Nuclear Energy Advisory Committee
December 19, 2013
Marriott Hotel at Metro Center
Washington, D.C.

Committee Members Participating:

Brew Barron
Ashok Bhatnagar (via telephone)
Matthew Bunn
Margaret Chu
Michael Corradini
Susan Eisenhower, Co chair
Donald Hintz
Susan Ion (via telephone)
Raymond Juzaitis
Mujid Kazimi
William Martin
Regis Matzie
Richard Meserve, Co chair
Carl Paperiello
Burton Richter
John Sackett
Alfred Sattelberger

Committee Members Absent:

Dana Christensen

Other Participants:

Keith Bradley, Technical Director, Nuclear Energy Advanced Modeling and Simulation, Argonne National Laboratory
Nancy Carder, NEAC Support Staff, Medical University of South Carolina
Joyce Connery, Director, Nuclear Energy Policy, Office of International Economics, National Security Council
Trevor Cook, Deputy Director, Office of Advanced Modeling and Simulation, Office of Nuclear Energy, USDOE
Matthew Crozat, Program Analyst, Office of Nuclear Energy, USDOE
Marvin Fertel, President and Chief Executive Officer, Nuclear Energy Institute
John Hamre, President and Chief Executive Officer, Center for Strategic and International Studies
Shane Johnson, Deputy Assistant Secretary for Science and Technology Innovation, Office of Nuclear Energy, USDOE
Alexander Larzelere, Program Manager, Modeling and Simulation Energy Innovation Hub, Office of Nuclear Energy, USDOE
Peter Lyons, Assistant Secretary, Office of Nuclear Energy, USDOE
Edward McGinnis, Deputy Assistant Secretary, International Nuclear Energy Policy and Cooperation, Office of Nuclear Energy, USDOE
Frederick O'Hara, NEAC Recording Secretary, Medical University of South Carolina
Robert Rova, Office of Nuclear Energy, USDOE
Monica Regalbuto, Deputy Assistant Secretary for Fuel Cycle Technologies, Office of Nuclear Energy, USDOE
Michael Schmidt, NEAC Support Staff, Medical University of South Carolina

About 40 others were in attendance in the course of the meeting.

Morning Session

The meeting was called to order at 8:37 a.m. by the cochairs, **Susan Eisenhower** and **Richard Meserve**. The members were asked to introduce themselves. Eisenhower noted that the next Intergovernmental Panel on Climate Change (IPCC) assessment was under way, and the statement had been made that climate change cannot be addressed without nuclear power. The Megatons to Megawatts program has blended down 20,000 former Soviet warheads plus American ones, furthering nonproliferation.

Robert Rova noted that there was a public comment session on the agenda and he made safety and convenience announcements.

Peter Lyons was asked to review the current issues being addressed by the Office of Nuclear Energy (NE).

In a speech at Georgetown University in June of this year, President Obama spoke to the environmental benefits of nuclear power and pointed out that several nuclear power plants are under construction in the United States. Secretary Moniz will join this meeting during the discussion of the future of domestic nuclear power. He recognizes the need for nuclear power in addressing climate change. The role of the U.S. Department of Energy (DOE) is seen to be reducing the regulatory risk of nuclear proliferation and terrorism, reducing the technical and financial risks of nuclear power, and managing nuclear wastes.

The budget outlook is confusing. There is a presidential request that has been marked up by the Senate and House in self-contradictory ways. The House supports fellowships, but the Administration does not. The government is operating under a continuing resolution, but a new budget seems to be imminent. It is hoped that there will be concrete budget guidance soon.

The Office's leadership team was introduced.

Recent events included the celebration of the last shipment in the Megatons to Megawatts program a few weeks ago. This is the number one achievement in recent history.

NE is responsible for the United States Enrichment Corporation research, development, and demonstration program contract. The joint project between DOE and USEC and American Centrifuge Demonstration will be completed on January 15, 2014, but may be extended by Congress for a few months. The project will have demonstrated the technical reliability and robustness of the American centrifuge technology. Many milestones have been met. Now, commercial and national-security decisions need to be made.

In 1985, Presidential Reagan under Section 8(b) of the Nuclear Waste Policy Act confirmed a DOE recommendation [*An Evaluation of Commercial Repository Capacity for the Disposal of Defense High-Level Waste*. DOE/DP/0020/1] and called for the pursuit of one repository for both commercial and defense nuclear waste. The Blue Ribbon Commission on America's Nuclear Future and Secretary Moniz have seen that decision to be in need of review. There is no obvious end to the production of nuclear waste. Many sites need environmental cleanup. State agreements were not in place in 1985, but they certainly are today. The review is well under way. It would be very difficult to pursue a separate repository for defense waste. A report on waste-form disposal options will be available soon. It will likely conclude that all wastes should go to one mined repository; no wastes require a specific disposal concept; and deep-borehole disposal scores well for some small and low-volume waste types. The evaluation did not provide a compelling basis for choosing one medium over others; all media considered in the study are viable for all wastes.

In waste management, the key strategic elements are consent-based facilities siting, system design, and governance and funding. This strategy has been brought to Congress. The Secretary says that this is a workable framework. The Senate markup for the bill is scheduled for early 2014. There are many views in the House; the path forward there is uncertain. The bill would allow DOE to move forward with defense-waste disposal. Senators Wyden, Murkowski, Feinstein, and Alexander have introduced comprehensive nuclear-waste legislation, the Nuclear Waste Administration Act of 2013. Some factions in Congress are ready to move on from Yucca Mountain while others are not. A recent decision by the

D.C Circuit directs the Department to stop charging the waste tax. How that will be responded to by DOE is under review.

The Small Modular Reactor (SMR) Licensing Technical Support Program shares costs between government and industry for design certification of SMRs. Awards have been made to B&W mPower America and NuScale Power. The NuScale Power SMR emphasizes innovative approaches to nuclear safety. At 45-MWe, it is a relatively small unit. It uses passive circulation (i.e., it has no pumps) and an integral pressure-vessel design. The containment vessel is immersed in a pool of water.

Eight more nuclear plants have been announced in China.

20% of the NE R&D funding is allocated to the Nuclear Energy University Programs (NEUP), almost $300 million. No U.S. funds go to foreign partners; however, other countries are eager to participate in these partnerships. This is extremely important, and the Office is very proud of it. The FY13 NEUP awards are used to form consortia to address a highly focused program. One awarded program uses high-fidelity ion beams to simulate high-dose neutron irradiation and to assess radiation damage. If successful, this program could produce higher-quality data in much shorter times for many material-damage mechanisms. If the program meets its milestones, continued funding is very likely. This program was highly competitive.

A question to be addressed is the transition of FY11 NEUP Integrated Research Projects (IRPs). Transition options have been evaluated, and the process is being formalized, structured, and applied to r the two IRPs nearing the end of their funding. Those projects are (1) High-Temperature Salt-Cooled Reactor for Power and Process Heat and (2) Fuel-Aging in Storage and Transportation (FAST): Accelerated Characterization of Performance Assessment of the Used Nuclear Fuel Storage System. There will be a new IRP competition in 2014 for 3 years of funding. These two projects will compete in this award process. This process will be repeated each year as IRPs mature.

All 18 members of NEAC have been reappointed, with two rotating out on December 31, 2014, William Martin and Michael Corradini. It is hoped that they will continue on with their subcommittees. Two new members will join the Committee on January 1, 2014, Warren "Pete" Miller and Joy Rempe. The same transition process as has been used in the past will be employed: old and new members' tenures will overlap for a year, so there will be 20 members for one year.

There are several plants under construction in the United States and many in China. Significant time in this meeting has been set aside to discuss how to help the U.S. nuclear industry and its implications for national security. It is hoped that new ideas might lead to solutions.

Bunn asked at what point the Department will have to stop collecting fees if the utilities' court case is not responded to. Lyons replied that the Secretary would have to propose to Congress that the fee would go to zero dollars. The Department has until the end of January to make that decision. The zero-dollars fee would kick in in 60 days, and Congress would have to act to block it.

Meserve asked whether the Department needed congressional action to separate commercial and defense waste. Lyons said that the Act applies only to civilian waste. The defense waste disposal could move forward under current legislation.

Alfred Sattelberger was asked to report on the Fuel Cycle Technologies Subcommittee.

The Subcommittee's charter calls for it to review, comment on, and make recommendations to the Assistant Secretary for Nuclear Energy on the R&D and current and future directions of the Office of Fuel Cycle Technologies. Its November 22, 2013, meeting covered a lot of topics [used-fuel disposition, fuels, Nuclear Energy Advanced Modeling and Simulation (NEAMS), the National Research Council's (NRC's) proliferation risk study, and the security of spent-fuel storage and transportation]. The final report was delivered on December 17.

Used-Fuel Disposition is a demonstration project designed to take high burn-up fuel out of a pool, put it in a cask, monitor it, take data, and characterize the spent-fuel and cask performances. The Subcommittee found that the scope of the project is complex and consists of many participants. This raises the concern that all possible instrumentation options will be explored and employed, rather than the *necessary* instrumentation to meet NRC requirements. The Subcommittee believes that it is appropriate that DOE work closely with industry and the national laboratories to ensure that the scope of the project

meets the required programmatic objectives. This project is very timely. It is working at a Dominion Power site in Virginia.

In the Accident-Tolerant Fuels (ATF) program, a high-level description was given. The effort is working toward a fuel selection and then a cladding system. This work is connected to two IRPs. Multiple cladding alloys, e.g., molybdenum alloy, silicon carbide, etc. are being investigated. The Subcommittee recommends that the ATF program should develop contingency plans in the event that resources and milestones are inconsistent. It also notes that the current program focuses on fuel and cladding and does not address other lower-cost reactor enhancements. The Subcommittee strongly recommends that the program become cognizant of the implications of severe accidents on other reactor components, such as control rods, by performing reactor-system response analyses, rather than just focusing on the fuel and cladding.

The Subcommittee studied NEAMS, the goal of which is to develop a capability of using NEAMS outside the limited range of available engineering-scale data. The Subcommittee expressed concerns about validation of these tools that are similar to those expressed previously by the NEAC NEAMS Subcommittee. The Subcommittee recommends that, without additional validation data, NEAMS developers should acknowledge the limitations that exist with the new fuel-product-line tools.

The proliferation risk study undertaken by the National Academies was overwhelmingly written from the perspective of the policy utility of these quantitative risk assessments to define what a proliferation risk is. It considered new barriers to proliferation. However, "risk" remained undefined. The Subcommittee concluded that the decision to embark on an advanced proliferation-resistant nuclear-energy system cannot depend on a "perfect" proliferation-risk assessment. More fundamental, high-level decisions derived from nonproliferation and nuclear-material security imperatives must be made to promote global nuclear-energy development, informed at each step of development by the most accurate proliferation-resistance assessments consistent with design-definition and actual data.

Juzaitis noted that the National Research Council missed an opportunity to work across the National Nuclear Security Administration (NNSA) figures of merit that have been developed for different materials. That quantitative information could have been integrated to use risk assessment to develop new opportunities.

On the topic of spent-fuel storage, transportation, and disposal, DOE released its "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste" in January of 2013. This document provides the framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel and high-level waste in the United States. The strategy sounds great. It includes a phased, adaptive, and consensus-based approach for siting and implementing a management and disposal system. At its core, the strategy endorses a waste-management system containing a pilot interim-storage facility, a full-scale interim-storage facility, and ultimately a geologic repository (in 2048). The Subcommittee is of the opinion that the present scope of the pilot facility may be overly complex for pilot demonstration. A thorough analysis is recommended to determine what an optimal pilot plant should consist of and how the pilot program can assist in the development of the large-scale storage facility. That is, what questions need to be answered? The evaluation of high-level waste and spent-fuel inventory and disposal options provides a good framework to understand the problem at hand in a macro sense. The Subcommittee recommends a conceptually similar study on the entire spent-fuel inventory in light of the storage and transportation requirement evaluations. The Subcommittee further recommends that the inventory data be rendered flexible so that it can be sliced in different ways, depending upon the activity under consideration. A study such as this can provide guidance to the design of a pilot interim-storage facility as well as to the prioritization of R&D activities.

Chu noted that the motivation of the recommendations was based on the problems and the concerns that have been raised and dealt with on an ad hoc basis. DOE should do a good study of the options for the future of disposal.

Bunn noted that a lot of the work on proliferation resistance is on how hard it is to get the nuclear material out of the spent fuel. One needs to look at leakage of technology. How much would the frameworks available in military projects help limit this leakage?

Kazimi said that the ATF program is vital for the future of the U.S. nuclear program. It is great that the United States has such a program. Both Korea and China have started similar programs. Different geometries should be looked at, not just fuel and cladding materials. The international efforts should coordinated.

Meserve noted that validation of fuels to get through the Nuclear Regulatory Commission (NRC) licensing process opens the door for the next step: systems.

Lyons said that the Department agrees on the need for international cooperation. There are several bilateral agreements on nuclear energy. The Office would be very open to cooperation in this area. The program is keeping in its view to characterize and license fuels that *can be* used. At the end of the day, these fuels must be able to be used in power plants.

Matzie asked what was going to be done in a pilot facility. The assessment of dry storage casks could be done quickly. The Nation needs to get on with a dry-storage facility. A plan needs to be developed for such an interim-storage facility. Regalbuto stated that everyone is in agreement on this topic. The Office needs the funding authority to do so. The pilot facility is not in the budget. Also, the problem may be too complex for a pilot facility. The timetable *could* be compressed, but the budget authority is needed first. More instrumentation is needed than is currently available. An NRC license is needed to conduct the tests. DOE intends to load a second cask and look at different variables. The objective of the program is to look at current reactor design. An international expert group is set up.

Michael Corradini was asked to present the Reactor Technology Subcommittee report on plant closures.

Recently light-water-reactor (LWR) plant closures prompted NE leadership to consider contributing factors and what can be done at the national and regional levels. The Subcommittee was asked to consider what can be done in keeping the nuclear power option viable now and into the future and to provide initial findings and recommendations. The Subcommittee considered both currently operating plants and future light-water reactors under construction or planned. The charge called on the Subcommittee to identify the circumstances for each plant shutdown to get a common understanding of the situation; to determine if any changes have occurred in market structures that may recognize value in certain clean-energy resources; to see if current energy markets are not appropriately valuing existing nuclear generation; to look for any important issues facing the Light Water Reactor Sustainability Program; and to determine if there are any actions/incentives that need to be considered for current plants, advanced large light-water reactors, or small modular reactors.

All the recommendations of the Subcommittee focused on current plants. There have been five recent nuclear-plant closures or closure announcements. All of these closures were business decisions. In the longer-term, except for decadal power-purchase agreements, capacity markets as currently structured do not provide adequate revenue streams to assure that positive cash flows will be produced for merchant nuclear-plant owner-operators. There is also evidence that some of these markets will not support investment in new generating facilities of *any* fuel source. Combined with the anticipated Environmental Protection Agency (EPA) regulations (e.g., coal-emission requirements and water-cooling limitations), regional reserve margins may shrink below those generally regarded as prudent.

During the Subcommittee's discussions, Thomas Cochrane had pointed out that NE should work with the Secretary of Energy to begin high-level discussions to develop a sense of urgency at the federal level to ensure that electricity markets take into consideration desirable attributes that are not currently reflected in electricity prices. Such attributes include fuel-source diversity, electric-supply reliability, and environmental sustainability attributes. The federal government does not have control here but can inform and influence.

The Subcommittee had two recommendations. (1) NE should assess the amount of nuclear power plant capacity that may be at risk and the vulnerability time frame and key contributing factors. It should also develop a strategy and action plan to address potential near-term loss of generation capacity that

otherwise would be retained if restructured electric markets took into account the attributes identified above. (2) Given the desirability of having an electricity market that takes into account the attributes identified above, an interagency task force should be formed at the federal level to help promote regional and state policy that would influence public utility commissions and load-serving entities to create electricity markets that take these attributes into account.

The Subcommittee also recognized that new nuclear-power generation capacity (e.g., advanced light water reactors) will also be influenced by these findings on economics and market structure. The Subcommittee will take up this investigation in its future meetings.

Matzie said that the Committee gets the message that the state and local regulatory bodies are driving the utilities on the directions to take. Someone has to inform them about how to balance economics, environment, and capacity availability. The states even have to approve power-purchase agreements. Barron said that the current construct is quite flawed. Hintz suggested that the Subcommittee look just at current plants. Current and future plants are two separate issues. The decision to shut down Vermont Yankee was purely economic, although there were a lot of political pressures. On the issue of cheap natural gas, it will be around for a long time. It will be a threat to new nuclear construction. The biggest threat is market design with two factors entering in: green energy a little bit above market (to expand it would require a lot of expensive upgrades, such as in transmission) and long-term power-purchase agreements (which will shut down a lot of fossil and nuclear plants).

Lyons asked who has the responsibility to fix the market design. Barron responded that the Federal Energy Regulatory Commission (FERC) has approval of those market designs as proposed by the Independent System Operators (ISOs). Corradini added that the states often have review powers, also.

Bunn noted that taking a lot of other factors into account than just short-term prices would make the political case for nuclear powers stronger. It might make sense to get Bill Hogan before this Committee to talk about market design. This problem was created by moving to unregulated markets that shifted risks from ratepayers to stockholders of utilities. If one is comparing externalities, fine particulates emitted by coal plants are a bigger problem than is carbon.

A break was declared at 10:33 a.m. The meeting was called back into session at 10:52 a.m.

Matthew Crozat was asked to discuss the future of domestic nuclear power and get the perspectives of the Committee.

In 1998, Millstone I was shut down, and the future of nuclear power was in doubt. Beginning in 1999, there was a nuclear renaissance, and applications for new starts peaked in 2007. However, lately there has been a spate of closures. Electricity demand increased about 2.7% per year from 1970 to 2008. Thereafter, that rate has declined to 1% per year. At the same time, a lot of activity was going on on the supply side. Natural gas production increased dramatically and rapidly, and gas prices went down from $6 per thousand cubic feet in 2004 to $4 in 2013. However, the cost of producing nuclear power has risen significantly from about $30 to about $42 per megawatt hour. This increase has occurred across the fleet but with greater variation for single-unit versus multiunit plants and older versus younger units.

Policy signals include an emphasis on nonemitting generation; in the past year, the Administration has looked less at Congressional action and more toward what the Executive Branch can do on its own.

In a dramatic retirement scenario, one-third of the reactor fleet might be shut down; replacing that generating capacity with fossil-fuel-fired plants would add 125 Mt of carbon per year to the atmosphere. However, the near-term target is to reduce emissions 17% by 2020, and the long-term target is to use 80% clean electricity by 2035. To do this, one would need 2900 TWh of nonemitting power. The Energy Information Administration (EIA) says that adding 800 TWh of nuclear and 700 TWh of renewables might be possible. The resultant 1400-TWh shortfall grows to 1600 TWh with retirements. Meeting energy goals will be challenging. Retiring nuclear plants early will make that challenge more daunting.

The first retirements in 15 years come at a time of change for the domestic nuclear industry. Weak electricity load growth and inexpensive natural gas have resulted in low power prices while rising costs and insufficient policy signals pressured nuclear regions. The key questions are: How does one assess the valuable attributes of nuclear power (reliable base load power without emissions) in the face of

challenging economic conditions? And how does the domestic nuclear industry relate to international interests and influence?

John Hamre was introduced to discuss these questions.

Hamre said that the Center for Strategic and International Studies (CSIS) did a study on the economics of nuclear power [*Market-Distorting Policies Will Lead to U.S. Nuclear Reactor Shutdowns*, by George David Banks, Aug 29, 2013] and found that one cannot compete with cheap natural gas, which can be brought online quickly. There are benefits to a broad portfolio, though. Nuclear power has important national-security benefits. Nuclear power was originally tied to weapons production. Atoms for Peace set rules to separate nuclear power from nuclear weapons. Much of what we know about the current Iranian nuclear program comes from their being a signatory to the Atoms for Peace Program. The United States could lose one-quarter of its reactors in the coming years. If the United States abandons nuclear power, it loses nuclear expertise in the nuclear proliferation area. The natural gas bonanza is undermining the whole nuclear enterprise in the United States. America should be in the forefront of developing small modular reactors for national-security reasons, not just looking at economics.

Richter said that nuclear power is safer than natural gas and coal and oil, but nobody knows this. The real costs of other power sources are never spoken about. The United States starts much but finishes almost nothing because of shifting personnel and priorities. The recent Presidential Memorandum [Federal Leadership on Energy Management, December 5, 2013] said that all federal agencies have to increase renewable-electricity generation. It says nothing about reducing emissions. Nuclear power needs a marketing campaign. Marvin Fertel and the Nuclear Energy Institute need to get on it. He agreed with everything Hamre had said. Every bit of the technology for next-generation reactors was developed in the United States, and nothing was done with it. The ranking of future fuel cycles is moribund. Furthermore, it does not take 35 years to open a repository. We have a repository in the Waste Isolation Pilot Plant (WIPP) that could take commercial waste today.

Matzie said that the small modular reactor is not the savior of the nuclear industry. The United States' passive-plant technology for big power plants is able to produce safer and cheaper electricity and is the right technology for the rest of the world. The word needs to be gotten out to the world about this U.S. technology. Hamre said that, several decades ago, a decision was made to shut down the power-generation plants at military installations and to rely on commercial sources. That was a mistake. The national security is now at risk because the Nation's commercial power sources are not protected against disruption. National-security facilities need to have reliable, self-sufficient, baseload power sources. These installations cannot use the power from a 1000-MW reactor, but they could use that from an SMR.

The Secretary of Energy, Ernest Moniz, joined the meeting.

Bunn asked how the United States was to deal with recent plant closures and to respond to low electricity demand growth and cheap natural gas. A policy environment is needed to deal with these scenarios. This situation has implications for climate change and national security. Hamre said that the national security of the United States depends on leadership in nonproliferation and that depends on maintaining commercial power production. Richter said that nuclear has an image problem. It could be safer and cheaper than other sources if all externalities were accounted for. The United States has the talent but not the program. How to open a repository in 10 years is known. He asked why the United States is taking so long to do what it knows it can and must do.

Moniz said that the focus of the Administration is driving toward lower carbon. The plan is based on administrative authorities and will be implemented. The President is open to working with Congress to develop a more comprehensive approach to climate change. Statutory authority will ultimately be required. Within the extant constraints, the Department will work across all fuels and technologies, including small modular reactors, the Vogtle plant in Georgia, and this list should be extended further. Also important is the waste end; the Yucca Mountain issue is complicated. Other key areas should be independent of where repositories are. One can make significant progress rapidly, but these efforts require legislative authority. There is a Senate bill cosponsored by senators Feinstein, Alexander, Murkowski, and Wyden that will be coming up for debate in 2014. The Blue Ribbon Commission on America's Nuclear Future also mentioned re-examining the decision to comingle commercial and defense waste; the

Department is moving forward on that recommendation. Boundary conditions, waste forms, etc. have changed in 30 years. That re-examination might open up new possibilities. He understood that the nonproliferation regime is deeply rooted in the commercial power industry. The 123 process is the backbone of the Nation's international cooperation; there will not be any 123 agreements if the United States does not have a technology to offer foreign partners. The Department is having discussions with several other countries to cooperate on nuclear technology development. He had visited Fukushima, and he had to say that walking around there for a few hours impresses one about how different it is to deal with the conditions created by the incident. The United States has a lot to offer in helping others in liability rulings and other issues. The Japanese Prime Minister Shinzo Abe has said that the Japanese were open to international participation in the cleanup there.

Meserve said that there are a lot of externalities to power production that are not taken into consideration to the detriment of nuclear power. There are a number of plants that are on the bubble for being shut down for economic reasons. A lot of supplies may disappear. What should the United States do about this?

Fertel agreed with both Richter and Hamre. One can have the best public relations and still lose money because of economics. The nuclear industry is not asking for subsidies and would not get them. Kewaunee Power Station in Carlton, Wisconsin, was shut down on May 7, 2013, for economic reasons, and a lot of reserve capacity, jobs, and tax base went with it. In the near term, one needs to work at the state level and get visibility at the federal level. FERC was interested in doing systems analysis on how these things fit together and how to avoid unintended policy consequences. In the long term, *all* currently operating nuclear plants will be shut down by 2050. There probably will not be any of today's gas plants operating, either; the technology will change. That is not being thought about today. It *is* a national-security issue; but selling overseas is important from a safety viewpoint, also. The United States needs to export its safety experience and regulatory culture. The nuclear industry is working to aid state-level decision-makers become aware of the overall economics and safety issues.

Moniz basically agreed. The government cannot determine what the market share should be. It needs to build regulatory structures. The value of the portfolio is being assessed along with the strains produced by cheap natural gas. It does not sound good to complain about what is widely seen as a great boon for industrial construction and job creation. Coal and renewables must be looked at, also. Natural gas will sell well; one must consider what other values nuclear holds for the country. There has been a disfavoring of long-term contracts, even for natural gas. The question is, is that the best way to go? Gas is unique in its capital costs for construction, but debt financing is also cheap. If one wants to do large capital projects, now is the time to do them.

Fertel said that he did not consider natural gas bad, but a condition that one has to deal with. Moniz said that the Department is putting more emphasis on outreach to state and local governments. Its expertise is highly valued at the state and local levels. It needs to build its programs around the realities that vary widely across the nation.

Hintz said that a lot of the U.S. plants operate in a dysfunctional market. Even functional, efficient plants will be shut down, an unfortunate situation. Moniz said that the Quadrennial Energy Review and other opportunities for discussion can influence and help state and local governments to do the actions that the federal government cannot take. DOE has an analytical group that reports directly to the Secretary that analyzes state actions and provides feedback to the states.

Richter said that the United States has not built a plant in a long time and has lost infrastructure and the manufacturing capabilities to build plants. He asked whether costs will come down as the nation builds more new plants. This important question needs to be investigated.

A break for lunch was declared at 12:09 a.m.

Afternoon Session

The meeting was called back into session at 1:30 p.m.

Shane Johnson was asked to describe the Nuclear Energy Advanced Modeling and Simulation (NEAMS) efforts.

The purpose of NEAMS is to pursue advanced modeling and simulation to enhance opportunities for new insights into the complex phenomena occurring in nuclear reactors. NEAMS provides new capabilities and tools to validate codes and compare model results with experimental data. Its efforts will affect existing and future reactors. The DOE Energy Innovation Hubs, which are integrated research centers that combine basic and applied research with engineering, and form a complementary partnership with NEAMS. The hubs use successful R&D and business models to improve other programs from a technology-independent point of view.

The NEAMS budget has seen wild gyrations since its establishment in FY08; the hub has seen good stability. The results seen from NEAMS show the success of the management and project workers and are a testimony to what those personnel can do despite unstable funding. The MOOSE-BISON-MARMOT codes provide an advanced, multiscale fuel-performance capability to analyze crack development, fuel-cladding interactions, and an operating environment to translate from physical to engineering states. In these codes, neutronics, thermo mechanics, fluid mechanics, structural mechanics, and system response work in unison in an operating system for software quality assurance and verification. A NEAMS toolkit-component roadmap shows the interaction of the various frameworks and codes.

The NEAMS users come from 60 institutions and companies. Each one uses one, some, or all of the NEAMS components. Feedback is received from those users on desired upgrades and additions.

NEAMS will provide baseline validation for every physics module. Validation plans have already been established for each of those modules.

NEUP and the Integrated University Program (IUP) have a well-established competitive process for awarding R&D infrastructure and scholarships and fellowships. NEAMS validation and verification was added in the past two NE calls for proposals. This year, 43 preproposals were received in verification and validation alone. The university community is listening and responding; there were more than 200 preproposals received this year

In summary, NEAMS has a robust and growing user community. It is developing a toolkit that is technology neutral with the capability for simulations of light-water reactors, sodium-cooled fast reactors, and very-high-temperature reactors. NEAMS and the Consortium for Advanced Simulation of Light Water Reactors (CASL) partner and complement each other, already making a difference and promising much more for the future.

Alexander Larzelere was asked to summarize the activities at CASL during the past 3.5 years.

CASL started on July 1, 2010. Its purpose is to take or find new high-technology and put it into a product that will make a difference. The original funding opportunity announcement (FOA) asked proponents to identify a real reactor, instrument it, and then create a "virtual reactor" that addresses industry-defined challenge problems. CASL got industry at the table, an important element. It started on a high-performance computing environment and then shifted to industry-class clusters. It is a virtual environment, a collection of codes that are brought together. It is designed to be flexible to allow modules to be activated as needed to address specific challenge problems. Most of the system was put together from existing codes.

CASL is focused on a real reactor (Watts Bar-I), and simulation and modeling results can be compared with the data from that reactor. CASL has employed advanced modeling applications, physics integration, thermal-hydraulic methods, and radiation-transport methods, including a new nucleonics code. The team has taken a good look at validation and uncertainty quantification and at materials performance and optimization. Tools for these tasks have been developed and then used in specific applications.

CASL continues to plan and execute with its evolving plan-of-record process, which operates in 6-month periods. A plan of record is a documented implementation plan of L1 to L3 milestones [major milestones to detailed milestones], tasks, and risks. It spells out who does what when. Each plan of record is a living document, describing expectations for the next 6 months. They are guided by a Science Council.

If CASL does not deploy technology to industry, it has failed. It makes limited public releases of the codes through the Radiation Safety Information Center. It deploys test stands for early deployment to industry for rapid and enhanced testing, use, and ultimate adoption of the Virtual Environment for Reactor Analysis (VERA) to support real-world LWR applications. Westinghouse has done a VERA simulation of the AP1000 first core, the Electric Power Research Institute has tested VERA fuel performance, and the Tennessee Valley Authority is planning to investigate a lower-plenum flow anomaly.

An Industry Council assures that CASL solutions are useful and are used by industry and that CASL provides effective leadership in advancing the state-of-the-art of modeling and simulation. The directors of CASL meet with the Nuclear Regulatory Commission (NRC) and industry regularly. NRC observers attend the annual review.

CASL has a good handle on what it is looking for in renewals: to deepen and to broaden the Phase-1 reactors scope. CASL will be expected to define the details of the exact problems and their expected impact, the approach, and the team.

Richter asked how these modules, which started with first principles, stacked up in comparisons to real data. Larzelere replied that, so far, they stacked up well. For example, the modelers started with first-principles chemistry to investigate crud formation and ended up predicting a new form of crud. When the workers went into the reactor during a shutdown, they found it. Thermohydraulic and other data are being compared now.

Sackett asked what has been driving budget concerns. Lyons responded that a very austere budget condition is in control now, and the Office is trying to fund Idaho National Laboratory (INL) at a credible level, and it is not doing a very good job. The Office has some directive language in its budget from Congress that limits its funding allocations. Its budget has gone down while starting a small modular reactor program. NEAMS is discretionary in that it is not proscribed by Congress.

Sattelberger noted that CASL seems to have changed in its communication between itself and NEAMS. Larzelere said that the program is looking at longer-term situations that will afford better conditions for communication with industry. The budget is a restraint, though. Industry has identified a number of codes that need to be upgraded or created, and those codes are going into the NEAMS process now.

Kazimi stated that the integration of fuel modeling has worked well. However, he did not feel that other domains (physics and thermal hydrodynamics) benefit from such integration. He asked if there were efforts to bring those people together. Johnson replied, yes. NEAMS stands ready to assist but not to manage or direct. Bradley said that there are examples outside the fuel area where integration has been conducted, and that integration is being increased. Cook said that NEAMS is creating tools all the time. CASL had to figure out what it could do. Early on, it picked codes that met the physics needs. Over time, those tools were updated by NEAMS. As a result, there is a NEAMS toolset and a CASL toolset. Matzie pointed out that, to use codes in industry, they have to be validated and verified for the NRC. He asked if there were plans to validate and verify the NEAMS and CASL tools. Larzelere replied that one does not need an NRC-approved code; one needs an NRC code to make an application to the NRC. Industry can use these codes for a lot of tasks without NRC approval of the codes. It will be up to industry to invest in the validation and verification of the tools so they can use them in subsequent applications to the NRC; it is not a CASL responsibility.

Corradini said that there are three applications of these codes: design, operation, and safety. It is not clear how the tools developed will be mapped upon those applications. From a long-term strategy point of view, that needs to be thought through. He was looking for a master map that delineates CASL and NEAMS to show where they exist separately, overlap, touch, migrate and fuse. Larzelere said that CASL is focused on understanding operating reactors to design new reactors and to improve operations without compromising safety.

William Martin was asked to report on the International Subcommittee.

The Subcommittee's report was delivered on the 60th anniversary of Atoms for Peace. The Subcommittee has been asked to focus the scope of its activities. This is difficult because nuclear

technology touches on many national interests. The Subcommittee offered a series of recommendations and asked the Committee's acceptance of them.

In regard to NE's programs:

- Increase the budget for NE-6 to $8-10 million because this relatively small increase could do much good in regard to accomplishing overall objectives.
- Develop an international nuclear-energy R&D roadmap.
- Develop a catalog of existing and planned NEUP-type university projects and study whether any of these are related or could be linked to international nuclear initiatives.
- Continue efforts to complement existing SMR program activity, with the aim of seeking early overseas deployment within legal guidelines.
- Establish a more comprehensive program to maintain nuclear workforce expertise, both domestically and internationally, noting this can only be done in conjunction with a healthy U.S. nuclear industry.
- Assign a high priority to participating in climate-change initiatives across DOE.
- Develop a specific topic of increased interaction with the Advanced Research Projects Agency-Energy.

In regard to Team USA programs:

- Identify the advantages and disadvantages of international competitors for nuclear-plant construction, fuel services, and infrastructure support for nuclear-energy development in emerging economies.
- Assess the potential for the United States to provide bundled services, including priorities, processes, and recommended actions.
- Analyze the extent to which current lending terms are inhibiting investments, and to what extent an expansion of lending terms would relieve this limitation.
- Leverage current the U.S. nuclear industry's advantage in design innovation through the TEAM USA initiative with an emphasis on manufacturing innovations.
- Continue to enhance efforts to aid American vendors in their bids to compete in key nuclear markets.

In regard to International Collaboration:

- Maintain active involvement in Organisation for Economic Co-operation and Development's Nuclear Energy Agency (NEA) activities, recognizing that recent activities of NE have led to the sustainability of the NEA.
- Continue to support post-Fukushima research and development to assure that the lessons of Fukushima are studied and experience is gained.
- Work at being more involved and influential at the International Atomic Energy Agency (IAEA) because new-entrant countries always look to the IAEA for guidance and help.
- Continue to support the IAEA international laboratory at Seibersdorf and international activities within the Idaho National Laboratory.
- Maintain the International Framework for Nuclear Energy Cooperation (IFNEC) program, recognizing that U.S. leadership in an international forum strengthens overall U.S. nuclear objectives and that the budget for NE's participation in IFNEC is not large enough to add a mission as potentially broad as nuclear-energy operations and safety.
- Reinvigorate the U.S.'s role in the Generation IV International Forum (GIF) through the leadership of the DOE Deputy Assistant Secretary for Nuclear Reactor Technologies in his new role as Chairman of GIF.

There needs to be a process to bring together the leaders of the U.S. nuclear industry.

Martin presented his successor (Matzie) with a matrix of activities to be carried out on international issues. Matzie said that he would immediately meet with Edward McGinnis to ascertain the status of each element in the matrix.

Richter said that the IAEA could take on the job to help countries to develop a nuclear-power capability. It is important to make sure that these developing countries do it right.

Connery said that the United States needs to work from its strengths and to work with all agencies to pool talents. There is not a safety program, which would be very helpful in going to other countries. Richter pointed out that that is good for dealing with friends, but not so good in dealing with those who are not friends. Connery said that the United States needs to step up in support of the existing IAEA programs.

Bunn stated that the United States needs to demonstrate that it can build reactors on budget. Also, there was an earlier recommendation that got dropped out: The United States needs a nuclear R&D influence in the Office of Policy Analysis. Martin replied that that recommendation was dropped in an effort to focus the Subcommittee's activities during this phase of its deliberations. Bunn said that a lot of these countries have a high rate of corruption. An anticorruption initiative is needed within the nuclear-technology enterprise.

Meserve said that he had narrowed the charge of the Subcommittee to make the report a more actionable document. There is awareness of the need to support the IAEA; the problem is the shortage of funding. The Committee needs to push for new funding, especially in nuclear safety. He noted that the major reactor vendors have developed a Code of Conduct that deals with safety, security, nonproliferation and other issues (such as corruption, child labor)., and other issues).He observed that this was a very commendable exercise and should be recognized.

Paperiello asked whether the United States will get data on the operations of its new plants being built overseas. It is believed that these plants are better than those built here in the 1960s and 1970s. The question is, are they really better? Lyons said that DOE was working with the regulatory authorities of the foreign countries to get those data. Larzelere said that CASL is working with China to get operational data on the AP1000s being built there. Matzie stated that such data gathering should include design changes, startup, and training during both construction, and operation.

Ion said that the world will have both pressurized-water reactors (PWRs) and boiling-water reactors (BWRs) in its fleet. There is great opposition in the United Kingdom to shut down any of this operating capacity. It is also taking a close look at small modular reactors and will be doing a close analysis of any and all proposed small modular reactors.

The discussion returned to the report of the International Subcommittee. Eisenhower called for acceptance of the recommendations.. Meserve moved acceptance, and Corradini seconded. The motion carried unanimously.

John Sackett was asked to report on the activities of the Facilities Subcommittee.

The purpose of the Facilities Subcommittee is to identify, prioritize, and make available those facilities important to nuclear-energy R&D. It considers facilities at national laboratories, universities, industry, and international centers. There have been many studies of needed facilities, but attempts to prioritize those lists have been frustrated because facility needs come and go. Previous studies have provided an excellent library of information. The facilities are well documented, deficiencies are noted, and levels of use are reported, with university facilities generally underutilized and national laboratories often oversubscribed. A consistent theme is the need to maintain U.S. expertise at a high level by conducting relevant research. The question is how to accomplish that goal with seemingly ever-changing priorities for facility-based research.

Since 2007, DOE and INL have been conducting a pilot program for the creation of a virtual-laboratory user facility. It provides a means for researchers at national laboratories, universities, and industry to access facility capabilities that would otherwise be unknown or unavailable. That pilot is the Advanced Test Reactor□National Scientific User Facility (ATR□NSUF).

The ATR was originally used by the U.S. Navy, but has been opened to universities and industry to conduct research on fuels and materials. It now contains the ATR Critical Facility, significantly upgraded examination equipment, a network of university partners who provide irradiation and examination capability, and connections to other user facilities. Westinghouse has joined as an operating partner along with three national laboratories and eight universities that have elected to participate. The benefit of self-

selection is that it draws capabilities that are both current and relevant, with demonstrated support from the parent institutions in the form of training and assistance to researchers who are interested in the use of a particular facility.

The pilot program offers

- Team visits at offered facilities to verify advertised capabilities and expertise
- Reviews by independent experts to confirm capability and need
- Training for researchers and use of facilities and equipment
- Assessment of research proposals to recommend the best facilities, considering capability, availability, and cost
- Subsidies for research on the basis of priorities and need

There have been 76 projects awarded, university and laboratory researchers have produced 114 research papers, and an average of about 90 people participate in users' week each year.

The scope of DOE interests in nuclear technology is much broader than materials development. Consideration should be given to including facilities that support other areas, such as criticality safety, thermal-hydraulic testing, ion-beam irradiation, and severe accident testing. Others who might be interested in participating are researchers of detector testing. The modeling and simulation community needs support in validation and verification. An expanded scope could help the user facility become the linchpin for this role. A library of fast-reactor test data is being compiled. With the expanded scope, a name change is in order, perhaps to the National Nuclear Scientific User Facility (NNSUF).

The Subcommittee had three specific recommendations:

- The NE pilot program for a virtual user facility, which began in 2007, should be expanded to include the use of all facilities important to NE's programs in nuclear-technology R&D.
- The scope of the user facility should be expanded beyond its present emphasis on materials development.
- The user facility should be prominent in the next update of the NE roadmap for nuclear technology R&D as the coordinating mechanism for nuclear-facility use and prioritization.

Corradini said that this program has been successful, and the expansion of it might be a way to connect experimental work with the validation of simulation and modeling efforts, thus connecting two programs that would be more successful together than separate. Sackett said that the ATF user facility is reaching out to others and adding expertise and instrumentation. They are finding that some facilities are underused and others oversubscribed, pointing to areas that need to be fixed. Bunn said that there was a broader, international activity: partnerships from many institutions to use one reactor. Many research reactors are being shut down because they have operated on highly enriched uranium. There is a new test fast reactor being planned in Russia. He asked whether the United States should become a partner in that effort. Sackett said that people do not know what test facilities are available. A role of the new user facility would be to market this capability. It could bring users to the United States to work at this user facility while making research capabilities known.

Lyons noted that no request for funding has been forthcoming for participation in the Russian reactor; the Office is actively engaged in providing training to their researchers. There is currently a nuclear review ongoing to restart the Transient Reactor Test Facility (TREAT) or the Annular Core Research Reactor (ACRR).

The floor was opened for public comment. There being none, the floor was opened for closing remarks from the Committee members.

Eisenhower noted that the Committee focused on communications and strategy. The nuclear community will need to concentrate on impressing on the public why nuclear power needs to be supported. Andrew Krepinevich and Barry Watts have written a book on military strategy, *Regaining Strategic Competence*. That book contends that the United States does not think strategically anymore and it lists the 12 biggest mistakes, among which is failing to set goals. The Committee should adopt a strategic perspective and align its goals and objectives with its resources. To be successful in getting more

funding for NE, this Committee needs to communicate what an increase in the NE budget would result in in terms of actionable improvements in U.S. and DOE policies.

Paperiello said that the Office is doing what it can. He could not recommend any reallocation, given budget restraints. In modeling and simulation, R&D is going in the right direction.

Matzie said that the most important activity to be focused on is getting across the strategic importance of nuclear power and technology.

Martin said that it is time for the nuclear enterprise to talk to the other industries in the country. The Secretary pointed out that the United States is once again the energy superpower. This drama seen today is the result of deregulation; all the externalities of electricity production need to be recognized and factored into costs.

Kazimi wanted to endorse the need to propagate knowledge of the benefits of nuclear power. Those involved in nuclear power and those in other countries need to be gathered together to get more benefit from the limited dollars available.

Barron suggested that, during the next 6 to 12 months, a method be devised to get some reports to spur action and show more leadership. In realigning needs and priorities, the CASL report was reassuring. That reactor is the most modeled one in the world. There is a lot of work to be done in modeling and simulation of future reactors.

Chu had two comments: She was very encouraged and pleased about DOE's actions on comingling waste and separating defense wastes. It will lower the obstacles and start showing Congress what can be done in the backend of the fuel cycle. Also, the international program has a high return on investment. A lot of emerging countries are interested in developing nuclear power. The United States should pick one country and develop a program with it to produce tangible results.

Juzaitis said that validation is important and it needs to be done in a strategic way. In the weapons program, weapons designers did the validation. In the reactor program, the nuclear engineers should do the validation and then turn the codes over to the universities for use. Nuclear power *is* a national-security issue. The governance of the NNSA is under review. A continual dialogue should be held within the nuclear enterprise.

Bunn said that the direction of the legislative branch is to separate things rather than integrate them. Training and regulatory authority are important contributions to emerging countries getting into nuclear technology. There is a big connection between the nuclear enterprise and exports. DOE should provide analysis to inform heads of the electricity market to bring more nuclear in.

Sackett pointed out that the action in energy policy is happening on the state and local levels. The information that they are relying on is not always reliable. DOE needs a strategy to develop reliable sources of power on the basis of decisions that are well-informed.

Sattelberger said that costs have gotten out of control; as a result, the Chemistry and Metallurgy Research Replacement (CMRR) project at Los Alamos National Laboratory was halted. The Office of Science gave $100 million to fund simulation and modeling. If that activity went over budget, it would be killed. SC has Lehman reviews to keep things on budget and on time. NE needs something akin to that.

Ion said that, like the United States, the United Kingdom has realized that nuclear energy (and a role in its international development) is important for national security as well as energy security. The United Kingdom is taking steps to revitalize the R&D that underpins its nuclear sector and has set up a Nuclear Innovation Research Advisory Board that will be populated by senior academics, industrialists, and government officials. She has been appointed to be its Chair. One of the first steps the U.K. Government has taken is to launch a study of the prospects for deployment of SMRs within the United Kingdom and globally and to determine the risks and the challenges to successful realization of this technology as an economic source of nuclear energy. Reality has to be shown to match aspiration before significant funds will be allocated. The rate and pace of change in the nuclear sector is increasing, especially in overseas markets like China and India. It is vital that the United States continues to have a global leadership role in reactor technology if the safety, regulatory, and operating regimes on the international stage are to continue to be influenced and driven by nuclear energy's founding nation. The importance of a joined-up

approach within Government to nuclear matters is vital; so, although NE may not have the lion's share of the budget, its role as a significant influencer of policy must be recognized and utilized.

Meserve complimented all the subcommittee leaders for excellent reports and great work. Two items were confused in the discussions: (1) the need to market nuclear technology; a long-term effort is needed here; (2) the short-term problem created by deregulated markets that do not value capacity Industry and the government need to get their arms around the immediate problem or more plants will close to the detriment of US electrical supply. He observed that this is a bigger problem than DOE or even the federal government can solve. Congressional legislation is needed; it has to address all fuel sources. Markets have been designed on entirely different assumptions than the current situation presents.

Lyons expressed the hope that the importance of the economic and national-security aspects of nuclear power is better recognized and he summarized the major points discussed at the meeting and ones that are well worth additional consideration in the Department. There is the possibility of involving FERC and the ISOs. Also, there should be closer ties with the Department of Defense and an understanding of their electric-power needs. There is a need for a stronger state and local involvement in energy policy. Validation came up many times; NEAMS and CASL could set validation priorities and strategy. Some validation problems are inappropriate for the university community, but some are appropriate. DOE has been holding discussions with the OECD's NEA to use its vast quantities of data to internationalize validation experiments. The current dry-cask storage system should be reviewed. There is a concern about getting data on dry-cask storage. Opening a dry cask and keeping its contents dry is an important but difficult problem; there is no such capability in the United States at this time. Developing a roadmap of International R&D on nuclear technology is an important idea. The United States should work to prevent corruption on international markets. Idaho National Laboratory is developing a library on radiation effects on materials. Communication channels need to be expanded and extended; DOE has small contracts on education and communication with the National Conference of State Legislatures and frequent contacts with the Energy Communities Alliance and with the National Association of Regulatory Utility Commissioners for developing better communication with education opportunities for decision makers (e.g., on what it would take to host an intermediate storage facility). He agreed with the comment on aligning goals and resources, a constant challenge. CASL needs to be tied into SMRs in the future. He personally was interested in funding CASL for another 5 years after defining new goals (SMRs are very much on that list). At the next meeting, there will be a discussion of comingling. There is a need to know what the International Program budget would fund and accomplish if it were expanded; it is a congressional line item. The IAEA has programs for helping developing countries; the Department of Energy is trying to develop a program with the Department of State and the U.S. Agency for International Development to help developing countries adopt nuclear power.

The meeting was adjourned at 3:59 p.m.

Respectfully submitted,
Frederick M. O'Hara Jr.
Recording Secretary
January 17, 2014