FY02 work), an analysis of liquid metal and gas cooled/Rankine and Brayton systems has been conducted for the multimegawatt nuclear-electric-propulsion unit, and a fuel-element analysis and examination on performance parameters has been completed for the nuclear thermal rocket.

In FY02, the focus will be on small in-space applications. As resources permit, a small study will be performed to address mission-system integration issues for the surface power unit and to support programmatic assessments.

Miller asked what institutions were involved with the assessment. Wheeler replied: Brookhaven National Laboratory (BNL), Idaho, Sandia, LANL, Oak Ridge National Laboratory (ORNL), and ANL. Hartline asked if there was any NASA participation. Wheeler said they involved NASA wherever they could.

Hartline asked where the $30 million goes. Wahlquist responded that it goes to planning, fuel encapsulation, and scrap recovery.

A. Klein asked why they included national laboratories but no universities. Wheeler replied that they had very little money, were performing initial work, and are establishing direction at this point.

Hartline asked what out-of-the-box technologies were involved. Wheeler replied, reactor controls, navigation, etc. Magwood commented that NE had held a workshop on what is left to do in space and had about 30 people show up. NASA also exhibited strong support. There just was not time to pursue the topic; now, they are showing more activity.

A. Klein commented that the Subcommittee should be spun up and asked if that Subcommittee should address isotopic systems. Magwood said that there were some issues to look at, but they are far down the road. What NASA wants to put on the spacecraft needs to be determined first.

Todreas commented that Wahlquist and Wheeler should look at the Gen-IV plan because there are similarities.

Till asked if there was a change in the reluctance to send reactors into space. Magwood replied that NASA realizes that they cannot do what they want to accomplish without reactors.

Hartline asked what the age demographics were of the people working on this project.

Wheeler replied that quite a range was represented, from younger to older researchers; those with hands-on experience are getting harder and harder to find. A. Klein noted that a number of students had gone into other careers and would love to come back.

Wheeler turned the floor over to **Jerry Langford** of NASA to review the benefits of nuclear fission in the civilian space program. Power is crucial in space exploration; it drives the design and limitations of each project. The use of gravity assist limits the launch windows severely. NASA has had many past uses of nuclear power. The initial focus was on a 10- to 500-kW NEP, then a 1- to 500-MW NEP, and then advanced systems. The early focus was on NEP for outer-solar-system exploration. The solar intensity decreases rapidly as one goes to the outer planets, and solar energy is not a good option. The long distances and flight times require gravity assist with chemical fuels. Nuclear electric (plasma) is better than chemical fuels by providing increased propulsion. The environmental extremes (micrometeorites, radiation, and temperature) are terrible, especially for the electronics. Getting parts that resist the environment is difficult.

The high power capability of NEP opens up new scientific opportunities: active radar, more-detailed imaging and mapping, deep-space communications, ring dynamics, and auroral "movies." These capabilities enable missions that NASA was not able to do before: satellite landers, Pluto orbiters, Kuiper Belt orbiters, and Titan sample returns.

One technological problem is converting fission energy to thrust. NEP has a rich heritage, some in the United States and much in Russia. The United States has design capability in power conversion, space reactors, electric propulsion, and next-generation ion thrusters. Reactor options include the Safe, Affordable Fission Engine (30 kW with existing technology); testable multicell in-core thermionics, and direct gas-cooled. Power-conversion options include Brayton, free-piston Sterling, thermoelectronics, and thermoionics. (The Brayton subsystem is of simple design, a closed system, fairly efficient, with no high-technology issues.) Thruster options include electrothermal, electrostatic, and electromagnetic (e.g., magnetoplasmadynamic, pulse-inductor thrusters, and VASMIR (variable Isp). NASA is focusing on the gridded ion source for NEP. Additional challenges are system integration, lightweight deployable radiators, and other components.

NEP can evolve to meet future NASA needs to provide surface fission power supplies and support for human exploration. Surface power can go from radioisotope systems to multimegawatt systems. Propulsion for human exploration will be the largest problem. Transit time needs to be minimized to minimize risk.

For any mission beyond Mars, solar power is infeasible. A robust outer-solar-system program will need both radioisotopic and NEP systems. Nuclear-fission sources will revolutionize space exploration.

Miller asked what the likely time period would be for the first NEP plant in space. Langford said that the very earliest possible deployment would be 2010. Ahearne asked where DOE fits in. Langford pointed out that NASA does not build reactors or even radioisotope sources.

Hartline asked how much NASA would be able to put into reactor development. Langford answered, for FY 2002, about $4.6 million; it is hoped that that number will go up in the conference committee.

John Taylor took the floor to report on the Operating Plant Subcommittee. It had meetings on August 13 and September 19 by telephone conference. The primary purpose of the meetings was to review and comment on the recommendations of the Coordinating Committee for FY 2002 projects of the NEPO Program. He gave an update of the membership.

The Coordinating Committee has made its recommendations. A FY02 project list totaling $24.732 million was presented for consideration. Selections were made for a FY02 DOE funding level for NEPO of $5 million (House Bill) as well as $9 million (Senate Bill). (The final level was $7 million.) The industry cost share through Electric Power Research Institute (EPRI) is more than 50%. The selection committee focused on aging issues like corrosion, electric-cable deterioration, and monitoring the aging of electrical equipment.

The Subcommittee and NERAC are concerned that restricted funding allows little opportunity for new projects in 2002. Nonetheless, several new projects are being proposed. New work was initiated on Alloy 600 cracking (reactor head penetration) as a result of recent operating-plant inspections. It is commendable that program plans are treated as "living documents" with the flexibility to address new urgent issues.

In the $5 million funding case, the Coordinating Committee did not recommend any - instrumentation and controls (I&C) or risk-technology projects for DOE NEPO FY 2002 funding, and recommended the such discontinuation of projects from 2001. The impact is modest on three of the continuing projects because carryover funds from 2001 will be used for most of planned continuation work. The impact is greatest on Project 5-110 for the development of the technical basis and guidance for determining control-room capabilities and designs to help utilities with their modernization programs. This project is important because utilities are currently starting major I&C modernization programs that will lead to substantial control-room changes, and this project would be very helpful to them.

No projects on human performance were recommended. Two proposed human-performance projects (Potential for Technological Solutions to Alleviate Specific Staffing Problems and Capturing Valuable Work-Related Personal Knowledge) came after the voting sheet was made up. Rather, the proposed projects were identified separately, leading to a question as to how seriously they were considered. The Subcommittee recommends again that human-performance projects be supported by NEPO. Industry has given high priority to improving human performance and maintaining excellent operating staffs in a times of serious attrition.

Materials issues are given a higher priority than I&C, risk, and human-performance projects because they have an immediate impact on plant reliability and a longer-term impact on aging management to support increased interest in license renewal. For that reason, there is reluctance to devote resources to projects judged to be technically "soft" compared with projects in materials or components based on "hard" science. In light of these considerations, the Subcommittee agrees with the Coordinating Committee selections at the $5 million level, but recommends that serious consideration be given to I&C, risk-technology, and human-performance projects in the final selection.

A summary of the Joint EPRI-DOE Strategic R&D Plan to Optimize Nuclear Power Plants was completed and issued in mid-June. This report was a substantially improved document over previous drafts reviewed by the Subcommittee. The recommendations of the Subcommittee generally were brief, focused on R&D needs and the expected value of results, identified new initiatives, and minimally discussed broad nuclear-power issues. A copy of the report was distributed.

Future actions are straightforward. Consideration should be given to a yearly update of the summary document in lieu of updating Volume I, the summary of the Plan. Volume II will be kept up to date on the details of work to be done. DOE and EPRI staff will need to update the schedule of interactions with the Subcommittee for CY 2002. When recommendations are made by the Coordinating Committee for projects to be funded to the $7 million level, the Subcommittee will meet to review these selections.

Comfort asked what consideration was taken into account of the NERI activities. Taylor said, not very much and that he would pass on the suggestion that the Coordinating Committee be cognizant of NERI. Mtingwa noted that a booklet is available on the NERI program and its projects.

John Ahearne was introduced to report on the NERI program, which has been in existence now for about 3 years. It arose from a President's Committee of Advisors on Science and Technology (PCAST) recommendation to explore what could be done to revitalize the academic world of nuclear science and nuclear energy. Funding was recommended to be $100 million by 2004. The current and proposed funding is nowhere near that amount. For the past couple of years, however, the authorizations have been larger than the requested amounts. Currently, NERI program funding is at $32 million after conference.

There are a lot of university participants and one university with a lot of projects. An analysis of how many of these projects are led by universities indicated that universities are far more likely to be collaborators than leaders. The number of students participating in NERI is

Total number of students involved with a NERI project	130
Number of PhD students with thesis based on work with NERI	51
Number of masters students with thesis based on work with NERI	57
Number of graduate students working with a NERI project	2
Number of undergraduate students working with a NERI project	20
Number of professors involved with NERI	51

The Subcommittee was pleased with these numbers. It sat in on about 31 of the NERI onsite reviews and was pleased with the uniformly high quality of the projects and felt that NERI is better because of the opportunity for collaboration between industry and academia. True to expectation, the universities are providing more of the innovative ideas, and industry is providing the reality check on the market and regulatory hurdles. An issue for NERAC to consider is: What is the purpose of the NERI program? There appears to be some disagreement, particularly between NE and the NERAC Subcommittee members. It is vital for NERI to keep its basic-research, university-oriented focus if the goal remains to use the program to build the workforce.

Another reservation expressed by the Subcommittee was that the research projects were not as closely tied to the Gen IV initiative as was initially expected.

One of the goals of the NERI program was to rejuvenate active research in issues regarding nuclear energy. At this time, *creativity* is one of the most important aspects of the program. Several good examples are evident in the program, but there are also inhibitions, both in the administrative aspects of grants as well as in some slanting towards Gen IV.

The Subcommittee members concluded that the review process was adequate. However, the members offered several recommendations for improvement. The first question raised was, “Who does the review?” The concern was raised that DOE does not have a sufficient number of competent people to conduct these reviews. The reviews conducted are is not suitable for evaluating the technical merit of NERI projects and for providing technical guidance on the preferred future direction of the projects. Achieving this objective will require reviewers having expertise in the subject area of each project. More high-caliber researchers need to be involved in these reviews.

The student involvement is good. This is a pump-priming issue.

It is not clear, however, how the various projects fit into NE’s overall plan for nuclear-energy research, development, and demonstration or even whether there is such an overall plan linking NERI to the other components of NE’s program. NE should develop a strategy for the transition of NERI results into applications.

In summary, the overall impression of the Subcommittee members is that the NERI-funded research is of high quality. The funding available remains much less than that called for in the PCAST report. The NERI review process is useful and should be continued. One thing that needs to be looked at is how the projects are selected. This selection process will have implications for the I-NERI program.

Mtingwa noted that PCAST also wanted new ideas and asked if NERI had done that. Ahearne said that what PCAST had hoped for is just beginning to be in evidence. It is drawing in more students. It is, therefore going in the direction PCAST hoped for, just not very fast. Hartline pointed out that the four-year output was what was projected for the first year by PCAST, so it is too soon to judge. She asked how the training of people is involved in the projects. Ahearne responded that the effects are broad in spectrum; as nuclear engineering departments closed, nuclear sciences are in a variety of departments. Comfort noted that a fabulous proposal was received from a computer science department. Todreas commented that many of the MIT projects are led from outside the nuclear engineering department.

Duderstadt stated that the Committee should send a letter to the Secretary, letting him know that the program is working.

Powell commented that the statement about the quality of reviewers should be stated more cautiously and asked how the reviewers are selected. Ahearne replied that the initial reviews are performed by external reviewers. After a project has been running a couple of years, a review team visits the site and writes a subsequent letter of review. It is those reviewers who were not always knowledgeable about the projects and areas reviewed. Shane Johnson (NE) stated that there may be a different view on what the reviews are intended to do. The Department wants to know if the researchers are covering the scope, content, and cost that they agreed to; the reviews are not technical-merit assessments. Croff pointed out that, in Office of Science, these reviews are discipline oriented, whereas the NERI reviews are done by site, so the expertise required varies widely from review to review. Ahearne concluded that he was interested in growing the program, and to do so, it must be apparent that the quality is high.

Till commented that NERAC is driving NERI to be highly innovative. To be continued, a project has to be producing high-quality technology and science. He pointed out that the opinion expressed about review quality is not unanimous. Reba said that the point to attain high quality is in the peer review process, not the follow-on program reviews. You have to reassure Congress that the awards are made on the basis of strict, high-quality peer review.

Duderstadt put on the table the question of how to break the logjam constraining the DOE and NE budget. Several directions are possible: offering compelling projects in line with the NEP and Congressional interest; developing a near-term deployment plan with industry cooperation; and addressing needs beyond civilian nuclear power needs (e.g., DP's need for trained personnel). He asked for a motion to accept the Near-Term Subcommittee's report. Comfort moved to accept the report, and Fertel seconded. It was approved unanimously.

Todreas commented that the Subcommittee is still cleaning up the format of the report, so minor comments could still be accommodated. Duderstadt said that he would like to get comments on the report. Comfort stated that he would like to ensure that it gets implemented.

Powell stated that Card asked the Committee for direction. The Committee should also include suggestions for policy changes and send a group to Card with those suggestions, making it clear what is needed to push forward. Corradini observed that Card seemed to be asking for help in ensuring deployment and that the Committee needs to give him help to do that. Till said that the ball is not in the Committee's court. Powell responded that the Committee can be a catalyst.

Fertel said that a lot is happening in the industry that is not visible but bears on this. These activities would lend themselves to joint government-industry cooperation. Industry's market-driven approach can work well with Card's "what can we do to help you get the technology out faster" approach. Duderstadt asked how this fits in with the long-range plan. Ahearne responded that the long-range plan is oriented toward classical development. Card said, "build something now, even if its wrong." That is not what the long-range plan envisions. Fertel said that industry does not share that opinion, either.

Duderstadt said that the only way the near-term plan will work is if NERAC pushes industry and industry asks Congress to put the infrastructure in place. Miller observed that the only time

Card wrote down anything was on the need for infrastructure help. Duderstadt asked how NERAC could get the need for infrastructure before NNSA. Magwood suggested, through their advisory committee.

A. Klein noted that DOE is providing technology support to NASA. Perhaps that is a good model for nuclear energy.

Powell asked if a NERI follow-up program could be set up with individual cost sharing. Fertel responded that Card said what he was interested in. That does not mean NERI stops. The Committee needs to make sure that what has been identified as important gets implemented. Those needs have to be prioritized, though.

Long commented that the Committee's discussion is too focused on nuclear power. Far more dollars are being spent on other applications of nuclear science (e.g., industrial isotopes, medicine, etc.). The Committee needs to support and shore up the means to populate this field. Duderstadt pointed out that the National Science Foundation (NSF) is fighting battles of its own. DOE needs to beat money out of the National Institutes of Health (NIH) for the use of isotopes etc.

Hartline observed that none of the NE budget line items was big enough for Congress to bother with and asked if NERAC should try to collapse the number of items to a smaller number. Magwood said that, with few exceptions, the program is an interactive mosaic of activities. They all support each other. Some projects could easily be merged. The question of merging things is a budget strategy . Is it easier to fight for two \$50-million projects or for one \$100-million program? Powell commented that, the more pieces, the more one is inviting micromanagement. Till countered that, if one is to be lost, a lot more is lost if the projects are joined together. He pointed out that one of the practical realities is that the strongest political support came from state interests. A. Klein added that that applies to universities, too.

Cortez said that he would like to include university reactors in the letter to Card and to tie the issue to manpower needs. Nuclear science has to be recognized as a broad-based enterprise. The NEP requires much scientific manpower and many facilities.

Magwood pointed out that, although the number of dollars NE gets is small, it is growing rapidly. NERAC and PCAST are major reasons why. For university reactors to survive, they have to have relationships with the national laboratories so students and researchers can move up in their knowledge and research development.

Fertel called the Committee's attention to the fact that the NEP called for nuclear energy from a clean-air standpoint and pointed out that a lot will happen in clean air in the next few years. It is a window of opportunity for nuclear power. The Committee needs to identify the policy changes that go with those opportunities. In addition, NE itself does not have enough qualified personnel. We should look at those manpower needs and see how we can help grow the program. Magwood observed that it requires expertise in Washington to get programs on track and keep them on track. NE would appreciate any help.

Todreas ticked off a list of issues that had been cited: university reactors, NERI, the need for concept development, and near-term deployment. He asked about the Gen-IV roadmap and whether it will get into the budget cycle in time to not lose a year. He suggested adding to these four but making sure that they are prioritzed. Mtingwa added that the need for isotope production should not be forgotten. A dedicated facility was recommended. He would like to see this Committee take some action to make sure this action goes forward. Reba asked if the isotope program should be in NE or even in DOE. That is its historical place, but Congress has not encouraged the continuation of this program. Magwood commented that the level of user support is pathetic, almost invisible. The Society of Nuclear Medicine has disappeared. The Secretary sees the mission of DOE to be national security, including energy use. Where this leaves NE and the isotope program needs to be figured out. Reba noted that the authorization bill of NIH funded a new initiative and called for NIH to partner with DOE (specifically) and other agencies. That may be a good place to focus isotope efforts.

Duderstadt invited those that signed up to make public comment to come forward.

Kenneth Hughey said that his company, Entergy Nuclear, had been in existence for 3 years and had 10,000 MW of nuclear power and 4000 MW of other power plants. It was the first purchaser of a nuclear plant (Pilgrim) on the open market. It is the largest provider of license renewal services, and sells those services to the outside. It is a leading provider of decommission projects and very committed to nuclear power. It is trying to figure out how to build that next new nuclear plant. It has identified seven possible sites and will recommend to its board of directors two sites for ESPs. It will bank that site for 20 to 40 years.

The Near-Term Subcommittee had a hard job. He wished that both plants had been identified as much as possible. A technology must be selected by 2003 to deploy by 2010. Major equipment orders have to be placed by 2005. Entergy's board has only allowed the company to select sites for an ESP. The commercial industry has to decide what technology should be pursued. It is not large baseload plants. They disturb the market too much.

Enterty's plants are located in the Northeast in an unregulated environment. That favors a plant that is modular in design and can keep operating at some level if some portion of the plant goes down. Furthermore, the future power mix will change. The hydrogen economy is coming. A plant that could make hydrogen at night and electricity during the day would be economically favorable. Therefore, Enterty is evaluating a GT-MHR plant and is lining up cooperative funding to pursue licensing of that plant. He would like to see more involvement in the near-term deployment by other industry players. Those companies need to be reached out to and gotten involved. Enterty has a proposal for government-industry cooperation that is considered reasonable and a starting point for talking with decision makers.

Long noted that the task force on university reactors recommended that $250 million be made available to university-reactor operators. Those grants were not approved by the chief financial officer of the Department. The message is, "you cannot trust DOE to supply any funding for university reactors." Magwood replied that the money was not in the University Programs budget and would have to have been transferred from other sources. That could not be done before the end of the fiscal year. As soon as the conference committee report comes out, the Department will be able to move forward with that request. Long commented that the senior management of DOE did not support the request and that relying on congressional interest to drive it is not the way to go.

There being no further business, Duderstadt adjourned the meeting at 11:49 a.m.

Prepared by
Frederick M. O'Hara, Jr.
Recording Secretary

Submitted by
James J. Duderstadt
Chaiman

Acronyms Used

AAA	Advanced Accelerator Application (Program)
ADTF	Accelerator Demonstration Test Facility
ALWR	Advanced Light Water Reactor
ANL	Argonne National Laboratory
ANS	American Nuclear Society
ASCI	Accelerated Strategic Computing Initiative
ATA	Advanced Test Accelerator
ATR	Advanced Test Reactor
ATW	Accelerator Transmutation of Waste
AVLIS	atomic vapor laser isotope separation
AWR	Accelerated Waste Retrieval (project)
BNL	Brookhaven National Laboratory
CAMS	Center for Accelerator Mass Spectrometry (LLNL)
CASC	Center for Applied Scientific Computing
CBD	*Commerce Business Daily*
CGSR	Center for Global Security Research
COL	combined construction and operating license
CRIEPI	Central Research Institute of Electric Power Industry
CTAP	coordination, technology, assessment, and planning (team at DOE)
DC	design certification
DoD	Department of Defense
EBR	Experimental Breeder Reactor
EBS	engineered barrier system
EOM	electro-optic modulator
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESP	early site permit
FCCG	Fuel-Cycle Crosscut Group
FE	Office of Fossil Energy
FFTF	Fast Flux Test Facility
FMEF	Fuels and Materials Examination Facility
GIF	Generation IV International Forum
GRNS	Gen IV Roadmap NERAC Subcommittee
GT-MHR	gas turbine - modular helium reactor
HENP	High Energy and Nuclear Physics Division
HEU	highly enriched uranium
I-NERI	International Nuclear Energy Research Initiative
I&C	instrumentation and controls

IFR	Integral Fast Reactor
INEEL	Idaho National Engineering and Environmental Laboratory
ITAAC	Inspections, Tests, Analyzes, and Acceptance Criteria (NRC)
JNC	Japan Nuclear Cycle Development Institute
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LBE	liquid lead-bismuth eutectic
LBNL	Lawrence Berkeley National Laboratory
LEDA	Low-Energy Demonstration Accelerator
LEU	low-enriched uranium
LIS	Laser Isotope Separation
LLNL	Lawrence Livermore National Laboratory
LMR	liquid metal reactors
LRP	Long-Range Plan
LWR	light-water reactors
MIT	Massachusetts Institute of Technology
MOX	mixed-oxide fuels
NARAC	National Atmospheric Release Advisory Center
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NEA	Nuclear Energy Agency
NEI	Nuclear Energy Institute
NEP	National Energy Policy
NEPD	National Energy Policy Development (group)
NEPO	Nuclear Energy Plant Optimization
NERI	Nuclear Energy Research Initiative
NIF	National Ignition Facility
NIH	National Institutes of Health
NMSS	nuclear-materials safeguards and security
NNSA	National Nuclear Security Administration
NRC	National Research Council; Nuclear Regulatory Commission
NSF	National Science Foundation
NTD	near-term deployment
NTP	nuclear thermal propulsion
OECD	Organisation for Economic Cooperation and Development
OMB	Office of Management and Budget
ORNL	Oak Ridge National Laboratory
P/T	partitioning and transmutation
PBMR	pebble-bed modular reactor
PCAST	President's Committee of Advisors on Science and Technology
PSI	Paul Scherrer Institute
RFI	request for information
RFQ	radiofrequency quadrupole
ROD	record of decision
SC	Office of Science; superconductivity
SCM	subcritical multiplier
STAR	Secure, Transportable, Autonomous Reactor
STEP	Science and Technology Education Program (LLNL)
T&D	transmission and distribution
TMT	target and materials test

TOPS	Subcommittee on Technological Opportunities for Increasing Proliferation Resistance
TREAT	Transient Reactor Facility
TRISO	Tri-isotropic
TRU	transuranic (waste)
UC-B	University of California at Berkeley
UREX	uranium extraction
USEC	U.S. Enrichment Corporation
VASMIR	variable Isp