Report to NEAC

Fuel Cycle Subcommittee

Meeting of April 29, 2015

Washington, DC

June 26, 2015

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I. Introduction

The agenda for the April 29, 2015 Fuel Cycle Subcommittee meeting is given below. The meeting provided members an overview of various research efforts funded by the DOE Office of Nuclear Energy's 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. All members of the Subcommittee, with the exception of Margaret Chu, were present.

Agenda
Chair: Dr. Alfred P. Sattelberger
Location: Argonne National Lab Offices, L'Enfant Plaza

8:30 am	Executive Session
9:00 am	Fuel Cycle Technologies FY 2016 Budget Request overview
9:15 am	Separations Research and Development: Electrochemical Processing (Pyro) Technology
9:45 am	Joint Fuel Cycle Study system/application
10:45 am	Break
11:00 am	Domestic Program
11:45 am	Accident Tolerant Fuel Update - Overview/update - Test/evaluation Plans
12:45 am	Working Lunch - Stakeholder Tool for Assessing Transportation (START) demonstration
1:45 pm	Nuclear Fuel Storage and Transportation Select Topics - Interim Fuel Storage Concept Task - Standardized Transportation, Aging, and Disposal (STAD) Task
3:00 pm	Break
3:15 pm	Used Fuel Disposition R&D Update - High Burnup Demonstration Project - Deep Borehole Demonstration Project Status
4:15 pm	Executive Session
5:00 pm	Adjourn

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

II. Electrochemical Processing (aka Pyro) Technology and the Joint Fuel Cycle Study

The Subcommittee heard three complementary presentations, with the first being an enthusiastic overview by Patricia Paviet, program manager of DOE's electrochemical (EChem) processing program. As noted at a Subcommittee meeting several years ago, DOE prefers not to use the term "pyroprocessing" but instead uses "electrochemical processing" since it does not carry some of the connotations linked to complex high temperature technology. DOE pursues this program because, if fully demonstrated, it would be crucial to reducing the long-term radiotoxicity and heat load of high-level wastes emplaced in a geologic repository. Moreover, there is the possibility for the recovered actinides (all TRU together or only U-Pu depending on the EChem potential) to be reprocessed into new reactor fuel. The Subcommittee was happy to see the involvement of university programs in the overall EC research activities. Specifically, contributing universities include the University of Utah, University of New Mexico, University of Wisconsin-Madison, Ohio State, Virginia Commonwealth University, and the University of Tennessee-Knoxville.

Currently, the EChem program is divided into two parts: a $1 M core domestic program, which seems a bit underfunded, and the $7 M Joint Fuel Cycle Study (JFCS). Mark Williamson (ANL) described the domestic program and Mike Goff (INL) described the JFCS. In addition to EChem studies, the JFCS program also investigates safeguards and security issues and alternatives to fuel recycling, such as long-term dry-cask storage.

Started in April 2011, the JFCS consists of the following three phases:

Phase I Already completed in 2013, it demonstrated the laboratory-scale EChem processing of about 100 grams of used nuclear fuel.

Phase II Over the next five years, it will integrate the testing of EChem recycling in a DOE facility beginning with used LWR oxide fuel, culminating in U/TRU recovery for fuel fabrication in Phase III. The plan is for a kilogram-scale demo.

Phase III Over the next three years following Phase II, this phase will involve using fuel fabricated from recycled LWR fuel for irradiation and post-irradiation examinations (PIE).

Historically, EChem processing has been aimed at electrorefining used metallic fuel. Figure 1 shows a general schematic of the process. However, current technology has allowed it to be applied to used oxide fuel as well, which is more relevant for U.S. commercial reactors. To accomplish this, an electrolytic reduction step must be introduced into the EChem processing flowsheet (Figure 2), to convert the oxide fuel to base metal. Electrorefining then partitions actinides from the fission products, where the latter can be recovered from the system in subsequent processes.

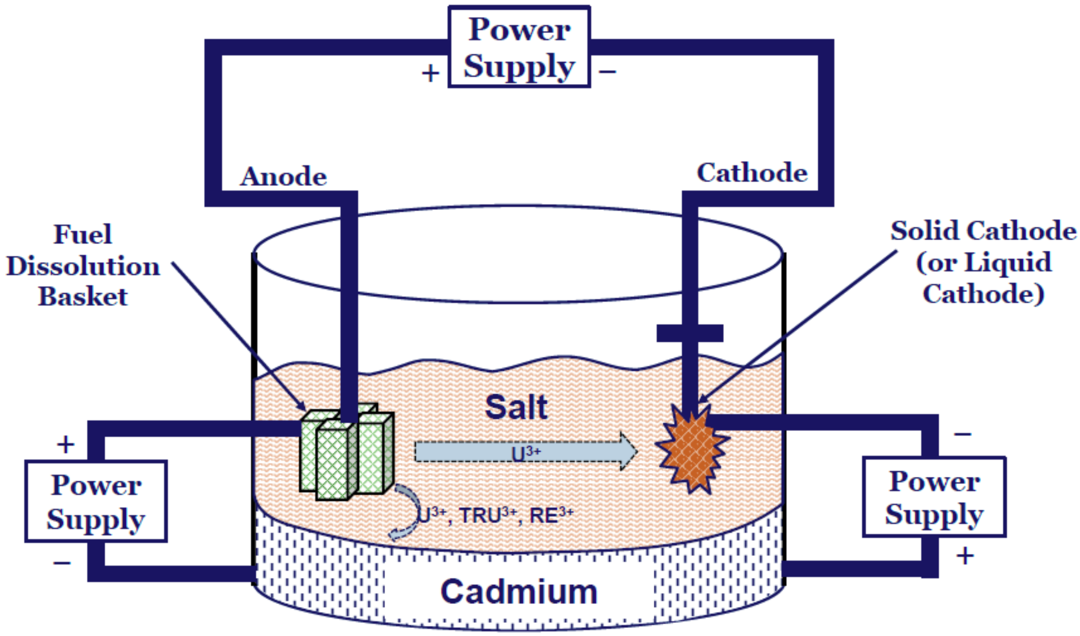

Figure 1. Electrorefiner

DOE believes that salt recycle could reduce the amount of EChem processing salt waste by a factor of up to six. Using electrolysis, researchers can recover actinide metals from the molten salt solutions. However, initial theoretical studies suggest that the better the actinide recovery, the poorer the separation between the actinides and lanthanides. For 99.9% Americium (Am) recovery, the majority of the Lanthanides (Lns) will co-deposit. For 65% Am recovery, one obtains almost complete separation of the Lns. This is an issue that will be investigated further.

The Subcommittee is pleased with the progress made to date on EChem processing. We think that the $1 M budget for the domestic program is too low, although we are not ready to endorse the $5 M suggested by the research team. Rather, we recommend that a phased increase in the domestic budget. This seems more appropriate. The JFCS is an excellent addition to the DOE international portfolio of programs and should continue to be supported. On a number of issues, the Subcommittee recommends that more laboratory-scale research be done before moving to engineering-scale studies. One such issue concerns the dependence on input parameters of the Am/Ln composition in the molten salt recovered for possible recycle. On another note, the Subcommittee looks forward to hearing from the aqueous reprocessing team at a future meeting.

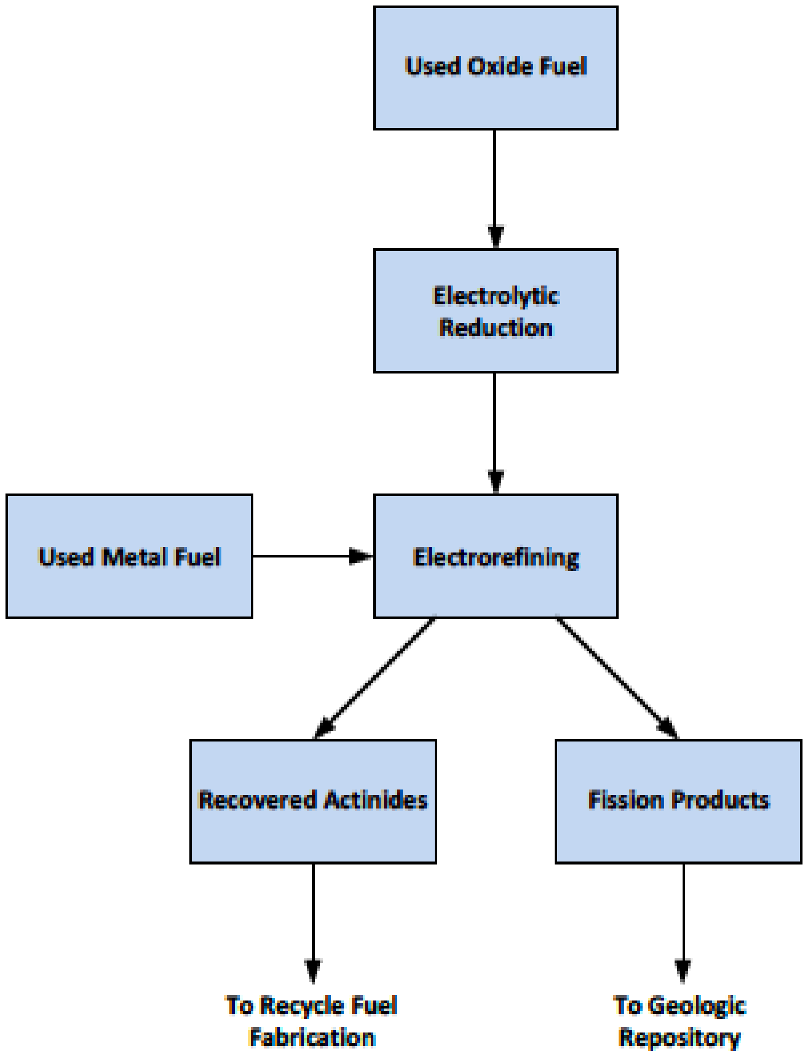

Figure 2. Electrochemical Processing Flowsheet

Despite the fact that aqueous reprocessing and EChem are completely different technologies, it would be interesting to see comparisons between the two in terms of expected performances, technology maturity levels, deployment challenges, and non-proliferation objectives. Such comparisons would be most appropriate when linked with the nuclear fuel cycles identified as most promising in the Nuclear Fuel Cycle Evaluation and Screening Study that DOE recently produced.

Finally, the Subcommittee applauds the collaboration of NE and NNSA (NA-24) in the application of “Safeguards by Design” to the EChem recycling process investigated and developed as part of the Joint Fuel Cycle Study. This may be one of the first examples of a collaboration that we have seen between these two DOE elements that may shed some technical light on the issue of (relative) proliferation “resistance” or proliferation risk attending fuel cycle alternatives. Given that such deliberations are typically driven by qualitative arguments, a technical investigation with quantitative outcomes would be welcome. However, it would be most valuable for the study to go beyond flowsheet analyses of material balances, to actually deploy candidate safeguards technologies in bulk experimental flow/processing systems to better understand the precision with which actinides and/or transuranic materials could be accountably tracked. We were disappointed to hear that the overall dedicated resources for these studies were limited, and encourage the collaborating parties to seize the opportunity to make a significant contribution in this regard.

III. Progress on Accident Tolerant Fuels (ATF)

Background. The program is functioning consistent with Congressional direction. This was provided in the Consolidated Appropriations Act of 2012, which stated that priority is to be given to developing enhanced fuels and cladding for Light Water Reactors (LWRs) to improve safety in the event of accidents in the reactor or spent fuel pools. The direction also indicated that special technical emphasis and funding priority was to be given to activities aimed at the development and near-term qualification of accident tolerant nuclear fuels that would enhance the safety of present and future generation LWRs.

ATF Program Goals and Accomplishments. Consistent with the direction provided above, the goal of the Fuel Cycle Research and Development (FCRD) ATF program is to insert a Lead Fuel Rod (LFR) or Lead Fuel Assembly (LFA) into a commercial reactor by 2022. This is a top-level, over-riding goal for the ATF program. To support and achieve this goal, activities within the program have been reorganized to more fully focus important technical expertise on the goal.

Supporting this goal, the program achieved a major milestone on February 10, 2015 with the insertion of "rodlets" for four ATF concepts into the Advanced Test Reactor (ATR) as capsule tests. Three of the concepts were developed by fuel vendors (AREVA, GE, and Westinghouse) and one by a DOE national laboratory (ORNL). This is a very significant milestone for which INL, the lead laboratory and overall test manager; and the four fuel developers should be complimented.

Current Status of the ATF Program. The program is currently in the feasibility assessment phase and is exploring multiple ATF concepts. These concepts are at varying technology levels of maturity. In 2016, the concepts will be prioritized and selected for the next development and qualification phase based on rigorous technical evaluation (using the metrics developed by the program in 2014), DOE-NE procurement process requirements, and vendor products developed for the evaluation phase. Other concepts showing significant promise, but requiring more development before consideration for insertion into a commercial reactor, may be carried forward as these concepts could offer other possibilities for improving the safety envelope of LWRs.

The significance of the February 10, 2015 milestone should not be understated as it is an essential step on the pathway to the 2022 milestone to insert a LFR or a LFA into a commercial reactor. Nonetheless, it is only the first step and additional tests, such as instrumented tests in a flowing loop, will be required in order to proceed successfully along this pathway.

Maintaining schedule along this development and qualification phase is all important and it is possible that some of the concepts may be eliminated because of their inability to adhere to the necessary schedule drivers.

Assessing ATF Capability Analytically. It has been determined that a key attribute of ATF is the ability to extend the time before initiation of the exothermic oxidation reaction associated with hydrogen generation and before fuel or other core components relocate. At the December meeting of the full NEAC committee, several members questioned the ability of the program to evaluate the safety of proposed accident tolerant fuel without actually evaluating the benefit of such fuels during severe accidents. State-of-the-art plant systems analyses codes, such as the NRC-sponsored MELCOR code or the EPRI-sponsored MAAP codes were mentioned as possibilities. It was subsequently decided to use the computer code MELCOR as a starting point for applying systems analysis tools to assess this capability, and the initial results were presented at the recent April 2015 meeting of the FCRD Subcommittee. Several members of the Subcommittee questioned the usefulness of this MELCOR application, particularly its ability to provide accurate information given the uniqueness of the ATF designs and the absence of accurate input data for the materials used in these designs.

For example, the candidate fuels under consideration by the program employ unique attributes to increase the time to melting such as coatings on zirconium cladding, different cladding alloys such as Fe-Cr-Al alloys, as well as silicon carbide ceramic matrix composites. The absence of accurate thermo-physical data for these materials limits the utility of current models in MELCOR to assess the benefits of proposed candidates.

However, the limitations associated with thermo-physical properties for MELCOR should not allow one to overlook two possibly important facts. First, at the temperatures calculated, other core materials may be at a temperature where they are no longer intact and able to perform their function. And secondly, there are other sources of hydrogen or other combustible gases that can be produced during a severe accident.

Discussion and Implications of MELCOR Results. In our May 2014 report, we expressed concern that the safety of LWR plants could not be determined solely by enhanced accident tolerance of the fuel. During a beyond design basis event or 'severe' accident, the performance of other core components may be equally important. One example would be relocation at lower temperatures of control rod materials that could result in a loss of reactivity control, while another would be oxidation of BWR channel boxes and other steel structures that could result in hydrogen production.

The Subcommittee reviewed initial results from MELCOR analyses comparing peak temperatures of proposed accident tolerant fuels with temperature predictions from existing fuel designs. The calculations used the TMI-2 accident scenario as the basis for this analysis. Without Zircaloy in core components, the calculations showed lower peak fuel temperatures because exothermic reactions associated with Zircaloy oxidation were eliminated. Such results may overstate the potential benefit of proposed cladding concepts with SiC coating over-layers because they may still exhibit oxidation of the underlying Zircaloy layers. In addition, there are as yet unknown uncertainties in predicting the high-temperature performance of SiC coatings on the Zircaloy. There are likewise uncertainties in predicating the high-temperature performance of ferritic stainless steel cladding materials. Examples would be the absence of accurate high temperature data needed to characterize oxidation, materials interaction phenomena of the proposed cladding materials in steam environments, and the ability of proposed claddings to withstand re-flooding without degradation.

Nevertheless, important insights from systems analysis codes can be obtained with respect to the enhanced safety margin possible with proposed accident tolerant fuel by considering the response of other core components. But such insights require an accurate portrayal of the behavior of the Zircaloy remaining in the fuel cladding and other fuel assembly components and the potential for oxidation of other core components. Analyses to obtain this data would require appropriate nodalization of radial and axial locations, a consideration of hydrogen generation from all Zircaloy and stainless steel components within the core, as well as an assessment of the survivability of core control materials, core support structures, and structural fuel assembly components. Given these challenges, it is important that analytical models be appropriately applied (and developed, where needed) to assess the safety case and economic benefits presented by teams proposing accident tolerant fuels.

Capsule Irradiations in the Advanced Test Reactor (ATR). As noted above, irradiation testing was initiated with the ATF-1 capsule tests in ATR. The intent of these tests is to assess fuel-cladding interactions. Desired temperatures for these tests range from 670 to nearly 1760 °C. Although pre-test analyses are performed to predict peak temperatures during irradiations, PIE results from some prior FCRD static capsule irradiations have indicated higher peak temperatures than predicted in these pre-test calculations. Temperature monitors were included in the Westinghouse fuel rodlets. However, other developers will need to consider temperature uncertainties in evaluating irradiation results.

Future irradiations include loop tests with instrumented capsules at the ATR (ATF-2) and the Halden reactor (ATF-H) and transient testing at the TREAT reactor. Efforts are underway to select candidate instrumentation for measuring parameters, such as changes in fuel length, diameter, and temperature during irradiation, with the intent that the instrumentation will perform adequately at the anticipated test conditions. An instrumented lead test capsule design effort is underway to consider candidate instrumentation types for inclusion in ATF-2 and ATF-3.

Summary and Conclusions. The ATF program is to be complimented on accomplishments to date, particularly the insertion of capsules containing rodlets for the selected ATF concepts into the ATR. The Subcommittee supports the efforts to ensure that qualified data for as many parameters as possible are obtained from these irradiations. Although there were questions about the utility of existing analytical tools to evaluate fuel concepts, the fact that other core and structural components are at risk and that other core components can result in combustible gas generation at such temperatures are important outcomes of these analyses. Because of the importance of this area and the integrated performance of fuel, structural materials, and other core components, this area will be reviewed in more detail at the next Subcommittee meeting, which will also include participation from the Light Water Reactor Sustainability program to discuss analytical tools being used or developed under that program.

IV. Stakeholder Tool for Assessing Transportation (START)

The Subcommittee appreciated Erica Bickford's presentation on the START tool and its many capabilities. The tool can be a powerful educational instrument for interacting with *knowledgeable* stakeholders regarding the options for routing both truck and rail shipments of high-level radioactive materials and the potential impacts of those shipments. In addition, the START tool can be very useful in identifying routes for Section 180(c) training funding allocations, in anticipation of future shipments.

This tool is only intended for use by Local, State, and Regional officials in the planning, security, safety and emergency response responsibilities for routing used nuclear fuel and high level waste shipments. We note that the full NEAC also received a briefing on this tool during on June 5, 2014. During our briefing on this tool, we learned that it is still under development and will evolve with improvements as feedback is provided from stakeholder engagement.

Highway Shipments:

The tool does not appear to specifically address the DOT Federal Highway regulations and their impact on the shipment of high-level radioactive materials. Hence, the user should be knowledgeable in DOT regulations or the tool should include a built-in tutorial on DOT regulations or a route-limiting algorithm that keeps highway route selection in compliance with those regulations. Otherwise, the tool could mislead the user regarding what is legally required. In this regard, those highway routes that have already been selected by States for the movement of these materials should be hard-wired into the program.

Rail Shipments:

Since all rail shipments will take place on privately owned track, the selection of the rail routes will essentially be undertaken by private railroads. Again, unless the user is knowledgeable on DOT regulations, a tutorial on the process of rail routing and the limitations on track class and availability is essential to understanding how the rail routing process will work. Track class limitations should also be hardwired into the program.

START Program Disclaimer:

Regarding the disclaimer that is presented with the program, it should be substantially expanded to clearly outline the limitations of the model and the data that support it. The amount and types of data that the program presents will continually change. As such, the user needs to be informed that the information may not be current and is subject to substantial variation from what is presented. In addition, the disclaimer should address the limitations of the shipper of high-level radioactive materials regarding routing for both highway and rail shipments (see above).

Risk Analysis:

It was unclear from the presentation and viewgraphs what is meant, or intended to be conveyed, regarding the assessment of risk for each analyzed route. General accident rate statistics over a particular highway route or railway route can be presented, but are probably not applicable to escorted shipments (highway) or dedicated train shipments (rail). As such, accident risk factors would probably not be useful and can be highly misleading. If general accident rates are to be used in the risk assessment numbers, a disclaimer should be provided to the effect that they may be inflated since specific accident risk numbers for escorted truck shipments and dedicated train rail shipments are not yet available. Regarding radiological risk, the amount of radiological exposure to a passing shipment either on a highway or rail car is negligible and probably should be excluded. In summary, the risk aspects of the model should be carefully thought out before inclusion, even as a theoretical proxy.

V. Nuclear Fuel Storage and Transportation

The Department is pursuing a variety of activities related to the implementation of interim storage facilities. Design concepts for the facilities are being conceptualized and evaluated, as well as activities intended to standardize containers for storage, transportation and disposal of spent fuel. These activities are being undertaken in anticipation of new legislation that would provide authorization for implementation. As discussed at the briefing, the potential for the enactment of such legislation in the near term is unclear. The Department is also evaluating concepts to develop a standardized spent fuel canister for the industry that could be used for spent fuel storage, transportation and disposal – STAD. The rationale for implementing such an approach is to 1) minimize the amount of repackaging; 2) reduce total system-wide costs; 3) streamline fuel handling and licensing; 4) increase flexibility, and 5) reduce waste acceptance liability.

Interim Storage Facility Design Development:

The rationale presented for the pursuit of Consolidated Interim Storage facilities addressed the President's Blue Ribbon Commission, the Administration's published strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Waste, and the March 24, 2015 Statement of Secretary Moniz. The Department should clarify that, in order to site and construct such facilities, new authorizing legislation will be required.

The Department indicated it is pursuing a canister-based storage facility and will give priority to the receipt of canistered spent fuel from shut down reactors. Part of the rationale for pursuing this approach is the intent to reduce the growth of the liability of the Department for its failure to meet the requirement in the Standard Contract to begin to receive spent fuel for disposal by January 31, 1998. Although the Department has the authority under the Standard Contract to give priority to the removal of spent fuel from shutdown reactors, it is incorrect that such spent fuel receipt would necessarily reduce the liability that continues to grow each year. To reduce that liability, spent fuel would need to be removed from reactor sites in accordance with the Oldest Fuel First (OFF) priority. Deviation from that ordering could exacerbate the liability.

In addition, the Subcommittee observed that many design decisions may be hindered due to uncertainties in requirements associated with ultimate storage facility and in regulatory requirements. For example, on-going discussions with the regulator about revising the definition of 'retrievability' from an assembly to a canister basis could impact facility design optimization. The program plans to down-select to a non-site specific generic design and submit a topical report to the NRC. It is anticipated that the NRC safety evaluation report issued in response to this topical report will have defined regulatory requirements. Last, our Subcommittee notes that two industry-led efforts to develop Interim Storage Concepts have been announced. It is unclear to the Subcommittee how the DOE-funded design effort is coordinated with these two industry efforts.

NFST Standardization and Integration Activities:

Although a STAD concept has merit in certain applications, previous comprehensive system analyses have shown that the smaller the canister deployed to utilities, the more handling and system wide dose occurs and the greater cost to the Government for implementing the system. For the Yucca Mountain TAD concept, the 21 PWR/44 BWR canisters were not optimal, and a larger size would have been more efficient from a dose and overall cost standpoint.

Regarding the disposal aspect of the STAD, it is unclear to the Subcommittee how much more concept development can be undertaken without a firm understanding of the ultimate repository geochemical characteristics, as well as an understanding of the licensing strategy to avoid long term criticality events in the underground. In other words, the geometry of the ultimate waste package, as well as the structure and amount of poisons placed in the package must be known in order to assure a STAD design will be compatible with any criticality licensing strategy. Absent the above necessary information, any STAD design will proceed at substantial risk. Accordingly, the Subcommittee recommends that further work on the STAD concept be deferred until a final repository site is identified and under development.

VI. High Burnup Dry Cast Storage Research and Development

DOE is co-funding a full-scale "High Burn-up Dry Storage Cask Research and Development Project (HDRP)" to provide the technical bases for the behavior of high burn-up fuel (>45 GWd/MTU) during long term storage. This project is led by the Electric Power Research Institute in collaboration with AREVA Federal Services, Dominion Virginia Power, AREVA fuels, Westinghouse Fuels, NAC International, and several national laboratories (ANL, INL, PNNL, SNL, and SRNL). The project will use a Transnuclear (TN)-32 bolted metal cask that will be placed on a storage pad at Dominion's North Anna Power Station. The cask will include three different kinds of high burn-up fuel /cladding: Westinghouse fuels with Zircaloy-4 cladding; Westinghouse fuel with Zirlo cladding, and AREVA fuel with M5 cladding. The TN-32 cask lid will be modified to allow insertion of thermocouple lances for obtaining axial and radial temperatures. The cask lid is also designed such that samples of gas inside the cask cavity can be taken to determine if fuel has failed during drying or storage, if residual water after the drying process is present, if any of the helium backfill gas has escaped, and if oxygen is present.

Prior to loading the cask, twenty-five 'sister' fuel rods will be removed from assemblies for detailed nondestructive and destructive examinations. These characterization examinations will provide essential information about the initial state of the high burnup rods and the fuel contained in the rods prior to the loading, drying, and long-term dry storage process. Similar tests will be performed at the end of the long-term storage period to identify any changes in the properties of the fuel rods during the dry storage period. Fuel cladding properties to be measured include: zirconium hydride concentration and orientation, cladding metal and oxide thickness, internal gas pressure, ductility, and the amount of creep that the cladding will experience prior to rupture.

In general, the Subcommittee found the HDRP to be a well-thought-out project. It is planned to use HDRP data to address aging management programs required by the U.S. Nuclear Regulatory Commission (NRC) in response to license renewal requests for high burn-up storage. Clearly, HDRP data will be applicable to the fuel /cladding combinations included in this demonstration. However, the Subcommittee was informed that licensees will need to demonstrate the applicability of obtained HDRP data for other fuel types to the NRC. The HDRP includes activities to support "cross-cutting" extended storage data needs. For example, data will be collected to gain insights about the performance of cask internals and the adequacy of existing drying methods to remove sufficient water during drying and storage.

The project is on an accelerated time schedule. Sister rod extraction processes are underway, and a License Amendment Request (LAR) will be submitted to DOE in July 2015. NRC review activities and cask loading and emplacement activities are scheduled to be completed in 2017. Although it is not anticipated to affect the schedule of initial HDRP activities, DOE informed the Subcommittee that the selected site for examinations of the sister rods and post-storage evaluations has not been finalized. Initial plans to complete these inspection activities at the Idaho National Laboratory may be possible, but alternate sites are under consideration.

VII. Deep Borehole Demonstration Project Status

The concept of using deep boreholes in geologic formations for the disposal of high-level radioactive waste has been considered and debated in the U.S. and abroad for decades. In the past, the concept was not 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 under discussion again as a possible disposal method.

Tim Gunter, program manager for Disposal R&D, 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 to about 5,000 meters
- Waste could potentially consist of DOE-managed waste forms, including spent fuel, 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 expected to provide good isolation of radioactive materials from entering into the biosphere because of geochemically reducing conditions, as well as the low permeability and long residence time of high-salinity groundwater at 3,000-5000 meter depth. In addition, crystalline basement rock formations are common in many stable continental regions (including most of the states in the U.S.). 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 until NRC review is complete.

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 field test will demonstrate the feasibility of drilling to 5,000 meter depths 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 estimated to be in the vicinity of $80 M and will take approximately 5 years. A Request for Information (RFI) was released on October 24, 2014 and a draft Request for Proposals (RFP) was released for comment on April 7, 2015. Responses to the latter are due May 7, 2015.

This is not a new topic for the Subcommittee. As stated previously, we find the deep borehole disposal concept has merit, but should be evaluated in the context of the overall waste management strategy. The cost and schedule estimates for the field test appear to us to be overly optimistic given the previously identified regulatory and technical uncertainties. We again recommend that a comprehensive scenario analysis be performed early in the project, once a site has been selected. This will identify the 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.