DRAFT
Minutes for the
Nuclear Energy Research Advisory Committee Meeting
November 3-4, 2003
Crowne Plaza Hotel, Arlington, Virginia

NERAC members present:

John Ahearne, Vice Chairman
Thomas B. Cochran
Joseph R. Comfort
Michael L. Corradini (Monday only)
Jose Luis M. Cortez
Allen G. Croff
Marvin S. Fertel
Beverly K. Hartline
Silvia S. Jurrison
Andrew C. Klein
Dale E. Klein
Robert L. Long
William F. Martin, Chairman
Warren F. Miller
Sekazi K. Mtingwa
Harold B. Ray
Richard Reba
Joy Lynn Rempe
Michael B. Sellman
Allen L. Sessoms
Daniel C. Sullivan (Monday only)
Neil E. Todreas

NERAC members absent:

Steve Fetter
Corbin McNeill
Richard A. Meserve
Jerry Paul
Charles E. Till

Also participating:

Arnold B. Baker, Chief Economist, Sandia National Laboratories
James C. Bresee, USDOE Office of Nuclear Energy, Science, and Technology
Nancy Carder, Medical University of South Carolina
Howard K. Gruenspecht, Deputy Administrator, U.S. Energy Information Administration
John W. Herczeg, Acting Associate Director, Office of Advanced Accelerator Applications, NE, USDOE
William D. Magwood, IV, Director, USDOE Office of Nuclear Energy, Science, and Technology
Frederick M. O'Hara, Jr., NERAC Recording Secretary
Matthew Quint, Assistant Counselor (Nuclear), Embassy of Australia
Burton Richter, Professor of Physical Science, Stanford University
H. Mark Roth, NERAC Designated Federal Officer, USDOE Office of Nuclear Energy, Science, and Technology
Michael G. Schmidt, Medical University of South Carolina
Elizabeth D. Sellers, Manager, USDOE Idaho Operations Office
Kenneth C. Wade, USDOE Office of Nuclear Energy, Science, and Technology

In the course of the meeting, about 40 others were present.

Monday Morning, November 3, 2003

Chairman **William Martin** called the meeting to order at 9:19 a.m. He welcomed the members and had them introduce themselves. Dale Klein had just returned from Iraq and gave a summary of the security and energy situations in that country. His recommendation about the production of electricity was for utilities to bring in modular plants rather than try to restart the aged and disintegrating units that are there now. Martin asked for approval of the agenda for the current meeting. Sessoms so moved, and Ahearne seconded. The motion was approved unanimously.

Martin introduced **William Magwood** to review recent developments in the program of the Office of Nuclear Energy Research, Science, and Technology (NE).

The trends in funding of the programs of NE are positive, although no quantum leaps have occurred. A major change in the program is the absorption of Idaho Operations into this budget. The budget request reflects increased investment in several areas: nuclear hydrogen production, Generation-IV reactors, and the Advanced Fuel Cycle. The Department's budget is currently under a continuing resolution as issues are worked out. NERI is a broad project, and the focus is flexible; that makes it useful as a funding mechanism but difficult to defend in budget requests. The hope is to focus the program more on universities. D. Klein asked if the National Science Foundation (NSF) was going to pick up more funding for nuclear education and research. Magwood replied that they had not talked with NSF lately. Martin asked if the Department of Defense (DoD) should be a leading agency in energy security. D. Klein replied that DoD has a specific mission and does not want to stray from that mission. Andrew Klein noted that DoD uses a lot of nuclear-trained people and posited that it is in DoD's interest to have those human resources available. D. Klein responded that such training programs exist at the Defense Advanced Research Projects Agency (DARPA) and the Defense Threat Reduction Agency (DTRA).

Martin noted that energy economics and military matters need to be settled to give diplomacy more of a chance.

Miller said that the National Nuclear Security Administration (NNSA) also needs nuclear-trained individuals but has not put its money into such training.

Mtingwa called the Committee's attention to the fact that there has not been a clear set of priorities about isotopes and asked about the status of the Brookhaven National Laboratory (BNL) facility for isotope production. Magwood responded that the issue has really been governmental in nature. The Department provided money to look at new ways to make isotopes but reached the point where large amounts of money were going to the National Institutes of Health (NIH) and NIH was not paying for the isotopes they used. The Department now has a program that no longer subsidizes medical isotopes. A new facility will go online at Los Alamos National Laboratory (LANL) by the end of the year. The Brookhaven Linac Isotope Producer (BLIP) recently converted to heavy ions, which is not of use in making medical isotopes. The Office hopes to replace that capability with a $20-million cyclotron, but it is difficult to get that type of money.

Fertel asked what NE would do if it was given an additional $4 million for nuclear hydrogen production. Magwood said that that topic would be discussed later.

The positive trend in funding was pleasing but all the funding is for university programs and none is for research.

This Committee has contributed significantly to the planning base of the Office. It has produced a number of reports that have had a positive influence on the funding of nuclear technology.

Generation-IV nuclear energy systems are moving out of the paper stage to the next-generation nuclear plant, which couples the Gen-IV nuclear reactor with high-efficiency hydrogen production via a 1000 to 1100 degrees C thermochemical water cracking process, such as the hydrogen iodide process. This is a very advanced technology. NE is working with international partners and hopes that a pilot plant will be up and running by 2015 to demonstrate a modular approach.

Cochran noted that this program has two components: heat production and hydrogen production. He asked if they are sufficiently decoupled so one can make independent assessments. He stated that we know how to make hydrogen and asked, on the heat side, why not cost a high-temperature gas-cooled reactor (HTGR) for electricity? If it is not cost-effective for electricity, it will not be competitive for hydrogen production. Magwood replied affirmatively: this topic is being developed on two different tracks. Three processes for hydrogen production are being looked at. NE is doing this on the nuclear side because nuclear is the best source of high-temperature energy. These high-temperature processes are about twice as efficient as electrolysis, which is about 35% efficient.

In quick succession, Sellman noted that there may be some materials problems at 1000 degrees C and asked if 930 degrees C would be good enough. Fertel asked if DOE would take up the slack if DoD does not fulfill the responsibility for human resources. And who knows what the cost of electricity will be in the future. R&D should not be limited to that producing "competitive" electricity today. Todreas asked what DOE was going to do with supercritical-water and fast reactors?

Magwood replied that the Department is working with other agencies on the Hydrogen Initiative and is working specifically on hydrogen production. Competing options are being considered; the most effective and reliable will have the best chance for the future. DOE will always be looking at processes that employ materials that can meet the process needs. Very aggressive economic goals are being set, but it will not be known how competitive the different options will be until the demonstration plant is up and running. DOE wants to develop something that will move quickly into commercialization. At some point, the nuclear technology will have to be licensed by the Nuclear Regulatory Commission (NRC). Under some conditions, DOE could approach NRC on technical issues. No one has started evaluating supercritical-water reactors yet; one of the partners is very interested in it. There are several materials and other issues, though. NE is interested in fast reactors and is looking at reducing the toxicity of spent fuel. Its approach is to observe several sodium-cooled technologies in other countries. It is also looking at the French fast gas reactors. No decisions will be made for several years.

The past year has seen a number of major accomplishments:

- The transfer of Idaho National Engineering and Environmental Laboratory (INEEL) to NE management, in which 19 headquarters and 225 field staff were transferred to NE. A draft request for proposals (RFP) is expected to be issued this fall.
- Three early site permits (ESPs) have been filed by utilities under the Nuclear Power 2010 partnership.
- The Gen-IV International Forum (GIF) is moving into its R&D phase. An agreement on an enduring organization is being formulated. Nuclear Energy Agency (NEA) support is being

sought for a secretariat franchise. Helen Leiser (UK Department of Trade and Industry) is in the United States as GIF Policy Director. Bill Magwood was elected first chairman of the GIF. The countries have formed into "System Steering Committees" to guide work on each system under consideration.

- Bill Magwood was elected Chair of OECD [Organisation for Economic Cooperation and Development] Steering Committee on Nuclear Energy.

Mtingwa asked Magwood, as chair of the GIF, when Russia will be included. Magwood said that it was hoped that the relationship would be moved forward.

Todreas asked what the DOE Gen IV program was considering in terms of fuel cycles. Magwood responded that fuel cycles will be discussed on an individual-system basis; several considerations have to be balanced.

The Department would like NERAC to form four new subcommittees:

- Subcommittee on modeling to model nuclear energy's role in the U.S. energy and economic future;
- Subcommittee on Gen-IV nuclear energy systems to advise and assess the U.S. Gen IV R&D effort;
- Subcommittee on evaluation to provide an independent assessment of the progress of NE programs; and
- Subcommittee on nuclear laboratory requirements to identify the qualities, capabilities, and attributes that will transform the new Idaho National Laboratory (INL) into the world's leading nuclear laboratory.

The formal request to establish these subcommittees was made later in the meeting.

Martin thanked Magwood for this comprehensive progress report and called upon Mark Roth to perform several housekeeping duties. A break was declared at 10:45 a.m.

Martin called the meeting back into session at 11:10 a.m. and initiated a discussion of the data, assumptions, and modeling of energy production and demand. The Energy Information Administration (EIA) models energy production and demand, and the EIA's projections have an impact on the investments in nuclear energy. The EIA model is independent of political and industrial influences. Sandia National Laboratories (SNL) have run case studies from the EIA numbers that are interrelated with climate change, the economy, and the environment. He introduced **Howard Gruenspecht** of EIA to speak about the EIA model.

The EIA is an independent agency within DOE. It collects and analyzes energy data. It also does modeling and analysis. It publishes a national and an international energy outlook, providing guidance in, for example, fuel availability. It can do "what if" studies but relies on no new policy assumptions in its analyses.

Economic growth will drive energy use. With regional annual increases in gross domestic product (GDP) ranging from 2.3 to 5.1% during the next 25 years, there is room for both broadening and deepening energy use around the world. Electricity and transportation will drive energy consumption trends, and Asia will be a very important region.

A plot of commercial energy intensity (million Btu per capita), which does not include traditional energy sources like wood, showed historic declines for the European Union and former Soviet Union, for developing countries, and for industrialized countries, alike. For the industrialized countries, part of this decline is the exporting of heavy manufacturing to the developing countries. However, appliances, lighting, etc. also increase energy use (and intensity)

as developing countries are electrified.

Historically, the industrialized nations have used the bulk of the world's commercial energy; the United States alone uses 25% of it. In the European Union and former Soviet Union, energy consumption fell dramatically after 1990 and has not returned to those prior levels. Most of the growth in energy consumption has occurred in the developing nations because of growths in population, energy intensity, and economic activity. These trends have created new markets for investments in energy generation.

Another way to look at the same data is to consider world energy consumption by fuel. Projections indicate that fossil fuels, especially oil and natural gas, will account for most of the growth in world energy consumption. Oil will fuel transport. Natural gas (and to a lesser extent oil and coal) will fuel electrical generation. Nuclear will hold its own, but its share will decline.

Forecasts are highly uncertain. The International Energy Agency (IEA) also makes projections that the EIA findings can be compared with. In comparing projections of growth rate for the consumption of world energy consumption by fuel, a pretty similar picture emerges for petroleum, natural gas, coal, and nuclear. The EIA and IEA projections diverge widely, however, in assessing the contribution of renewable energy sources. In comparing projections of the primary energy consumed for electricity generation, the EIA and the IEA results are again similar. The growing fuels are natural gas and coal. Oil and nuclear stay about the same. And renewable energies (especially hydro- and wind power) grow in importance.

Martin asked how the retirement and replacement of power plants affected these figures. Gruenspecht responded that, in the projections for the United States, virtually all of the nuclear power results from life extension. In the rest of the world, some nuclear power plants are expected to be built in Asia. Martin asked if nuclear power was economical. Gruenspecht replied that, no new nuclear plants are expected to be built in the United States; in other parts of the world, they have other reasons to build new plants. Martin noted that natural gas prices are rising rapidly and oil use is rising rapidly but expressed the opinion that existing policies are folly if they depend on oil production to rise. He wondered when nuclear construction would occur. He sees the choice being between new nuclear or liquified natural gas (LNG) down the road. He asked what the cost of natural gas might be in the future. Gruenspecht replied that the EIA expects average annual wellhead prices in the range of $3.50 to $4.50 per million Btu between 2005 and 2025.

Magwood noted that utility and vendor costs for nuclear plants are being driven down. Fertel pointed out that $1200/kW is the breakeven point for nuclear, but Wisconsin Energy is buying a fossil plant at $1880/kW.

Gruenspecht said that the EIA is not interested in looking at the past. The view of current projects expressed in the Massachusetts Institute of Technology (MIT) study is the same as that of EIA. Estimates must be comparable across technologies, and contingencies have to be included for all technologies, too.

Ahearne asked where EIA stood on relicensing at this point. Gruenspecht replied that it was expecting all plants to be relicensed.

Martin commented that these projections are more optimistic for nuclear than they were a few years ago.

Cochran stated that the Committee's mission is to review the R&D budget. Whether new plants are built is irrelevant. This Committee should be discussing what fuel cycle should be used and therefore what the R&D program should look like. Martin responded that he would like to

know if this industry is going to be phased out. If it is, it will not need R&D.

Sellman said that the MIT study expects a cost of $2000/kW to build a nuclear plant. Industry seems to want a $1000/kW level. If the operations and maintenance (O&M) cost is reduced to $0.01/MWh and the overnight cost is brought down, one can get the price down near $1000/kW.

Ray noted that, ultimately, one has to deal with the customer. Now, the customer can go shopping. If utilities can get long-term commitments, a different opportunity presents itself.

Todreas stated that, on capital costs, the MIT study had a wide range to see what that range would yield vs oil and gas and what incentives would be needed.

Gruenspecht continued with a consideration of world oil trade. A chart showing data for 1973, 2001, and 2025 indicated that the Persian Gulf trade is expected to grow rapidly but that its market share is expected to decline. More production is expected outside the Persian Gulf.

Current world oil reserves are greatest in Saudi Arabia, followed by Canada (data include tar sands) and Iraq. Gruenspecht said that he would not count on high natural gas prices to drive nuclear into the market.

In world carbon emissions, the trend is toward significant increases. Fuel switching opportunities will be limited. The cheapest place to get carbon reductions will be in electricity generation. This is important in that fossil fuels will meet most of the demand for energy in the next 25 years.

The historic data and projections indicate that the United States is much less dependent on foreign sources for natural gas than it is for oil. Domestic production of natural gas meets and will continue to meet a large portion of the demand. LNG is a small player now and will increase slightly. The United States built four LNG receiving terminals; two continue to operate, and two were placed in mothballs. Now all four are being used and are planned for upgrades; in addition, new terminals may be built.

EIA projections of U.S. electricity generation indicate that nuclear power production would be increased in response to technological advances that brought costs down and policy changes (e.g., those embodied in S. 139, Global Warming). However, those same projections indicate that advanced nuclear power would have a negligible effect on carbon dioxide emissions from U.S. electric power plants, whereas the provisions of S. 139 would reduce those emissions by about 75%. These projections assume fuel switching to gas, driving up gas prices.

The major conclusions that can be drawn from the projections are

- Developing countries will the dominate growth in energy demand.
- The United States will experience a growing reliance on oil from the Middle East for transportation.
- Global carbon dioxide emissions from fossil fuels will grow.

Key uncertainties in projecting the data to 2025 include:

- Oil prices and natural gas supplies and prices (compounded by the security implications of those financial flows),
- Technology costs (e.g., for nuclear, renewables, and carbon sequestration),
- Policies (if any) that emerge to reduce greenhouse-gas emissions, and
- Hydrogen's role as an energy carrier.

A break to get food for the working lunch was declared at 12:20 p.m.

Monday Afternoon, November 3, 2003

Martin called the meeting back into session at 12:40 p.m. and introduced **Arnold Baker,** Chief Economist at Sandia National Laboratory, to demonstrate and address four models of energy and environmental policies.

1. U.S. Energy and Greenhouse Gas Model (USEGM)
2. Global Energy Futures Model (GEFM)
3. Electricity Generation Cost Simulation Model (Gen Sim)
4. Hydrogen Futures Model

The USEGM is an energy demand model that shows (1) the total energy demand broken down by fuels and (2) the carbon emissions under various fuel-share scenarios that are user selectable within energy-use sectors.

Miller asked how accurate the model was. Baker replied that a lot of data from the EIA and several elasticities are built into the model, and the "what if" projections are based on the EIA reference case. Miller asked what error margin would be found 25 years from now, 25%, 50%, or what? Baker replied that the model is a good thought exercise to bracket a bunch of possible outcomes.

Comfort pointed out that there will always be policy changes that will negate a lot of the model's assumptions and calculations. Baker agreed and said that that is one of the reasons that a variety of runs are used.

Hartline asked how the model accounted for technological advances. Baker responded that the EIA goes into good detail about the effects of such advances.

The GEFM tries to benchmark the next 25 years and to project energy demand and carbon emissions for five regions (United States, China, Former Soviet Union, the rest of the developing world, and the rest of the developed world) for basic fuels. It also tracks plutonium from all sources (by source). It extrapolates IEA trends and can run scenarios relative to an electricity fuel source. This model's results show that, whatever technology is developed in the United States, if it is not cost-competitive in China and other developing countries, it will not have a significant effect on world carbon emissions in the long term.

Martin commented that something is going to happen if these trends continue. Policymakers have to realize that there is no silver bullet; ANWAR [the Arctic National Wildlife Refuge] is just a drop in the bucket. Baker commented that Sandia plays in a number of energy sectors and tries to be balanced in its analyses. These models are used to allow us to focus on the long term, and they need a step function in energy technologies, especially in the developing countries. Martin said that these models are tools that the Committee and others need to appreciate and use.

The Electricity Generation Cost Simulation Model calculates the cost of electricity at the busbar under different capital costs (O&M costs, fuel costs, etc.).

Ray pointed out that busbar costs are mainly a cost of the type of technology. But if the source is not dispatchable (e.g., wind), the busbar costs move around a lot.

Corradini asked if all the costs are U.S. averages. Baker replied affirmatively. Corradini said that three values should therefore be presented, the average and the two extremes. Ray added that the total capacity and its timing are very important.

The Electricity Generation Cost Simulation Model can factor in tradable permits for certain pollutants (e.g., SO_x, NO_x, and mercury) and calculate externality costs at the same time that the scrubbers and other controls are changed.

Ray pointed out that one of the most readily projected assumptions is market prices. Baker agreed that that was a take-home message: If one is going to depend on light-water reactors (LWRs), a lot of spent fuel will be stored aboveground or a lot of repositories will have to be built. Sellman commented that the Cambridge Research Institute does such market-price projections, and the most recent one for the Midwest for baseload power in 2010 was $26/MWh in 2003 dollars.

Martin said that the best shot will have to be found for producing the step function needed, and the government will have to step in because the needed research is well beyond the corporate planning horizon. Government has to tie its R&D to industry so we do not go off totally misguided.

The initial version of the hydrogen simulation model has just been finished. It can focus on product storage and delivery, end use, using various sources and product technologies for production, carbon pathways (carbon sequestration), storage, thermochemical via nuclear, and other variables. One can calculate production costs via various technologies; see how different storage methods can affect delivery costs; assess capital costs and costs associated with maintenance, insurance, licensing, and registration. (The fuel cost is usually a small part of the total vehicle cost; capital costs are the biggest, insurance next, and maintenance next.)

Martin asked if hydrogen is really going to happen in the marketplace. Baker responded that the answer partially depends on the fuel price. Market forces work despite the best efforts of government policy makers. At some point society will have to cross over from petroleum to something else. If the new technological platforms that the market wants to take on can be realized, that change can occur. All major auto companies are looking at fuel cells and direct-combustion hydrogen cars. Those changes will be incremental. Unless R&D can create new platforms that industry can adopt, a successful transition will not be made.

Ahearne asked if Europe is changing to alternative fuels. Baker replied, no, they are going to diesel.

Cochran stated that government R&D on nuclear-coupled hydrogen is appropriate. The planned effort, however, requires developing a high-temperature reactor and another hydrogen-production plant. The money would be better spent on the next-generation HTGR and the use of the electricity by hydrolysis. He did not believe that the economics are there to support building and deploying an HTGR.

Comfort commented that, in terms of the overall energy budget, the costs involved in making energy elsewhere seem to outweigh the benefits. Baker agreed. Hydrogen is an energy storage medium that has to be manufactured at a significant energy cost. It makes sense only in the strategic use of energy that it allows.

Sessoms cautioned that, when one uses and demonstrates these models, the uncertainties involved should be displayed at the same time.

Martin commented that what he liked about these models is that one can play with them and learn from them.

Todreas stated that reprocessing will be the savior of the spent-fuel buildup. When this process is fully modeled, the TRU (transuranic waste) will be found to be dispersed in the fuel-cycle facilities.

Magwood noted that using an HTGR to make hydrogen extracts energy from the reactor and makes it a usable form of energy. Also, hydrogen use can be very efficient.

Cochran said that the main purpose of Gen IV was to make electricity cheaper. That

fundamental objective is being lost. Magwood replied that the selection of hydrogen production technology has not been made yet, and it will be made on competitive terms.

Martin introduced **John Ahearne** to address what has been learned during the five years of NERAC operation.

NERAC was formed to reinvigorate nuclear power in the United States. A lot of designs are in place now: the Gen-IV concepts; Tsuruga 3 and 4, Japan Atomic Power Company's pressurized-water reactors (PWRs); Framatome ANP (with Siemens) boiling-water reactor (BWR); South Africa's pebble-bed reactor (PBR); Westinghouse's International Reactor Innovative and Secure (IRIS) design, which is in the preliminary design step; Gas Turbine - Modular Helium Reactor (GT-MHR); Russia's lead-bismuth reactors; India's investigation of the thorium cycle; China's helium-cooled high-temperature PBR; molten salt reactors; and the upgrade of the Russian large PWR KLT-40s. However, there is a large difference between a paper (planned) reactor and a real reactor.

The previous administration was negative on nuclear power but did take three positive actions: (1) the disposition of weapons plutonium by its conversion to MOX fuel for power-plant applications, (2) the 1997 PCAST [President's Committee of Advisors on Science and Technology] report stating that nuclear had great potential, which led to the Nuclear Energy Research Initiative (NERI) and Nuclear Energy Plant Optimization (NEPO) programs; and (3) Moniz's invitation to NERAC to develop a long-term nuclear-technology research plan.

Today, NEPO has vanished, and NERI is vanishing; the Nuclear Engineering Education Research (NEER) program is still alive. The DOE-industry matching grant program is apparently growing. Gen-IV and Power 2010 have grown into major programs. The NRC has asked for tighter security of nuclear materials across the nation. Exelon purchased 1200 MW of generation power for $200/kW. Erosion of the pressure-vessel head at Davis-Besse shocked the nuclear community; it now has a new head and is ready to operate. Several early site permit applications have been filed. The global availability factor for nuclear power plants rose from 74.2% in 1999 to 83.4% in 2001. Six new units came online in 2002 worldwide; 32 reactors are under construction worldwide, many in Asia (many, however, do not have the funds to go to completion). At least 16 plants had licenses extended in the United States; another 37 are likely candidates for extension requests. The International Atomic Energy Agency (IAEA) projects a 14% increase in electricity production by nuclear plants between now and 2010.

MOX fuel was loaded into 36 European power plants in 2001 and 2002, constituting 25 to 50% of the core loadings in those reactors.

The advanced CANDU [Canadian Deuterium Uranium Reactor] reactor design is undergoing license review by the NRC. China and India are building breeders. The Thorp reprocessing plant is to be shut down by British Nuclear Fuels, Ltd., (BNFL) in 2010. Tax breaks are being offered to nuclear plants in Ontario, Canada, for their clean energy. On the thirtieth anniversary of the Organization of the Petroleum Exporting Countries (OPEC) oil embargo, 66% of U.S. oil is imported, an all-time high. U.S. energy use will reach 100 quads in 2004 or 2005. General Electric advanced BWRs being built in Japan and Taiwan take 51 months to construct at $2000/kW.

Cochran asked why Canada is supporting nuclear power. Ahearne replied that he did not know; that is Ontario's preference.

Mtingwa asked what NERI's focus is. Ahearne responded that NERI was intended to revitalize nuclear R&D and to foster and investigate new ideas. Magwood added that NERI got

started in 1999 and has lasted four years. Its report card is mixed. It stimulated new ideas in universities. It never got full funding; it peaked at $35 million. It could only fund 22 out of 130 applicants. What was done with the available funds was great. Ahearne commented that the number of applications that came in indicates the capabilities available and the magnitude of the unmet need. The amount of money available was insufficient to maintain that enthusiasm.

Miller said that he believed that NERAC has helped Magwood rebuild the program. Where the Office should be going is not so clear. The question is, What do we do now? The topics of the four subcommittees that have been proposed do not indicate where NE should be going. Ahearne observed that there will be a lot of discussion of that on the following day of the meeting.

Sellman said that the light-water breeder reactor (LWBR) was a thorium reactor that was considered by the Rickover team and that there may be formerly classified designs that are now declassified that, if made public, might save a lot of time and money.

Long asked if many NEPO projects will not get finished because of NEPO being zeroed out. Magwood said that that is not known for a fact. The Administration has cut the funds out each year, but Congress has put them back in each time. What will happen this year is not known. It would be desirable to move to something more structured and focused. NE is working with several partners to get a new cooperative program started.

Mtingwa asked Magwood about his thoughts about some form of fast neutron reactor in Gen IV. Magwood said that a lot of new research is being done, but there are no fast-reactor test facilities for new materials. The research teams are looking overseas for that type of capability. A number of domestic facilities are under discussion, but sooner or later, a U.S. fast reactor will be needed.

Cochran called the Committee's attention to the fact that someone had put a waiver to the Reduced Enrichment for Research and Test Reactors (RERTR) program requirements, allowing foreign research reactors to be supplied with highly enriched uranium (HEU) fuel. He suggested that the Committee make a recommendation to Congress to remove that exemption. He said that the United States should be tightening rather than relaxing such export controls. D. Klein asked if the restriction applied to the HEU targets. Cochran replied, yes. D. Klein asked how many were involved. Cochran said that he did not know. D. Klein asked if it was in the range of milligrams or kilograms. Cochran said that he was not sure how it was specified. D. Klein said that the Committee should know more about the situation before it takes a stand. Magwood promised to track down information about this subject for discussion at the next day's session of the Committee's meeting. He explained that the countries that were exempted were ones that got annual exemptions because the United States could not give up the medical isotopes produced by those reactors. What is needed is to replace the HEU without disrupting the supply of molybdenum-99. Cochran stated that HEU should be removed from the commercial sector. D. Klein said that this concern fits more under the Office of Nonproliferation and National Security (NN) than NE. The DoD spends a lot of time considering the threats constituted by research reactors in Pakistan et al. On the other hand, the United States does not want to give even the impression that it is harming the health care in those countries.

A break was declared at 3:07 p.m. John Ahearne, Vice Chairman, called the meeting back into session at 3:23 p.m. and called upon **Michael Corradini** to describe a Web-based course entitled Introduction to Engineering using e-Teach.

The online course was developed in the context of the Big 10 Innovations in Nuclear

Infrastructure and Education (INIE), with the Big 10 INIE industry/lab participants acting as advisors. One of the tasks of the Consortium is nuclear engineering education and outreach. So the Consortium wants to look at developing innovative distance-learning modules for Big-10 institutions committed to maintaining nuclear science and engineering as an integral part of their colleges and at strengthening the ties with our nuclear industry partners (utilities, vendors, and national laboratories) and developing focused educational programs. A key concept of this venture is that an institution could provide credit to students of other schools and colleges.

In universities today, instructional material is presented to students in a number of ways. Web-based courseware is used as a substitute for on-site lectures, to share lectures among students at distant campuses of a university, to provide lectures to senior high-school students, and (potentially) to share lectures or complete modules with other major engineering colleges or with universities without a complete set of engineering degrees.

The Consortium chose to use e-Teach educational software because NSF has sponsored educational software development for Web-based courses through the NPACI (National Partnership for Advanced Computational Infrastructure) program; e-Teach is a versatile web-lecture authoring tool that is compatible with Web-CT or similar instructional software; students help the instructor develop video in coordination with presentation and lecture outline and add post-process video, slides, outline, links, etc. (a relatively low-tech task with the authoring tool in hand); e-Teach allows the instructor to use the classroom experience for other purposes than lectures (e.g., for in-class problem solving); and e-Teach extends the reach of an introductory course. INIE set up this course several years ago because it believed that a resurgence in nuclear-engineering education was going to occur.

The course surveys nuclear engineering applications:

- Fission reactor engineering,
- Plasma science and fusion technology, and
- Radiation science.

Each Web-lecture can also provide links to topical information and video demonstrations. The first draft of the lectures is complete, and video tours of key experimental facilities are under way.

He demonstrated a use of the software; the software package can be offered over the Web. With this technology, one can reverse the educational paradigm: Nuclear-engineering programs and faculty can work together to develop a common core curriculum. This common core curriculum can be articulated in the form of educational modules that all nuclear-engineering programs develop cooperatively. A number of schools can share in the courseware, and this could become a model for engineering education. This approach is not inexpensive to do properly. Course design and production costs are about $35,000 to $70,000 per student credit hour plus about 10% per year for maintenance.

Rempe mentioned that similar graduate courses are available through an international nuclear-engineering education effort, the World Nuclear University (WNU). A. Klein said that the WNU plans to offer a master's degree. Todreas asserted that, basically, the WNU can encompass anything; it is not restricted to graduate study. Corradini said that, as an educator, he was cautious about such a broad-brush application; the WNU and other Web-based distance-learning efforts offer an opportunity to work across universities, which is very doable in core courses.

A. Klein noted that Oregon State University is using a similar program to teach degree

programs in public health and other topics. Corradini added that each member of the INIE group is exploring similar courseware on different topics.

Todreas passed out the minutes from the previous meeting. They contain an Appendix A on the context, content, and execution of the Gen-IV roadmap and an Appendix B that is a letter from Tom Cochran. Todreas said that these additions, which were made after the meeting, should be considered and voted on by the full Committee. The Committee was asked to review these minutes in preparation for the following day's session. The Chair will ask acceptance at the following day's session of the Committee's meeting.

Ahearne introduced **Robert Long** to present the report of the Idaho Infrastructure Task Force, a NERAC subcommittee. The report of the Subcommittee was distributed to the Committee.

The charter of the Subcommittee included (1) the updating of the Nuclear Science and Technology Infrastructure Roadmap and a review of the specific issues at INEEL, including Argonne National Laboratory-West (ANL-W) and (2) advising the Department concerning the maintenance, upgrade, and new construction needs of DOE laboratory infrastructures. This broad charge was narrowed to (1) assessing the current state of the facilities at INEEL and ANL-W and analyzing the infrastructure gaps that could prevent DOE from conducting R&D in key nuclear-technology areas during the next decade and (2) considering the availability of facilities and capabilities elsewhere when making final recommendations.

The Subcommittee was appointed Oct. 1, 2002. Its report was requested by the end of 2002. The Subcommittee reviewed documents and visited the INEEL and ANL-W sites on Nov. 6-8, 2002. It met in Albuquerque Jan. 7-8, 2003, to complete the review and prepare the report, which was completed and submitted on Jan. 16, 2003.

The first draft of the *Nuclear Science and Technology Infrastructure Roadmap* was completed in December 1998, and it was revised in March 2000. Subcommittee members and the staff of DOE HQ, INEEL, and ANL-W reviewed the roadmap and produced substantial new information for inclusion in the next revision of the roadmap. Revisions to the roadmap are needed because many changes have occurred since it was last revised.

New INEEL and ANL-W facility descriptions have been developed, programmatic needs and likely facilities to meet those needs have been assessed, staffing requirements have been analyzed, and a broader revision should be undertaken that takes into consideration the numerous changes to DOE facilities and missions that have occurred during the past 4 years.

INEEL consists of eight major facility areas scattered across an 890-square-mile area about 35 miles west of Idaho Falls. A ninth INEEL area includes offices and several laboratories in Idaho Falls. ANL-W is located on 800-acre tract within INEEL. Descriptions of ANL-W and INEEL were given to the full Committee at previous meetings.

The major programmatic facilities have been well maintained and are expected to last 15 years or more. The general-purpose facilities are in a workable state of repair. However, important experimental facilities have a backlog of needed repairs estimated to cost $9.3 million at ANL-W and $10.8 million at INEEL. An additional several million dollars is needed to address the balance of the plant facilities' deficiencies.

General-purpose program funding for the past decade was several millions of dollars per year below requested levels. An additional $10 million is needed annually for normal maintenance and repair and for compliance with environmental and safety requirements. Much of the equipment used at the two laboratories is in need of replacement and/or upgrading. The details

are mission and facility specific, but a reasonable estimate is about $50 million. Without such an expenditure, it is unlikely that new missions will be accomplished successfully or that these laboratories will be able to maintain positions as national leaders in nuclear-energy research. Few facilities at either lab are fully "mission ready." The resource requirements to bring all major facilities at both laboratories to mission readiness need to be determined and are likely to cost tens of millions of dollars annually.

In terms of specific facilities:

The Advanced Test Reactor (ATR) is well staffed and in very good operating condition. The reactor is run continuously. About 40 to 50% (i.e., two of the four nodes of the reactor) of its capability is presently used and funded by the Office of Naval Reactors and other smaller customers. Therefore, naval reactor operations are willing to cost share with NE, but scheduling appears to be a significant challenge. The ATR has the potential of supporting NE's GEN-IV programs including the

- Supercritical Water Reactor System
- Gas Fast Reactor System
- Lead-Cooled Fast Reactor System
- Very High Temperature Reactor System
- Advanced Fuel Cycle Initiative
- Nuclear Space Initiative

Possible ATR modifications include the design and deployment of a supercritical-water loop for supercritical-water-reactor materials testing; this facility would require more then $10 million dollars and 3 to 4 years to construct. Another potential modification would be building a fast-flux booster around one of the flux traps, which is estimated to cost in the $10 million range and could be done in about 3 years.

However, the ATR may not be able to simulate all the conditions called for in the proposed NE programs. It is unclear to what extent the facility can be modified to simulate the high-temperature and fast-neutron-flux conditions needed to study new fuel materials etc. And it is also unclear that the determination will require a better definition of the extent and scope of future GEN-IV programs.

The Fuel-Processing Facility (FPF) is a second-generation nuclear-fuel-processing facility that was built to reprocess naval fuels but never completed. (It is about 75% completed and incredibly big.) The facility would not be useful unless several hundreds of millions of dollars were spent to install basic services, such as electrical, heating and ventilation, control rooms, and the basic fuel-processing equipment. Even just a study to determine the modifications to the FPF needed to perform a new mission will cost hundreds of millions of dollars, including costs of safety analyses and NEPA requirements. The Subcommittee recommends that the FPF be abandoned.

INEEL is proposing consolidating many of the facilities now available to undertake new advanced reactor NE programs. Some of these facilities are scattered all over the Idaho desert and are in various stages of readiness. An updated Roadmap is needed to identify the INEEL facilities to be considered for consolidation.

The Subcommittee identified a number of issues that should be looked at:

- A high-quality work environment will attract the new personnel needed to undertake new NE missions

- The high-risk functions involving the handling of irradiated nuclear materials could be consolidated out in the desert
- The lower-risk activities could be moved to Idaho Falls to reduce operating costs and to make it more attractive to the workforce.

The Subcommittee believes that consolidation could yield long-run benefits, but with limited funds, consolidation should be second in priority. Program funds should be used for program development (e.g., a new transient test facility). Mothballed in 1993, TREAT (the Transient Reactor Facility) has the potential for restart, but no staff with experience is any longer available. Once the NE technical mission is better defined, a consolidated facilities plan should be developed.

The Subcommittee believes that extensive discussions are needed on INEEL and ANL-W staffing and management, including

- Effective recruitment, development, and retention of the staff that are essential to the success of the R&D programs at INEEL and ANL-W (the Subcommittee report describes both laboratories' current efforts) and
- Improvement through benchmarking against other organizations' practices.

The Subcommittee engaged in a lot of discussion about the INEEL/ANL-W interfaces. Three major interface agreements are in place:

- A memorandum of understanding (MOU) between DOE-ID and DOE-CH (1997),
- The DOE Nuclear Reactor Technology Lead Lab Charter: ANP and INEEL (1999), and
- A programmatic memorandum of agreement between ANL-W and INEEL (2001).

The Subcommittee stated (in January 2003) that DOE needs to ensure that the resources of both laboratories are optimally used to carry out this R&D mission.

On April 30, 2003, the Secretary of Energy announced that the Idaho laboratories would be renamed Idaho National Laboratory. The Laboratory would be managed by NE, would be composed of INEEL and ANL-W, and would specialize in developing advanced nuclear-energy technologies. Environmental cleanup [managed by the Office of Environmental Management (EM)], which has been these laboratories' focus for the past decade, will be separately bid. Work will include the remediation of legacy wastes and disposition of many surplus facilities.

Interfaces between the Laboratory and universities were talked about at length. Leadership of this wide range of endeavors requires active and careful coordination with other DOE laboratories (whether they are Office of Science or NNSA laboratories) and with leading research universities. The Subcommittee believes an INEEL external review process for laboratory activities would greatly assist strategic planning and missions coordination.

Additional topics that were not addressed but need to be are

- The effectiveness of INEEL communications and working relationships with other DOE laboratories, private industries, and universities
- The need for strategic planning to establish focus and priorities for nuclear energy programs
- The need for a review of the industrial-health and radiation-safety programs and integrated safety and security management
- The need for a review of the quality management, quality assurance, performance indices, and self-assessment programs
- Recognizing and dealing with the impact of INEEL and ANL-W (now INL) DOE contract negotiations on workforce morale and productivity (particularly on projects with demanding

time schedules)
- The effectiveness of management–craft labor relations
- The effectiveness of community and public relation activities, including advocacy role for nuclear-energy R&D

The Subcommittee concluded that

- To have a designated lead laboratory for nuclear energy research and development is significant and important.
- The funding at the Idaho site, given the lead-lab status, is clearly insufficient.
- Certain facilities (e.g., the Fuel Processing Facility) have lost their missions and/or have significant maintenance challenges; these facilities should be abandoned.
- If Idaho site facilities are to be used for the proposed missions (e.g., Advanced Fuel Cycle Initiative, Gen-IV reactors, and other nuclear-energy programs beyond 2010), resources must be provided at appropriate levels.

Therefore, the Subcommittee recommends that

- Given events since the National Energy Strategy was issued, the federal commitment to nuclear energy needs to be restated and reinforced by the White House and other senior administration officials
- For the Administration to go forward with "nuclear energy beyond 2010," the lead-lab site at Idaho requires an immediate and significant increase in funding to clear up maintenance backlog and make key facilities mission ready, inter alia.
- University participation (by faculty and students) must be a basic element of research and development in "nuclear energy beyond 2010."
- Some facilities should be shut down or not considered for further development, such as the FPF and perhaps the Flourinel Dissolution Process (FDP) cell.
- New facilities will probably be needed for the purposes of "nuclear energy beyond 2010," and they might include a source of fast neutrons; therefore, a specific study on the need for steady-state and transient fast-neutron facilities in the United States should be conducted to consider the accessibility of existing support facilities.
- To optimize the use of resources, facilities beyond the Idaho site (e.g. ANL, Oak Ridge, and Savannah River in the United States and international sites in the Gen-IV partner countries) should be used.
- Given the designation of INEEL (now INL) as the lead nuclear-energy laboratory, it should establish an external review process for laboratory activities.

Rempe questioned whether the study for the FPF conversion would really cost hundreds of millions of dollars. Long replied that the Subcommittee had been told that it would cost $200 million to plan the transition, meet NEPA requirements, etc.

Cochran asked why the Subcommittee's recommendations seemed to go beyond the reaches of DOE. Long responded that the Subcommittee's logic was that an appeal has to be made to the top for a commitment but there has been no evidence of a willingness to provide that funding yet. Fertel asked if they were asking that the White House ask the Office of Management and Budget (OMB) for the money. Sessoms replied, yes.

Comfort asked what support of education INEEL and ANL-W have shown. Long answered that both institutions have a long history of hosting university students and faculty members.

Elizabeth Sellers commented that the Idaho Operations Office appreciates the

Subcommittee's work. The Office has documented all the work done in nuclear research and will do the same thing for environmental activities. That documentation delineates what has to be done and what it will cost. Communications and public relations will be stressed, focusing on the meaning of this change on the people of Idaho. The ATR has been shut down for several months to resolve some safety issues. It should be back up soon.

Ahearne asked how the budget for a joint laboratory will be less but the opportunity to grow NE will improve. Sellers answered that, as the environmental work gets completed, the funding will be converted for R&D. Ahearne said that such a situation makes him nervous. Environmental cleanup funding is uncertain; specific R&D funding is needed.

Fertel asked if the 10-year site plan is a priority. Sellers responded, yes, definitely. It will be used to communicate to those who might fund the research. Sessoms added that the sense of the Subcommittee was that there is no way this can be a world-class laboratory; it needs a lot of money now. Management of the laboratory by a university would allow them to attract young bright minds. Sellers noted that a contract competition is under way now. Magwood said that there will be a very vigorous interaction between academia and the laboratory no matter who the contractor is. NE agrees with and has responded to all of the Subcommittee's recommendations. DOE would like to reduce the footprint of the facility and consolidate activities.

Cortez expressed concern about how DOE will fund this new laboratory. The Gen-IV International Consortium is watching to see what the United States is going to do in nuclear-energy research. The United States needs to demonstrate to the world community that it will commit the money needed to fund Gen-IV activities.

Corradini asked what the schedule is for the RFPs. Magwood replied that the current contract ends Sept. 30, 2004. The new contract is expected to start Oct. 1, 2004. The final RFP might be out the end of December or the beginning of January.

Miller noted that a lot of work and money are needed to make this the lead nuclear-science laboratory. Care should be taken to ensure that the money to do this is forthcoming and that the funds are not going to come out of EM funding. Magwood described the funding process as "a day-to-day wrestling match with a lot of parties." The objective is to achieve net advances over the long term. In the past months, NE has been encouraged by the trend of the commitment of funds.

D. Klein noted that state and university budgets are tight and asked what was being done to encourage universities to consider operating INL. Magwood replied that universities will be encouraged to become engaged in the main nuclear-research center in the nation. What is being looked for is a partnership between universities and industry.

Long stated that the subcommittee was frustrated by the lack of meetings of the Committee and the resulting slow process of acceptance of this report. The report had been prepared the previous January and is only now being discussed in committee. Meanwhile, the necessary actions and events to bring about the transition continued to mount. He pointedly asked if the Committee was going to accept the report here. Ahearne, acting as the chair pro tem, said that he favored accepting the report it, but would like Martin to entertain that motion when he returns.

Hartline asked if the Committee should consider the new subcommittee's focus on the funding of INL now. Ahearne answered that the Committee would consider that topic at the next day's session.

Corradini predicted that the Committee will support this concept, but warned that DOE has to come up with the funding or the reorganization and bidding will be for naught.

Ahearne introduced **Chuck Wade** to discuss the status of the joint DOE–Environmental Protection Agency (EPA) analysis of nuclear energy.

The Subcommittee looked at the benefits of nuclear power in reducing atmospheric releases of SO_2, NO_x, and mercury during the generation of electricity. A variety of scenarios was considered in terms of the costs of nuclear power and the results on air pollution. The EPA members of the subcommittee have met many obstacles, and the effort is moving at a snail's pace. Each run takes a long time, and many runs had to be redone. The followup runs have just been completed and are being analyzed. Therefore, the Subcommittee went ahead and wrote the nuclear-power section. Based on EPA's model, there is no benefit to the environment to building a nuclear rather than a coal plant because the presence of the nuclear plant raises the cap of emissions that the local utility has to meet.

Comfort asked if the EPA takes into consideration the human health, acid rain, and other environmental effects. Wade replied that he did not know. The EPA has not told the Subcommittee members. He did not believe that the EPA representatives want to open up the issue of social costs. The utilities' interpretation of the actual report when it comes out would be of interest.

Sessoms called this situation "a bureaucratic stone wall" and asked why DOE does not just do its own modeling. Ahearne pointed out that DOE was directed to have a joint DOE/EPA assessment. Cortez said that he was amazed that DOE continues to work with EPA.

Ahearne stated that these are calculations that you can do on an envelope. The trick is to get a joint report from the two agencies.

Ahearne opened the floor to public comment.

Magwood asked for a clarification about whether there were any recommendations in the Richter documents (the Advanced Nuclear Transformation Technology Subcommittee reports) that needed approval. Ahearne replied, yes.

Reba said that either NE or the Secretary of Energy wrote to the NIH about NIH's working on the issue of funding medical isotopes. Magwood answered that NIH's response was positive but their bureaucracy is slow and difficult to get through. Any help that could be given to move it along would be appreciated. Reba asked at what level the dialogue is being held. Magwood replied, at all levels, from the program manager to the Secretary. Reba suggested that NIH does not have to give NE the funds; they could make the funds part of their research grants. Magwood said that the problem is committing the funds in advance. Hartline suggested that the Office of Science and Technology Policy (OSTP) might be able to foster cooperation as they have in funding beamlines at light sources. Magwood said that DOE has started discussions along this line.

Martin returned and resumed leadership of the Committee at 5:20 p.m.

Fertel asked what subcommittees are active now. Roth responded

- Advanced Nuclear Transformation Technology,
- Long-Term Planning,
- Space Applications, and a
- Task Force on Evaluation.

Martin commented that each of these four subcommittees seems reasonable to pursue and stated that he would welcome suggestions for these subcommittees or others.

No one having signed up for public comment, Martin adjourned the meeting for the day at 5:26 p.m.

Tuesday Morning, November 4, 2003

Martin called the meeting to order at 9:11 a.m. and asked for comments on the addenda to the minutes for the September 30 to October 1, 2002, NERAC meeting.

Beverly Hartline pointed out several typos in Appendix B, a memo from Tom Cochran, and questioned the rationale for including this communication in the minutes. Cochran said that the Committee had had discussion about that topic at the previous meeting, but there was no formal letter of concern entered into the record at the meeting.

Roth noted that, when these minutes are accepted, they will be posted on the Web. He suggested that this appendix could be linked to that page as a dissenting opinion. Cochran said that it goes beyond that. The Web site should post each report and any dissenting opinion and any actions by the Committee. That should be how the information should be presented. Hartline stated that each report should have a letter of transmittal that would note the status, history, appended dissents, etc. Magwood noted that, when the Committee sends a report to the Secretary, such a cover letter is included, but Cochran is referring to the Web.

Martin called for approval of the Minutes with the addenda. Ahearne so moved, and Cochran seconded. The motion was accepted unanimously.

Long moved to accept the report of the Idaho Infrastructure Task Force. Mtingwa asked if he wanted to update the report. Long answered, NO!

Cochran said that the first three recommendations should be redrafted to reflect the need for additional funding. Ahearne agreed; NERAC should go on record about the need for significant, additional, direct funding for the new INL. Sessoms objected that the language was negotiated almost a year ago and should not be altered now. Cortez agreed that the Committee should leave the report as submitted by the Subcommittee.

Martin offered that NERAC could insert the revised language in the transmittal letter and that the Committee was accepting, not approving, the report.

Sessoms moved to accept the report as written with a cover letter with the Committee's comment and interpretations. Ahearne seconded. The motion carried with Cochran abstaining.

Magwood referred to the previous day's discussions about the exemptions to restrictions on the export of HEU and how much material was involved. It was found that 25 kg of HEU is allowed to be exported to Canada each year to be fashioned into targets.

Cochran reminded the Committee that his recommendation was to oppose the amendment that called for allowing the export of HEU targets. It now appears that what is involved is kilogram amounts of HEU. We have a program with the Russians to get HEU out of Russian research reactors. It seems to add to the difficulty of maintaining that program to allow this export of HEU.

Sessoms stated that the Committee should support RERTR and get it fully funded. It should not support the amendment but should call for the conversion to low-enriched-uranium (LEU) fuels. Ahearne agreed, but, he said, funding remains an issue. The U.S. RERTR program has stalled. ANL has designed a replacement LEU fuel that can be used in these research reactors.

Cochran pointed out that this amendment was placed in the Energy Bill with no discussion. The issue should be open to discussion.

Jurisson asked how high the enrichment is. Cochran replied, 93%; it sends the wrong signal to the Russians.

Magwood said that the recommendation before this Committee would obviate the need for

the exemption process. The question is how quickly the recommended actions could be implemented.

A. Klein asked how long they have been making these targets and how long has the exemption been in place. Hartline replied that they have been making these targets for a long time; the concern about export has been recent.

Cochran said that his recommendation would be to withdraw the amendment pending hearings.

Magwood said that he wished he had a presentation by the National Nuclear Security Administration (NNSA) on this issue. He did not know what type of informed debate had occurred on the topic.

Cochran moved that the Committee go on record opposing the Burr Amendment pending hearings by the relevant congressional subcommittee. Hartline seconded the motion.

Fertel pointed out that this is one small amendment in a monstrously huge Energy Bill and asked if opposing that amendment would set a bad precedent.

Sessoms said that the Committee does not know enough about the amendment, but it does know about RERTR and should support that program. He said that Magwood can argue for funding for that program.

A. Klein suggested that this topic is out of the Committee's purview and that the motion is ill advised.

Martin stated that this is an important point but seems to be outside the Committee's scope. The subject should be addressed by and with others. In the future, a background paper should be prepared ahead of time to form the basis of discussion. This issue should be brought up with NNSA.

Magwood suggested that the Committee could make a recommendation on converting from HEU to LEU and how. Martin added that it should educate NNSA about the content of the Burr Amendment. It could also entertain a motion about what the solution should be.

Cochran offered to amend his motion to drop the reference to the amendment and to ask NE to consult with NNSA about the Burr Amendment.

Martin asked that actual text be drafted for consideration and possible adoption. Cochran agreed to draft the text. Martin promised to revisit the issue later in the meeting. He introduced **Burton Richter** to present the report of the Subcommittee on Advanced Nuclear Transformation Technology [ANTT; also referred to as the Advanced Fuel Cycle Initiative (AFCI) Subcommittee]. Two interim reports from the Subcommittee (dated January 2003 and October 2003) were distributed to the Committee.

The AFCI mission has evolved. The old mission was to evaluate the transmutation potential against four goals, the ability of the process to

- Reduce the required waste-isolation time,
- Benefit the repository program,
- Reduce the plutonium-proliferation risk, and
- Improve prospects for nuclear power.

That mission led to the recommendation of a three-phase program, which was outlined in an April 15, 2002, report to NERAC. Phase 2 (a 6- to 7-year program of focused R&D, critical-technology development, and engineering and system studies) has been slowed, and Phase 3 (scalable demonstration) has been delayed indefinitely by a shift in focus.

Today, the focus has shifted toward an analysis of options that might affect the Secretary's

recommendation on the need for a second repository. Many variants of partitioning, transmutation, and storage have to be sorted out to help make that recommendation. The AFCI is, of necessity, entangled in the Gen-IV evolution, which will develop the fuels. In addition, it must deal with what is coming out of the Gen-II and Gen-III reactors (all LWRs) and give a smooth transition to GEN IV.

The emphasis has shifted from early implementation of technologies to focused R&D to inform the Secretarial recommendation in 2007 to 2010 on the need for a second repository. The design of a large-scale spent fuel treatment facility has been deferred indefinitely. The group is supposed to reduce the scope of the UREX+ [uranium extraction plus] Engineering Scale Experiment and investigate other advanced aqueous processes with more emphasis on systems analysis, including modeling.

To do all this, the AFCI has to define the optimal research needed to inform the 2007 Secretarial recommendation. Analysis and modeling has to be included with experiments. U.S. nonproliferation policy has to be related to the program. The integration of AFCI and Gen-IV program goals has to be understood. A fast-spectrum test facility must be available. And, as with all programs, reliable long-term funding is a problem.

The Senate mark-up language says that NE should

- Assist the Secretary with the development of alternative technology options that may influence the decision on a second repository,
- Explore new and alternative separations technologies,
- Study global uranium reserves and demand,
- Report to Congress in March 2005, and
- Use the national laboratories and universities for research and systems analysis of reactor- and accelerator-based transmutation approaches.

There is a problem: The Nuclear Waste Policy Act of 1982 prohibits "…emplacement in the first repository of a quantity of spent fuel containing more than 70,000 metric tons of heavy metal, or a quantity of solidified high-level radioactive waste resulting from the reprocessing of such a quantity of spent, until such time as a second repository is in operation." The offices of NE and Civilian Radioactive Waste Management (RW) are now cooperating in defining and developing a program.

The Subcommittee has taken two steps to address the question of proliferation risk It has established a "Blue Ribbon Panel" that has issued an interim report, and it has asked Paul Longsworth (NNSA) to evaluate the proliferation risks of various isotopic mixes of plutonium. Others (Gen-IV and RW) also have proliferation studies under way; it might be a good idea to get these three groups together.

Several technical issues govern repositories and control repository capacity:

- The tunnel wall temperature must be less than 200 degrees C.
- The temperature midway between adjacent tunnels must be less than 100 degrees C.
- Channels must be available for water to trickle down.

Fission fragments (particularly cesium and strontium) control the temperature in the early days, and the actinides (plutonium and americium) control it in the long term. After 80 years, the ventilation can be turned off; the wall temperature shoots up at first and then declines. If one removes the actinides, the early-year temperature constraints are eased; if one removes the plutonium, the long-term temperature constraints are eased. The removal of heat generators and

mobile nuclides not only reduces the heat load but also lowers the dose rate. As a result, the capacity of the repository increases. With a transuranic-element-recovery efficiency of 99.9%, one could store all the nuclear waste produced by nuclear power plants during the next 200 years in the Yucca Mountain Repository. This indicates that one does not need to close the fuel cycle, just partially close it.

Indeed, a partial loading of Pu-based fuel (up to about 30%) in current LWRs would mitigate problems and allow plutonium multirecycle. Three strategies for the practical implementation of plutonium and minor actinide (MA) recycling have been explored:

- Pu + MA mixed with enriched uranium (the MIX concept),
- Separate the MOX and enriched uranium pins (the CORAIL concept), and
- Pu + MA loaded in a nonfertile fuel (this last can achieve a greater net destruction rate).

A major concern is options overload. The separations possibilities include advanced aqueous, pyrochemical, new processes, EBR-II [Experimental Breeder Reactor] spent-fuel treatment, Gen-IV fuels, and a treatment-facility scoping study. The fuels include MOX, MOX + minor actinides, nonfertile plutonium loaded with minor actinides, very-high-temperature gas-cooled-reactor, and Gen-IV fuels.

The NE programs have to narrow their options during the next two years.

Some new international collaborations are occurring. One new possibility is the use of the NE/RW/COGEMA UREX+ for testing as a lower-cost substitute for INEEL. NE should consider the effect on U.S. facilities and expertise as well as budget. Potential partners in such programs are China, France, Germany, India, Italy, Japan, Korea, and the United Kingdom.

The issue of test facilities is going from bad to a disaster. The Fast-Flux Test Facility has finally been shut down (which is regrettable), and Phenix will be shut down in 2008. The others (in Russia and Japan) are heavily booked. Two possibilities would give the research community more testing capacity: the addition of a spallation-target test station to LANSCE and/or a flux booster to the ATR. These facilities would cost $10 to 20 million each.

Richter added some personal comments to the findings of the Subcommittee. The MIT study is a valuable contribution, but, if fossil energy had to pay the cost of garbage disposal (instead of pushing its waste products up a smokestack), nuclear energy would be the low-cost option. With the number of reactors assumed by MIT in 2050, "once-through" implies a new repository every seven to ten years (at $40 to 50 billion each). That will not happen. Reprocessing costs are wildly overestimated in the MIT report. With partitioning and transmutation, the system is probably safer than once-through, and Yucca Mountain can last for 100 years. In addition, the proliferation risks from reprocessing are exaggerated.

DOE has done a reanalysis of the Yucca Mountain costs. The report, *Nuclear Waste Fund Fee Adequacy: An Assessment*, May 2001, DOE/RW-0534, concludes 0.1¢ per kWh remains about right for nuclear-waste disposal. CO_2 sequestration is estimated to cost 1 to 1.5¢ per kWh for gas-fired plants and 2 to 3¢ per kWh for coal-fired plants (Freund & Davison, *General Overview of Costs, Proceedings of the Workshop on Carbon Dioxide Capture and Storage*, http://arch.rivm.nl/env/int/ipcc/ccs2002.html).

Richter had modified the MIT study's summary table to include both waste-sequestration costs as well as capital and operation costs. The table showed total power costs of 4.2 to 6.7¢ per kW(e)h for nuclear generation, 6.2 to 7.2¢ per kW(e)h for coal generation, and 4.8 to 7.1¢ per kW(e)h for natural gas generation.

Another study from Cambridge said that, in U.S. terms, the cost penalty is negligible, 0.13¢

per kW-hr for the MOX cycle (*The Economics of Reprocessing Versus Direct Disposal of Spent Fuels*, M. Bunn et al., July 2003, Belfer Center for Science and International Affairs, Harvard University, Cambridge, Mass.).

MOX is safe, as demonstrated by the record of the French plants. *UNSCEAR 2000* said that it produces negligible radiation effects on the public. And the decrease in uranium mining decreases mine accidents, radon release, transportation accidents, and fuel-fabrication problems. All in all, this type of reprocessing and transmutation seems better than what is done now.

In terms of proliferation, the "spent fuel standard" is a weak reed. However, repositories become potential plutonium mines in 100 to 150 years. For governments, the only barrier to going nuclear is international agreements. North Korea is a good example. They built their own reactor and can reprocess the fuels (according to news reports). Reprocessed material is difficult to turn into weapons and even harder to divert. The isotope of proliferative concern is Pu-239. The plutonium in LWR spent fuel is 60% Pu-239; after a MOX burn, it is 41% Pu-239; and after a 70% burn of a nonfertile plutonium fuel, it is 8% Pu-239. It is not clear that a weapon can be made out of plutonium with only 8% Pu-239.

M. El Baradei in *The Economist* (Oct.18, 2003, p. 47) proposed a new nonproliferation regime that relies on internationalizing both enrichment and reprocessing (i.e., having politically diverse fuel suppliers). He says this is the only way to reduce the proliferation risk from sovereign nations and nongovernmental organizations.

The Subcommittee's major conclusions are

1. The AFCI program is making good progress toward its new goals.
2. In principle, transmutation of a nonfertile plutonium-americium fuel in one-third of an LWR core plus separation and separate storage of cesium and strontium vastly increases repository capacity.
3. The final burn in a fast system of the plutonium-americium multicycle residue with curium added accomplishes all of the *original* goals as well. But all this is not necessary to lower the demands on the repository.
4. Proliferation risks are still under study and will be difficult to deal with.

Mtingwa asked if the Bunn report is saying that reprocessing is cheaper. Richter replied, no. It is saying there is a small increase.

Cortez commented that this is an excellent report. The United States should start MOX fuel use and look at the Gen-IV study to make sure that it takes these results into consideration.

Cochran asked if, on the cost issue, the Harvard study contradicts the MIT report. Richter responded, no; it is the magnitude of the cost increase that is different. Cochran stated that the MIT report is still in draft form and the Subcommittee's report should reflect that. MIT compared a new MOX fuel assembly to that for an LEU assembly. In a deregulated industry, the fuel buyer is unlikely to pay the 4 to 5 times more for an MOX assembly. The breakeven cost today is $1000/kW. The reprocessing costs cited in this report are 2 to 3 times that. Richter responded that the MIT study was incomplete in relation to the Harvard study; the Harvard investigators used U.S. terms and amortization that did not involve government subsidies as the French numbers did. One has to trade 1.3¢/kWh against the political problems involved in developing additional Yucca Mountains. He did not disagree with MIT on the fuel costs, but that is a small cost in comparison to paying off the capital costs of the repository's construction.

Cochran said that there were a large number of issues in the two reports from the Subcommittee that he would like to discuss.

Long noted that the ACRR at Sandia gives a fast spectrum. Rempe added that that reactor is heavily committed. Long asked if the Committee could find out more about the Nuclear University Research Initiative (NURI). Mtingwa said that it was a new program. James Bresee said that the program is looking at various parts of university nuclear-energy research and will put out a solicitation to encourage the development of broad new ideas in advanced fuel cycles. NE hopes to have it fleshed out for the next meeting of this Committee. A. Klein asked if the universities have been asked about this program. Magwood replied, no; it is still in the conceptual stage.

Todreas said that the advanced fuel cycle and the Gen-IV activities are intimately combined. Instead of starting new activities, NE should consider enhancing the activities of these extant committees. These subcommittees should look at the safety performance of current plants to gain a handle on the safety risks involved in these new activities. The differences in costs between Richter and Cochran is the whole enterprise cost. The blended cost is only one-third of the total enterprise cost. The numbers in the report should be formed on the same basis. He was interested in how long Yucca Mountain can be operated. For example, he would like to know if the ventilation could be kept on longer to enhance the facility performance. Richter answered that the late-term problem arises in a peak after 7000 years.

Sellman noted that utilities typically pay 0.4 to 0.7¢/kW for fuel. An addition of 0.13¢ would be within the normal range of variance.

Rempe suggested that, because the Gen-IV and AFCI committees are related, maybe there should be one committee.

Ray stated that both sides are right. The fuel manager will choose the cheaper fuel. But one also has to consider public policy, so more-expensive MOX may be found acceptable if it solves a significant problem.

Cochran asked who the blue ribbon committee was. Richter said that it was set up by NE; Allen Walters of Pacific Northwest National Laboratory (PNNL) is the head. John Herczeg added that this is a panel that NE set up to aid Dr. Richter's subcommittee.

Cochran asked if the amount of uranium will affect the capacity of Yucca Mountain. Richter replied that it will not; it is only a small second-order effect.

Cochran asked if the Subcommittee was suggesting dispersing the storage out of terrorism concerns and if it was concerned with the heat loading or neutrons of the plutonium. Richter replied, both. Longsworth is looking at this.

Ahearne noted that the two Subcommittee reports had several recommendations. One was to make the development of fast reactor to burn MOX fuel a high priority, and another was to speedily develop the UREX concept. He asked if the Subcommittee was asking NERAC to approve these recommendations. Richter responded that, at the time that report was written, the Subcommittee thought there would be a need for 100,000-year repositories. The goals of the program are now different, so what has to be done is different and the questions that have to be addressed are different. Ahearne asked if the Committee should conclude that the January report has been overturned by events. Richter replied, yes, but closing the fuel cycle should still be considered by the Gen-IV program. Ahearne pointed out that, in the October report, there are statements (on p. 10) about issues to be pursued and asked if these were recommendations for NERAC to approve. Richter replied, yes.

Martin suggested that the Committee could accept the Subcommittee's January report after withdrawing the recommendations because the goals of the Subcommittee and the program

direction have changed.

Comfort so moved. Cochran seconded. The motion passed unanimously.

The Committee then considered the Subcommittee's October 24, 2003, report. Long moved to accept the report, including the recommendations on p. 10 and p. 4. Hartline seconded, agreeing that the items on p. 4 were actual recommendations.

Cochran said that he was troubled not by the recommendations but by the statement in the report about the Fast-Flux Test Facility (FFTF).

Fertel noted that the Committee was just accepting the report, not endorsing all the statements.

Cochran said that another statement that bothered him was that removing the uranium increased the length of the usefulness of the repository. Richter said that that statement should not have been in there and that he would like to recast the paragraph to remove that statement.

Cochran said that the Bunn report should be noted as a draft.

Magwood said that the discussion of the NURI program is premature and should be removed. Richter said that he did not have any problems with that.

Cochran asked if he wanted to "disagree" with the MIT report or "observe" about it. Richter said that he would agree that the Subcommittee "disagrees with the implications" of the MIT report.

Ahearne moved that the amended report be accepted. Mtingwa seconded. The motion carried unanimously.

A break was declared at 11:27 a.m.

Martin called the meeting back into session at 11:50 a.m. He asked Ahearne to address several issues. Ahearne reported that two questions had been raised during earlier discussions: the employment of HEU targets and funding for INL. During the break, language had been developed for motions on those topics. The language about HEU targets was displayed, discussed, and modified. Sessoms moved, and Ahearne seconded the following motion:

> The Committee requests the Director of the Office of Nuclear Energy, Science, and Technology to consult with appropriate officials of the National Nuclear Security Administration to determine whether the Department has already developed and made public, or should develop, an Administration position on the use of HEU targets for the production of medical isotopes (e.g., as raised by the Burr Amendment). The Burr Amendment language, currently proposed in the comprehensive energy bill, calls for easing highly enriched uranium (HEU) exports for use in reactor targets producing medical isotopes. The Committee believes that any Administration position should strongly urge full funding of the Reduced Enrichment for Research and Test Reactors (RERTR) program and other activities necessary to support the continued worldwide conversion of HEU fuels to low-enriched-uranium (LEU) fuels and the use of LEU targets for the production of medical and other isotopes as early as possible, consistent with the medical efficacy of the isotopes.

The motion passed unanimously.

The proposed language for the motion about INL funding was displayed, discussed, and modified. The discussions centered on (1) the need for independent funding for INL (rather than keeping a fixed budget for INL and putting funding for it in the NE budget as EM expenditures declined) and (2) whether a specific level of funding should be recommended to make INL a fully functional center for nuclear-energy research. The final language was

> NERAC recognizes that

- The environmental cleanup at INEEL has many obstacles and
- The NERAC Infrastructure Task Force and the NE 10-year plan for INL have identified significant long-delayed facility improvements of several hundred million dollars.

To make INL the leading nuclear-energy laboratory, as is the DOE goal, it is essential that DOE provide the necessary finding. NERAC also recommends that the Department not link INL funding to expected decreases in EM cleanup funding.

Sessoms moved, and Ahearne seconded the motion. The motion was unanimously accepted.

Magwood said that DOE would like to form four new NERAC subcommittees:

- Subcommittee on modeling to model nuclear energy's role in the U.S. energy and economic future
- Subcommittee on Gen-IV nuclear-energy systems to advise and assess the U.S. Gen-IV R&D effort
- Subcommittee on evaluation to review and evaluate NE programs
- Subcommittee on nuclear laboratories

Martin asked Magwood to send the Committee a charge letter specifically asking the Committee to establish the four new subcommittees.

Miller asked for a history of the subcommittees formed, completed, and continuing. Cortez asked that the purposes and goals of the new subcommittees be listed in the charge letters.

Martin said that he enjoyed the Committee and its meeting and apologized for the lapses in procedure. He said that he would work with Magwood to ensure that, in the future, reports to the Committee clearly point out any specific recommendations so that the Committee can efficiently and effectively address them. He asked if there was any public comment.

Matthew Quint of the Embassy of Australia called the Committee's attention to a statement by Paul Longsworth of the NNSA (in response to a question from Ed Lyman) at the October 22, 2003, DOE-sponsored Atoms for Peace Anniversary Conference to the effect that "I believe the Administration is opposed to the Burr Amendment."

Cortez said that two initiatives have been placed on NE: improving university research infrastructure (including research reactors) and educating nuclear engineers. These initiatives have not gone forward. New money should be requested to fund these initiatives.

Roth said that the reason it took so long to hold this meeting was that a member's status as a potential federal employee was raised when he was considered for another federal advisory committee. DOE had to reappraise all the Department's advisory committee members. The NERAC charter was renewed September 12 and amended September 30. The new charter makes clear the status of all members of the advisory committee. The results of the GAO audit are not in yet, so more changes may be made in December 2004 when the current charter will expire. Federal employees on advisory committees have to make personal financial statements to ensure there are no conflicts of interest.

Todreas asked when the next meeting might be. Martin answered, "Spring." He adjourned the meeting at 12:30 p.m.

Respectfully submitted, Dec. 16, 2003
Frederick M. O'Hara, Jr.
Recording Secretary

Revised, Feb. 19, 2004
Mark Roth and John Ahearne