DRAFT
Minutes for the
Nuclear Energy Research Advisory Committee Meeting
January 10-11, 2001, Crystal City Marriott, Arlington, Virginia

NERAC members present:

John Ahearne
Thomas Cochran
Joseph Comfort
Jose Luis Cortez
Maureen S. Crandall
Allen Croff
James Duderstadt (Chair)
Marvin Fertel
Steve Fetter
Beverly Hartline
Andrew Klein
Dale Klein
Robert Long
Sekazi Mtingwa
Lura Powell
Richard Reba
Joy Rempe
Allen Sessoms
John Taylor
Ashok Thadani (ad hoc)
Charles E. Till
Neil Todreas
Joan Woodard

NERAC members absent:

Michael L. Corradini
Leslie Hartz
J. Bennett Johnston
Linda C. Knight
Warren F. Miller, Jr.
Benjamin F. Montoya
Daniel C. Sullivan
C. Bruce Tarter

Also present:

Thomas Blejwas, Director, Nuclear and Risk Technologies Center, Sandia National Laboratories
Nancy Carder, NERAC Staff
Madeline Feltus, Associate Director of Technology, Office of Nuclear Energy, Science, and Technology (NE), DOE
Norton Haberman, Senior Technical Advisor, NE, DOE
John Herczeg, Lead Nuclear Engineer, Office of Technology, DOE
William Magwood, Director, NE, DOE
Ernest Moniz, Under Secretary, DOE (Wednesday only)
Gail Marcus, Principal Deputy Director, NE, DOE
F. M. O'Hara, Jr., NERAC Recording Secretary
Burton Richter, Professor of Physical Science, Stanford University
Craig Williamson, NERAC Staff

About 30 others were in attendance during the course of the two-day meeting.

Wednesday, January 10, 2001

Chairman James Duderstadt called the meeting to order at 10:30 a.m. A photograph of the Committee was taken. Duderstadt asked the members to introduce themselves. He welcomed new members and reviewed the agenda. He called the Committee's attention to the agenda of the upcoming National Academy of Engineering meeting in California in February, which will be focused on nuclear power in the 21st Century. He also mentioned that Committee members might be interested in commenting on an upcoming Senate bill to authorize funding for university nuclear science and engineering programs for fiscal years 2002 to 2006.

He introduced **William Magwood** to discuss developments in the nuclear-energy research program at DOE. Magwood started with a review of the R&D budget of the Office of Nuclear Energy, Science, and Technology (NE). The program has been restructured to devote more funds to the R&D program. That program is stable during this fiscal year. Notable features of this budget are

< the stability of the Space Power Program;
< the recovery of the Universities Program, receiving $12 million this year;
< the sustained funding of the Nuclear Energy Plant Optimization (NEPO) initiative at $5 million;
< the increase in funding for Nuclear Energy Research Initiative (NERI) from about $22 million to $35 million with the dedication of $7 million to the International NERI Program;
< the inclusion of funding for the Accelerator Transmutation of Waste (ATW) activities, which went from $8.2 million for FY 2000 to $34 million for FY 2001 (this funding for ATW will be discussed at length later in the meeting);
< the appropriation of funding for Nuclear Facilities Management, which is a new name for what NE does at Argonne National Laboratory (ANL), which funds are devoted to the shutdown of the EBR-II reactor and to demonstrate the technology of treating spent fuel [since the May 2000 NERAC meeting, a record of decision (ROD) to proceed with treatment of EBR-II fuel];
< the stable funding for the isotope program;
< the movement of the uranium programs to the Environmental Management (EM) budget; and
< the decrease in funding for program direction because some of the staff was shifted to EM with the uranium programs.

A chart of R&D funding during the past decade showed the sizable decline (almost to zero) and the subsequent recovery since 1998.

The Fast Flux Test Facility (FFTF) issue is nearing an end. Secretary Richardson in December decided to use the existing infrastructure to produce Pu-238 for future space missions. The ROD is expected to be issued within a week. The Advanced Accelerator Application (AAA) program will add a $34 million appropriation to NE and an additional $34 million to Defense Programs (DP). AAA is a modification of the ATW Program and will be discussed under that topic by other speakers later in the meeting.

The Advanced Nuclear Medicine Initiative was funded at $2.5 million, and the first research grants have been issued; a solicitation for applications for education grants is to be issued soon.

A new Fuel Cycle Security Program has been established to maintain the facility at the Portsmouth Gaseous Diffusion Plant in cold standby. The program is also responsible for an advanced gas-centrifuge technology program for the separation of uranium isotopes. Work on this technology was halted in the eighties in favor of investigating the atomic vapor laser isotope separation (AVLIS)

process. The U.S. Enrichment Corporation (USEC) came to the conclusion that AVLIS would never be profitable. As a result, renewed attention is being paid to the centrifuge program. Ahearne asked how much research had been done on maintaining the gaseous diffusion plant in cold standby and whether that could actually be done for four or five years. Magwood said that he was not familiar with all of the technical analyses done on this subject, but that a pilot plant had been constructed at the K-25 Plant in Oak Ridge and was successfully held in cold standby for a year before it was closed down. The key reason to do this is that analyses have shown that the gaseous diffusion plant in Paducah, Ky., standing alone, would not be enough to meet possible future needs. As assessments are worked out, we want to have the Portsmouth capacity available.

NE's staff is being rebuilt. Several people have been hired, and some solicitations are on the street. Todreas asked how many people are being hired, and Magwood responded, about 15.

A conference was held in Miami on the future on nuclear power in Latin America. The Department hopes to hold such workshops every couple of years.

Cochran, noting that, if you take out the uranium program, the division's budget had a $70 million growth, with half of that in the ATW and some of it in the FFTF decommissioning. He asked if the funding for the ATW program had come from Congress or if the Department had asked for it. Magwood responded that the Department did not request money for the AAA or for ATW and that it is using that money to fund materials and fuels experiments related to the ATW and AAA.

Duderstadt asked how the growth in FFTF is explained. Magwood responded that the money available was not enough to keep it on standby so more was requested. Once the ROD is in place, the money will be used for the shutdown.

One of the more gratifying activities of the Office is international cooperation on the Generation IV Nuclear Energy Systems Initiative, commonly referred to as Gen IV. The United States, and specifically NE, is being looked to for leadership in pulling this all together.

Ahearne asked in what way the Committee's Long Range Plan (LRP) influenced the budget process. Magwood said that the report did not come in time to affect the FY 2001 budget, but it is having an effect on the FY 2002 budget, specifically in the area of space reactors. Gen IV is where a lot of the plan's recommendations will be carried out.

Hartline noted that NE's priorities for FY 2002 formed a backdrop for NERAC's 2001 discussions, and she asked if Magwood or anyone else would be outlining the Department's perspective on 2002 before the Committee had those discussions. Magwood said that priorities have not changed a lot. The Division will be springboarding off the LRP. The isotope program and the university-reactor program will also be major areas of investments.

Ahearne asked Magwood if he saw changes in the positive or negative direction, and Magwood responded that he saw positive changes. NE has closer relations with the Office of Basic Energy Sciences (BES) within the Office of Science (SC), especially in material science and other areas of the NERI program. In other programs, our work with DP is improving. Ahearne asked how NERI has been going, and Magwood responded that it is a success. It has reinvigorated the NE research community. A lot of people are interested in it. Currently, NE is trying to link NERI with the Gen IV process.

Mtingwa asked about having a dedicated cyclotron isotope-production facility (as opposed to a reactor). Magwood said that the cyclotron idea seems worthwhile pursuing. An isotope-production facility is being built off the Los Alamos Neutron Science Center (LANSCE) for the production of

proton-rich isotopes. A need is also perceived for a cyclotron to pair with that facility. Between those two machines, basically 100% of the need for proton-rich research isotopes would be covered. Where neutron-rich isotopes are concerned, reliance will be placed on existing facilities. The High-Flux Isotope Reactor (HFIR) is still making isotopes, although capacity is limited. The Advanced Test Reactor (ATR) should also have some capacity for producing research isotopes for the next five to ten years. If no new infrastructure is built, other organizations can be expected to rise to the occasion. That topic will be left for others to worry about in the future.

Duderstadt asked Magwood for an assessment of the past two years of NERAC and what improvements are needed. Noting that some effects of subcommittee reports should be seen in the budgets, he asked where the Committee should focus its reports for the most impact. Magwood responded that, in his estimation, NERAC has been extraordinary. The activity and output of its subcommittees have been very high. It needs to expand to have an Executive Committee to do planning and to get things moving faster and pushing the staff to action. The composition is about right, but a way may be needed to reach out to the international community. Maybe Gen IV will turn into something NERAC can interact with. The members of the Committee should be very proud.

Dale Klein said that he thought that the Committee needs to push a little harder to see, for example, that the aspects of the LRP are implemented. It has been a good two years, but it is only a beginning.

Taylor said that his opinion was that DOE has not been very responsive to the Committee's recommendations; for example, responses to its recommendations on the international NERI activity have not been in evidence. Duderstadt said that his impression was that the Committee's recommendations are warmly received by Congress, but are slow to be acted upon by DOE.

Cochran said that it seemed to him that if NE had gotten $34 million for programs that the Committee was interested in, this problem would not exist. Instead, representatives from the New Mexico laboratories went to Congress to get funds for their own projects.

Sessoms said that he thought that the Committee should see to it that the Director of NE is heard by the highest levels of the Department and at the Office of Management and Budget (OMB). The DOE laboratories get a hearing on the Hill because they are good at that. The Committee should use some of the same techniques. The Organisation for Economic Cooperation and Development (OECD) in Paris could be used as a venue to hold symposia on Gen IV; that would not leave DOE out on a limb alone.

Reba said that he thought that DOE has been very receptive to the Committee's recommendations on isotope production, but the Subcommittee did not include a funding recommendation. He would like to add such a section to affect the 2002 budget. After the issuance of the Subcommittee's report, the funding for isotope production actually went down. When he went to the Hill, the pertinent staffer would not support funding for isotope production. The senator from New Mexico, unasked, saw to it that funding was provided.

Long noted that utilities have a lot of contact with their senators and representatives, but they are not very well informed about NERI. Some initiative could be made to brief utility executives so that they can bring those points to their representatives.

Fertel said that the Committee may want to look at the timing of its meetings. NERAC should meet early enough in the budget cycle so it can comment on priorities that it would like to see in the budget request. Duderstadt noted that the National Science Board does that, meeting in June to advise the National Science Foundation (NSF) on its budget, and it has worked well. Hartline commented that that is what happened to the LRP: the report did not come out until too late to influence the current

budget request. The Committee should plan its meetings to coincide with the budget cycle. This Committee and its subcommittees have been historic in that, for the first time, a plan for nuclear-energy research has been produced. The Committee now needs to integrate the planning for research, education, etc.

Duderstadt said that the Committee should ask Secretary-Elect Abraham to meet with it, and it should meet with others in DOE to hear how they have reacted to the budget requests and appropriations and why. Magwood said that he was certain that the Committee could engage at least the under secretaries in such a dialog.

Ahearne noted that this is an advisory committee. Advisory committees tend to think they are a management function. NERAC needs to be clear about to whom it is offering advice. Sometimes it is the Director, sometimes the Secretary, and sometimes Congress. The documents it produces are appropriate for the Director and staff of NE; but as you go up the chain, these reports become too detailed to be absorbed. To hit all these constituencies, a variety of documents is needed.

Powell said that the timing is right for advancing the cause of NE because of the energy crisis in California. This Committee with all its contacts could be quite a coalition.

Cortez commented that the Infrastructure Subcommittee did not get much information about what university facilities were available. The NERI program got diluted by funding going to existing laboratories and institutions and did not bring new people into the community.

Todreas asked rhetorically where the Committee should be moving. It has three roles: planning, advising, and influencing. The Committee has a major responsibility to get this office fully staffed. Its recommendations need to be executed, which requires government employees with the authority to speak on the international level. Fifteen new staff members sounds large but is not when you consider attrition.

Fertel said that the Committee needs to know whether it is having an influence because if it is not, it needs to find out why. The Committee has done a lot of work and needs to get it understood by the new system and administration. But the Committee should not try to work in too many areas.

Woodard suggested that the Committee should prepare a briefing document for the new people coming in. Duderstadt noted that a first draft of a summary of the Committee's interests and recommendations has been produced. Woodard said that that message has to be simple and focused. Taylor agreed that the report is too long.

Mtingwa commented that the Committee has studied the facilities at the national laboratories but should do the same for the universities. Duderstadt stated that Michael Corradini's subcommittee has done just that. Their December 21 report on that subject is in the same depth and detail as those on the national laboratories. It is a serious situation; several universities are shutting down their nuclear-engineering education programs this year. Dale Klein noted that there was vision and analysis in the new report that addresses the concerns of Mtingwa. Duderstadt continued that the university research reactors constructed with Atomic Energy Commission (AEC) funds in the fifties to the seventies have become an expensive subsidy by university administrations. Cornell and the University of Michigan (and likely soon MIT) have decided to close their reactor facilities. As go those institutions, so will go most of the rest unless DOE acts quickly to provide some support. It might be decided that these facilities are not in the national interest (relying rather on user facilities at national laboratories). The Corradini report recommended competitive grants to keep these programs functioning. The engineering deans have asked for a rapid resolution of the issue.

Dale Klein observed that nuclear-engineering programs have a high cost-to-student ratio, raising the question of whether you should have reactors and a graying workforce. Some believe that DOE should help maintain a nuclear engineering education infrastructure. He suggested that DOE come up with a plan and have NERAC review it. Andrew Klein stated that the relicensing process for these reactors is critical during the next six years. These reactors have an important public-education and outreach role. The people who are in grade school now will build the Gen IV reactors.

Fertel noted that, in the letter, $10 million is cited and asked if that is what would be needed to sustain that infrastructure. Dale Klein said that it depends on how you do it: internally or contracted out. Duderstadt said that Michigan figured that it would cost from $10 to $15 M for upgrades to meet licensing requirements. With only 50 students in nuclear engineering, that cost is high.

Thadani said that the Nuclear Regulatory Commission (NRC) has been working to increase university support by farming out research tasks to the universities. But that agency cannot afford to significantly increase that support. If university research reactors were shut down, the NRC will have to go overseas to have its research done.

Duderstadt stated bluntly that Michigan and Cornell are going to be shut down. Todreas said that MIT is awaiting more detailed estimates of decommissioning costs and that a decision will be made in August.

Ahearne said that there is no clear explanation of which reactors are needed by DOE and therefore require being upgraded. No real justification has been put forward for why the federal dollars should be spent. Duderstadt said that there is a recognition of the winners and losers in this process. Corradini's report recommends peer review as to where those dollars should be spent. Ahearne stated that there has to be some commitment that the peer review and the dollars will be forthcoming. And Duderstadt said that it is a commitment that must come out of DOE/NE.

Sessoms commented that projections of workforce demands are always wrong. If there is a market demand, you could stimulate student interest with scholarships. The case has to be made in concrete terms. Andrew Klein said that the case has been made time and again and that he gets calls weekly for nuclear engineers and there are none available. Sessoms said that, if there is a demand, these companies should get together to support nuclear engineering education.

Todreas noted that university reactors are of two types. Some are large enough to do research. Others are small and are useful for activation analysis and training. The larger ones could be supported by research grants. The others would have much smaller monetary support. NE programs are becoming more discipline oriented. Nuclear power is less a focus. Radiation science is what is becoming the focus, with a broad spectrum of activities. Duderstadt stated that the assumption is that the primary responsibility for training rests with DOE/NE; SC has not provided this support. Hartline noted that local decisions are not optimized for national priorities.

Dale Klein said that many of these graduates go to DOE and the laboratories. The utilities do not know where restructuring will take them, so their financial support is drying up.

Rempe observed that she had not seen the universities seeking funding elsewhere than DOE. Duderstadt observed that there is considerable cost-sharing by the institutions.

Hartline commented that, if there is peer review, the criteria have to be clear; this report says nothing about criteria. If this infrastructure was being built from scratch today, would university research reactors be a part of that infrastructure?

Reba asked why such a large variation in the full-time equivalent (FTE) in staff size occurs from

university to university. Todreas said that he would guess that it depends on the size and mission of the reactor. Andrew Klein noted that these data were supplied by a variety of institutions with varying measurement methods.

Magwood commented that a Darwinian process is taking place. Some reactors that DOE would like to keep are being lost because there is no system for training nuclear engineers that would make use of some or all of these reactors and therefore DOE does not know whether any given reactor is needed. The Corradini subcommittee said they were not the right people to do this.

Duderstadt said that there is no sense in the Corradini subcommittee's (or any other subcommittee's) going through an exercise to determine who gets in the lifeboat if there is no commitment from DOE that there will be a lifeboat to get into.

Under Secretary Moniz joined the meeting. Asked what his perspective of university reactors was, he said that his perspective is irrelevant after the next 10 days (when a new administration would take over). Seriously, though, he believed this issue warrants national attention. The health of nuclear-engineering departments is at risk, student numbers are declining, and such technologies are broadening. The government should take a role in advancing a sensible, sustainable, long-term effort to ensure campus-based reactor programs. The Department must look to see how other DOE facilities will link together to interact with those campus reactors. The Department should provide appropriate funding. How does DOE fit into education programs? How would it stabilize nuclear training and a continued workforce? Minor programs within engineering may be the answer. The long-range R&D plan put forward by NERAC is a good step and needs to be integrated with the information on nuclear-engineering education. If that occurred, a response from DOE should be forthcoming in two months.

Duderstadt asked where the leadership responsibility rested. Moniz answered that NERAC advises DOE and the Secretary of Energy. Members of NERAC can educate members of Congress about the contents of the Committee's reports. To get that information together for this year's budget cycle will be difficult. The first stage is not picking winners and losers but developing a commitment to a process.

Comfort asked if he was saying that earlier reports from this Committee should be integrated. Moniz said that the information in those reports is what is needed to make decisions about supporting an infrastructure for nuclear-engineering education. If the nation had a reasonable number of university reactors capable of doing reasonable research and being operated in coordination with national facilities, the Department should be able to support that.

Sessoms asked if he thought the new administration and Congress would be willing to commit to $20 or 30 million for this initiative. Moniz said that he did not know but that this would be fertile ground for investment. Some congressionally directed programs work well (e.g., the one in Environmental Management that directed SC to support a specific program).

Duderstadt asked if he had any words of wisdom on the evolution of NERAC. Moniz responded that he extended his thanks to the members for making NERAC a success and providing a great service. NERAC's challenge is to come up with a more integrated long-range plan for the nuclear-energy enterprise.

A break to get food for the working lunch was declared at 1:00 p.m. The meeting was reconvened at 1:19 p.m. with the introduction of Thomas Blejwas, who gave a luncheon talk about the capabilities of Sandia National Laboratories (SNL) and the next nuclear-energy era.

SNL is located in two major facilities in Albuquerque, New Mexico, and Livermore, California. In round numbers, it has 7500 full-time employees, of which 6500 are in New Mexico and 1000 are in

California. It has 800 buildings with 6 million square feet. Its employs have 1400 people at the PhD level and 1700 at the master's degree level, of which 55% are in engineering, 33% are in science and mathematics, and 12% are in computing and other disciplines.

Sandia's missions emphasize national security in the design and development of the nonnuclear portion of U.S. nuclear weapons; in safety, security, and use control; in the production of some components; and in verification, nonproliferation, and counter-proliferation. It also performs work in the energy and environment sectors, the countering of weapons of mass destruction, and assessments. Its strength is in five technical areas: computational and information sciences, materials and processes, pulsed power, engineering sciences, and microelectronics and photonics.

Sandia's funding is predominantly from the National Nuclear Security Administration (NNSA). It has four "Sandia business units" (SBUs): energy and critical infrastructure, nonproliferation and materials control, emerging threats, and nuclear weapons. The teamwork across the business units and management units has been excellent.

In dealing with the challenges and opportunities of the next nuclear era, Sandia's personnel see three ways to go: (1) Put the genie back in the bottle; this is not practical. (2) Continue in the current direction; this course has not been satisfying. (3) Develop responsible leadership and re-engage with nuclear technology. The thesis behind this re-engagement is that global nuclear policy and technology needs U.S. leadership. Issues regarding nuclear include civilian nuclear energy as an arms-reduction vehicle, expansion of the Nuclear Nonproliferation Treaty (NPT) club, the bombing of Iraq, and the development of nuclear weapons by India.

Sandia is well positioned to deal with these issues because it supports all parts of the nation's nuclear program. It is involved in (1) nuclear materials management and nonproliferation, (2) transportation of nuclear materials and weapons, (3) long-term storage and disposal, (4) nuclear site and material stewardship, (5) nuclear deterrence, and (6) nuclear power. In accord with its corporate nuclear initiative vision, Sandia provides integrated nuclear technology and policy-analysis tools to ensure global stability in the interest of national security.

Blejwas's interest is in the energy and critical infrastructure (E&CI) SBU programs that support the nuclear initiative. That SBU is active in nuclear energy, transportation, repositories, environmental restoration and monitoring, and energy research.

The corporate vision is that Sandia should provide U.S. leaders with the policy and technology options to lead the world into the next nuclear era. Nuclear issues and a balanced strategic policy rest on a four-legged stool: energy, environment, arms control and nonproliferation, and defense deterrence.

Several recent actions have addressed the nuclear future:

< Center for Strategic and International Studies (CSIS) briefing in the Capitol attended by Senate and House staffers,
< supporting Nuclear Strategy Project (NSP; Vic Reis). NSP facilitates policy discussion and decisions through participant "games" as well as conferences and reports,
< many studies support investment in nuclear power [e.g., the President's Committee of Advisors on Science and Technology (PCAST)],
< Nuclear Caucus, March 2001, and
< Sandia's Nuclear Strategy Model.

The Sandia Nuclear Strategy Model is used to look at nuclear issues. It is a high-level dynamic simulation model and strategic analysis tool that integrates nuclear topics. It is an unclassified global

model that runs on a laptop, is not "pronuclear," is benchmarked against credible data sources, is user-friendly, and easily runs "what ifs." It integrates the nuclear fuel cycle, defense materials, global energy demand, and global carbon emissions, and it provides annual global projections through 2050.

These models give insights not answers. One insight: If you are really serious about atmospheric CO_2, you must deal with the transportation sector. Nuclear and renewable electricity production alone cannot meet the Kyoto requirements for CO_2 reduction.

A video, "The Next Nuclear Energy Era," was shown, highlighting the physical facilities, activities, and skilled personnel at SNL.

In its Nuclear and Risk Technologies Center, Sandia has the following technologies:

- fusion technology,
- energy conversion devices,
- methods for estimating proliferation potential,
- radiation effects, and
- medical isotopes.

It developed these capabilities from work in the seventies and eighties on integrated nuclear reactor safety research. Through model behavior, analysis, and testing, Sandia developed severe-accident codes allowing it to develop probabilistic risk assessment (PRA), which gives the investigator insight into what is important. As a result, it has an Integrated Nuclear Reactor Safety Research Program.

It has large-scale facilities that are used to produce realistic representations of complex phenomena and processes, such as the Annular Core Research Reactor (ACRR), the lower head failure test at the Explosives Dynamics Laboratory, and the Hot Cell Facility. Sandia's major programs in nuclear energy have historically come from the Nuclear Regulatory Commission, such as modeling and code development, experiments, risk assessments, licensing support, and regulatory guides.

Sandia is also active in DOE Defense Programs. Radiation effect simulators include the ACRR, the Sandia Pulse Reactor (SPR), and the Gamma Irradiation Facility (GIF). In addition, Sandia performs component and system certification and black programs, all at Tech Area V.

DOE NE programs that Sandia is involved in include the Light Water Reactor (LWR) Technology Center (started in the late seventies) that performs plant life-extension, siting, aging, and reactor pressure vessel annealing studies; Space Nuclear Power; Accelerator Transmutation of Waste; NERI; and medical isotopes. It is developing concepts for a gas-cooled space reactor for deep-space exploration.

Successful NERI proposals Sandia is involved in include:

- experimental investigation of burnup credit for safe transport, storage, and disposal of spent nuclear fuel;
- application of innovative experimental and numerical techniques for the assessment of reactor pressure vessel structural integrity;
- "smart" equipment and systems to improve reliability and safety in future nuclear plant operations;
- a direct-energy-conversion fission reactor; and
- teaming with others on
  - a risk-base assessment of regulatory and design requirements for future nuclear power plants (with ABB),
  - the development of advance technologies to reduce fabrication and construction costs for future nuclear plants (with Duke Engineering), and

< high-efficiency generation of hydrogen fuels with nuclear power (with General Atomics).

A few years ago, Sandia decided that it should be a leader in the revitalization of the United States' nuclear energy. As a result, it is using internal money to support nuclear-energy research in four areas:

< reactors [including design (using the SPR and ACRR), computations, experiments, radiation-effect tests, and medical isotopes];
< power conversion (including space power/propulsion, thermionics, and direct conversion);
< reactor safety (including severe-accident experiments, severe-accident codes, PRA, and regulatory reform); and
< design methodologies (including risk assessment, reliability analysis, predictive maintenance, and system optimization).

It sees itself as being strong in reactor technologies, especially small-reactor technologies. Given its history in testing reactors, Sandia decided to pursue (1) advanced test reactors, (2) real-time safety and proliferation management, (3) advanced reactors and fuel cycles, and (4) regulatory change for Gen IV. A potential resurgence in U.S. nuclear power exists, but it is not yet large enough to support the activities of a national laboratory.

Andrew Klein asked where they got their nuclear personnel from. Blejwas responded that they have experienced such a decline in support that they have needed little new blood.

Crandall asked how much of their budget comes from DOE's Office of Intelligence (IN), and Blejwas answered that he did not know. Crandall asked if he was familiar with the International Energy Agency (IEA) projection of nuclear power coming to a halt. Blejwas responded that that is where they started and, in talking with utilities, they heard a lot of optimism for nuclear power.

Dale Klein asked if they were participating in Nuclear Material Management. Blejwas answered that they were not; that was a separate activity within CSIS.

Sessoms asked if he had seen any impact on students by Sandia's program, and Woodward responded that Sandia has 800 students come in each summer to work there. Blejwas also noted that Sandia has intern programs, but not much in nuclear engineering because of the low level of funding.

Cortez asked how he saw universities contributing to Sandia's small-reactor research program. Blejwas answered that Sandia is trying to team with one or two universities, including them even in the original proposals. In addition, several of Sandia's NERI projects also have university participation.

John Taylor then took the floor to speak on the Subcommittee on Technical Opportunities to Increase Proliferation Resistence of Nuclear Power Reactors. He said that the membership was chosen to represent a wide spectrum of viewpoints and included knowledgeable overseas representatives. The views of other interested technical organizations were solicited through the sponsorship of workshops and meetings, and the Subcommittee operated on a consensus basis. Although differences of opinion exist on the merits and relative promise of some of the advanced-reactor and fuel-cycle systems, all members fully support the basic recommendations.

The Subcommittee's study is founded on the "international nonproliferation regime," which is centered on the NPT, which was extended indefinitely in 1995 with 187 signatory nations. The institutional features of the nonproliferation regime constitute an essential element of the efforts to abate the spread of nuclear weapons. Comprehensive, comparative assessments of the inherent nonproliferation characteristics of different nuclear power systems have been performed. Two key assessment efforts were carried out in the seventies: (1) the U.S. Nonproliferation Alternative Systems Assessment Program and (2) the International Nuclear Fuel Cycle Evaluation by the International

Atomic Energy Agency (IAEA), with more than 60 nations and international organizations participating. Recent assessments have been carried out by the National Academy of Sciences.

The technological goals are to

- improve the effectiveness of inspection, surveillance, monitoring, accountancy, and physical security embedded in institutional controls or extrinsic measures;
- devise new intrinsic features to make nuclear power more proliferation resistant;
- reduce opportunities for diversion and theft from civilian nuclear activities;
- strengthen the U.S. ability to exert constructive technical influence on future developments; and
- improve proliferation resistance, which, along with safety, waste management, and economics, is important to growth of nuclear power.

The primary goals of R&D are to

- help assure that the use of civil nuclear power remains a comparatively unattractive route for those nations or groups interested in acquiring nuclear weapons;
- limit the degree to which civilian nuclear-energy systems contribute to dedicated military programs; and
- provide a comparative evaluation of pathways to acquiring nuclear weapons other than civilian nuclear power.

The R&D objectives in pursuit of those goals are to

- evaluate the nonproliferation implications of existing and new technologies;
- support the development of systems that
  - increase the effectiveness of institutional nonproliferation measures,
  - make weapons-usable materials highly inaccessible through the development and use of advanced open and closed fuel-cycle systems,
  - reduce the attractiveness of nuclear materials for potential weapons purposes,
  - reduce the quantities of weapons-usable material produced per unit of energy output, and
  - limit spread of knowledge that can be directly used to design and fabricate nuclear weapons; and
- evaluate, in cooperation with other interested countries, a range of reactor and fuel-cycle options that could potentially meet the above objectives.

Two proliferation-resistance technologies were examined: (1) an integrated safeguards evaluation methodology being developed under the U.S. support program for the IAEA safeguards system and (2) an “attributes methodology” that identifies the intrinsic, or material/technical, barriers against proliferation in a given nuclear system. Both are integrated methods; the first starts with extrinsic measures, and the second with intrinsic measures.

A two-day international workshop was held to focus on proliferation-resistance-assessment technologies and to obtain the views of experts on how to achieve the objectives. The workshop was based on the premises that R&D is needed to improve and standardize proliferation-assessment technologies, an integrated assessment of both the technical features and the necessary institutional measures should be provided for the different reactors and fuel cycles, and the proliferation risk posed by a particular system depends on the character of the threat (i.e., whether it is a sophisticated or unsophisticated state or a terrorist group).

The results that came out of that workshop were

- an attributes methodology should be used to make preliminary assessments of the comparative

intrinsic proliferation-resistance features of a variety of advanced nuclear power systems and

< the potential value has been demonstrated, but the Subcommittee took no position on individual assessments.

Areas that were highlighted for increased R&D attention are (1) the enrichment phase, where clandestine facility modification could circumvent intrinsic barriers; (2) the weakening of the spent-fuel-repository radioactive barrier by decay over many decades; (3) undeclared alterations in fuel content or the introduction of target material to produce weapons-usable material; and (4) the complexity and cost-benefit criteria that need to be included in assessment methods. Six general areas for additional R&D were recommended:

< Develop improved methods for assessing the proliferation resistance of nuclear systems, including trade-offs between intrinsic and extrinsic measures.
< Develop and adapt technologies to strengthen the extrinsic barriers against proliferation.
< Explore and further pursue new technologies to enhance the intrinsic barriers against proliferation.
< Build new technical efforts to strengthen international safeguards on national-support programs for safeguards already under way.
< More closely exchange and integrate the ideas and plans of designers and safeguard specialists.
< Pursue proliferation-resistance R&D in a context of the overall development of the reactor or fuel cycle concept, addressing all the facilities of the integrated system.

The workshop participants also identified some R&D opportunities for specific reactor and fuel-cycle systems:

< LWR systems designed to produce smaller amounts of nuclear material in their spent fuel (such as high-burnup, thorium-uranium fuels and nonfertile fuels);
< LWR systems designed to allow recycle without separating weapons-usable material;
< providing facilities and processes that could not be readily modified for such separation (such as dry chemical reprocessing or recycle without reprocessing);
< high-temperature gas-cooled systems designed so that material in their spent fuel would be highly unattractive for weapons use;
< liquid-metal reactor and fuel-cycle systems designed to avoid the production and separation of weapons-usable material (or the provision of facilities and processes that could not be readily modified for such separation);
< faster and more proliferation-resistant reductions in world stockpiles of separated plutonium;
< small, modular reactor systems designed with little potential for the host state to have access to weapons-usable materials and limited requirements for transfer of technologies that could contribute to nuclear-weapons programs;
< transmutation technologies for spent fuel and nuclear wastes that could reduce long-term safeguards requirements; and
< dual-use advanced monitoring and analytical systems that could handle both safeguard needs and efficient plant operations, seeking improvements on the systems already in place in the United Kingdom and France.

Of prime importance is developing an international consensus on proliferation-resistant technologies and standards. In addition, the participation in international collaborative research is vital to the preservation of U.S. technical influence and credibility. Collaborative R&D among international partners should focus on the following major themes identified in the report of the Subcommittee:

- methods for assessing measures to strengthen international safeguards;
- high burnup fuels, thorium/uranium fuels, nonfertile fuels; and
- advanced fuel cycle concepts.

The Subcommittee's report concludes with some specific recommendations:

- Proliferation-resistance R&D should be allocated an additional $25 million in the DOE budget for FY 2002, increasing thereafter if promising opportunities are identified that require increased funds.
- A significant portion of these funds, in the range of $5 to 8 million annually, should be devoted to adding to ongoing efforts in international safeguards and Material Protection, Control, and Accounting (MPC&A) technologies that could improve the extrinsic barriers to proliferation in existing reactor and fuel-cycle systems.
- A small portion, approximately $2 million in the first year, should be devoted to improving methods for assessing and comparing the proliferation resistance of proposed systems.
- The remaining $15 to 18 million should be devoted to the evaluation, analysis, and experimental work on approaches that could improve the intrinsic proliferation resistance of current and future reactor and fuel-cycle systems.

He asked for approval for the report of the Subcommittee. Duderstadt observed that this subject seems to relate closely to Gen IV. Taylor responded that many of the aspects of this study contribute directly to the concepts on which the Gen IV effort is based; it is a vital element thereof. Todreas commented that a lot of the points made in the report are an integral part of the discussion tomorrow on the Gen IV Technology Roadmap.

Hartline said that the Subcommittee had done a fine job. NERAC might want to emphasize some of the points in the cover letter to the Secretary.

Comfort noted that two reports came out about the same time: the FFTF Environmental Impact Statement and the Technological Opportunities for Increasing Proliferation Resistance (TOPS) report. He asked if there was a consistency between the two, what sort of priority should be given to a nonproliferation R&D program, whether the issue of nonproliferation should be enhanced, and whether $25 million should be devoted to nonproliferation R&D. Taylor replied, no; that would overwhelm the budget. Maybe 10% of that. Other topics are much more urgent and require the funding.

Till asked what was new. He noted the explosion of information technology and commented that there may be some payoff in R&D in that area (in monitoring, assessing, and processing information). Therefore, information technology might be stressed. Secondly, he noted that it is technologically impossible to assess a quantitative difference between two very different systems and asked if the Subcommittee looked at the production of military materials with civilian power reactors. Taylor said, no, the Subcommittee did not go into that.

Sessoms said that the Committee needs to emphasize the IAEA and international aspects of these efforts. This report should also emphasize that it is a part of a larger effort (Gen IV). The report should not make it seem that what we have is very bad; we want to make it say that what we have is okay and we want to make it stay okay.

Taylor responded that the LWR once-through reactor is proliferation resistant, but it has been the focus of Iraq and Iran to get what they want through undeclared activity. So you cannot just set aside LWRs as totally proliferation resistant. Cochran noted that Iran's approach to getting nuclear weapons is built around getting LWRs and enrichment technology from Russia.

Todreas suggested that the cover letter should focus on the effects of the report on operating near-

term reactors and then on longer-term reactors. Taylor noted that, in the report, there is a discussion of three time phases and what should get emphasis in each of these time frames. Todreas said that the impact is better if you say "operating reactors," "reactors that will be operating in 10 years," etc.

Ahearne moved to accept the report and to endorse the recommendations. Sessoms seconded. The motion passed. The editorial work of Hal Bergelsdorf was acknowledged.

Taylor then presented highlights of the Operating Plant Subcommittee report. That report noted that $5 million was appropriated for the FY 2001 NEPO Program and that funding was to be matched by industry through the Electric Power Research Institute (EPRI). The NEPO projects recommended in FY 2001 were on the topics of

- Steam generator nondestructive in-service inspection upgrading
- Electric cable aging degradation
- Aging, irradiation degradation, and fatigue in components and structures
- Risk analysis methodology
- Human performance
- Irradiation-induced swelling and stress relaxation of reactor-vessel internals
- Digital instrumentation and control upgrading

Nine of the projects are continuations of FY 2000 projects, and nine are new projects. The key Subcommittee comments expressed

- concern about the increasing constraints project selections will be under if funding remains constant (conflicts will occur between innovative projects and the ability to address new or changing issues versus completing existing projects sufficiently to gain their expected value) and
- disappointment at the possibility that Project 5-108, "Organizational Factors Leadership Process Development," would be dropped.

In response to the Subcommittee's recommendations, an events calendar and communication plan (for communications between DOE and the Subcommittee) have been prepared for the FY 2001 NEPO Program.

Thadani said that he thought Project 5-108 was going to be supported. Taylor responded that it was recommended but is now on the questionable list in the funding selection process. The Subcommittee believes that this project should be supported in the process by DOE/NE.

A break was declared at 3:26 p.m. The chairman called the meeting back into session at 3:48 p.m. Duderstadt introduced **John Ahearne** to speak on the activities of the Long-Term Nuclear Technology R&D Plan Subcommittee. In July of 1999, the Subcommittee put out a short document, the Strategic Plan Subcommittee Report. In June of 2001, it put out a lengthy LRP document with 56 pages and a hundred-page appendix that was accepted at a previous meeting of NERAC. To remind people that may have forgotten that they were on the Subcommittee, he listed the members.

Subsequent to that report's being accepted by the full Committee, three questions arose:

1. What issues should the Subcommittee address and in what detail?
2. How should such a report relate to the DOE Strategic Plan and the budget process?
3. Should a top-down plan be developed and, if so, should it include more than NE?

After discussing these questions, the Subcommittee ended up with a set of issues:

1. Does the Subcommittee start with the goals as given in the latest version of the DOE Strategic Plan or with that plan plus the materials from the two PCAST (President's Committee of Advisors on Science and Technology) R&D studies and other such materials?

2. Should the scope be restricted to NE or be expanded to include all of DOE's R&D activities, present and prospective?
3. Should the Subcommittee work from a gap analysis, first examining or refining DOE's missions and objectives in a particular area and then looking at the adequacy of the programs in that area?
4. To what extent should we involve the nuclear-energy research community and to what extent should the top-down approach be based on or linked to the bottom-up approach used in developing the LRP?
5. In regard to budgets and related issues, should the Subcommittee develop funding priorities, explicitly stating how funding should be allocated, say, among universities, national laboratories, and industry?
6. What should be the time frame covered by the document?

Several ideas were put forward: The Subcommittee should use some comparisons in its budget recommendations [i.e., putting these budget numbers in perspective with other major areas that DOE funds (such as high-energy physics) and with NSF funding]. Should the Subcommittee be reviewing NERI? Is the assessment missing new and innovative ideas (i.e., outside the mainstream)?

Some complications also arose in attempting to develop a top-down approach: (1) the FFTF and what is going to happen to it, (2) the startup of the Gen IV, (3) the NE budget and whether it reflected the LRP in any significant way, and (4) making the LRP mesh with the objectives of the new administration.

As a result of these thoughts and questions, the Subcommittee would like feedback on several issues:

1. The Subcommittee charter includes monitoring NERI and making recommendations for that program. NERI is supposed to be an idea generator. How might the NERI process be improved?
2. The LRP did not lead to a set of priorities. Should the Subcommittee set those priorities? To what degree should the top-down plan start with the large number of broad policy statements that are available (e.g., the DOE Strategic Plan, statements by Senator Domenici, and the views of the new administration)?
3. NERAC has now produced many reports. We should integrate these, distilling out the main priorities and, from the plethora of recommendations that have been put forward, determining which ones should be ranked the highest.

Powell suggested that the Committee pull these recommendations together, critically examine them, arrive at a list of desired ends, and then market them to the appropriate entities. Fertel said that he did not think that there was a lot of conflict among these documents and that it should not be too difficult to produce a three- to four-page summary.

Comfort said that he was confused by the term "top-down" and asked if that meant one would start with DOE's Strategic Plan. Ahearne said that it means starting with NERAC, rather than with the whole nuclear community, using available documents. Rempe asked if the Summary (Independent Expert Recommendations) does not already do this, and Ahearne replied, no, that Summary does not accomplish what the Subcommittee desires.

Hartline commented that, if one does not know what the budget is going to be, it is difficult to set priorities. One could say, if the budget was *X*, here would be the priorities; if it was *Y*, these would be the priorities.

Sessoms asked what the Subcommittee wants to accomplish. Is it an impact on the budget? A few burning issues are on the table: infrastructure, education, etc. The proposed summary has to be succinct and clear in the context of the broader vision.

Taylor said he thought it would be best to use the reports that have been accepted. The content of those reports cannot be changed.

Todreas said that the university needs (reactors and scholarships) are one piece of the nuclear puzzle. Nuclear power needs basic research and Gen IV development. Someone has to integrate these segments.

Comfort commented that the LRP is evolutionary. Now that these other reports are in hand, maybe now is the time to reorganize and reprioritize the LRP. Ahearne suggested that he come back the following day with a reassessment of the LRP. Sessoms pointed out that the short-range plan needs to reflect the contents of the LRP.

Comfort asked if there was any idea what the incoming administration might be considering. Long said that he did not have a strong sense that DOE is going after the same things that this Committee is saying in the LRP that the Department should go after. DOE has to be enlisted in the process so that it buys into and will pursue what is recommended. Duderstadt said that one of the problems with DOE is that much of its program has been determined by people on the Hill. Once the new administration determines the directions it wants to go in, agencies will have to follow.

Cortez asked what the Committee has gotten from the DOE/NE staff that indicates what they want to do. Ahearne said that we have the DOE Strategic Plan. Cortez stated that NERAC needs something from NE to guide it.

John Herczeg was introduced to talk about the Advanced Accelerator Applications (AAA) Program, a joint NE/DP program. In a preface to his presentation, Herczeg announced that ANL has been working on the AAA concept and has separated uranium with an efficiency of 0.99999 to make it a Class C waste. The researchers there are also evaluating a dual-strata scheme: Instead of burning waste in an accelerator, plutonium is separated out of the waste and is burned in a dedicated reactor that generates electricity; only the actinides are burned in an accelerator.

Ahearne asked if separating Pu is a proliferating step. Herczeg replied that all types of plutonium are separated out together, not just weapons-applicable isotopes. This is similar to the French approach.

Todreas asked if they were also looking at a reactor to burn the actinides. Herczeg replied, no; that would be done with an accelerator. Todreas asked if that result was arrived at by fiat, and Herczeg said that he would not comment. In the summer of 2000, we came up with ideas that initiated some actions by the Senate. The Senate markup of the appropriations bill provides $60 million to establish an AAA office within NE that combines the Accelerator Production of Tritium (APT) Program and the Accelerator Transmutation of Waste (ATW) Program. The mission of the AAA Program is to include conducting scientific research, engineering research, development, and demonstration on the accelerator production of tritium as a backup technology, transmutation of spent nuclear fuel and waste, materials science, and other applications. The conference committee provided $34 million to "establish a new program for Advanced Accelerator Applications" and $34 million for DP for the design and

development of the accelerator production of tritium. The Appropriations Act directs DOE to "prepare a program plan for managing and executing this (AAA) program using the extensive expertise of the Office of Science and the Office of Defense Programs in accelerator research, design, and applications ... and ... of the Office of Nuclear Energy in the transmutation of nuclear waste."

The AAA program will address (1) energy security and stability; (2) national security; and (3) scientific, technological, and educational well-being. In the $34 million was $3 million for the University of Nevada, Las Vegas (UNLV) to do research. We have established a contact point to coordinate what we are doing with UNLV.

Cochran asked who is doing the radiologic comparison between the dose produced by this Class C waste and that from leaving the uranium in the spent fuel and disposing of it in the repository. He said that it seems that you would need some assessment that shows you have a reasonable program. Herczeg said that experiments need to be conducted. Cochran asked why experiments must be performed if a cheaper paper study will show that the proposal is not viable.

The first long-term goal for AAA is to develop (1) the technology base for the environmentally sound transmutation and separation of spent nuclear fuel for long-term waste management through the demonstration of spent-fuel recycling, (2) separations technology and its impact on repository storage, and (3) coupling of technologies and integration of operations.

The second long-term goal for AAA is to strengthen the national nuclear infrastructure by building an Advanced Nuclear Technology Center (ANTC) consisting of an Accelerator Driven Test Facility (ADTF) and supporting infrastructure at a site to be determined. That center will demonstrate (1) the technologies for the transmutation of spent nuclear fuels and waste and (2) alternative tritium-production capabilities. The ANTC will be a world-class test and user facility for industry-association members, university participants, and international collaborators. The education component of this strategy will establish an AAA university program with research partnerships to rebuild a declining national nuclear-science technology base, addressing the re-establishment of a diminishing nuclear engineering and science infrastructure, and enhancing university curricula.

Ahearne asked what schedule and cost he envisioned. Herczeg replied that the facility would be operational in 10 years; costs are estimated to be less than $2 billion over these 10 years.

Cochran asked what the power requirements of the accelerator would be, and Herczeg replied that he did not know off-hand.

The third long-term goal for AAA would be to continue to develop the technology base for tritium production, to include (1) documentation of the APT design and engineering development and demonstration (ED&D) activities and (2) providing alternate tritium-production capabilities.

The goal of the new University Grants Program for the AAA Program is to produce 100 (plus) new master's and PhDs by 2010. Research would be conducted in new areas of engineering:

< Target: spallation physics and target design
< Subcritical Multiplier (SCM): design, cross-section data, criticality analysis, and heat transfer
< Accelerators: design and reliability
< Separations technology and waste form

The focus would be to support master's- and PhD-level students and professors, tightly integrated with the experimental design and analysis of the ATDF. The approach would be competitive, peer-reviewed grants for research directly related to the AAA Program. $555,000 is available this year.

Dale Klein asked if students could get in to work on these projects without Q clearances. Herczeg said that they could get in but just could not work in certain buildings. NE hopes to have 10 people in place this summer.

Herczeg showed a schematic diagram of the basic building blocks of the AAA Program:

< Block 1: Technology Development would include transmutation (separations, fuels, etc.), advanced nuclear system development, tritium technology completion, and support to Blocks 2 and 3.
< Block 2: The Intense Neutron Source Facility would be a 400-MeV accelerator based on the APT design. (All the work done to date has been performed on the Low-Energy Demonstration Accelerator.)
< Block 3: Nuclear Engineering Tests would include subcritical-multiplier experiments and arrays of nuclear technology tests (fuels, coolants, materials, isotope production, etc.).
< Block 4: Future Options would include the full-scale ATW facility and the tritium-production capability.

Three AAA External Independent Review Committees have been set up to oversee what is being done:

< AAA (former ATW) Subcommittee of NERAC (Dr. B. Richter, Chair)
< Facility Design Requirements Task Force (Dr. R. Omberg, Chair); these requirements are currently all over the map, and therefore costs are all over the map; this Subcommittee will tighten up the requirements.
< APT External Review Committee (Dr. Herrmannsfeldt, Chair)

The major AAA accomplishments and impacts that are expected to be accomplished during the 10 years of the program are:

< In the first two years, APT design will be completed, first ever coupled-system demonstration, "clean" uranium from spent fuel, a conceptual design of the facility, and the initiation of the Student Awards University Program;
< In the third and fourth years, high-power target demonstration, first-phase small-scale transmutation plus separations demonstration, the ROD, and the completion of master's degrees;
< In the fifth and sixth years, the decision on whether or not to proceed with the tritium pathway, the production of qualified fuel, the start of construction, and the completion of the first PhD from the AAA education effort;
< In the seventh and eighth years, coupled separations, second-phase scaled transmutations plus separations demonstration, and the operation of a users group;
< In the ninth and tenth years, the practicality demonstration starts, operation with ADTF and the separations facility, operations acceptance, and first-of-a-kind nuclear research and test facility.

Fertel asked why 10 years was chosen. Herczeg replied that the Department determined that it would take more than 6 years. The French plan to do it in 15 years. It should be able to be done in 10 years, and will therefore probably take 12 to 13 years.

Cochran asked if he were referring to proof of principle in 10 years, and Herczeg said it will be operating in 10 years. Reviews of proof of principle will be done early on. Cochran asked how much tritium would be produced, and Herczeg responded that that is not NE's mission.

Sessoms asked if the FFTF could be used to speed up this program. Herczeg said that it would be so expensive that you might as well build an SCM from scratch.

Rempe said that she expected the reactor to be a light water reactor rather than a gas-cooled reactor. Herczeg said that both are going to be studied both because of a program that is going on in Russia.

Todreas asked about putting the tritium targets in the beamline. Herczeg said that it is technologically feasible to take the current-design [Tennessee Valley Authority (TVA)] targets and put them in the beamline, but there is a political problem in using a waste-disposal machine for weapons production.

Reba asked how many master's students the program would turn out, and Herczeg replied, ten per year.

Taylor asked how, if you are talking about some new process here and integrating it into tritium production, you avoid classification issues. Herczeg said that he had asked about this, and the advice he received was to make the program just for U.S. citizens. But, Sessoms said, more than half the students are foreign. He did not think that DOE will be able to find 100 U.S. students. But, Herczeg pointed out, this is over 19 years.

Magwood asked what part of the four blocks would require people with Q clearances. Herczeg replied that, in this chart, none. When you get into separation, that would change. Magwood asked if DOE might want to get some international cooperation in developing this program. Crandall said that this seems a bit of an anomaly 10 years after the end of the cold war and asked what constituency was driving this idea. Magwood responded that that is a key question. The origins lie in the old tritium program. It is slowly evolving from a tritium program to a broader purpose. Two years from now there will be a conceptual design of an R&D facility. As a cousin to this work (being paid for by the Defense people), there will be a backup design for the production of tritium.

Crandall suggested that maybe the broader issue needs to be changed a bit and asked if it makes sense to expand this program's funding while there is a need for additional funds for other programs. Magwood stated that, if the funds did not go into this program, they would not be available for those other programs.

Cochran noted that the government did not build a dedicated tritium-production reactor, but instead decided to use TVA reactors. He went on to say that that left a DOE staff without support, so they cobbled together a proposal for a backup tritium-production facility. They took that proposal to the Hill and, as a result, DOE got these unrequested funds. He said that he thought it is a huge boondoggle. A roadmap and several other studies have told us that this pathway is absurdly expensive. Nothing in this program makes the case for taking the plutonium out. That separation effort would open up several incentives for R&D in support of proliferation. Nor does this program make any sense environmentally.

The meeting was adjourned for the day at 5:30 p.m.

Thursday, January 11, 2001

Chairman Duderstadt called the session back to order at 8:03 a.m. He called attention to the day's *USA Today* in which appeared an op-ed piece by Lester Thurow on the need for nuclear power. He then introduced **Burton Richter** to present a report from the ATW Subcommittee.

This is an interim report; a larger one will be presented next spring. The developing world uses one-sixth the energy per capita that the developed world does. As those countries develop, they will

increase energy demand greatly, producing great economic and pollution pressures. We need to conduct the R&D to produce greater amounts of energy at low economic and environmental costs. To improve the environmental impacts of nuclear energy, the long-term waste problem associated with nuclear energy needs to be addressed.

In the course of its review, the Subcommittee saw some excellent work on (1) technical screening to reduce options, (2) separation technology, (3) new and promising approaches, and (4) the beginnings of effective international cooperation. There was not much progress on the key issues of nonproliferation issues, fuel fabrication (not expected until options are more limited), and accelerator reliability criteria.

In the United States, current policy calls for spent fuel from LWRs to be packaged and sent to a repository. The Europeans and Japanese, in an effort to reclaim the energy content of the spent fuel, separate the plutonium from that spent fuel before sending that fuel to the repository; the plutonium is combined with uranium to produce a mixed-oxide fuel (MOX), which is then reintroduced as fuel in the LWR. The ATW concept is to separate the (long-lived, highly radioactive) actinides from the spent fuel before sending it to the repository; those actinides would then be subjected to the beam of an accelerator to transmute them to more benign isotopes. The product from the transmutation step would then be run through a separation step to extract any remaining actinides for reintroduction to the accelerator beam.

In the classic ATW separation process, the waste stream is separated into three components: the short-lived fission fragments, which are sent to a repository for 200 to 300 years; uranium, which is disposed of as Class C waste; and the long-lived fission fragments, plutonium, and higher actinides, which are diverted to the transmuter. Some long-lived residuals are also sent to the repository.

Separation of uranium has been demonstrated at 99.999% efficiency, producing a uranium sample whose contamination with other radioactive material is below the threshold of concern. The same research team has looked at how to handle zirconium cladding (by the Pyro-B process) and how to handle some nonstandard fuels. There has been excellent progress on these last two topics since the March 2000 meeting.

Also, a dual-tier approach has emerged as a new concept. In this scheme, the waste stream is separated into short-lived fission fragments, which are sent to a repository for 200 to 300 years; uranium, which is disposed of as Class C waste; the long-lived fission fragments and higher actinides, which are diverted to the transmuter; and plutonium, which is fed as fuel to the critical burner in the form of nonfertile plutonium-bearing fuel. This critical burner can be an LWR with a 30% core loading of plutonium (a technology that is available now) or a new-design gas-cooled plutonium reactor allowing about 80% Pu burnup in a single cycle through.

The advantages of this dual-tier approach include:

< The accelerator/transmuter size is reduced by an order of magnitude (to 60 to 80 MW).
< The transmuter does not need to produce electric power; the energy in the spent fuel is accessed by burning the plutonium in a reactor.
< The smaller transmuter and lack of power production ease the accelerator reliability criteria; as a result, 800-MW pulses of electricity to the grid are avoided.
< The system is rapidly deployable with an LWR critical burner.
< Consuming military plutonium as well is simple.

No disadvantages are obvious, but the comparative proliferation resistance needs review. This approach is of great interest to the Europeans.

Work is just starting on assessing the ramifications of the proliferation resistance of this concept. No system is perfect; nothing is 100% proliferation resistant. The question that should be answered is the global impact of ATW compared with the present regime; the assessment should compare how the possibility of diversion of plutonium changes from traditional methods to the ATW.

Several longer-term R&D issues were raised in the 23 May 2000 report:

< How does electrical production distort the program? In the "classic" ATW scheme, it does increase the accelerator-reliability requirements. In the dual-tier scheme, it is not an issue because power comes from a plutonium-burning reactor rather than from the output of the accelerator.
< The impacts of the ATW and of the separation of high- and low-heat radionuclides on repository design have not been studied. The Office of Radioactive Waste Management is beginning to look at this. This is a long-term issue, and they have not done a lot of work on this, as yet.
< The program could benefit from domestic and international collaborations in several areas. For example, as part of the proposed AAA program, it would bring universities into the research program and provide training for engineering students. On the international level, major collaborative programs may come out of a meeting with the French in February.

The AAA Program is to combine ATW and APT into a single, coherent program. The goals sound good:

< ATW R&D
< peer-reviewed university involvement
< a 5- to 10-MW, 600-MeV proton accelerator for materials testing (1 to 3×10^{15} n/cm^2; E > 0.1 MeV)
< a user facility including student training
< upgrade capabilities to much higher power for the APT, if that is needed. This upgrade would be expensive, and it is not clear that the upgrade would be economically feasible.

At the most recent meeting with DOE staff in December 2000, the AAA concept had not yet fully hatched from the egg. The Subcommittee recommends that users not be required to be Q cleared and that the accelerator project be subject to in-depth cost and schedule review. The next ATW Subcommittee meeting will be held April 18-19 in Washington, D.C. A longer report will be produced then.

Ahearne asked if the mechanisms to burn plutonium are more expensive than burning uranium. Richter responded that it is too early to look at the economics because the design path has not been narrowed down. Generally, the MOX fuel cycle costs 20% more than the uranium cycle. However, no one has looked at how waste-disposal costs affect this. Marcus commented that what NE is asking of this Subcommittee is to look at the technology involved; that is what it has a mandate to do. Richter went on to say that the technologies of the plutonium-burning reactor and the accelerator are doable. You could build them tomorrow. The transmuter needs some work. It is too early to answer the environmental and proliferation questions now.

Sessoms asked how NERAC can help, and Richter responded that the Committee could conduct a serious study. The Europeans, Russians, and Japanese point at the huge amount of energy left in spent fuel. But our nation's policy is not to separate plutonium. Without separation, this program will not go anywhere.

Comfort asked if the Subcommittee is looking at the benefit of ATW in terms of the radioactivity that results with and without an ATW, measured, for example, in curies. Richter responded that the major environmental concern is the long-term storage of radioactive waste. ATW improves that situation by a factor of 10.

Cortez asked if it is a good idea to posit a facility with both cleared and uncleared personnel. Richter answered that it is easier if the entire facility is unclassified. ATW has no problem doing that. If you require some associated experimentation that is classified, you can do that elsewhere at a laboratory with some classified areas.

Todreas stated that the use of a critical vs subcritical reactor for the minor actinide transmutation process should be examined now. The major challenge is reactor controllability, but there may be means to deal with this challenge that the Subcommittee needs to examine now.

Cochran asked when Richter thought the Subcommittee will be in a position to make reasonable judgements about the economics, environmental, and nonproliferation aspects of this program. Richter responded that, for ATW, he would guess about five years. The options and processes need to be sorted out. Cochran asked what costs the R&D would have, and Richter replied, more than a million dollars but less than billions of dollars. Just for the accelerator, $100 million would be needed for R&D; the rest would require $20 to 30 million per year. But the Subcommittee has not looked at this issue.

Cochran said that a good amount is known about MOX economics and asked why some economics of the ATW cannot be given now. Richter responded that the Subcommittee should start looking in that direction. Cochran went on that he had a problem with the makeup of the ATW Subcommittee and asked if the Committee could make some changes in the Subcommittee. Duderstadt suggested waiting until Magwood was able to join the discussion.

Duderstadt introduced **Neil Todreas** to report on the activities of the Gen IV Subcommittee. The goals today were to review the roadmapping activities and to present and discuss the goals the Subcommittee is suggesting to the international community.

Todreas listed the membership of the Subcommittee and noted that they had met five times. He presented a block diagram that illustrated the Gen IV roadmap organization. It showed the Gen IV Technology Roadmap Subcommittee reporting to NERAC, which in turn reported to DOE/NE. NE itself has a Roadmap Integration Team made up of several technical working groups and an evaluation-methodology group. Separately, NE also has a Near-Term (approximately 10 years) Deployment Working Group. Parallel to DOE's activities are those of the Gen IV International Forum on which are represented research organizations from eight countries.

Cochran commented that he saw in these working groups the usual groups (industry, university wackos, etc.). He said that he had been under the impression that Gen IV was going to look at novel concepts and should all belong in the Nonclassical Concepts box. Todreas replied that even a novel-concept reactor has to be cooled. Using these methods of cooling does not mean that just the same designs dealt with in the past are being considered. From the goals it can be seen that the near-term-deployment items do not fit the Gen IV criteria.

The roadmapping strengths are that (1) there has been vision from DOE/NE; (2) the Roadmap Integration Team has a lot of technical weight and capability while vitally depending on DOE direction and vision; and (3) the Technical Working Group membership involved industry and university people along with advisors from the national laboratories. The Technical Working Group's industrial cochairs

know how to run and lead a technical group. Its large number of workers will be supplemented by international cooperation, representing a broad range of individual competencies.

The challenges faced by the Subcommittee are brought about by several factors:

< international participation and coleadership (integrating the international collaborators through a structured process will be difficult)
< coordination with the Near-Term Deployment Working Group
< crosscutting groups (candidates: fuel cycle/waste, fuels/management, nonproliferation, safety/risk, plant design/operation, economics) and reactor-concept-based working groups (each coolant concept will have a crosscutting group)
< the DOE staffing depth (currently only one full-time worker; DOE needs to staff this effort fully)
< the lack of evaluation methods to winnow down the concepts put forward, particularly in ranking the proliferation-resistance features and in assessing the uncertainties associated with a concept (these methods must have intelligence, coherence, and continuity)
< the need for an interface with the NERI Program (there has been talk but no plan for implementation to make Gen IV and NERI flow together)
< uncertainty about whether the end product is to be reactor concepts (how many?) or fuel cycles or both

Taylor noted that "ranking" implies a greater precision than he would feel comfortable with. He suggested using the term "assessing." Todreas agreed.

The strategy is to achieve, by summer of 2001, a winnowing down to 20 to 30 concepts; by 2002, 8 to 12; by 2007, 3 to 6; and by 2112, 1 to 3. Because the budget for executing the plan will be finite, a real challenge will be the sorting of concepts with little data. Also, getting the international community to agree on one to three concepts will be a great challenge, the accomplishment of which is not assured.

The goal-setting effort is very important. Goals will determine the long-term path. The Subcommittee has three models for goals:

< the 1990 Advanced Light Water Reactor (ALWR) requirements, which focus on economics, safety, performance, and environmental impact;
< EPRI's 1994 criteria for practical fusion power systems, which focus on economics, public acceptance, and regulatory simplicity; and
< the principles for sustainability (1972 to date), which range from soft to mainstream to hard.

A spectrum of activities has been associated with sustainable development:

< among nuclear-energy organizations, the OECD on Dec. 7, 2000, issued its "Nuclear Energy in Sustainable Development Perspective," which offers a very narrow view
< among the mainstream organizations, The Alliance for Sustainability offers its four principles for sustainability (they started in Sweden and have been adopted in the United States)
< among soft green proponents, Gregory Bateson published his *Steps to an Ecology of Mind* in 1972, and the Institute for Sustainable Design at the University of Virginia published Will McDonough's *The Hannover Principles, Design for Sustainability*
< among hard green proponents, Peter Huber published his *A Conservative Environmental Manifesto* in 1999

Across the spectrum, the major message is that what is being dealt with is resources and waste. The major themes are do not produce waste, turn waste into materials for new products, and do not consume resources. Under sustainability, there would be three types of products: renewable (return everything to the soil), durable (return the product to the manufacturer), and unmarketable.

The question arises how nuclear power fits in here with its long-term radioactive waste. What is needed on the research agenda is fuel-cycle innovation. The Subcommittee has, accordingly, written a preamble to the goals statement. It contains the following broad Gen IV project principles:

< Gain broad public acceptance.
< Consider complete nuclear energy systems.
< Strive for international applicability.
< Stimulate innovative systems development.
< Exclude no technologies *a priori*.

The objectives of the goals are to stimulate the search for innovative nuclear-energy systems and to serve as the basis for developing criteria for comparative assessments. These objectives will lead to a problem down the road: To stimulate innovation, you need openness; to evaluate possibilities, you need constraining criteria. Some general constraints on these goals to be borne in mind were identified:

< What is needed are technology stimuli, not regulatory requirements.
< It is highly unlikely that all goals will be met by any single nuclear-energy system

Todreas turned the floor over to **Salomon Levy**, who pointed out that the Gen IV goals need to project what the conditions and future drivers will be in 2030. Among those future drivers:

< a sharp rise in energy/electric demand [by 2030, electricity demand will grow by 50%; by 2050, by 100% (78% by very low projections)]
< environmental constraints will get tougher and will be linked to greenhouse gases
< fuel availability (what fuel will be available then?)

The nuclear industry is looking for an enduring supply of nuclear energy that is environmentally acceptable. To do this, it needs to attain a number of goals. Sustainability is the overarching goal. The available ways to achieve sustainability include (1) management of the integrated fuel cycle, (2) resistance to proliferation, and (3) management of radioactive waste.

Cochran said that he thought that Levy was putting a premium on the fuel supply. The price of uranium has gone down, not up. He did not see the need to elevate sustainability to such a high position. Levy said that he looks at the whole fuel cycle and the full, integrated fuel cycle. Cochran asked if the primary goal is price or just using the uranium, and Levy said that you have to move on all fronts. Progress is needed on all fronts: safety, environment, etc. Till said that the question is what magnitude of electric load are you going to maintain. Levy said that he would like to preserve the option to meet a very large load if it is needed. Cochran stated that the Department's predecessors put billions of dollars into a concept that was not economical, and that model was copied around the world. Levy said that what was being looked at was using uranium more efficiently.

Ahearne noted that sustainability is cited as the overarching goal and that economics is way down the list. Maybe the path that is being followed here is the same one industry went down in the eighties. Levy replied that there was no issue here; nuclear power has to be economically competitive.

Returning to his presentation, Levy said that, to gain the public trust, safe performance is essential.

These plants will have to work very well, so well as to remove the need for off-site emergency response. They will need to (1) incorporate core-damage prevention, (2) demonstrate their safety, and (3) provide radiation protection.

A final goal is favorable economics.

He then considered each of these goals separately.

The first goal to be discussed was sustainability. Future nuclear-energy systems will advance sustainable energy development through long-term environmental compatibility, conservation and/or the recycling of scarce materials, and the long-term availability of systems and especially fuel for energy production. The nuclear fuel cycle is of fundamental importance. Clean air and no greenhouse gases are advantages. It must be recognized that nuclear energy has different fuel sources and alternative integrated fuel cycles. The different fuel cycles have certain advantages and tradeoffs.

Fetter asked if the goal was to use uranium more efficiently or to advance nuclear energy. Levy replied that he did say to use uranium more efficiently, but there are advantages to other fuel cycles.

The second goal is the management of the integrated fuel cycle. Proper management of Gen IV integrated fuel cycles will significantly increase and maximize the utilization of nuclear fuel in meeting the long-term worldwide energy demand. Options include going to an open uranium cycle, an open uranium/thorium, an open thorium, closed cycles, or fast reactor cycles. Taken in this order, these fuel cycles produce an increasing fuel availability and decreasing waste volume/hazards. These cycles should be looked at as part of the Gen IV process.

Cochran said that he did not see that waste volume /hazard gets less with the open uranium cycle. You can just put spent fuel in repository without opening up the fuel and releasing volatiles, etc. Levy replied that, if you separate high-level waste, you reduce the volume. Cochran said that you reduce the volume of high level waste but not the overall waste volume.

The third goal is resistance to proliferation. Gen IV nuclear-energy systems will increase the assurance that they are a very unattractive and the least desirable route for diversion of nuclear materials.

The fourth goal is management of radioactive waste. The proponents are proposing that Gen IV nuclear energy systems will significantly advance the minimization, utilization, and management of radioactive wastes. The advances will exceed current levels of protection for public health and the environment and will reduce or eliminate the stewardship burden in the future. Ahearne asked what he meant by "eliminate." Levy acceded that that would be very difficult, but different recycling possibilities may be possible.

The fifth goal is public trust/acceptance. In order to gain public trust and acceptance, the participation by the public in the decision-making process for Gen IV nuclear-energy systems should be increased, and public understanding of nuclear energy should be enhanced by the transparency of the information being disclosed about these systems. Sessoms said that he did not see this as a technical issue that needs to be dealt with in Gen IV. It should have been done for the whole industry 20 years ago.

The sixth goal is safety and performance. Gen IV nuclear-energy systems will excel in safety and performance. Improvements here improve costs.

The seventh goal is to eliminate off-site emergency response. In order to eliminate the need for off-site emergency response, Gen IV nuclear-energy systems will reduce the likelihood and severity of any off-site radioactive release. PRA will be used to ensure that no incident will require an emergency

report. Thadani stated that this assertion implies that you have plants with robust containment systems. You will need to address methods of bypassing the containment.

The eighth goal is core damage prevention. The likelihood of core damage and the degree of core damage will be limited in Gen IV nuclear-energy systems to permit plant restoration to power.

The ninth goal is the demonstration of safety. Future nuclear-energy systems will fully demonstrate their safety. This concern will not need to be addressed for some time. It would be achieved through a prototypical demonstration supported by validated analysis tools and testing or through reliance on proven technology supported by analysis, testing, and research results.

The tenth goal is radiation protection. Gen IV nuclear-energy systems must assure that radiation exposure satisfies the applicable radiation standards at the time and place of deployment. The requirements apply to the total system and its entire lifetime. The ALARA (as low as reasonably achievable) standard will take into account economic and social factors.

The eleventh goal is economics. Gen IV nuclear-energy systems will have a clear economic advantage over alternative energy sources at the time and place of deployment. Emphasis will be placed on the reduction of capital cost and construction duration, and cost reductions will be pursued in a balanced manner and through tradeoff assessments.

The twelfth goal is finances. Future nuclear-energy projects will have an attractive return on their capital investment, significantly reduced project and/or construction lead times, and a level of financial risk comparable with competing energy projects at the time and place of deployment.

Taylor commented that the Subcommittee has selected comprehensive and challenging goals and noted that experience has shown that systems developed in the past did not meet the expectations held for them.

Rempe asked how one would assess the implementation of these goals. For example, how would one assess the economic needs? Todreas responded that this point is, as yet, unresolved.
Rempe suggested that one option that might be considered is going forward with two of the sets of assumptions, rather than with one.

Comfort said that these goals are very acceptable, but one must determine how sufficient the methods to measure the goal achievement are. They cannot be set so high that you can say that a concept is eliminated because it does not meet a goal. The LRP had a lot more in it than is reflected in the Gen IV effort (modeling, evaluation of nuclear data, etc.). He asked if all the R&D is under the Gen IV umbrella or will some fall under other umbrellas. Magwood responded that, for those portions of the LRP that deal with Gen III and Gen IV, the research should be under that umbrella. If the research did not have a goal, there would be no reason to do it.

Duderstadt commented that a certain level of basic research is needed to achieve any goal. One of the great weaknesses of the nuclear-energy program is that it lost that basic R&D. Will NE rebuild that basic research as part of a program (that needs to be much broader than the Gen-IV effort), or will it have to be rebuilt by SC? Such a basic-research program is desperately needed. Magwood said that NE fully intends to fund such basic research under a NERI investigator-initiated program, but NE would also like to have a nuclear power technology program, which is another thing that it does not have now.

Duderstadt's concern was that the past experience has been that technology programs tend to overwhelm the basic research program.

Woodward stated that, if the United States does not push the standards across the board, it may compromise its effort to be an international leader. That is clear from the Boeing model. It will be important to judge whether national or international standards would advance us the farthest.

Long noted that the utilities have to be involved. In the ALWR review, some important insights came out of the industry review. Levy commented that that has to be done throughout the program. Crandall noted that many of the cited items will be out of your control and that the statements about "at the time and place of development" do not take into consideration that conditions change. Levy responded that that is why we say that these goals have to be constantly reviewed and updated.

Fertel said that one has to be careful about what you say about the market forces; we cannot agree what the market forces are today let alone what they will be 20 or 30 years from now.

Magwood commented that Todreas and Levy were asked to do something that is nearly impossible and that their good work was appreciated. These goals are aggressive, otherwise they would not be good screens for the hundreds of concepts out there. Conversations with the French make clear that the next generation of reactors must be designed for the international market. Boeing's market is not just the United States. That is why they succeed. In the next few months, we will try to reconcile the competing interests to produce a program that the international community can contribute to. Comments on this roadmap activity should be sent to rob.versluis@hq.doe.gov by the end of next week.

Woodward explained that her point was that Boeing does not make one plane in accordance with U.S. safety standards and another in accordance with Chinese standards. Making a plane that meets the most demanding standards brings us all forward.

A break was declared at 10:43 a.m. The Committee was reconvened at 10:50 a.m. **John Ahearne** was asked to review what the Strategic Planning Subcommittee will need and need to do. Ahearne said that the Subcommittee will need three products.

1. A one- to two-page top-down statement of goals is needed by NERAC. That statement will be developed by each NERAC member sending a one-page list of specific goals for NE to Haberman. All of those submissions will be sent to all of the Subcommittee members. Each Subcommittee member will draft a one- to two-page statement of goals, and Ahearne and Woodward will work these up into a common statement to be presented to the full NERAC for approval.
2. A three- to four-page summary is needed of the reports that have been produced by the various NERAC subcommittees. In about one page, each subcommittee should state the key stories and dollars that come out of the subcommittee's report. Ahearne will synthesize these one-page submissions from the subcommittees into the three- to four-page summary document, have Duderstadt review it, and submit it to the full NERAC. This process will not include the ATW or Gen-IV subcommittee activities because their reports have not yet been approved by NERAC.
3. The Strategic Planning Subcommittee will review the NERI program at a number of meetings this spring, reviewing the quality of the work.

Duderstadt asked Cochran to review his ideas about the ATW Subcommittee. Cochran said that the ATW Subcommittee takes a different view of that program than he does. The Subcommittee says that nuclear power is essential, and therefore research on ATW is necessary for approximately five years. He believed that ATW has been around for about 25 years and has been seen not to solve the waste problem in a cost-effective manner. Before $170 million is spent on research, a stronger case should be made for the economic and nonproliferation cases. What might be good would be to add

three or four members to give that Subcommittee more balance. Ahearne said that he was sympathetic to those views; the Subcommittee would do well to have someone raise a broader range of issues. Magwood said that, for the most part, the Department has chosen to take a wait-and-see attitude. The policies in question were not written with the ATW in mind. The Department has not made a decision on ATW but has been instructed to look at ATW and AAA. He would suggest considering a short-lived activity to look at these broader issues and letting the extant Subcommittee restrict itself to the narrow charge that it is to answer about the technical details of ATW activities. Another single-purpose task force could look at the political issues and advise DOE about that topic.

Duderstadt stated that the questions Cochran brought up have to be answered quickly before too much is committed to.

Dale Klein said that this comment has to be directed to Congress because ATW is Congressionally directed. If so, NERAC should do that. Cochran said that the Committee advises the Department, and if the Department program does not make sense, the Committee should tell the Department so. Dale Klein said that, if the Committee has a message to send, it should send that message where it would make an impact.

Sessoms said that he thought that what Magwood is suggesting is what Burton is pleading for. Ahearne commented that he did not get the sense that there was agreement among the Subcommittee members that they were going to be restricted to the technical issues. Duderstadt said that this matter should be discussed with Richter.

Fertel asked what the original charge was. Magwood said that it was to review the technical potential. Ahearne asked if the Subcommittee sees its charge as focused on the technical issues. Rempe answered, yes and no; we (the Subcommittee) are looking at the technical issues but also see these other issues that need to be addressed. Cochran said that he did not see any balance in the report presented here.

Duderstadt said that, if DOE is going to make decisions about a large-scale program, it will need advice beyond the technical realm, and NERAC is one place where it could get such advice. On the topic of university research reactors, Moniz's reaction was just a passing of the buck.

Dale Klein said that DOE knows the facts about university research reactors, and NERAC should encourage them to take action and address the situation in a fair and logical way.

Comfort noted that in the report were four criteria for the continuation of a university reactor facility. He suggested that to those four should be added a requirement for performing research addressing national needs.

Mtingwa said that he would like more information on what the whole situation is at MIT. Why might they shut down their reactor?

Duderstadt said that this situation is a near-term crisis. Three reactors will be closed soon and 24 are at risk. DOE needs to act or all of these reactors will be gone. Mtingwa asked if it was too late to save them. Duderstadt replied, some of them, yes. Sessoms noted that, with the change of administration, one cannot expect any immediate action out of DOE.

Duderstadt said that he would like to see a simple calculation of what DOE spends per faculty member and per student in high-energy physics vs nuclear engineering. Till said that, if nuclear is important, any university that takes on the responsibility of supporting nuclear engineering should be supported by this Committee and DOE. There is no substitute for practical experience.

Magwood said that DOE should step up to the plate. He suggested that NERAC, with its objectivity, subject specialization, and knowledge is in a good position to present the case (e.g., to congressmen and their staffers) for supporting university nuclear-engineering education programs. DOE should gather the information, review its quality, and standardize it. It also needs to figure out what the costs look like for a national system of university reactors. DOE should issue a proposal (by March or April) for funded research to keep universities from taking precipitous action; DOE should also put additional funds into the FY 2002 budget that would solve the problem. NERAC should put together a three-person subcommittee to help gather the needed information and to make a specific recommendation to NE about universities' needs.
At least one of those subcommittee members should be from the university community.

Todreas responded that that was a constructive suggestion. If DOE does not line out a definitive program, this situation will degenerate. DOE should state outright that there is going to be a competitive, peer-reviewed process for whatever the program is. Duderstadt said that the sense of NERAC is that there is a near-term crisis but also a longer-term strategic issue: that any response by DOE should be based on merit and the peer-review process that would focus the resources on the national interests and not just sustain the status quo. He said that this plan made sense to him, and he would put together the team.

Fertel suggested that, in the request to universities for data, a signal be sent that a process is being developed to provide aid.

Magwood stated that DOE is evaluating the technology of space nuclear power and that NASA is looking at using that technology over a long term. He suggested that NERAC form a small subcommittee to keep abreast of developments in the field so it and the Department could respond in a timely manner if NASA calls on DOE to provide aid in this technical area. Cochran suggested also looking at Russian space reactors.

Duderstadt opened the floor to public comment.

Yue Guan of Advanced Systems Technology and Management stated that sustainability is a most important issue, not only in nuclear energy but in all industries. For nuclear fuel we use it all the time. We talk about boundary conditions, depletion, and initial conditions. The goal is to simulate what happens in time. The same issue applies to PRA. But similar philosophies have not been used very often in management, budget commitment, planning, political development, and implementation. All the issues discussed at this meeting are related to this. Mr. Magwood has been thinking of how to integrate all the programs. That is a point where you can start to build on these issues. Three issues that remain are bundling issues, time issues, and interconnectability issues. All of these items are connected with each other, even the goals.

But we must realize that there are always boundaries.There is a budget boundary. For example, in the early nineties, the Hill put out a signal and a pot of money that was to be used to develop the joint standard weapons. When you have an issue like that, you do not go back to the Hill and say that the money should be committed to something else. The challenge is, how to use this pot of money to develop the best weapon that not only has the best technology but, in the long run, also has the lowest M&O (management and operating) cost. So there are always boundary issues for any problem. You have to ask how much you want to tackle, and you stay within that boundary and at the same time realize what effects externalities have within the system you are considering.

Another issue is how the issues and the programs are connected together. The Gen IV list of desired attributes looked like a laundry list. Economics were not mentioned until the eleventh and twelfth priorities. But when you develop something that has long-term stability, it has to be economically viable. In terms of the public acceptance, economic issues, safety issues, and public-acceptance issues are all interconnected. We should look to see where they are placed on this list. That issue remains in Gen IV. But if you take the same issue to go more broadly, into all of DOE and into NRC, this integration study can be so effectively done that it can have a broad impact and can be extended to other areas to provide insight.

There being no other public comment, the meeting was adjourned at 11:47 p.m.

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Chaiman