Report to NEAC

Fuel Cycle Subcommittee

Meeting of October 30, 2014

Washington, DC

December 1, 2014

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I. Introduction

The agenda for the October 30, 2014 Fuel Cycle Subcommittee meeting is given below. The meeting provided members an overview of various research efforts funded by the Department of Energy Office of Nuclear Energy (DOE-NE) Fuel Cycle Technologies (FCT) program and related research that is coordinated with the FCT program. As usual, the meeting started with a budget overview by Bill McCaughey. It also included a briefing on the Nuclear Energy University Programs which is managed by NE-4. All members of the Subcommittee were present.

Agenda

Chair: Dr. Alfred P. Sattelberger

Location: Argonne National Lab Offices, L'Enfant Plaza

8:45 Executive Session

9:00 Fuel Cycle Technologies FY2015 Budget Overview

9:15 Nuclear Fuel Storage & Transportation - Overview

10:00 Used Fuel Disposition – International Programs

10:45 Break

11:00 Deep Borehole Disposal Concept

12:15 Lunch

1:00 NEUP Programmatic Overview

2:00 Fuel Cycle Options Study & Software Demo

3:00 Multi-Physics Benchmark Evaluation & Validation and INL V&V Center Program Overview

4:00 Break

4:15 On-line Instrumentation H Canyon

5:15 Executive Session

5:45 Adjourn

Our report is organized more or less along the lines of the agenda.

II. Nuclear Fuel Storage & Transportation

During our Subcommittee meeting, an overview of current activities pursued by the Nuclear Fuel and Storage Transportation (NFST) Planning Project was presented by Jeff Williams, Director of NFST. Assuming the 100 reactors in the US continue to operate, spent fuel associated with these plants continues to accumulate at the rate of ~2000 MTHM annually in the US. The objectives of the current program, which is proposed to receive $35 M in FY15, is to lay the groundwork for implementing interim storage and associated transportation, including a pilot interim storage facility that would focus on accepting fuel from facilities located at shut-down reactor sites and a larger interim storage facility that could accommodate sufficient fuel to reduce expected government liabilities related to spent fuel. Both facilities would require legislation prior to being implemented.

Because legislation is required for full implementation, the program is undertaking activities within existing Congressional authorization to plan for the eventual transportation and storage of spent nuclear fuel. Activities include evaluating design concepts, but are designed not to limit the options of either the Administration or Congress and could be transferred to the new waste management and disposal organization when it is established. Many of these activities were recommended by the Blue Ribbon Commission (BRC), such as development of a database characterizing the input to the waste management program (e.g., the type and amount of fuel, the type of storage canisters, site conditions and infrastructure, etc.) and a data base characterizing prior waste facility siting activities in the US and abroad. Other activities include identifying what is required for railcar certification, interim storage facility system studies and design reviews, and development of a standardized storage cask design that would simplify transportation, storage, and disposal. A high-level, near-term program implementation plan with an execution strategy for NFST activities was developed and briefed to the Subcommittee (without any dates because of uncertainties relating to legislative authorization) to identify the overall requirements related to required activities, necessary interfaces, and the timeframe for completing such activities. This plan, which is useful for identifying activities that can be conducted now and the critical path for developing such facilities, is unclear regarding the time period necessary, after legislative authorization, before a pilot interim storage facility could be operational. Time did not allow for a discussion on the specific dates of the activities underway, and the Subcommittee wishes to explore the specifics to the extent possible at a subsequent meeting.

General Comments:

The Subcommittee understands the sensitive and challenging aspects of making progress in this area due to the lack of legislative authority to proceed with the development of a new approach to spent fuel and high level waste management. Most of the activities in the existing program are appropriate and necessary to pursue within the existing policy construct, and in anticipation of new authorization that may occur sometime in the future. Other activities seem less focused and need to be couched in the form of an overall approach to deal with specific policy implementation issues. In addition, many of the activities seem open-ended with no sense given when they might be completed in the future. Although we recognize the schedule challenges in this area, as well as the unsettled policy environment, we believe that it would provide more credibility to the overall effort if clear completion timeframes were given to ongoing and planned activities.

In addition, the program is focusing on preparatory activities for interim storage facility deployment necessary to inform future decision makers on the development on an integrated waste management system. The current activity of railcar certification is an example. If one has not been completed, the Subcommittee recommends a comprehensive assessment that identifies potential opportunities (e.g., technical, safety, regulatory) that could be addressed. If any such assessment has been completed, the Subcommittee would like to review and provide additional inputs in this area, as appropriate.

Specific Comments:

Our Subcommittee identified several areas of concern with the program as currently formulated:

- The current strategy for management and disposal of spent fuel and high-level radioactive waste sites target dates for deployment of a pilot interim storage facility by 2021 and a larger interim facility to be available by 2025. Emphasizing milestone dates that are likely unachievable, regardless of their source, undermines the credibility of ongoing activities. The effort would be better served by stressing the need to undertake activities to deploy a facility expeditiously. Schedule end-dates should be downplayed until specific authorization to undertake such a facility is provided through legislation.

- The discussion on the near-term program objectives to lay the groundwork for strategy implementation does not provide target dates to accomplish any of the objectives. The impression is left that all the objectives are essentially open-ended and will continue indefinitely. Program objectives traditionally have end dates when they are planned to be achieved, while program goal attainment is more nebulous. Recognizing that the details of all the activities could not be briefed in the requested overview, the sub-committee looks forward to a future more detailed briefing that describes specific time frames for completing these objectives.

- Although milestones and activities necessary to site, develop and deploy pilot and larger interim storage facilities for spent fuel were presented, several will be challenging to manage from a temporal standpoint (siting, NEPA, etc.), while other activities (design, construction, hardware development, etc.) will be more conducive to be managed to specific timeframes. It is suggested that the program continue to separate out the more institutional aspects of the activities, acknowledge their schedule vulnerability, and focus attention on the more manageable technical issues, activities and milestones.

- Activities that are necessary for the deployment of interim storage facilities for spent fuel were identified, but the Subcommittee was not given any sense about when the ongoing or planned activities are expected to be completed. It would be useful to provide some schedule information for completion of these activities.

- Activities for standardization of industry canister technology were identified that respond to previous recommendations by this subcommittee, the BRC, the Nuclear Waste Technical Review Board, and that have been funded with specific congressional language. It would be helpful to

brief the subcommittee on the results of the on-going technical assessment of this approach, including its benefits, that could be used for the 120,000 MTU of spent nuclear fuel expected to be discharged by reactors over their lifetime that has not been placed in dry storage.

- The $35 M FY15 funding, if authorized, will be split between the national laboratories and industry. Twenty percent of the funding is dedicated toward completing a design for adapting a facility at the Idaho National Laboratory so that it will be suitable for removing a small portion of fuel from the cask (TN-32) used in the high burn up demonstration project for examination. The Subcommittee observed that use of this facility will require acceptance by the State of Idaho.

DOE fully recognizes the need to work closely with the State of Idaho if it is determined that an existing facility is feasible for supporting the NE research and development program.

III. Used Fuel Disposition – International Programs

Within DOE-NE, FCT has initiated planning projects since 2012 to address the recommendations by the BRC which will lay the groundwork for the future development of storage and geologic repository facilities, as well as support the transportation infrastructure. The DOE/NE-53 has published a strategic plan in 2012 for the Used Fuel Disposition (UFD) International Program, with the four main goals being (1) to leverage global knowledge, (2) to increase global deployment of advanced technology, (3) to build a foundation for collaboration and joint action, and (4) to accelerate global learning and innovation. A presentation was provided to the Subcommittee by Bill Boyle, National Technical Director, UFD, on collaborations with international programs dealing with UFD R&D. A detailed report has been prepared this year outlining such multinational and bilateral cooperative activities, describing the opportunities, initiatives and status of the collaborations for UF disposal, storage and transportation; the observations and conclusions drawn below are based on the presentation mainly focused on UF disposal, which was an overview of this report.

The status of five key international disposal R&D projects, all implemented under large multinational initiatives that DOE has now joined, has been addressed, which the Subcommittee considers as almost fully exhaustive of the worldwide R&D activities on this topic; in FY 2014, the estimated budget spent abroad is $1 M of the $30 M of the UFD R&D campaign, which appears reasonable.

The Mont Terri Project is an international research project for hydrogeological, geochemical and geotechnical studies in a clay/shale formation that DOE formally joined in July 2012 with the opportunity of accessing numerous past, ongoing and future experimental data and conducting its own experiments. The US experiments include a Full-Scale Emplacement (FE) heater test for performance of geological disposal in clay in order to confirm system and process understanding, to validate coupled models and to demonstrate buffer emplacement

technology. Members of the Subcommittee concurred that the program is well structured with an impressive array of 16 country organizations, R&D being conducted to benchmark interpretative models of system performance based on observation of used fuel in various storage conditions. The Subcommittee recommends pursuing this fruitful collaboration, possibly with technical goals and planning being more focused and defined. The DECOVALEX Project (10 country organizations) is a long standing activity established in 1992 that DOE joined in 2012 with different stages focusing on modelling and analysis of existing data in clay and crystalline matrices; it should be mainly used in support of the Mont Terri results.

Colloid-facilitated radionuclide migration is studied in crystalline rock conditions at the Grimsel Test Site and within the Colloid Formation and Migration (CFM) project, which provides a unique opportunity of evaluating the migration behavior of real materials containing Na, Ba, Cs, Np, Pu and Am radionuclides in water-conducting features under realistic conditions. A DOE partnership started in 2012. Bentonite engineered barrier long term behavior (key physical properties, corrosion, mineralogical interactions at near-field) will be tested and interpreted until 2016 with the Full-Scale High Level Waste Engineered Barriers Experiments (FEBEX) and FEBEX-Dismantling Project (FEBEX-DP) also at Grimsel. In 2014, DOE joined the Swedish Nuclear Fuel and Waste Management Company (SKB) task force, an international forum for Groundwater Flow and Transport of Solutes established in 1992, and the Organization for Economic Cooperation and Development Nuclear Energy Agency (OECD- NEA) Thermochemical Database Project, which provides chemical and thermodynamic data relevant to safety assessment of radioactive waste repositories. The Subcommittee will continue to monitor progress gained with these international collaborations. Our initial review indicates that these collaborations should be able to provide responses to some fundamental questions and allow the US to assess our modeling tools and re-assess assumptions for nuclear waste disposal science and technology.

Bilateral agreements exist with China, Germany and ROK:

- China: This cooperative action with China includes deep borehole disposal concepts, with China possibly accepting a US test as discussed recently with the Beijing Uranium Geology Institute;
- Germany: The current joint memorandum of understanding allows the US to advance the basis for salt disposal; lessons learned from Gorleben site included in this agreement should also be useful to the US;
- ROK: Important tasks in this collaboration, within the disposition subgroup, include topics pertaining to waste storage and transportation and borehole research.

Based on the information presented in the meeting, the Subcommittee acknowledges the important work done to initiate and to establish new and active collaborations which now constitute a US portfolio of international activities in disposal science. The comprehensive

results should provide guidance to the US program, and support future actions and decisions. Although a consent-based siting process cannot be actively pursued in the US at this point due to legislative constraints, there are several international examples of this process that are of interest. For example, significant progress has recently been made in countries such as Switzerland or Canada, using a consent-based siting approach. Our Subcommittee recommends that the US program examine the lessons learned from these countries on these topics.

As a final point of interest, the format used to display the international agreements and arrangements was particularly easy to understand and should be used by others in presenting their international programmatic strategy.

IV. Deep Borehole Disposal Concept

The concept of using deep boreholes in geologic formations for the disposal of high-level radioactive waste has been considered in the US and elsewhere for decades. In the past, the concept was never seriously pursued because of the lack of drilling technologies appropriate for very deep geologic formations. In recent years, due to advances in drilling technologies by the oil and gas industry and lack of progress on the development of a mined geologic repository, this concept is once again under discussion as a possible disposal method. Bill Boyle, Director of the Office of Used Nuclear Fuel Disposition R&D, gave an overview presentation of the concept and the status of activities funded by DOE/NE.

The key features of the deep borehole concept consist of the following:

- Boreholes are drilled into crystalline basement rock down to about 5,000 m
- Waste could consist of DOE-managed waste forms including high-level waste or other specialized waste types
- Waste canisters would be emplaced in the lower 2,000 meters of the borehole
- The upper borehole would be sealed with compacted bentonite clay, cement plugs, and cemented backfill

The deep borehole disposal concept is believed to provide good isolation of radioactive materials from entering into the biosphere because of geochemically reducing conditions and low permeability and long residence time of high-salinity groundwater in very deep wells. In addition, crystalline basement rock formations are common in many stable continental regions (including most states in the US).

A borehole reference design has been developed by DOE-NE. The design includes borehole casing, liners, seals and plugs, canisters, as well as a waste emplacement device. The reference

design includes discussion of the potential retrievability of waste, given that current regulations require that waste must be retrievable.

The planned next major step in DOE's program is to deploy a field test to demonstrate the feasibility of the concept and to facilitate further research and development. The BRC has suggested that deep boreholes may offer benefits for disposal, but boreholes are a less well developed concept than mined repositories, and require further exploration (concurrent with development of an updated safety standard).

The field test will demonstrate the feasibility of drilling to a 5,000 m depth and the construction of the borehole. Key components include identifying candidate sites, obtaining field test permits, design and fabrication of canisters, borehole construction, and canister emplacement. Scientific and engineering studies will also be conducted as part of the field test, evaluating the feasibility of drilling technologies, verification of conditions at depth and wellbore stability, evaluation of materials, and testing of engineering methods for canister emplacement. The cost of the field test is currently estimated at ~$80 M and will take about 5 years. A Request for Information has been released. Given the importance and cost of this field test, it is recommended that a disciplined approach to data gathering be employed, such as the Data Quality Objective (DQO) process. The Subcommittee is encouraged that DOE-NE program managers have requested information regarding this process and are providing it to the project managers.

A number of ancillary benefits were discussed. The borehole field test is seen as a concurrent test of consent-based siting, a key recommendation of the BRC. There is also significant overlap with the technical interests in DOE's broader Subsurface Technology and Engineering Research RD&D Crosscutting Initiative, and the potential exists to coordinate with investments in other parts of the SubTER crosscut.

Comments:

The Subcommittee is appreciative of the potential benefits of examining deep borehole disposal, but believes that aspects of the proposed program could be better articulated. The mission of deep borehole disposal should be evaluated in the context of the overall waste management strategy. The Subcommittee is unclear regarding the priority given to the field test. The Department's Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Waste states that the Department intends to pursue a mined geologic repository as the centerpiece of its disposal efforts. Furthermore, Congress mandated through the Nuclear Waste Policy Act of 1982, as amended, that geologic disposal was the National Policy for the disposal of high-level radioactive waste materials. The Subcommittee recommends that DOE-

NE provide a clearer rationale in this context for the mission need (e.g., types of waste and requirements) for borehole disposal.

The cost and schedule estimates for the field test appear to be overly optimistic given the previously identified uncertainties (both regulatory and technical). The schedule and sequence of activities may need to be reassessed. For example, it may be premature to provide site selection guidelines without understanding the permitting requirements and identifying potential key scientific and engineering issues.

The presentation asserted that "*thermal-hydrologic modeling of a deep borehole disposal system has been coupled to an updated performance assessment model indicating no radionuclide releases within 1 million years*". Given the technical uncertainties identified in the presentation and BRC report, our Subcommittee was concerned that this could be the best case scenario. We recommend a comprehensive scenario analysis be performed early in the project, once a site has been selected. This will identify vulnerability of features, events, processes of the site as well as engineering components that may create release pathways for radionuclides. Information collected can be used to guide and prioritize project activities, as well as design risk mitigation strategies.

In addition, our Subcommittee stresses the importance of evaluating other factors, such as leveraging other DOE expertise and for co-locating this demonstration with the FORGE R&D site. These factors may impact the evaluation of criteria for siting, or drive site layout and design. Careful consideration should also be given to the cost-benefit tradeoffs.

V. NEUP Programmatic Overview

Funding for university nuclear science and engineering research, infrastructure and education programs is heavily dependent upon a single source for the vast majority of support, namely DOE. As a result, student enrollments in nuclear science and engineering education closely track funding support provided by DOE. In 2008, the American Physical Society's Panel on Public Affairs (APS POPA) studied the effect of DOE funding on university programs[1].

[1] See aps.org/policy/reports/popa-reports.

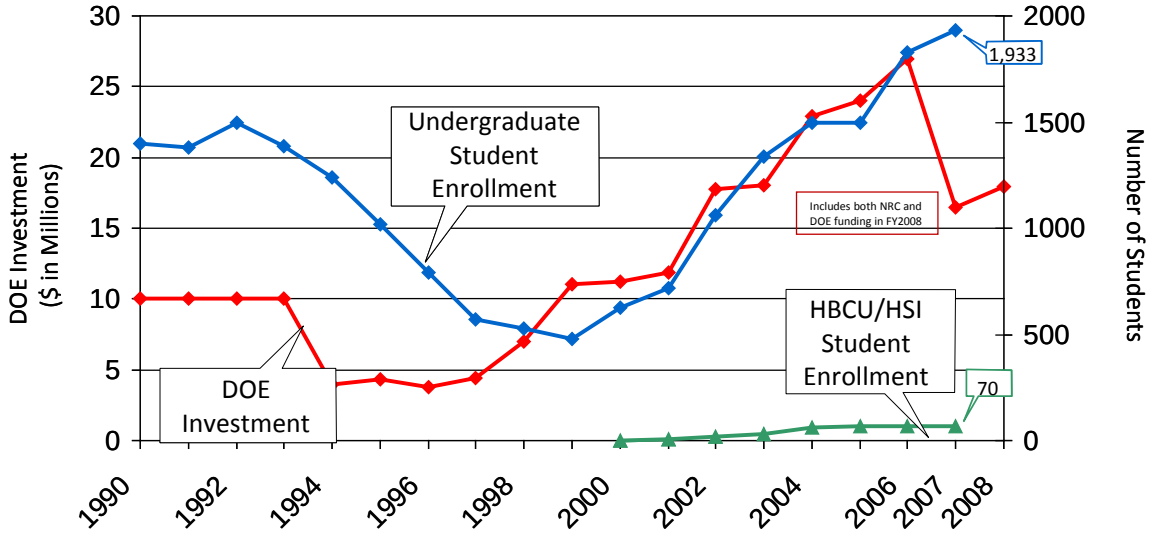

Figure 1. Past DOE investments in university programs and undergraduate enrollments in nuclear engineering[2].

As shown in Figure 1 from that report, as DOE's funding increased in the decade 1997 through 2007, undergraduate student enrollments in nuclear engineering increased in concert – quadrupling from a low point of 480 students in 1999 to a high of 1,933 in 2007.

As stated in the APS POPA report, "In 1997, the President's Committee [now the Council] of Advisors on Science and Technology (PCAST) issued a report that urged President Clinton to reinvest in university nuclear science and engineering research and education[3]. PCAST also urged him to establish the Nuclear Energy Research Advisory Committee (NERAC) [now called the Nuclear Energy Advisory Committee (NEAC)] to provide advice to DOE on this reinvestment. In the mid-1990s, the Clinton Administration recognized the potential for resurgence in nuclear technology, and constituted NERAC in 1998 to advise DOE as it began reinvesting both funds and management attention to rebuilding the educational infrastructure for nuclear engineering, health physics, and to a more limited degree, nuclear chemistry and radiochemistry."

After the success of a university research program called Nuclear Energy Research Initiative (NERI) that DOE instituted, NE decided that it had accomplished its mission relative to university funding. Thus, it requested zero dollars for both FY 2007 and FY 2008, except for a small amount allocated for university reactor fuel. Congress refused and allocated funding to university programs, although at a greatly reduced level relative to prior years. Congress also

[2] Data source: DOE.
[3] whitehouse.gov/sites/default/files/microsites/ostp/pcast-nov2007.pdf

began funding a university program at the Nuclear Regulatory Commission. This is all detailed in the APS POPA report.

Heeding the recommendations of the APS POPA report, in 2009 NE began allocating approximately 20% of its R&D budget to university programs. R&D projects and Scientific Infrastructure Support awards are awarded through an open, competitive solicitation process managed by NE's Nuclear Energy University Programs (NEUP) Office. Moreover, NE holds a Webinar and uses social media (LinkedIn, Twitter, Facebook, mass e-mail) to ensure that the solicitation is disseminated widely and questions about it are addressed. NE also provides undergraduate scholarships and graduate fellowships totaling approximately $5 M per year through the Integrated University Program (IUP), and provides university reactor fuel services, and maintenance of fuel fabrication equipment via the Research Reactor Infrastructure (RRI) program. To date, NEUP and IUP have awarded $343M to 97 institutions of higher education. These university support programs have provided a major boost to universities across the country. As an example, the number of university nuclear energy departments has increased from thirty (30) at the time of the APS POPA report to over 40 today. Thus, NE has enjoyed major success in rejuvenating university nuclear science and engineering research, infrastructure and education programs.

Although all US funding is limited to US universities, national laboratories and US incorporated industries, NE encourages international research partners. For example, NE has established a successful collaboration with Research Councils UK, with UK funding to date totaling ~$6 M, resulting in a significant research multiplier for a US investment of ~$18 M.

NE is continually taking actions and seeking feedback to improve its university programs. For example, it will send out a request in FY15 to solicit input for FY16 technical work-scopes. In FY2014, NE expanded the Scientific Infrastructure Support program to include awards to national laboratories in an effort to better integrate NE infrastructure awards.

The Subcommittee applauds the work that NE has done via its 20% funding allocation to university programs and recommends that it maintain that level of commitment in the future. Moreover, the management of the allocation of those funds has been exemplary. Leveraging the investment with international partners should continue. The Subcommittee further recommends that NE continue its commitment to "blue sky" university research, especially in the present climate of tight Federal funding that limits DOE laboratories from undertaking any significant amount of blue sky research. The Subcommittee also supports NE's efforts to establish traineeships for nuclear chemistry and radiochemistry. This will serve an important role in training the personnel necessary both to educate the next generation of nuclear chemists and radiochemists and perform the research needed to process fresh and used nuclear fuel.

Finally, the Subcommittee recommends that DOE study the pros and cons of widely distributing its research and infrastructure awards in its present open competitive process. There is no requirement for awards to be allocated primarily to nuclear engineering departments that bear the main responsibility for training the next generation of researchers to complete NE missions. Furthermore, an initial award to one university-led team may result in that team's developing or enhancing infrastructure for a particular research area; while a subsequent award on a similar topic may be given to a completely different team of researchers that may spend NE resources to develop duplicate capabilities. Hence, the process may preclude the ability of any team to develop an established long-term capability that NE can rely on for completing future missions. Along those lines, NE tasked the ATR NSUF program to develop and maintain a database of NE research capabilities to minimize duplication of effort. Our Subcommittee commends DOE-NE for initiating this effort to monitor university and national laboratory capabilities .

VI. Fuel Cycle Options Study & Software Demo

A presentation was provided to the Subcommittee on the Fuel Cycle Options Study; the final report and software are now publicly available. This constituted an update to the presentation provided at the May meeting, outlining resolution of additional discussions on the application of certain criteria and further discussion on the use of the Screening and Evaluation Tool (SET).

The study was originally chartered to define a set of criteria for evaluation of potential future fuel cycle options as alternatives to the current "once-through" fuel cycle, and to identify promising fuel cycle options for further development. The results of this study are intended to provide a framework and process to evaluate the impact of policy decisions and to provide information for prioritization of R&D relevant to domestic fuel cycle implementation.

Our Subcommitte was first briefed about this study during our May 2014 meeting. Since this initial briefing, the report on the study was finalized. The Subcommittee did not have adequate time to thoroughly review the report and appendices prior to our October 2014 meeting, but a number of questions on the use of criteria (and their implementation in the SET evaluation and screening software tool) were discussed in the course of the briefing.

The study employed nine evaluation criteria to evaluate 40 alternate "evaluation groups" (EG's). The nine evaluation criteria were specified by DOE and include six "benefit criteria" (areas in which benefits could be derived through improvements - nuclear waste management, proliferation risk, nuclear material security risk, safety, resource utilization, environmental impact) and three "challenge criteria" (where challenges may impact development and implementation - development or deployment risk, institutional issues, and financial risk and economics).

The presentation defined four groups as possessing the best combinations of "highest improvement" in the benefit criteria combined with "least challenge" when compared to the current US baseline; all involve continuous recycle, and none requires uranium enrichment.

Over the intervening six months between our May and October meetings, further discussions have taken place within the Department of Energy on the application of two of the benefit criteria – proliferation risk and nuclear material risk. In our prior evaluation of the project, the Subcommittee suggested that the overall functional level of the evaluation in the study could render these criteria less material, given that their assessment was dependent on the veracity of technology implementation. Indeed, the DOE sponsored a National Academy Study in 2013 ("Improving the Assessment of the Proliferation Risk of Nuclear Fuel Cycles") that concluded that there was strong disagreement on the utility of tools to inform nonproliferation decisions, given the significance of factors not easily incorporated into technical assessment methodologies (e.g., intent of host state). The limited application of this study and its associated software tool to US fuel cycle options suggested that these benefit criteria be given less weight. The number of metrics was reduced, and the metric data associated with these criteria were not included in the software tool. The Subcommittee understands the rationale behind this modification, and recommends that the executive summary of the report be modified to reflect this limitation (it is discussed adequately in the body of the report). We further encourage continued dialog within the Department to examine whether more useful criteria could be developed (e.g., cost associated with the development and/or implementation of appropriate safeguards).

The study suggests that only the nuclear waste management and resource utilization criteria were strongly affected by the choice of fuel cycle. This is not surprising; as noted previously, the study only evaluates the characteristics of fundamental fuel cycles (e.g., fast versus thermal reactors) and does not evaluate at specific technology levels (e.g., gas cooled fast reactor versus lead cooled fast reactor). For some of the evaluation criteria (e.g., safety, development risk) the differentiating factors may rely on the differences in specific technologies.

Overall, the study did not represent much new information or surprising insights on nuclear fuel cycle options. It does provide, however, extensive documentation for transparency of the process and credibility of the data. This vast information data base and cataloging will be very useful for DOE/NE as well as the nuclear community in general.

VII. Multi-Physics Benchmark Evaluation & Validation and INL V&V Center Program Overview

Dr. Phillip Finck, Chief Scientist, INL, briefed the Subcommittee about initial DOE-NE efforts to develop a US program plan for forming a knowledge and validation center. Over the past decade, NE has funded development of several new science-based "multiphysics" analysis tools

to reduce margins in systems analyses predictions, reduce the need for complex integral experiments, accelerate the research, development, and deployment process, and promote the understanding of basic phenomenology. The NEAMS Subcommittee and our own have previously expressed concerns about the need to validate these new DOE-NE modeling and simulation tools. If successfully implemented, the proposed program plan for establishing a knowledge and validation center would address this important need by establishing a framework to oversee validation efforts for the new modeling and simulation tools developed by DOE-NE. Furthermore, the proposed effort is planning to leverage a similar effort recently initiated at the OECD Nuclear Energy Agency, Nuclear Science Committee.

The program plan for this effort is still under development. However, initial ideas presented to the Subcommittee included the following elements:

- The need to establish standards and best practices for validation experiments
- The need to validate each aspect (microscale, mesoscale, and 'engineering' or macro scale) of a multiphysics code before it can take advantage of the 'science-based' approach and be extrapolated beyond the conditions over which the validation data are available
- The need to integrate and prioritize various code data needs
- The need for international coordination of validation experiments and developing appropriate benchmarking tests
- Preserving and using data from large, complex integral tests (e.g., the Loss of Fluid Test (LOFT) series, the Power Burst Facility (PBF) tests, etc.) that cannot be repeated due to their large expense
- Defining and designing new tests to obtain appropriate data not currently available

It is envisioned that the US program plan will be developed by a team that includes national laboratory, industry, the regulator, and university representatives. Candidate tests identified for near-term validation/knowledge preservation efforts presented to the Subcommittee included using data from LOFT, Chalk River Unidentified Deposits (CRUD), and fuel fission gas release tests.

The Subcommittee applauds DOE-NE FCRD for proactively starting to address this much-needed validation effort. Clearly, this effort is required before anyone will have confidence in predictions from new AFC modeling and simulation tools. We encourage the FCRD program to develop the program plan as a general framework that can be adopted by other programs within DOE-NE, such as the Reactor Technology efforts to develop new thermal hydraulic analysis tools and to enhance severe accident system analysis tools.

VIII. On-line Instrumentation H Canyon

Dr. Jim Bressee, Material Recovery and Waste Form Development (MRWFD) campaign manager, described a new program to perform an instrumentation evaluation by collaborating on an existing DOE Office of Environmental Management (DOE-EM) program to recover enriched uranium from the Material Test Reactor Fuel in H-Canyon at the Savannah River site. The presentation focused on activities with the goal to improve the separation process control through the use of advanced instrumentation. Such instrumentation is capable of enhancing real-time material balances based on the on-line measurement of concentration, valence and isotopics of key elements in a separation process. This program will be conducted as part of a DOE Environmental Management (EM) program to recover enriched uranium from research reactor fuel, which is a multi-year program.

The instrumentation testing and development plan is an innovative evolution which uses other existing programs, as described above, as a base for moving forward. The program will perform actual field testing of enhanced safeguards instrumentation to improve accountability during material recovery. The key features of this unique and innovative program are the combination of field testing during an actual material recovery campaign in an operating facility combined with the testing of improved measurement systems. The Subcommittee supports this effort for in-line measurements of the actinides of interest (e.g., U, Pu, and Np) and in sampling sites associated with future safeguards-by-design applications.

This program has the potential to shed light, and possibly answer a question, that has existed unanswered for more than thirty years, i.e., is it possible to account for a significant quantity of material during an actual material recovery activity? The problem of course is that a significant quantity is exceedingly small when compared to the normal through-put during a material recovery campaign in an actual plant; a target for such accountability measurements has been established by IAEA to be approximately less than one percent of the capacity of a commercial separations plant. In no way disparaging the value and uniqueness of this program, several important questions arise.

As presented to the Subcommittee, it appears that the program intends to perform a set of baseline measurements prior to installing the improved measuring systems. This will allow the experimenters to develop a baseline, and then to determine the effect of measurement improvements, over and above that of the baseline system. It was not clear from the material presented if the plan is to engage in a series of instrumentation improvement evolutions, or if only a single evolution is planned.

Another question arises with respect to the ultimate objective regarding enhancing real-time mass balance accountability. Is the objective in fact: (1) to account for a significant quantity, or (2) to determine the extent to which enhanced measuring systems can simply improve real

time accountability. The former, while more difficult than the latter, would be a significant breakthrough.

The Subcommittee recommends that the test planners, along with the DOE program manager, give some thought to (1) and (2) above and develop their test plan accordingly, especially in a 60+ year-old facility such as H-Canyon which operates today with much analog process instrumentation. Some thought should also be given as to whether a sequential series of instrumentation improvement evolutions is warranted and beneficial. This would be consistent with good test design practice as well with beginning with the end in mind. Possibly the use of Data Quality Objectives would help in this regard, and if so their use is recommended.

Despite the sensitivity of the subject, possible technical exchanges, even discussed at international level, could be of interest since other experimental or commercial material recovery facilities are operated in the US and worldwide, having this same goal of the improvement of separations process control through the use of advanced instrumentation and with various recovery processes such as PUREX, GANEX or ALSEP, as the practicality of the methodology would have to be independent of the process.