UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

TECHNICAL WORKSHOP ON THE IMPACTS OF
DRY-STORAGE CANISTER DESIGNS ON
FUTURE HANDLING, STORAGE, TRANSPORTATION AND
GEOLOGIC DISPOSAL OF
SPENT NUCLEAR FUEL IN THE UNITED STATES

Monday

November 18, 2013

Embassy Suites
1250 22nd Street, NW
Washington, DC 20037

OFFICIALS OF THE NUCLEAR WASTE TECHNICAL REVIEW BOARD PRESENT

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P R O C E E D I N G S

1:00 p.m.

EWING: Welcome to the Nuclear Waste Technical Review Board's workshop on the impacts of dry storage canister designs and the handling, storage, transportation, and geologic disposal of spent fuel in the United States. I’m Rod Ewing, the Chairman of the Board.

I'll discuss the Board's mission and introduce the other members of the board in a moment, but first I want to describe what we have planned for this two-day workshop and why we believe it's important and timely.

First, the broad overview. This afternoon, in order to be sure that everyone has the same information, we will start the workshop with four technical presentations on current practices and likely trends in the storage of spent nuclear fuel. Tomorrow, building on this background, we will attempt to identify the impacts of such practices on the storage, transportation and handling, and disposal of spent fuel. In order to facilitate a discussion, Board staff have prepared a framework document that outlines a number of the important issues, and there are copies of this framework document out on the tables just outside the entrance to this room.

The Board started examining these issues about two years ago as part of our ongoing review of DOE activities.

And since then, important issues have emerged that we believe should be examined for their potential impact on the management system as a whole. These issues are important regardless of any specific site for a geologic repository. And while much of the discussion will focus on commercial spent fuel, we also consider the impacts of DOE spent fuel.

For example, we know that unless the large dry storage canisters that utilities use for storing spent fuel can be directly disposed of in a geologic repository, it will be necessary to repackage, that is to transfer the spent fuel into waste packages designed for geologic disposal. Repackaging the spent fuel will take time and will involve handling operations, and there are number of important impacts including the potential for increased radiation exposure to workers and the generation of low-level waste.

On the other hand, we also know that direct disposal of large dry storage canisters loaded with spent fuel presents a number of significant challenges. Issues related to geologic disposal of these large dry storage canisters include retrievability and heat load effects on the design of the repository, such as constraints on the thermal response of buffer materials and the near-field geology.

As many of you know, the Board has long emphasized the importance of looking at how one part of the nuclear waste system affects the other parts or is affected by the other parts of the system, and, clearly, the issues that I've just mentioned have significant system-wide impacts. The Board believes that by discussing the implications of the issues in a workshop we can increase the common understanding of consequences and identify issues that will need to be addressed in future decision making. The Board also believes that the timing of this discussion is important, because the spent fuel inventory increases with each passing day.

Following the workshop, the Board will publish a report that we hope will advance the understanding of this problem and inform decision makers, particularly--or especially--from a technical perspective.

Many organizations and entities will need to be involved in some way in the storage and disposal of spent fuel. Some are federal agencies, and three of those agencies are participating in this workshop: The Department of Energy, the Nuclear Regulatory Commission, and the Board itself. I want to acknowledge the input we have received from DOE and NRC in planning this workshop, and thank both agencies for their participation. In particular, we appreciate that Dr. Peter Lyons, the DOE Assistant Secretary for Nuclear Energy, has agreed to open today's proceedings; and that Dr. Allison Macfarlane, the NRC Chairman, will close this afternoon's session with her perspective on these topics.

Of course, there are many other agencies, entities, and organizations whose views are critically important, such as the EPA, the Department of Transportation, Nuclear Utilities, industry entities, such as the commercial cask vendors, regional governments, non-governmental organizations, and the interested and affected public.

Over the next day and a half, we look forward to hearing from representatives of these many very different organizations as well as from concerned citizens, and I want to emphasize we've organized this workshop to maximize participation. Particularly tomorrow, individuals from these different organizations should seize the opportunity to participate and raise their concerns and express their points of view.

Now let me briefly describe the Board's mission and introduce the members of the Board. The Board's an independent federal agency in the Executive Branch. We are not part of DOE or any other agency or organization. The Board was created in 1987 by the amendments to the Nuclear Waste Policy Act. Our charge is to perform objective ongoing and independent evaluation of the technical and scientific validity of DOE activities related to implementing the Nuclear Waste Policy Act. The Board reports its findings, conclusions, and recommendations to Congress and to the Secretary of Energy. For those who are interested in a one-page handout, our summary of Board charge and activities, there's a handout on the tables outside, and the handout includes a list of the Board members and a brief description of each.

Now I want to introduce the members of the Board. Normally this is very easy, because we're separated from the audience; we exist in some "V" formation at the front of the room. But, again, to encourage interactions, the Board members and staff members are spread among the audience, so I'd ask them to raise their hand so that we can identify them as we go along.

Dr. Jean Bahr, a Professor of Geosciences at the University of Wisconsin, Madison. She is also a member of the Geological Engineering Program and is a Faculty Affiliate to the Nelson Institute for Environmental Studies.

Dr. Steven Becker is Professor of Community and Environmental Health in the College of Health Sciences at Old Dominion University in Virginia.

Dr. Susan Brantley is a Distinguished Professor of Geosciences in the College of Earth and Mineral Sciences at Penn State where she's also Director of the Earth and Environmental Systems Institute and is a member of the National Academy of Sciences.

Dr. Sue Clark is a Regent's Distinguished Professor of Chemistry at Washington State University.

Dr. Gerald Frankel is a Professor of Material Science and Engineering, and Director of the Fontana Corrosion Center at Ohio State University.

Dr. Efi Foufoula-Georgiou--she may not be here yet; she's still on her way--is the Distinguished McKnight University Professor of Civil Engineering and Director of the National Center for Earth Surface Dynamics at the University of Minnesota.

Dr. Linda Nozick--is there--is a Professor in the School of Civil and Environmental Engineering and Director of the College Program in Systems Engineering at Cornell University.

Dr. Lee Peddicord has served as Director of the Nuclear Power Institute at Texas A&M University since 2007 and is a Professor of Nuclear Engineering.

Dr. Paul Turinsky is a Professor of Nuclear Engineering at North Carolina State University. Since 2010 he served as the Chief Scientist for the Department of Energy's innovation hub for modeling and simulation of nuclear reactors.

Dr. Mary Lou Zoback--is there--is a Consulting Professor in the Environmental Earth System Science Department at Stanford University; she is a seismologist and member of the National Geophysicists and Seismologists; and member of the National Academy of Sciences.

As I've introduced myself, I'm Rod Ewing. I'm a Professor at the University of Michigan in Earth and Environmental Sciences, Material Sciences and Engineering, and Nuclear Engineering and Radiological Sciences.

All of the Board members serve part time, but we have a talented full-time staff. You'll recognize them by their blue name tags, similar to what the Board members have, and you should feel free to ask for any assistance that might be required during the meeting.

Now let me make a few detailed--give you a more detailed description of the workshop, particularly today's activities.

As already mentioned, Dr. Peter Lyons will open the workshop with a presentation on DOE's perspective on dry storage canister designs and how designs may impact the spent fuel management system including storage, transportation and disposal.

Next we'll hear from Jeffrey Williams, the DOE Director of Nuclear Fuel Storage and Transportation Planning Project. Jeff will discuss the range of dry storage canister designs currently in use in the U.S. and the projected inventory of canisters that will have accumulated by the time the currently operating reactor fleet shuts down. This will give us some idea of the scale of the problems that we're facing.

Then Rob Howard, Project Manager at the Oak Ridge National Laboratory, will present some of the challenges of repackaging spent fuel from large dry storage canisters into smaller containers for transport and disposal.

Dr. Evaristo Bonano, Senior Manager at Sandia National Laboratories, will discuss direct disposal of large dry storage canisters and some of its effects on repository design.

Dr. Thilo von Berlepsch, from the German company DBE Technology, will provide some insights based on experience in Germany, which has undertaken similar work related to managing spent fuel.

And then, finally, Dr. Allison Macfarlane, Chairman of the NRC, will wrap up the day with observations from the perspectives of the regulator.

Tomorrow morning, Nigel Mote, the Board's Executive Director, will set the stage for the breakout sections, which will occupy the entire morning. He'll explain the logistics, how we plan to keep the discussions focused and record outcomes, and he'll also explain the role of facilitators, which we've taken on in order to move this process along. We see these sessions as the primary opportunity for identifying critical issues, and it's our way of ensuring the fullest possible participation from the attendees. So please pick your session and be active participants.

The two breakout sessions will consider one of two imagined scenarios: The first scenario assumes the need to repackage the spent fuel stored in dry storage canisters. In this session, we'll identify the issues associated with repackaging all the way through geologic disposal. The second scenario assumes direct disposal of large dry storage canisters without repackaging, and here we will identify issues associated with the disposal of these very large packages.

Following lunch, we'll reassemble as a single group and the Board member rapporteurs will review the essential points from their respective breakout sessions. Each report will be followed by a facilitated open discussion, and then Nigel will lead a final discussion to record important takeaways. And at the close of the workshop, there'll be another discussion providing a concluding opportunity for public comment. And if you would like to take advantage of the public comment session at the end, please sign up on the list that's outside the room.

As usual, we want to remind everyone that the views expressed by Board members are their own, not official Board positions. That should also be considered as the case for the representatives of the other agencies and organizations who are participating in the workshop.

We're transcribing the proceedings, including both of the breakout sessions, so please, when you speak, speak at one of the microphones, identify yourself and your affiliation, so that that becomes part of the record. If there's additional material you want to add to the record, please send it to us and it will be added to the materials from the meeting.

So, now, after that long introduction--this morning I learned the Gettysburg Address was only 271 words, and all I can say is I've spared you a lot of the things that I cut out of the introduction. Okay. So, go ahead--please mute your cellphones--and let's begin, and I'm very pleased to introduce Dr. Peter Lyons.

LYONS: So shall I--you'll advance the slides? Okay.

Anyway, it's good to be back with NWTRB again. I certainly value these opportunities to get together and share perspectives and better understand some of the challenges that you're working with as well.

My comments today are going to be more of a fairly high level overview. There's going to be a number of more detailed talks following, which will go into more detail on several of the different topics that I'll introduce. But between Jeff and Rob and Tito, I think, over the course of the afternoon, we'll give you a pretty good introduction to the DOE programs.

Let's go on to the next slide. Okay.

LYONS: So how about the next slide and we'll forget about this fancy little tool here.

In any case, just a reminder that President Obama has spoken frequently on different aspects of the importance of nuclear energy. This particular quotation, certainly one that I would guess NWTRB members resonate very well with where he speaks about the importance of leaving our children a planet that is not polluted or damaged and by making steady progress on cutting carbon pollution. That second comment refers to some of his remarks about construction of new plants that is now ongoing in the country.

And the next slide. Dr. Moniz, of course, has now taken the helm of Secretary of Energy. He brings a tremendous portfolio of contributions across the widest range of different scientific specialties, and in particular in nuclear power, starting with some of his work--well, one of his key elements was the future of nuclear power study that he and a number of colleagues at MIT authored some years ago. He also was a member of the Blue Ribbon Commission, as I'm guessing that many of you know.

Dr. Moniz has spoken many, many times on the importance of nuclear energy, the importance of how we integrate nuclear energy into an overall nuclear technologies portfolio that includes nonproliferation as another key element of the overall DOE portfolio, and he's also frequently speaking on the importance of the President's climate action plan and the roles that DOE can be playing and is playing in reducing carbon emissions for the nation.

Next slide. I've spoken with this group many times, and I don't think this slide would surprise any of you, but the responsibilities within my office cover a wide range. Pretty much all, though, focused in research, development, and demonstration activities, everything from reducing technical and regulatory risks, financial risks. We do now have the responsibility for the nuclear waste program for the nation, but I'll talk a little bit more about how we at least would be hoping that that would transition in the not too distant future. And, of course, industry collaboration is a very important part of our activities.

Next slide. I have talked with the NWTRB I don't know how many times about the Blue Ribbon Commission recommendations, and I'm sure you can quote them by heart--or, at least if you're interested, I'm sure you can quote them by heart. One of your speakers later today--I know Allison was a member of the BRC. There may be other members of the BRC in the audience. I came running in so late that I don't honestly know who all's in the room. But I don't think it's appropriate to talk through the BRC recommendations; I think you're well aware of them. It's an outstanding set of eight very carefully worded recommendations that certainly was a very thoughtful approach to how the national can move towards a sustainable path for management of used fuel and high-level waste.

That report came out in January of 2012--and if I could have the next slide--the administration strategy in response to the Blue Ribbon Commission was published in January of 2013. Again, I believe I've had the opportunity to talk to this with the NWTRB, but just very, very briefly, the administration strategy started with endorsing the consent-based approach. It talked about the elements of system design starting with an administration support for a pilot consolidated storage facility followed by a full-size consolidated storage facility--well, facility or facilities. In all cases, we recognize that whether there's one or more facilities in some cases may well be determined through the consent-based process and recognizes the importance of moving towards geologic repository and developing a carefully engineered and thought through transportation system.

Off in that lower right corner, speaking to governance and funding, the administration strategy endorsed the Blue Ribbon Commission recommendations to move towards a new organization that would be focused on these challenges of the back end of the fuel cycle, specifically on the consolidated storage, and moving towards a repository and on funding. The administration strategy recommended and gave several suggestions on how one could move towards a sustainable funding formula for the activities of this new organization whenever it is constituted.

Next slide. In actions taking place, I believe, since I last addressed this organization, there has been some very important Congressional activity. Four key senators, leaders and ranking members on two key committees, have worked together to introduce Senate Bill 1240. That bill enables and authorizes many of the key aspects within the work--that were part of the Blue Ribbon Commission recommendation and, in turn, part of the administration strategy.

I believe S-1240 was introduced in the June timeframe. There was a hearing in July when Dr. Moniz provided testimony on behalf of the Department of Energy in general support for S-1240, and Dr. Moniz referred to S. 1240 as a very useful, very important framework on which to build further discussions with Congress and on which to be moving towards final legislation.

The exact path that may be followed by S-1240, certainly I don't have a crystal ball to tell you what that is. My hope would be that since it was introduced in the Senate that there will be an opportunity perhaps for the Senate to consider this in the not too distant future. I have to admit that as it gets to the House, my ability to predict what may happen gets substantially more and more clouded, and your guess is probably as good as mine as it gets to the House.

But, certainly, we regard S-1240 as an extremely important piece of legislation, as I indicated, providing a vital framework to how the nation can move ahead with used fuel and high-level waste and make very substantial progress on implementing the recommendations of the Blue Ribbon Commission and the administration strategy, and we would dearly love to have the opportunity to move ahead and work under this Congressional framework.

Next slide. I wanted to give you just a little flavor for an activity that is ongoing now within the Department. Within the Blue Ribbon Commission, there was a suggestion that the administration should review the commingling study. The commingling study, as I'm guessing this audience is well aware, was the 1985 study, which led to the 1985 Presidential decision, that there would be a single repository for both defense and civilian waste. When, again, the BRC recommended that that study be revisited, it didn't provide a recommendation on what the outcome would be, but it suggested that it was certainly time to review that decision.

Dr. Moniz, in his testimony to the Senate Energy Natural Resources Committee, also was asked about commingling, and he indicated in his testimony that the

Department has initiated an analysis of the pros and cons of relooking at the commingling decision.

The next slide. It's probably an eye chart for me; it's an eye chart for you. And perhaps it's sufficient to just note that a whole lot has changed since 1985, and whether one is looking at the--from a legislative standpoint, because we didn't have the amendments, the Nuclear Waste Policy Act in 1985. Whether one is looking at the types of waste inventory, that has certainly changed. DOE's mission has changed in that we're now very much--from a weapons standpoint, we're in a dismantlement, decommissioning mode for weapons, well into the environmental cleanup programs. Many, many changes in the DOE's mission since 1985.

In terms of a technical basis, I'm sure this audience could tick off far more items than I have here of changes that have taken place both nationally and internationally from the technical standpoint of disposal strategies. We didn't have WIPP in 1985. The progress around the world certainly was in a far more primitive state. And, just in general, there is a tremendous wealth of information that has become available as information as well as experience, as facilities, and WIPP being the premiere, have come into operation and demonstrated very successful operation.

And then programmatic considerations, very, very long list. And, again, you could probably identify several areas that we didn't have down there on this slide, but at least some of the key ones was that in 1985 you didn't have the various state consent orders, which levy substantial penalties if the Department does not take certain actions on removing certain wastes from certain states at a particular time.

So, all of these are different aspects that have changed since the decision in 1985. This commingling study is ongoing. I am certainly not at a point where I can report on details of that study or even on timeframe when this may eventually be released by the Department, but it's an active study, and I think I've at least indicated that there's some very good reasons why it's an appropriate time to be reviewing this study.

Let me go on to the next slide. The next slide. And let me use this slide to introduce pretty much the rest of the talk. And I'll be going through these in very high level and saving details for the talks to follow. But, just in general, within the programs in my office led by Monica Regalbuto as the Deputy Assistant Secretary, we're trying to lay a preparatory framework for implementing both the administration strategy and the Blue Ribbon Commission recommendations.

Indicated on those--whatever it is--six different bullets down there are a number of different studies and activities that are ongoing. A number of the leaders of those studies are in the room, and some will be speaking with you later. But these are different aspects of areas that we can do now under existing authorizations. And, of course, once and if a bill like S-1240 is passed, then we would hopefully have specific authorizations to move ahead with far more detail.

But, as indicated here, there are system analysis studies ongoing. There's studies of different modes of integrating the waste management system studies on the different aspects of the very substantial amount of transportation and transportation issues that will be raised by that transport as one looks towards moving ahead with the back end of the fuel cycle and with high-level waste. Issues associated with standardization of many of the components. Degradation mechanisms and long-term storage I'll say a little bit more about, and then a whole range of different, I'd say, foundational information that will be useful as we or this new entity moves ahead with the challenges that are being addressed here.

The next slide. I indicated on that last slide that one of the very important issues is to develop a technical basis and to conduct system analyses to understand different storage mechanisms, and also to study degradation mechanisms that can occur in protracted long-term storage. And then, finally, a number of different generic design studies for different aspects of the issue like standardized storage, transportation, and disposal canisters of various types.

All of these are different areas that are being studied within Monica's programs, but all are studied from the perspective of staying within existing authorizations, and, in addition, staying away from anything that is site specific. To the extent that we are doing generic research that covers the broad areas in these different topics we believe we have very adequate authorization to proceed, but we do not have authorization to proceed on anything that starts to resemble site-specific activities.

The next slide. On standardization and integration, this slide lists a number of different aspects of the overall challenge. There have certainly been a variety of different storage canister designs that have been used by the utilities. Some are certified only for storage, some certified for storage and transportation, but none of these have been certified for disposal. To the extent that one could come up with a standardized disposal canister, that would certainly be a highly effective and economical way of proceeding, but we're a long ways from having that situation now. We have awarded contracts to begin feasibility studies of what might eventually lead to standardized storage, transportation, aging, and disposal canisters, and I think you'll hear a little bit more about those studies as we move ahead.

And then, finally, we're also working with National Laboratories and with industry on a more quantitative assessment of standardization, trying to understand how that would impact different elements of the overall integration that we're working towards.

Next slide. Extended storage, I've mentioned, is an area where we recognize there should be additional research. We have some handles on the degradation mechanisms that could occur in long-term storage, but we see this as an area that should have additional research to support the fact of life that there will be substantial use of dry cask storage throughout the civilian complex, and it's important that we better understand what degradation mechanisms may be important to consider within those casks. So, we've been working to develop a better understanding of the gaps in our knowledge. We've continued material testing to support this modeling and simulation, and perhaps most importantly, we're participating with industry on a full-scale cask demonstration project.

And on the next slide, that shows some of the industry leaders who are involved in this study: EPRI is heavily involved. The instrumented casks will actually be located at a Dominion site, and we are looking towards this--if I can have the next slide.

This goes into a little bit more detail on some of the activities associated with this cask storage demonstration, but we're going to be focused on both experimental and analytical work that can be conducted without modification to existing facilities. The goals of this program, as enumerated here, are benchmarking predictive models and empirical conclusions as we test for aging in dry storage cask conditions. A second goal is to build confidence in our ability to predict the performance of these systems over extended periods of time. And, finally, to provide a platform that can be used for high burnup fuel and give us an opportunity to monitor and inspect degradation processes for extended periods of time.

You may be well aware that there has been limited work on this done in the past, but that work did not involve high burnup fuel, which, of course, is now the direction in which the industry is moving. So, we see this as very, very important work that will provide important information as we look into the future. This is not only coordinated with EPRI; NRC is heavily involved, and Department of Energy is all part of the collaboration on this issue.

The next slide. Noting here that--as you're well aware--in the current operations in our plants, we're required--they're required--to utilize dry cask storage to a very substantial extent as fuel pools are becoming fuller and fuller. Noting, also, that many of the storage concepts that are currently used by plants around the country simply are not compatible with either/or transportation and disposal. We have a variety of different sizes, shapes, loadings, and that will be a subject that Jeff Williams will be discussing a little bit more in his talk. And with limited pool space, we simply have the requirement that utilities will continue to have to deploy dry cask storage for a substantial time looking into the future.

The next slide. Some of the challenges here. I think it goes without saying that the utilities generally have a different set of problems and a different set of motivations than the Department of Energy on this particular issue. From the utility standpoint, certainly their main focus is to provide safe operations and to provide the production of electricity. But, from their standpoint, it may be more efficient, it may be more cost effective to utilize the largest possible containers and minimize the number of containers that they have to handle at their site.

But from the standpoint of an overall nationally integrated storage and disposal system, it may well be that that wouldn't be the first choice. It may be that smaller containers, different types of containers, would be the choice. Now, we certainly recognize that there's a great deal of existing history with the canisters that already exist, and we're trying to see to what extent we can work with those. But at the same time, we need to be looking ahead and asking how one could perhaps optimize a national system that could lead to minimizing the costs, the efficiencies, improving the safety for all aspects of the system.

So there's somewhat different motivations here, but we're hoping, through the course of these studies, to get a better handle on those differences and to move as close to an optimum situation as we can. Some of the other points noted on here are the challenges to do with the lack of transportation certificates and, just in general, a number of different challenges with the existing canisters that are in use. Of course, one can imagine repackaging, and there'll be discussions by Rob Howard later on that. Repackaging introduces its own set of challenges, and that may be necessary; but at this point in the studies, we're simply trying to understand this range of challenges and understand to what extent the overall system can be optimized.

Next slide. Other activities are initiating planning for large-scale transportation programs, looking at an evaluation of the inventory, the different interfaces associated with transportation. We can begin to focus, at least, on the shutdown reactors. We know we're going to have to be working with those, and the suggestion of both the legislation and the administration's strategy is that the initial focus should be on those shutdown plants. And, in general, we're trying to develop a complete assessment of the full range of transportation needs.

The next slide. A significant part of our program is also focused on the disposal aspects. We've frequently made the comment that the United States has quite a range of different disposal options, and within this work we're trying to increase the confidence in that statement and understand, at least on a generic basis, the different environments that we may have and the different challenges that those environments may present.

Included within this work is working towards a borehole demonstration project. That was one of the recommendations of the Blue Ribbon Commission. And even in our preliminary studies, we can see how for some categories of perhaps the high-level waste, the borehole may be a very interesting area to investigate. Now, I'm well aware that the NWTRB has suggested a somewhat reduced emphasis on boreholes. It's not that we're cutting back our emphasis on deep geologic disposal, but we continue to believe that there may be classes of particularly high-level waste where the boreholes may be an appropriate choice, and we need, in our opinion, to work towards a better understanding of what options may be presented there.

The next slide. As we look towards legislation, I already noted that the focus in the BRC, focus in the administration strategy, is on a new organization. S-1240 sets up that new organization. We're very hopeful that whatever bill is eventually passed does allow us to move ahead with a new organization that has a highly focused mission on the areas under consideration here and the focus of the NWTRB.

I've listed several other attributes that we certainly hope will be part of the post-legislation time period. We would anticipate that that would give us suitable authorization to move ahead with consent-based processes for these various facilities, and that would imply then that we would have the authorization. We; the "we" in this case is probably a new organization if that's how it's set up, but we would have the capability to move into site specific activities as we deal on a consent basis with individual locations.

I think these other points are reasonably obvious that all of these would be aspects of activities that the new organization would be conducting. And, of course, as I indicated earlier, we would hope that this legislation provides the framework for a rather complete reformation of the funding arrangements that we have in this country, which certainly are not working as intended today.

The next slide gives just a little bit of information on some of the geologic disposal and transportation issues. Some of the dates listed here are key in our thinking as we look towards geologic disposal. We've made the statement in the administration strategy that we believe we can have it operational in 2048. And while I've had some people express concern that that's a long time in the future, we're also trying to recognize that on a consent basis we don't know what sites may be proposed, we don't know what characterization may have already transpired on those sites. So, we've tried to put down dates that assume essentially that we're starting with a blank sheet of paper on the consent base and on the characterization. If we can improve on these dates--if the new organization can improve on these dates, that's great, but we have tried to put down realistic dates.

And, of course, transportation: The overall transportation system, the roots, the first responder training, all of that also has to be conducted in parallel with these activities. And, again, depending on the sites that are chosen, we may be able to piggyback on some elements of work that has gone before us.

The next slide shows the location of the shutdown sites. That wouldn't surprise you at all. I would note that for the newest shutdown sites: Kewaunee, SONGS, and Crystal River, we don't really have the final numbers available as far as what they will be in terms of casks and greater than Class C waste. So there's some uncertainty in these numbers, but this is at least our estimates in the case of the recent shutdowns, and the actual in the case of the ones that have been shut down for quite a while. But this represents what we would be dealing with for the shutdown plants.

The next slide notes our interest in international collaboration. I indicated that on a consent basis we certainly don't know what sites, what geologic formations may be proposed, and we recognize that within the United States we don't have strong databases on all of the different possible repository geologies.

In salt, of course, with WIPP, we have a considerable amount of information as does Germany. But what's noted on this slide is that we have sought to, in some cases, restart; in other cases, simply start collaborations around the world with countries and their organizations that are involved in characterization of different geologic media.

For example, Mont Terri in Switzerland on shale-based systems; cooperation with ANDRA shale-based systems. Granite would be Sweden and Finland. But with each of these different communities of expertise, we've tried to build collaborative activities with the idea that depending on what geologies may be proposed here, it may be appropriate for us to seek collaboration and information from some of these other international participants who have already made substantial progress in geologic media other than the ones we've considered.

And, finally, by way of conclusion, on that last slide we're trying to actively develop a fuel management set of strategies and technologies. We're trying to conduct R&D on both open- and closed-cycle technologies. Although we recognize and our focus in the near term is very much on an open cycle and moving towards geologic disposal, staying with the open cycle, the BRC did note that at some point in the distant future, the country may be in a position to move towards closed cycles.

And we have research programs that address several different aspects, under Monica's direction, that are looking at the key aspects of a closed cycle to provide the information if the nation ever did choose to go in that direction. But, in general, we're trying to lay a foundation now that can allow us to move ahead effectively on the immediate challenges of consolidated storage, geologic disposal, transportation, and throughout this we're looking at frequent interactions with NWTRB and continuing to benefit from your advice and counsel.

So, with that, I'll stop. I don't know if I've left time for questions or not.

EWING: So, thank you, Dr. Lyons, for a very nice opening for our workshop. And we do have time for questions, so I'll throw the floor open.

Yes, Jean.

BAHR: This is Jean Bahr, a Board member. You mentioned that you're looking at borehole disposal for some types of high-level waste. Could you amplify what particular types of high-level waste might be amenable to the kinds of borehole designs that are being investigated?

LYONS: I could ask Monica to do that, but, honestly, this is very early in the study, and I'm not at all sure that it makes any sense to be identifying specific candidates now. We see some that might be amenable to it, but, under Monica's leadership, there's a broad range of studies going on looking at the extremely wide range of different forms of high-level waste that exists around the complex. Certainly not suggesting that it looks very logical for spent fuel, but there's a whole lot of other wastes that are out there.

Monica, I don't know, do you want to add to that?

REGALBUTO: We're looking at small packages. So, one example is cesium-strontium some capsules, okay, but nothing big. Something that can fit in the current drilling technology. Certainly not advocating crushing spent fuel assemblies or nothing like that.

We will be publishing a report from Sandia--well, probably maybe mid-December, end of the year for sure--where we have analyzed the whole inventory. We did a similar study where we analyzed the whole spent fuel inventory, the commercial, and then this year we did it for the defense. And then, you know, you clearly have a lot more waste categories, and we tried to group it in terms of different characteristics that make them similar. And there is a group of them that are small packages that can potentially go in a borehole. So, we look forward for your review and comments. Perhaps by the next meeting we will be ready to present that study to the Board.

EWING: Okay. Thank you.

Other question? Mary Lou?

ZOBACK: Yeah. Mary Lou Zoback, Board member. Pete, nice talk. I have a question. You talked a lot about the standardized canisters and the transportation, and I hear a lot of words about research, demonstration project. What's the timeline for this? These things are getting loaded in every day into canisters, right, so when do you expect there'll be a standardized canister?

LYONS: I don't think I can give you a specific date. You'll hear in the more detailed talks where we are in that research. To actually move in that direction--well, there may be a question whether one wants to move in that direction until one has more information on what the geologies may be, although perhaps it will be possible. Some of the technical experts say it may be possible to come up with canister designs that could be more forgiving of multiple geologies. But I can't give you a specific answer now unless one--let me just say some of the subsequent talks are very specifically on the status of that work, and they'll give you our best guesses on this at the time.

And if one were to change how the utilities package, depending on those changes, you may well find the need to renegotiate standard contracts, too, so this is not something that necessarily would happen overnight.

EWING: Okay. Thank you.

The back, please.

FLETCHER: Hi. I'm Ken Fletcher with Exchange Monitor Publications. The NRC this morning asked DOE to move ahead with the supplemental environmental impact statement to support Yucca Mountain licensing. I was hoping you might be able to give us an idea of sort of what that would entail on your end and when you might be able to move ahead with that.

LYONS: Frankly, I haven't been out of a meeting since 8 o'clock this morning. I know the NRC issued a decision. I have not read it. You just told me more than I know about that decision. So, it's really premature for me to be commenting now, but give me a chance to at least read the decision, and that's not going to be until sometime later, I'm sorry.

I'm sorry, Allison, I wasn't listening over the phone while you announced it. I was in other meetings.

EWING: All right. Let me say, because we have very specific purpose for this workshop, so let's try to confine the questions to within the boundaries of the workshop. There are breaks, and at breaks you're free to corner people and ask other questions, so I don't let them off the hook entirely.

Other questions? Yes, sir.

BADER: Thanks. Sven Bader for AREVA. Pete, is there any possible future for a map of the United States for disposal be feasible? You know, in preparation for consent, you're going to have a lot of communities, hopefully, want to jump on this process. Is there any potential that there'll be a map of either exclusionaries, areas that you don't want to put a repository, or areas that you can put a repository? Or does it not matter because you'll have an engineered barrier system that solves all that?

LYONS: I don't know of how useful it would be. Honestly, on a consent basis, I think the first issue that will be evaluated by any community and state that would be interested would be to evaluate if for some reason they would regard themselves as being an exclusionary of some sort. That would strike me as a fairly logical thing to do early on.

There certainly are past studies that have identified general areas of the country that have different potential geologies: shale or granite or salt. Those are certainly available from past work, and based on what's going on around the world and our own success with WIPP, albeit for a different class of waste, I think it's at least reasonable to anticipate that maps like that would be very useful to communities as they look ahead. I don't particularly see anything large gained at this stage by coming up with exclusion areas. There will be many opportunities to discuss exclusion of any particular proposed site I'm sure.

BADER: Okay.

EWING: I have a question, Pete.

LYONS: Yeah, Rod.

EWING: An issue that you raised that's very relevant to the workshop and the mixture of people we have here is you pointed out that the utilities and DOE have very different perspectives and motivations when they look at putting spent fuel into a cask or a canister. How would those different perspectives be harmonized? What would be the mechanism for doing that? Would that be regulation, say, through the NRC, or is there some other path forward?

LYONS: Well, we certainly need to continue the studies that are ongoing, and we recognize that there's large numbers of casks that are already filled. To the extent one can deal with some, or perhaps even ideally all of those casks, that certainly simplifies the handling, the repackaging, and the greatest challenges that would be associated with that. My guess is if one really did decide on a particular future type of cask that was to be utilized, there probably would be a requirement to renegotiate standard contracts. Because right now that's not in the standard contract.

It doesn't say, thou shall use this cask. And I can well imagine those would be interesting renegotiations. But I certainly agree with your point, and I stated it too, that the utilities and potentially the disposal organization, waste management organization, are going to have different perspectives. And exactly how those are harmonized looking into the future is a challenge.

And I agree with the comment, too, that time's a wasting. It's been wasting for a whole lot of decades. So, it would be very nice to get to that point, but I don't think we're quite there yet.

EWING: All right. Thank you.

And let's thank Pete again for that presentation.

So, I'll be keeping us on schedule, and I realize that may mean that I'm cutting off some questions, but, again, there will be plenty of opportunities during the meeting for additional questions.

So, the next presentation is by Jeffrey Williams, DOE Director, Nuclear Fuel Storage and Transportation Planning Project, and he'll be speaking on present U.S. dry storage systems designs and the projected inventory.

So, Jeff?

WILLIAMS: Thanks, Rod.

This is on? Okay.

All right. I'm going to focus on commercial spent fuel with an emphasis on fuel that's in dry storage. And I think, as Rod said in the beginning, is this is going to set the stage for the issue. It might be rather dry to some of you, but, anyway, it's been something I've thought about for 25 years.

Go to the next slide. This is what Pete was talking about with the standard contract. And one thing I'd like to say on this is that the contract was written in 1983 and there were no canisters in existence at the time, so it was something that wasn't on people's minds. But we're going to be talking about spent fuel in these multi-assembly canisters—sealed, welded canisters, and so we put this slide up.

Go to the next one. So, what I'm going to talk about is the inventory at nuclear power plants, the inventory of spent fuel by reactor type, by storage method, by location and then projected inventory with, as I said, a focus on dry storage. And then I'm going to say a little bit about implications; however, Rob Howard is going to talk about what it takes to open a canister, and Tito will talk about implications associated with disposing of any of these canisters that have been built to date.

Next slide. Okay. This gives you an idea of where the nuclear power plants are, their history, and their location. There's 119 of them that have been built and operated; there's 100 of them in operation today, or as of November 2013. Two operating reactors have announced early shutdowns: That's Vermont Yankee and Oyster Creek in 2014 and 2019. There's a couple that are being built that are not shown on here at Vogtle, and there's four new builds also: Two at Summer, Bellefonte, and Watts Bar.

There were 10 nuclear power plants on nine shutdown sites. There's always been the talk about the shutdown sites, and these have been the ones that have been talked about for a while that were shut down prior to 2000, and the only fuel management activities they have going on is their spent fuel storage and then some decommissioning activities on some.

There was one nuclear power plant that was disabled, which was Three Mile Island, and there's three nuclear power plants that are shut down on sites that have operating reactors. That's Dresden, Millstone, and Indian Point.

And then there's four nuclear power plants on three sites that ceased operation this year, and there's five--that's San Onofre, Kewaunee, and Crystal River.

Okay. Where's all the spent fuel going? The future inventory? And what this shows you is the blue line shows the amount of fuel that's been discharged. The solid blue line is up to today.

I see this isn't projecting the bottom line, which is on my slide. You might be using the PDF version instead of the PowerPoint, which might be a problem, but in any event, what this shows--in my file it shows there's about 70,000 tons of spent fuel that have been discharged from reactors to date. About 20,000 of that is in dry storage, and so there's about 50,000 tons in pools to date.

And then it shows at the shutdown reactors right now there's on the order of 5 or 6,000 tons, and it also shows that as more and more reactors shut down--the bottom red line--more and more of that will go into dry storage. And by the year 2060, basically the assumption is most of the fuel will be in dry storage unless something different has taken place.

You can go to the next one. This gives you an idea of the amount of spent fuel by type: pressurized, water reactor, and boiling water reactor sites. And it shows that--you can count this up in different ways. You can count it up by weight, or you can count it up by assemblies. We normally count it up by weight. And by weight the PWR, or the pressurized water reactors, fuel is the majority, and boiling water reactors is somewhat less. I used to say it was 60/40 percent. It looks like now it's a little different than that, but this gives you an idea of where it is, of how much there is, and there's about 30 percent or so in dry storage to date. And since the pools are nearly full in all cases, the amount in dry storage is going to increase over time.

This doesn't include a couple of things like Three Mile Island debris, Fort St. Vrain, and some fuel at Idaho, but other than that, this is the majority of the amount of commercial fuel, which comes from data sources. 2002--what we called RW-859 database actually is undergoing revision today, and the call has gone out to collect new data. And so the data from 2002 through today is forecasts that DOE has been making for several years.

Okay. This slide up here is really to try and help people understand some of the terminology. People throw around the words canisters, casks, overpacks, and since I testified on this in court one day, I'm going to try and explain it to you here.

A canister of fuel--this is a multi-assembly canister here in the left. And in this canister there'll be several assemblies: 24, 32, 37, or whatever the number is, and that canister will be welded closed. That's loaded in a spent fuel pool. Here is a picture here of some of the canisters at Zion, and those canisters don't provide shielding. Okay, they do provide confinement; however, they don't provide shielding. They also help to get the heat out the way they're designed. They provide criticality control in a transportation accident, but they have to work with other components.

The far right there is--we'll use a transfer cask, which is different than a transportation cask. A transfer cask is what's used at a utility site. Thanks. There. Okay. The transfer cask is sitting there, and they will move the canisters from the utility building out and place it in an overpack, which can be a storage overpack or a transportation overpack. And the term "overpack" is more of a generic term, where the more technical term is a "cask." And they start to use the term "overpack" when you place a canister inside of either the transportation cask or the storage overpack.

Down on the bottom is a transportation cask, which you can see is different than a transfer cask. First of all, it has NRC regulatory dose limits, which the onsite transfer cask doesn't have to have. And it has these large what we call impact limiters, what AREVA will call shock absorbers, to reduce the G-loads during any kind of accident.

And then, lastly, down here you see these are the storage casks, or sometimes they're called overpacks, where the canister is placed in them and they're on storage at the utility site.

Okay. This gives you an example of the different types of dry storage systems. There's horizontal ones that are made up of concrete. The canister is placed in here horizontally, and they are ventilated. The air comes in through the bottom, out through the top. And this is Transnuclear. About 38 percent of the dry storage systems in the country are in these horizontal storage containers.

And then down below, this one is a vertical storage container. It's also concrete with a canister inside of it, and there's two companies that are in the business of making these: Holtec and the Nuclear Assurance Corporation.   You can see that these don't quite add up to 100. It's actually 96 percent, and that's because Fuel Solutions, which was a Westinghouse company, has a few of them; however, they're no longer in the business.

There's also a few cask canisters that are in metal transportation overpacks. This Holtec HiStar 100 is at three different plants: At Dresden, Hatch, and Humboldt Bay, and they're ready to be transported as soon as you put an impact limiter, or what's known as a shock absorber, on them, and they could be transported the way they are.

Right here, this Transnuclear 32 is a metal storage cask. This is the same cask that's proposed to be used at the high burnup demo project that Dr. Lyons talked about. Right now it's a storage cask only. It's been used at several places around the country, primarily Surry Nuclear Power Plant. And in order for this to be transported, and as part of the demo, the plans are to go to the NRC and try and get a certificate to transport the fuel after storage.

You can go to the next one. Okay. Bare fuel in bolted casks. You can see right here there's four vendors that have provided bolted casks. These top three: Westinghouse, GNB Castor, and NAC 128, there's only a few of those. There's 1 of the Westinghouse MC-10s, there's 26 of the Castor casks, and there's 2 of the NAC casks. And these were some of the very first dry storage casks that were ever employed at the Surry Nuclear Power Plant in Virginia, which was the first plant to need dry storage. They were all part of a DOE cooperative program. They're bolted closed, they're storage only, and that's what they have now. They've gone to a new system more recently.

I mentioned the Transnuclear 32, which has been used at Surry. It is also used at Prairie Island. There's not--the TN-40 is at Prairie Island. These are just variations of bolted metal casks that NRC has been using. Two of them, the TN-40 and the TN-68, have transportation certificates, so they could be transported. Those transportation certificates are specific to the casks themselves.

You can see the physical variation. Configuration varies in size and length and in weight. Just giving you an idea of what the bolted transportation casks look like.

Okay. Then we go to metal canisters that are in transportation overpacks. And this is the one I mentioned that's at three plants now: Hatch, Dresden, and Humboldt Bay. So, this is a metal cask instead of a concrete cask with fuel in a welded canister. And they could be used to be transported if they were to purchase impact limiters, which I think Holtec has told us may take two years to fabricate, and they could be transported off site. They also vary in size, and it's primarily because the Humboldt Bay fuel is a lot shorter. But they all have the same name, the Holtec HiStar 100.

Okay. Okay, now we move to the concrete ones. These are the ones that are mostly in use today. I mentioned before the horizontal type. There's the horizontal ones and there's the vertical ones. There's three different vendors. Transnuclear makes the horizontal ones. Nuclear Assurance Corporation and Holtec make the vertical ones.

The canisters, as I said before, provide containment for the spent fuel. They have criticality controls in them, and they also have the heat rejection capability; however, while it's in storage, they are ventilated. You see the vents down here and the air flows down and out the top. The same way in this, because there's a requirement by NRC to keep the fuel at a certain temperature, 400 degrees centigrade, which will prevent it from degrading in storage.

And then--okay, yeah, we'll go to this one. Now we go into a little bit more details about canisters themselves. And what we're showing here is there's been 26 different kinds of metal canisters that have been licensed by NRC. They all have light circular cylinders; they vary in length from 122 to 196; the internal diameters vary; and their weight varies.

A lot of people say, why are there so many of these different kinds of canisters? Well, it's primarily because there's a lot of different kinds of fuel in this country, and fuel characteristics have changed over the years, and this is what best meets utilities' needs for their operations and economic conditions.

The interiors of the canisters vary. You can see they vary in the number of assemblies: 7, 12, 24, 32, 37, and, as I'll say later on, in today's market they're mostly up in the 32, 37 assembly range. Fairly large. The 7 assembly one was sort of an outlier at H. B. Robinson that was part of a cooperative demonstration program with DOE in 1986. The 12 assembly one is also an outlier. That's the Three Mile Island fuel that's at INEL. They started, really, as 24s down at Oconee. That's in terms of PWR assemblies, and they have a corresponding number of BWR assembly size canisters.

One of the other things that is important to understand when you're doing the analysis for transportation and essentially--and disposal is that the neutron absorbing materials differ in the canisters. There's some that have gone to a new material called Metamic; there's some that use what they call flux traps, and all these things are important in any kind of analysis of future use.

In terms of NRC licenses, there's five that have been designated storage only. They were never intended to be transported, and they don't have, for example, criticality absorbers in them. There's been a lot of people that have speculated that, well, instead of having to open those, maybe we could get a one-time transportation certificate for those. And that may be a possibility; it hasn't been pursued yet.

There's 21 of the designs that are designed for storage and transportation, so they have from the NRC an approved storage certificate, and an NRC certificate. One other thing that causes a little bit of confusion are the vendors: NAC, NUHOMS, Transnuclear. They use different terminology for their canisters. Transportable storage canister is--I believe that's--I know multi-purpose canister is Holtec, and then dry shielded canister is Transnuclear, and TSC is NAC.

Is that right, guys, all you vendors? All right. Okay.

Okay, but as Dr. Lyons said, none are licensed for disposal, and there's never really been an attempt to try and do that yet. And they all allow for decay heat and fuel burnup. And some of them include failed fuel. And, as I said before, the reason why there are so many of these different canisters is to meet the needs of the different sizes, shapes, and so forth of fuel and to meet the needs of the utilities.

This slide, which isn't projecting the pictures for some reason--and I'm not sure why--it's intended to show how the sizes of canisters have grown over the years. I think I mentioned that to you earlier. They went from a 7 PWR up to a 37 PWR. And they've gone from 10 tons up to 55 tons.

Let's go to the next one. This one looks to have all of its pictures that are being shown. Okay.

What this is about is about shutdown nuclear power plants. And the reason I bring this up is because typically as plants shut down, what they have been doing is moving to dry storage. That's the case with the nine shutdown sites. All of the nine originals are in dry storage except for Zion, and it has a contract to move into dry storage, which will happen in the near term.

But what this slide is showing you is the--over here are all the shutdown reactors right now. And this group of shutdown reactors includes shutdown reactors that are at operating plants, which are Dresden, Indian Point, and Millstone, so I haven't talked about those before. And then what we call the stranded reactor fuel casks. Those are the original nine that we have been talking about that was addressed in the BRC Report. And, as I said, all of the fuel there is in dry storage except for Zion.

Then we have some new ones over here, and these have been shut down in the last year. Crystal River, which, as I understand it, they've forecasted 42 new casks. They don't have any in dry storage. I would say this might be a target to do something new with. Kewaunee already has some in dry storage. They've got 8 loaded; they're projecting 42 new casks. San Onofre has 50 loaded, and they project 166 more dry storage casks. So, these are pools, which they cost a lot to operate the pool, and so the incentive will be to move into dry storage.

Go to the next one. I'm not going to go through all this in detail at all, but you could study it. But this shows you the type of storage systems at the shutdown reactor sites. The point is that even at the nine that are stranded and the new recent ones, they're all using different kinds of casks. There's 12 shutdown plants here: The 9 original stranded, the 3 new ones, Crystal River, Kewaunee, and SONGS, and they have 17 different canister designs, eight different storage overpack designs which require eight different transportation overpack designs. So, some people would say the opportunity for standardization ship has sailed. And this was recognized back in 1989.

You can go to the next one. Okay. Now, this is just looking at the potential inventory in the future. And I haven't tried to project casks here, but, basically, if all these reactors run to the end of their lives, our projections show that there'll be about 140,000 tons of fuel that are generated. And if all of that were to go in the types of dry storage canisters that we're talking about now, that's on the order of 10, 11, 12,000 canisters of fuel.

The current pool capacity is about 50,000 right now, so that's an amount of fuel that has not been put into canisters. As more and more of these reactors shut down early, they're going to continue to reduce their pools, as we've seen at the stranded sites, as we're going to see at Zion and so forth. So, our projections show that that could drop to 40,000, which then is dropping the amount of fuel that you could do something new with. These scenarios really are based on no replacement of nuclear power reactors, no new early shutdowns, and no new builds are included. This is just to give you an idea of what the assumptions are that built up this 140,000.

Now, also not included in this is the new production, or the new reactors, and I just put these up here to give you an idea of what kind of discharges they would have from Watts Bar, Bellefonte, Vogtle, and Summer.

We can go on to the next one. Okay. Like I said before, earlier, I'm going to touch a little bit on the implications, but Rob and Tito will talk a little bit more about this.

One thing I think that's important to note is that you have casks that are certified for transportation and storage, and so some people think, okay, well if it's certified for both, then you should be able to transport it once it's been stored. However, all the fuel that's been placed in the storage canisters is placed in a way to meet the storage requirements.

The transportation requirements may be different than that. For example, there's fuel that's placed in casks where the fuel is high burnup, greater than 45,000 megawatt days, and there's no transportation ability for that. There's fuel that's hotter than what can be transported in the transportation casks. So, it's not quite that simple.

So, there is a difference between--even though you have a canister that's certified for transportation and storage, you might not always be able to transport it right away. For example, burnups in storage are going up to 65,000 gigawatt days, heat loads up to 40,000. For transport, have gone up to 40,000 gigawatt days and heat loads in the mid-20s. So, even though you might have a canister that's designed for storage and transportation, it could have been loaded in a way that you're not able to transport.

And this continues today because utilities continue to generate high burnup fuel and put it into their pools. And as their pools get full, then they need to move it into dry storage, which is going to require some sort of licensing action to be able to transport it or a certificate of a compliance amendment.

Okay. And then this one here just gives you a little bit of idea about the effects of thermal constraints, because the thermal constraints, as I said, for transportation are more stringent than they are for dry storage. As I told you before, in dry storage the canisters are ventilated, also, whereas in transportation they're enclosed in a metal transportation cask that has additional shielding and so forth, and so it's a more rigorous environment.

But this just shows you just some examples of some different canisters and what their storage heat limit is versus their transportation heat limit. And you can see they're quite a bit different. And at the same time, vendors are developing canisters with higher thermal limits, and which is necessary because of the fuel that's coming out of reactors today. The implication of that is that the large dry storage canisters that are loaded to a certain thermal limit may have to stay at the reactor site for extended periods of time, perhaps as long as decades before they can be transported offsite, just because of the thermal limits.

This slide here, which appears to be a little complicated, is from one of our system studies, which the main purpose of this is to show that if one was to operate in a system where all the fuel went into canisters as opposed to removing it from pools, how long it would take to be able to remove all the fuel from the site after it met its transportation limits. And, once again, the bottom axes aren't shown on this slide here for some reason. But the difference is about from 2065 to 2100. Thirty-five years longer you would have to leave the fuel in canisters onsite to be able to transport them before they were able to decay to meet their thermal limits for transportation.

And then we go to the next slide. And then this is just a little bit on the opening, and telling you what would be involved in opening them. And Rob Howard's going to follow up on that, but this just comes out of another systems study that we're doing. The potential amount of assemblies up here, 2,006, 400,000--close to 500,000 assemblies. And what's important about this slide is if all of it was in canisters, it would be in about 11,000 canisters according to our model's projections; however, if you took some type of action, depending upon what that action is, you could reduce the number down to 3,300 if you were able to start accepting spent fuel in 2021.

And then the bottom numbers here just talk about how many waste packages you might need to repackage, depending upon the size of them. And the size right here I put a 4-PWR; 9-BWR, which is consistent with a lot of the international repositories; a 12-BWR; and a 24-BWR the people believe could go in a salt repository; and a 21-44-BWR waste package that is consistent with what was done at Yucca Mountain. And none of those are larger.

And that's really all I had about inventory, and hopefully we'll continue on with the discussions of what this inventory translates to.

And that's all I have.

EWING: So, we have time for a few questions.

Yes, Lee.

PEDDICORD: Lee Peddicord, Board member. Jeff, you had mentioned a couple of cases about the cooling requirements, particularly for cask canisters and so on. Are all those natural circulation? Any of them forced circulation requirements?

WILLIAMS: No, they're all natural. And, yeah, the concrete cask is all natural circulation.

RESNIKOFF: Marvin Resnikoff, RWMA. If DOE were to transfer fuel from a transportable canister to a "tad," or whatever you call it, a smaller container, where would this transfer take place? At the repository or at the reactor? And if it's at the reactor, there are many reactors that don't have a fuel pool anymore, so how would that be done? A new fuel pool put in, or is there some other system?

WILLIAMS: And I think Rob is going to talk a little about repackaging; however, that was the exact scenario that was in the Yucca Mountain license application. And in that scenario, the objective was to try and put the majority of fuel in disposable canisters at the utilities, loaded in their pool. For the fuel that was already in dry storage, the idea was to transport that to Yucca Mountain and then open the canisters in a pool at Yucca Mountain. That's what that scenario was. I really couldn't speculate on other scenarios without a repository or an interim storage facility.

RESNIKOFF: But many reactors won't have a fuel pool.

WILLIAMS: Right. Right. And I'm saying the idea Yucca Mountain was, they would not repackage at their pool if it was already in dry storage. If it was already in dry storage, the scenario that was analyzed for Yucca Mountain would be that dry storage would be moved to Yucca Mountain to be opened.

Now, if it was canisters that aren't transportable, I'm not sure how it would be handled. All the ones that are not transportable today have a pool. Whether they will in 2100 or not is a different issue.

EWING: Right. Jerry, you had a question?

FRANKEL: Yeah. Jerry Frankel, Board. I'm interested in the design of your certified storage canisters. So, what's the design life of these canisters, and what are the design considerations that are life limiting?

WILLIAMS: Okay, well, they were originally designed and certified for 20 years. They've now--NRC has modified their regulations where the certification is for 40 years and they can get an amendment for another 40 years, so that's 80 years. You talk to the people that design them, and I think they talk in the range of 100 or so more years in terms of design life. The rate limiting things are what's being examined in several different cases within the UFD storage program, which I think Bill Boyle will talk about on Wednesday, but it's stress crack and corrosion of the canisters and so forth. And those are things that are being examined.

FRANKEL: They're all made from stainless steel at this--

WILLIAMS: Well, today they're mostly made from stainless--they're all made from stainless steel today. I think some of the earlier ones were some carbon steel.

EWING: Okay. We'll have to go on, but after the next talk we have some time set aside for discussion, so we can pick up some of your questions then.

Yes. Thank you.

The next speaker is Robert Howard, Project Manager at Oak Ridge National Laboratory, and he'll speak to the issue of implications of repackaging spent fuel from large dry storage systems into smaller packages for transport and disposal.

HOWARD: Good afternoon. As Rod said earlier today, the purpose of this workshop is to talk about the implications of current storage systems on the future waste management systems. One of the breakout sessions tomorrow is going to be on the what if scenario. What if we have to repackage all of or some of the current dry storage systems into smaller canisters? So I wanted to give you some background information on that so that we could all start off with the same sheet of paper tomorrow morning.

Next slide, please. Jeff already covered this, so I don't need to say anything more about it.

Next slide, please. So, why repackage? Well, what we need to think about over the next two days is that why, where, when, and how all matter. And all those will influence the scenarios and conclusions or issues that we think about and identify. So, as Jeff just mentioned, there are about 300 canisters out there in the inventory that are storage only, so that might be one set or subset of existing canisters that have to be repackaged just for transportation if it's not possible to get a one-time exemption for transportation.

And then, of course, repository constraints. We don't know, although Tito's going to talk about this a little bit more, whether or not we could actually directly dispose of these large dual purpose canisters in a geologic setting. No matter what we do, repackaging would be complicated. It's going to increase the total fuel handling operations that have to be performed throughout the waste management system; it's going to complicate pool operations at operating reactors; it will increase doses for workers at those reactors. It might be able to manage it a little bit better at a purpose-built repackaging facility, and we'll talk about that a little bit.

If you were going to do this at a shutdown facility where there is no pool--this is part of the question I believe that the gentleman asked a minute ago--it would require some infrastructure and facility development. And I'll go through some ideas about that and what some of those implications would be as well.

There's a low-level waste issue that has to be dealt with. We'll generate a lot of additional waste with these storage systems if we have to discard them. And what we may find is that having a purpose-built facility might be part of a more flexible waste management system.

Well, we could reduce the amount of repackaging or possibly eliminate it. One, we could eliminate it if we were successful in demonstrating that these dry cask storage systems are actually disposable. It's not a yes or no, on or off type of issue; it's not binary. I think there's a spectrum of things that have to be examined. You may be able to dispose of a subset of them. We don't know. There's a lot of work to do in that area. And as Dr. Lyons mentioned, it's a reason why we want to look at standardization. If you could do standardization sooner rather than later, you could lessen the impacts of repackaging. But that's got issues as well.

Next slide, please. You just saw a version of this that Jeff put up. The point here is that if we take the scenario all the way out to the end of lifetime for all the reactors, you're looking at about a half a million assemblies that have to be packaged. That's a large number in my mind.

When we do it matters, and how fast we do it matters. So, if we want very high throughput rates in our system, we need to consider that as well when we're thinking about these repackaging scenarios. We may not be able to get very high repackaging rates if we do it all at operating reactors or at stranded sites.

As Jeff mentioned, no matter what we do, the number of packages that we ultimately have to dispose of will depend on the geologic media, the thermal constraints and other constraints of the system. We could be looking at a significant number of canisters to dispose of, on the order of 80,000 if we were to go to these rather small PWR--4-PWR or 9-BWR canisters. And we use that as a benchmark by-the-way, because that's about the size of the systems that we’re seeing being contemplated internationally.

Next slide, please. So, where repackaging occurs is going to matter for the transportation system and its functions and requirements. I did a little peeking at the staff reading that was handed out earlier today, and there is a flow diagram in that that depicts the waste management system slightly different than this, but it's the same concept.

We've got a number of different options where we could do repackaging, either at a reactor or its associated ISFSI at a centralized interim storage facility. You could do repackaging at a repository. Each one of those options will change the posture, or makeup, of your transportation system. It'll change the number of shipments that you have; it'll change the kinds and types of transportation packages that you need.

Jeff showed you some of the complexity on the transportation system already just with the stranded sites. Well think about that; adding more and different canisters in there is going to change that even more, and it will also affect the fleet makeup and size. So, if we were to transport these smaller canisters one at a time on a single railcar, obviously that could make the number of transportation packages that have to be moved from one point to the other quadruple, or even up to eight times as many if we went from 11,000 to 80,000, depending on where that work was done.

Next slide, please. So, let's think a little bit about what the implications are for the regulations that we have to consider when we're thinking about where we're going to do the repackaging, because if you're going to repackage and you're going to repackage for a disposal environment, you kind of need to know where all the regulations lie. So, we know that Part 20 is going to apply everywhere and we've got to do our best to make doses as low as reasonably achievable no matter where it's at. So that's going to be applied across all repackaging efforts.

If you do it at a reactor, then we've got to make sure that we consider the Part 50 operating requirements on the repackaging system. If we do it at reactors, ISFSIs or an ISF, then the design requirements on that canister have to be considered as well for Part 72, and the disposal requirements would need to be considered. We can avoid the Part 71 issue on that package if we did the repackaging at the repository.

Next slide, please. So, throughput is an issue. My colleagues at Chicago Bridge and Iron did a study recently where they looked at repackaging operations at operating utilities and were looking at various throughput rates that you would need for the entire waste management system. And what they found was there were some configurations at operating reactors where if you wanted, say for example, to achieve a 3,000 metric tonsU per year throughput at getting spent fuel out of the reactors and into a consolidated storage facility or a repository, you just can't get there using the current loading practices that we use for these systems.

So, I believe it was several BWR type reactors that have shared pool facilities you can't get that kind of throughput that you would need. So that's something that needs to be considered if you're going to be dealing with it at a reactor, and it's a system implication. It's not just an implication for the reactor.

Obviously, if you're going to do it at an ESF and you're going to do purpose-built repackaging facilities, you can achieve the higher throughput rates, but you may not use those facilities for an amount of time that is economical. So, if you went to something like 6,000 metric tonsU per year, some of your facilities and equipment you may only be using on the order of 5 to 10 years. That may not be a very good return on your investment. So there may be a mix and match scenario out there where, you know, to get a really high throughput rate and make economic sense, you would need to do repackaging at several of these different locations.

Next slide. This is just a process flow for what repackaging might entail at an operating reactor. I want to go through this one in a little bit of detail. I'll note that we've got process flow diagrams similar to this for repackaging operations at other facilities, and also whether it was wet or dry. My colleague Robbie Joseph has got those flow charts, and we'll bring them to the breakout sessions tomorrow so that if people want more detailed information, we'll be glad to share what we have in that regard.

But, the first thing that I want to point out here is that if an operating reactor doesn't have room in its spent fuel pool to do the transfer, the first thing that they would need to do is make room. So they might, before they could even start to do a repackaging operation, have to do a packaging operation to bring enough fuel out of the pool to make room to do the repackaging. I know I said that a little bit complicated, but I think you get the gist of it.

So, think about it just a second. This first operation here is just to clear the pool. Now, if you think about it, where you're trying to unload a 37-PWR canister and you’re going to load it into a 4-PWR canister and you'd need to create that space in your spent fuel pool, you might have to--if that's pool's already full, you might have to load four or five 4-PWR canisters already just to get the space, maybe more. So that's not a trivial exercise at all.

Then, once it's cleared, you bring your disposable canister into the system just like you would the normal dry cask storage system, or dual purpose system, set it in there. You've got to cut open your dry cask storage system. We'll probably want to do this dry rather than wet. Then, once it's cut, you would lower it into the spent fuel pool, remove the lids, remove the fuel from the canister, put them in the racks, take that dry cask storage system out, put your disposable storage system in, and load the assemblies back into that, pull it out, put the lid back on it and dry it, move it out to the pad, or move it out to the railhead or to a truck to be shipped off to the next facility. Very complicated.

Next slide, please. So, has a lot of impacts on operating reactor. It's going to impact your resources that you need for loading; it's going to put demands on all of your operators, engineers that are associated with spent fuel pool operations that they didn't have before, so it's going to change the complexion and makeup of your staffing requirements.

Space and resources are an issue. We talked about one of those space issues with whether or not you actually have room in the pool to do this operation without unloading some fuel first. The low-level waste stream; we'll talk about that some more later. Radiation exposures are going to go up. And, with everything else, there's also going to be a training burden included on this.

Next slide. So what about at a shutdown site that doesn't have access to a pool? What would you do there? This is just a what if scenario. Well, you could deploy mobile hot cells. There have been some mobile hot cells deployed in Europe. This is an AREVA design that's being used in Europe right now not for high-level waste, but I think for low-level waste.

Chicago Bridge and Iron came up with a concept for a mobile platform that you could use to deinventory these sites. There's a couple issues with that. Obviously, you've got to make sure that the operations that you're contemplating are within the bounds of your safety analysis for that Part 72 facility. Again, it could impact storage or transportation operations the same way that any other part of the repackaging system could. You would probably want to do these operations if you're going to move from one facility to the next. You'd want to get it all done at one facility and then move on to the next facility, so there may be issues with queuing there and timing to get maximum use out of these facilities.

So when you think about having to go to something like this, then it really makes a repackaging facility with some additional flexibilities seem like it might be appropriate for the waste management system.

Next slide, please. So, here's just one concept of a repackaging facility. This one happens to be a modulized facility concept designed to move about 1,500 metric tonsU per year through the system. The design and operation of this facility would have to conform to Part 72 if it was at an interim storage facility. I believe that's the case. I hope we can get some discussion on that tomorrow on the appropriateness of that assumption. And it would have to comply with whatever the requirements are for a repository preclosure operation if it was done at a repository.

It has some advantages. This one is a wet transfer system. Whether or not you would actually need this receipt bay depends on where it's located. You could share that receipt bay with your other facility. You bring the fuel in, put it in an air lock. There's a cutting station where you would cut the lid, lower it into a pool. We've got two basins here: One for PWRs and one for BWRs. That way you don't have to necessarily change the grappling devices out all the time for these two different systems.

This one was sized for a 1,500 metric tonsU per year facility. It was sized to handle about 750 metric tonsU in the pool, so that would give you about six months of buffer capacity. So, you could actually do something to decouple your inputs from your outputs, which could have advantages, particularly if you're working on doing some thermal management activities with the assemblies. And then you would put it into a disposable canister on the other side, bring it out. We've got some welding stations there. Of course, this would be--if you wanted to release it to a transportation system, you would have another high bay there, but you could get rid of that high bay if it was done at a repository, because you don't have that transportation step.

So, that's just one concept. There's many out there, but it's essentially the same operations that you're going to have everywhere else. The other thing that you can do with this is you can do a lot more with remote handling so that your cutting and welding operations are done remotely. You're going to significantly manage the total overall worker dose much more effectively in a purpose-built system.

Next slide, please. So, no matter what we do, if we can't dispose of DPCs, we will have to deal with that empty shell, and we'll also have to deal with the storage overpacks. You've got the DPC itself; you've got the shield plug; you've got lids that you have to deal with; you've got the internals, the basket assemblies; you've also got a lot of concrete that you're going to have to deal with as well. Now, you could probably, if you're going to keep these things at a reactor and you wanted to load more DPCs--I'm not sure why you'd want to do that, but you could reuse these storage overpacks at that facility. I'm not sure that you would want to take those storage overpacks and move them to a consolidated interim storage facility. You probably want to fabricate your overpacks at that facility there.

You've also got to deal with the processed waste. If you do wet repackaging, you're going to have a pool;

you're going to have resins and that sort of thing that'd have to be dealt with, so that's an issue that has to be thought about as well.

Next slide, please. So, did a little bit of thinking about what this would mean just in terms of the amount of cost, and this is just a sample calculation to give you something to think about. But let's just say there's approximately 350 feet of low-level waste per DSC, so that's, I don't know, about 25 percent of the volume of an existing canister system. I guess if you do some minimization and compacting, you can get that down some. But for disposal cost range of about 500 to $1,000 per cubic foot, even if we just had what we currently have in inventory now, we're talking about a substantial amount of money, on the order of 350 million to 750 million dollars. This gets into the billions of dollars if we're looking at trying to deal with 11,000 of these systems out in the future. So, it is a significant problem. We need to really think about it. No matter what we do, it exists already down here. It could get bigger as we all age.

Next slide. So, the other thing that we need to realize is that dealing with these empty canisters requires facility and equipment. Whether it's at a reactor or at an interim storage facility or at a repository, we've got to have facilities, we've got to have people to do the work.

There's a transportation interface associated with it to move the material from your facility out to wherever it is that you're going to dispose of it as low-level waste.

Next slide. So, worker dose. Again, this is going to vary highly depending on the systems we use, the number of packages that we have to open, the size of the packages that we have to replace this fuel in, and where we do it, of course.

Just a little sample here; this was some data I took from CBI, but, basically, to load the dry cask storage system, you're talking about half a REM for BWR, about .2 REM for a P. And they estimated that to repackage that into a smaller package it was going to be the same dose even though you've got a smaller package, that--the welding operations and the closure operations are going to take about the same amount of time, roughly about the same amount of exposure. So you're going to increase--since you have to do more packages, you're going to increase that depending on whether you're going into a 4 or a 12. Right. If you do it at an ISF or repository, well, you can manage that a lot better with remote operations. We talked about that already.

Next slide. Cutting technologies. My colleagues at both AREVA and Chicago Bridge and Iron have been doing some studies on what's out there, what does it take to cut one of these canisters open. There's a wide range of technology that's available to us. How you do it, again, is going to depend on where you do it and why you do it. Essentially, if you're going to do it at a reactor, you go with whatever that cask vendor's recommendations are for cutting. If we're going to do it at an independent storage facility or a repository repackaging facility, we're probably right now go dry with skiving. There's a reason that we want to go dry. You can see here a lot of the milling that's going on. You don't want that stuff in your spent fuel pool. That's going to cause a lot of problems. If you can't reuse the dry storage canister, we might want to look at this wheel cutting option where instead of cutting off each lid one at a time, you go below it, cut beneath both lids and the shield slug, and get at this that way. But that would require some more R&D.

Next slide, please. Just one slide on overall costs. What I did here was I took some information from Chicago Bridge and Iron and a study they did, and I normalized it to the cheapest scenario that they analyzed, which was a dry transfer scenario at a repository, and then I unitized it down to one dollar. And, basically, the main point of what I want to show you here is that two significant figures whether you do repackaging at an ISF or repository is essentially the same. The big difference in cost here is the transportation costs between the two, and that's going to be assumption dependent. When you start backing it up to reactor sites, those costs can go up significantly if we don't think about it a lot harder.

Next slide. So, it's going to be complicated no matter what we do. When, why, and how matter, and we should spend some time thinking about how we can reduce or eliminate the need to do this.

Next slide. I just want to acknowledge some contributions. We did get some reports from AREVA, and they had a team from Transnuclear, URS, Dominion Power, and Coghill Communications that put together some of this information. Chicago Bridge and Iron had Holtec International, Exelon, and Longenecker Associates, and then the Nuclear Fuels Storage and Transportation Planning Project that had folks from DOE, Oak Ridge, Savannah River, Sandia, and Argonne.

Questions?

EWING: Thank you.

So, questions?

LANTHRUM: Gary Lanthrum from NAC International. You covered both the worst case and the best case, where the best case scenario is direct disposal of the current dry storage systems, which doesn't require any repackaging, and the worst case is where you have to cut open a whole bunch of dry storage systems and repackage. You didn't talk much at all about the middle road option where if you had a centralized facility of some type you could ship bare fuel in bolted lid transportation casks without going through the cutting operation. Could you speak briefly to some of the impacts that that might reduce--and then package into a smaller canister for whatever your disposal network was requiring.

HOWARD: Right. That's a good question, Gary. So, the implications would be exactly as you say. It's the middle ground. If we can contemplate a system that includes transfer of bare fuel in a transportation cask and move that to an interim storage facility or a repository's bare fuel, do that repackaging there, obviously that would help this problem as well as some others. I mean, one thing that you could accomplish by doing that is you could actually stop using or limit the use of keep filling up more dual purpose canisters, and that would help everybody, I think.

EWING: Just as a follow-up what's the motivation for bolting versus sealing the packages? Some are bolted, and some are welded shut.

HOWARD: I believe there are extra inspection requirements on the bolted systems, and so if you weld them shut, then you don't have the same inspections for storage. And if there's a cask vendor out there who wants to say something different, I would welcome it.

EWING: Thank you.

Adam.

LEVIN: Thanks, Rod. Adam Levin. Bolted versus welded systems. I think my experience at Exelon tells me that the bolted systems, from a reactor operator's perspective, is a nice place to be because you can load a bolted system in a five-day work week, normal working hours, one shift. Whereas a welded system's going to take you 7 to 10 days or longer potentially, so from an operator's perspective, it's certainly beneficial.

EWING: Good. Yeah. But following that, my impression is the movement is toward welding them shut.

HOWARD: Yeah. According to what Jeff said in his projections, I mean, that's what we're seeing is the welded system.

EWING: Okay.

HOWARD: But, I mean, that's between the utilities and the vendors on why they're doing it. And I think it would be good to get them up here to tell you about that.

EWING: Right.

Nigel? Oh, sorry. I didn't know you had the microphone. Go ahead.

MOTE: Just to add a comment about the German utilities, the German industry, have moved exclusively to bolted casks. Everything in Germany is bolted, and I believe it is specifically so that it gives that flexibility, but maybe when we have the last presentation from Thilo von Berlepsch, he can cull it out and say why the Germans moved that way and what the implications were and are for long-term storage, continued storage, and indecision on a repository site.

EWING: All right. Thank you.

Jean?

BAHR: Jean Bahr, Board member. Who is responsible for the costs and does where the repackaging happen shift those costs from the plant operators to the disposal operator?

HOWARD: I’m sorry, but that's way outside my portfolio.

EWING: But, in fact, the packaging onsite, I understand that to be the responsibility of the utilities; is that not--

GUTHERMAN: My name's Brian Gutherman. I think the key part of the question that Rob said that needs to be reiterated is if this place has somewhere to go. If you're talking about taking casks to an ISFSI, bolted casks are much more expensive than the ventilated systems with welded canisters; however, if you have a place to go, those bolted casks can be reused. You take the fuel right out of the pool so you don't--you kind of stop the hemorrhaging, if you will, taking fuel to the ISFSI, so that decision is all important in deciding which way to go. And right now, since there's nowhere to go, the utilities go with the sealed, welded canisters.

EWING: Okay. Thank you.

Other questions? Yes, Lee.

PEDDICORD: Yeah. Lee Peddicord, from the Board. You had mentioned about the AREVA mobile transfer facility, but it's not yet been sized for spent nuclear fuel. Has AREVA undertaken any studies of what that facility might look like in a mobile form to go to stranded sites?

HOWARD: Yeah, they have been thinking about it. Sven's back there; he can probably comment on that one.

BADER: Sven Bader from AREVA. We tried, but got defunded, or not funded I guess is the best way to put it politely. But, yeah, we are definitely trying to push the concept further.

EWING: Bob, back here.

EINZIGER: Yeah. It's sort of a follow-up on this. Bob Einziger of the NRC. This mobile hot cell, first off, that looks like a low-level so you don't have nearly the shielding.

HOWARD: Right.

EINZIGER: And it also looks like it's picking up canisters and repackaging in there, and it's not opening canisters and taking out bare fuel with the associated crud that could get spread around in the loading that's--so I don't think it's a good estimate to generalize from this facility to what you can have if you're going to unload a regular canister. I think that you're looking essentially a full-fledged hot cell with its massive costs and its massive decontamination hosts at the very end.

But irrespective of whether you're going to repackage at a reactor or you're going to repackage at your location where you're getting to--and the last speaker talked about having these orphan sites that had no pools and had systems with transportable casks--you still have the requirement on a transportable cask, because the cask itself acts as the containment barrier to change the gasket within a year of when you're going to transport it. So, you're going to have to have a facility to open that system up at those orphan sites and change that gasket, and that's something you need to think about. It's just not a matter of slapping an impact limiter on it.

EWING: Okay. Thank you.

You had a question?

HOXIE-KEY: I had a comment. Susan Hoxie-Key, Southern Nuclear. The repackaging is problematic even if you have a spent fuel pool. In today's plants, the operations are ongoing almost full time in the spent fuel pools, anyway, with distributing the assemblies for heat load and preparing for upcoming outages and carrying on a dry cask campaign. So, there's not much of an open window then to undertake significant repackaging activities.

EWING: Okay. Thank you.

Other questions? One.

MAKHIJANI: Arjun Makhijani, Institute for Energy and Environmental Research. Do we know how many failed fuel assemblies there are currently in dry storage and how many of them may be high burnup? And, if so, how are we going to test out the cask transfer of these for a fuel assembly?

HOWARD: Sir, I do not have that number at my fingertips.

MAKHIJANI: But there are a number of them.

HOWARD: Yes.

MAKHIJANI: I know there are 95 at San Onofre alone. So there must be in the hundreds at least throughout the nuclear power plant establishment.

HOWARD: Right. I mean, I know that there's high burnup fuel in some of the stranded sites like at Yankee, but they're already in damaged fuel canisters.

MAKHIJANI: Yeah, but irrespective of number. How are we going to figure out how to transfer these things from where they are to where they need to be?

HOWARD: That's an excellent question. I mean, I think that's part of the R&D activities that Used Fuel Disposition Program is taking on right now.

MAKHIJANI: Okay.

EWING: And so for questions like that, I'd encourage everyone to be present at the interactive breakout sessions tomorrow, because this is where we need the collective wisdom and to see where we have a lack of knowledge or experience in some of these proposals.

Any last questions? Yes.

BOYLE: It's not a question, but since we're--

EWING: Please identify yourself.

BOYLE: Oh. William Boyle, Department of Energy. Since we're a couple of minutes ahead of schedule--Dr. Lyons, on pages 14 and 15, mentioned this high burnup demo that DOE is undertaking, and the draft test plan is available for public comment. And I'll repeat this on Wednesday at the Board meeting on that day, but the easiest way to get access to not only the draft test plan but also a comment forum is go to--if you have your pen and paper ready--it's www.ID.energy.gov, and that's the home page of DOE's Idaho office. And on the left-hand side, in red font--it's the only link in red--is "Public Involvement Opportunities," and with one click it will take you to that page. And at the top of the page is the draft test plan and the public comment form.

EWING: Okay. Thank you.

Another question in the back there?

CUMMINGS: Kris Cummings, NEI. Has DOE evaluated the ability of repackaging on a fuel assembly basis under the current Part 72 regulatory requirements, whether that's even possible?

HOWARD: Well, as I said during my presentation, I think that that's a topic for discussion tomorrow. I mean, the assumption is that it can be done; or at least that's my assumption, but I'm not the regulator, so I think it warrants some discussion.

EWING: Okay. I want to be sure we have plenty of time for coffee, so I want to take advantage of the fact we're a little bit ahead of schedule.

So let's thank the speaker--thank you very much.

HOWARD: Thank you.

EWING: I'd ask you to be back promptly at 3:30, and we'll continue. Thanks very much.

(Whereupon a short break was taken.)

EWING: The next speaker will be Dr. Tito Bonano from Sandia National Laboratories, where he is a senior manager. And the title of his presentation is "Implications of Direct Disposal of Large Dry Storage System Designs for Repository Design."

BONANO: Thanks, Rod.

The title is a little bit different than what Rod said, but basically what I'm going to do is share with you some preliminary results of the evaluation that we've been conducting at Sandia with cooperation from a number of colleagues at the other national labs, at DOE, and some private sector companies to look at the implications of disposing directly of the dual-purpose cask canisters.

This is the same caveat that you have heard from both Jeff and Rob, so I’m going to move on.

As I said earlier, the work is being led by Ernie Hardin at Sandia, and Ernie is in the audience; Rob Howard, John Scaglione, and other colleagues from Oak Ridge; some colleagues from Lawrence Livermore National Lab; Savannah River; Tom Cotton is here from Complex Systems Group; Charles Fairhurst, University of Minnesota; and Bill Spezialetti and Bob Clark from DOE. So this is a--I got the opportunity of sharing with you the work of everybody else.

And, by the way, the Board had heard some time ago a presentation from Bill Boyle on the same topic. Bill describes it at a 30,000-foot level. This might be the 10,000-foot level, but we still are doing some more work.

I think the important thing to start with is that the direct disposal of very big canisters is not a new concept. In the 1990s DOE looked at the possibility of disposing of this. There were some preliminary analyses. They were then discarded. The concept was not further studied. During the days of the development of the Yucca Mountain license application, there were a couple of studies, one by Bechtel SAIC around ten years or so ago, that looked at the disposal of very large canisters. The study determined that the biggest issue had to do with postclosure criticality, so we'll be revisiting that as well.

In about 2008 EPRI did a study of the disposal of existing DPCs up to about 32 PWR assemblies. The study again looked at thermal issues and criticality and determined that at the time there didn't seem to be any technical impediments to the direct disposal of DPCs, but still further studies were needed.

Other national programs are looking at direct disposal. Germany is looking at the possibility of the disposal of a 10 megaton canister, and I hope our colleagues from Germany will talk a little bit about that. So this is another concept that is new, and other national programs are exploring it as well.

Some of the assumptions--the outline for the presentation, we're going to talk about the approach and assumptions. We're going to look at the main three issues that we see right now as being implications for the direct disposal of DPCs: thermal management, postclosure criticality control, and engineering challenges of actually handling these big casks.

We're going to talk a little bit about some preliminary results of disposal concepts; we'll talk about some thermal management results as well as criticality; and at the end we'll talk a little bit about some logistical analysis that we've looked at as to how fast can we actually dispose of the entire inventory under the assumption that everything is loaded into the big casks. And then we'll wrap it up with some summary and conclusions.

Why evaluate the technical feasibility of direct disposal of these large dual-purpose canisters? I think Rob did an excellent job of covering this issue, so I am not going to continue to basically repeat myself or repeat what he said. But I think there are some reasons why we want to do that.

This chart is one that I think Tom Cotton, who is in the audience, refers to as the obstacle course for direct disposal of DPCs. And what you have here is a number of questions that we've been asking as to whether or not we can actually dispose of these big honkers, as I call them.

The first one is: Can it be transported out of the site, the reactor sites, without being reopened? If the answer is no, then we talk about potentially the need for repackaging.

The question is, okay, if we can transport them, can we actually physically emplace them in the repository? The question. Some of this, when we look at the actual cask with the overpack, the shielding, the cart, if you were to put it down a vertical hoist, you're talking about 175 to 180 metric tons. So that is a very, very heavy load.

Can we actually emplace them in the repository? If the answer is no, then do we need to repackage?

Can we meet the thermal limits? Can we respect the thermal limits of the geologic formation, the repository, and of the fuel itself? And, again, if the answer is no, do we need to repackage?

And then can we address criticality? Can we meet the postclosure criticality requirements? Assuming that the answer is yes and we go down these purple boxes, then there is a preliminary assumption as to, yes, we possibly could dispose of these large casks, directly dispose of them. Then we will need to look at some generic repository options for direct disposal and do we need to incorporate this disposal--the characteristics of these big disposal canisters into siting and repository development plans.

So those are some of the issues that may affect. I think this presentation is going to be looking at primarily the three issues here: Can we physically emplace them, can we manage the thermal limits, and can we deal with postclosure criticality?

The scope of the study is a multi-year project, starting in FY12. The results that I’m sharing with you this afternoon are basically the results that we’ve gotten through about a month or so ago. As I said earlier, this is primarily concentrating in looking at the potential technical issues. We do not address regulatory or public acceptability issues, so we are looking at the technical issues. We are addressing--of course, we are not going to dispose of them if they're not safe, so basically we'll concentrate on engineering feasibility, thermal management, and criticality.

The goal of the approach is to map disposal concepts to existing DPC inventory. And, frankly, one of the things that we may come up with that not all DPCs may be disposable. It may be a function of geologic setting. It may be a function of high burnup rate fuels. It may be a function of the cask, you know, DPCs. Some of them go as high as 36, 37 PWR assemblies. So there are a number of issues there, and it's quite possible that as a result of this mapping what we end up getting is a combination of direct disposable of DPCs and repackaging into some purpose-built canister.

So the question is still unanswered, and that's what we hope to get out of this approach.

We want to identify what are the potential R&D activities that we need to address to really come up with a definitive answer. And at each stage of the process, each phase of the project we're doing an iterative analysis, so each step of the process we're going to look at where we are today with respect to answering the question: is it technically feasible? If it is, what other studies are needed?

As I mentioned earlier, we have a number of participants from the used fuel disposition campaign, from a number of the labs as well as universities and private sector companies. We continue and we'll look forward to external interactions like this and others to present our results of our studies.

A number of key technical assumptions for the analysis. First of all, we assume that we will complete disposal operations--I mean, we permanently close the repository, we have emplacement of waste, we have ventilated if ventilation is needed, and we have closed the panels--no more than 150 years of the fuel being out of the reactor. This assumptions is--the fact that we probably will have to store above ground for 50 to 100 years, and then we'll have another 50 years of repository operations.

We are also assuming that the fuel and canister conditions will be suitable for transportation and disposal for up to 100 years out of reactor. As was mentioned in the previous talks by both Jeff and Rob, the issue of whether we can transport this--this package is still a question.

We assume that the canistered spent fuel will be placed in disposal overpacks. And being that we still do not have a regulation, we're assuming that it's going to be a risk-informed regulation along the lines of 40 CFR 197 and 10 CFR Part 63. So basically what that means is that we will assume probabilistic assessment of features, events, and processes.

The last assumption is that, based on the technical report that we did for the Yucca Mountain license application regarding criticality, that we will be able to screen criticality on the basis of either low probability or low consequence arguments.

So the first results that I'm going to share with you have to do with the thermal management. And in the left-hand side here what you see are the different (inaudible) that we kind of turn to do the analysis. So we looked at--and, again, we assume that it was a package, a 32-PWR assembly, burn level of about 60 gigawatt per day per metric ton, so that's high burnup. We assume that we have 50 years of surface decay above--decay storage above surface and that we ventilate the repository for about 50 years. The spaces between the packages was 20 meters, and the drift spacing was 70 meters.

The main driver here, as you can see from these results, is the thermal conductivity of the rock. So you see a salt with a thermal conductivity of 5 watts per minute is basically shown here with the black curve. If we decrease the thermal conductivity, which is pretty close to what it is for sedimentary rock, to about 1 watt per meter per degree, you see this red curve here.

The jumps in the curves that you see here is about the time of emplacement; it's about 50 years. And this big jump here you see is about 100, 150 years at the time of closure.

We also looked at the repository spaces. What we find there is that it's not quite as important as thermal conductivity, but the spacing between packages is a little more important than the spacing between the drifts, and it's a little bit more important than the diameter of the drifts.

The main driver here is thermal conductivity. If we use backfill, then the backfill material has very, very low thermal conductivity. So, as a result of that, you're going to get higher and higher temperatures.

Criticality control, basically the main driver is: Can we get water as a moderator? And basically this analysis was using the results of the study done by John Wagner back in about 2001 where we looked at the disposal environment, availability of water, the presence of chloride in the groundwater--because if you have a lot of sodium chloride, it serves as a moderator--as basically the integrity of the overpack in the package.

We also looked at the possibility of whether or not we can add fillers through basically the (inaudible holes in the packages, and we assume that the burnup credit, as-loaded, were based on reactor operations.

What this chart shows you is that the peak radioactivity will happen in about 25,000 years. And, again, we're looking at a moderate burnup rate of 40 gigawatt per day per metric ton at 32-PWR assembly cask. And this is a plot of the K-effective versus Time. So the peak activity will be about 25,000 years.

Engineering challenges. We assume that we will be able to handle the fuel and the packaging using current practices. We have examined a number of different concepts for basically the underground operations. We looked at a heavy shaft hoist. Here is a concept that is being explored by DBE for an 85 metric ton weight. This spiral ramp, which is basically the process being used by SKB at the Aspo site, a linear ramp--this is a computer-simulated design used by Andra for the repository--and a shallow ramp.

We looked at opening stability constraints. Salt is fairly stable for a few years with fairly minimal maintenance. You can go to hard rocks. It could be 50 years or longer in terms of the stability of the openings. And for sedimentary rocks, depending on the geologic setting, maybe either 50 or longer years may be feasible. So this is an area that we are still researching.

The next set of slides what I'm going to do is I'm going to give you some ideas of some of the disposal concepts that we have been looking at. This one is primarily a salt disposal where the packages are laid horizontally. We use crushed salt as backfill. So, basically, when (inaudible) in salt, we take the material from one drift and use it as a backfill for the other. It could be used in either bedded or domal salt. We're looking at emplacing the waste 50 to 70 years out of reactor, and we're looking at a potential payload for transportation of about 175 metric tons.

Basically, we looked at a DPC that is loaded about 50 metric tons. The overpack increases to about 70 to 80 metric tons; and when you add the shielding, you're looking at about 150 metric tons and then the cart. So when you pile all that together, you're looking at a total weight of about 175 metric tons. Basically, what we're doing here is put in the packages horizontally and take advantage of that for the heat transfer capabilities of the salt. And you're looking at spacing between drifts of about 30 meters.

So when we assume that we have about 10,000 packages of these large DPCs, based on some of the projections that Jeff shared with your earlier, by about the year 2060 you're looking at a repository area of about 9 square kilometers with about 300 kilometers worth of drifts--so that's the size of the repository. For 10,000 packages you're looking at about 9 square kilometers in the terms of the areal extent of the underground.

Hard-rock concept unbackfilled, this is actually quite similar to the disposal concept that was considered for the Yucca Mountain license application. We're looking again at emplacing spent nuclear fuel at 50 to 100 years out of reactor, ventilate for up to about 50 years, so basically we're looking at permanent closure about 150 years or less. For unbackfilled saturated setting, this may be the best design concept, because it allows us to ventilate quite effectively.

It may require additional engineered barriers to be installed. For example, in the Yucca Mountain license application, DOE was proposing to use drip shields, and it provides some long-term opening stability. For this case, for about 10,000 packages, we're looking at a repository area of about 14 square kilometers with about 200 meters of drift space-—disposal drifts.

If we actually go to saturated conditions, including backfill, then we look at potential temperatures much higher than 100°C. So we're starting to see some real impact from whether or not we put a backfill--we backfill the drifts. And, again, as I showed you earlier, the reason for that is because the backfill materials which seem to be granular has a much lower thermal conductivity than some of the host rocks do.

The next concept we looked at is a sedimentary rock with both open and backfilled concept. Again, we looked at emplacement of the fuel about 50 to 100 years out of reactor. We looked at some potential flexibility that may be offered here, combining functions of storage and disposal. Again, as I said just a few minutes ago, with backfill we're looking at peak temperatures exceeding 100°C. It will take to permanently close a repository anywhere from a 100 to 200 years, depending on the burnup rate for the fuel that is being stored. And this is a big consideration as the utilities continue to load the casks with higher and higher burnup rates.

And you're going to see a chart that I'm going to share with you in a few minutes here about the impact of burnup rate as a function of the different sedimentary rocks, when we can start loading the--emplacing the fuel in the repository.

One of the big characteristics of this particular concept is the large spacing in between the drifts. This has to do with managing the thermal issues as well as preventing intersection of the drifts with some water bearing features of the geologic medium. In this case, for about 10,000 packages, you're looking at a repository areal extent of about 20 square kilometers. So, again, if you look at salt, there's about 9 square kilometers. If you look at hard rock, you're looking about 14 square kilometers. When you look at sedimentary rock, you're talking about potentially 20 square kilometers for the areal extent of the underground. So you're looking at perhaps even doubling the size of the repository site.

This is a concept that we have not studied in detail, but we included it in this presentation for the sake of completeness. Some countries--I think primarily the Japanese, I think Germany--may be also considering the potential of having a combined storage and disposal concept on their underground where the DPCs and packages are stored vertically in these very, very large drifts. Basically what happens is you have very large galleries for extended storage with ventilation exceeding 100 years. Again, this is a concept unsaturated settings may be preferred but not necessarily required, and may be the preferred way of doing it because of the ventilation capabilities, and we will have to install some engineered barriers at closure.

Like I said, we haven't started looking at this concept. We haven't analyzed it in as much detail as the previous three, but we threw it in here because it is a concept that some other countries are considering.

So having said all of this, this is a plot of the kilowatt power--the power of the representative 32-PWR canister as a function of time, panel closure time. And what you see here is different burnup rates. The dark curve here is about 20 gigawatt days per metric ton going all the way to

60, which is the solid black curve here. The center lines represent the hard rock open concept, and the bottom green line is about 10 meters of waste package spacing, and the top one is about 20. The blue line represents the salt concept with a 30-meter spacing between the waste package, 30-meter drift spacing. The magenta line is sedimentary unbackfilled site geology, and the red line is the backfill concept both for hard rock or sedimentary rocks.

I think that what's demonstrated here is it tells us how quickly we could emplace and close the panel as a function of burnup for the different types of disposal concepts. For example, if we have a backfill concept, whether it's hard rock or sedimentary, it's going to take a long time before we can close that disposal facility independent of the burnup rate. For a salt repository for a 20 low burnup rate case, you're looking about maybe 10 years or so. For the high burnup rate, you're looking about a little bit over a hundred--almost a hundred years.

So it gives you an idea of how quickly we could start emplacing waste in a repository as a function of the geology, as a function of the spacing of the waste packages, and as a function of the burnup. And this is for a 32-PWR size assembly, so I think it goes back to some of the statements that Rob made in his presentation about how long we need to let it sit either at a storage site or the reactor site before we can dispose.

The approach we use for postclosure criticality analysis for direct disposal of the DPCs, first of all, if there is no flooding, we cannot have criticality taking place. We have a moderator exclusion by making sure that they're looking at the integrity of the disposal overpack, and that becomes one of the most important characteristics.

Moisture is not present in some disposal concepts or is very little, and groundwater has some dissolved species that may absorb neutrons or displace the water. The neutron absorbers could be chemically and mechanically degraded on long-term exposure to groundwater, and we have both the absorber and the basket degradation--the basket degrading. Those are the cases that we looked at, which is very similar to the analysis that we did for the Yucca Mountain license application.

These are not necessarily realistic assumptions, but at this time it's the best we can do--that we've been able to do. One of the things that we have not considered is the presence of corrosion products.

One of the things really quickly here, we have flooded casks--37 canisters with intact configuration. If you look at the big arrows, basically what we have here in the solid black curve is when we have lost the absorber. In the red dotted curve here is when we have both the loss of the absorber, and we have degraded basket configuration. So it tells you how these things happen, how the likelihood for criticality increases. The small arrows going down basically shows the effect of adding sodium chloride.

Very, very quickly since my time is running out, we started looking at the logistics assumptions for different disposal scenarios. Basically what we have done is assumed that spent nuclear fuel will be generated at all operating reactors with 25-year life extensions and a gradual increase in burnup. We will put it in dry storage as plants are being shut down. The shipment of direct disposal from reactor sites to a centralized interim storage facility would begin in 2025, and the repository will start emplacing DPCs around 2048. And these are basically the same dates that are in the administration’s strategy with respect to the back end of the fuel cycle.

We would also assume that once the repository is operating, the DPCs will be cool enough for disposal and can be shipped from the reactors directly to the disposal site or from the central interim storage facility.

What this chart basically shows is two charts here and the number of canisters per year that we can dispose of and the amount of spent nuclear fuel in terms of metric tons of heavy metal per year of how quickly we can dispose. And basically what it shows is that at the current rate for PWR assemblies, by 2031 we will be almost done. If we were to repackage and we were to increase the throughput, these yellow and blue bars basically show that we can finish a little bit earlier.

So, to summarize, this is our preliminary technical evaluation of the direct disposal of the DPCs. We've looked at thermal criticality and engineering challenges for different disposal concepts. We have looked at some examples of potential disposal concepts for salt, hard rock, and sedimentary rocks. We've looked at the thermal results show that depending on the formation and the burnup rate, we can close the panels--the repository permanent closure--at 150 years or less out of reactor. For sedimentary rock settings and the higher burnup rate fuel, we have a little bit more challenges in terms of we may need to have some combination of longer repository operations and being able to increase the heating of the host rock more than 100°C and larger repository spacings. And the adding of backfill basically will increase the temperature significantly.

That's pretty much it.

EWING: Thank you.

BONANO: Thank you.

LANTHROM: Thanks, Tito. Gary Lanthrom again from NAC. You talked about the detrimental effect of using backfill, reducing your thermal conductivity. Have you looked at all at using engineered backfills like clays doped with carbon or with graphite that would significantly increase the thermal conductivity?

BONANO: It is one of the areas, Gary, that I think--is Ernie here? Yeah, it's one of the areas that we are planning on pursuing this coming fiscal year. It's in our R&D plan.

EWING: Okay, thank you.

Jerry?

FRANKEL: Jerry Frankel, Board. So when we talk about the corrosion allowance overpack, are you talking carbon steel, or do you--what's being--

BONANO: Yes.

FRANKEL: So have you considered the thickness of a carbon steel overpack that would be required and the weight of such a large structure, a thick overpack on such a large structure, what would that be?

BONANO: Not to the best of my knowledge, but, Ernie, do you want to address that a little bit better?

HARDIN: Ernie Hardin, Sandia Labs. Yeah, the--okay, DPC is loaded up with fuel weigh up to about 50 metric tons. The addition of 5 centimeters of steel all around that as an overpack would add about 15 to 20 tons. And, of course, you can scale up from there if you want a thicker one, thicker overpack. And carbon steel and most of the other materials that you might consider for such an overpack all have about the same density.

FRANKEL: And how long does 5 centimeters last in salt burn?

HARDIN: Well, our concept of a safety case for that concept is that we're looking for hundreds, maybe a few thousand years of performance out of that. It would serve to mechanically support the canister during transport and emplacement operations, and then it would provide some containment integrity through the life cycle of the repository underground facility. And after that we would not rely on it for postclosure safety. It also serves as a water-getter.

EWING: Yeah, right. So would there be engineered barriers? I mean, would the waste package matter with this thinking? Sorry, Rod Ewing, Board.

HARDIN: Okay, Ernie Hardin again. You might have gone just beyond the detail of our concept. Possibly. You know, WIPP has an engineered barrier. The current regulations would require that we have an engineered barrier, and there would be multiple barriers in that repository.

EWING: But, of course, WIPP is for something very different than spent fuel.

HARDIN: Yes. Yes.

EWING: Yeah. Okay. Another question here.

PEDDICORD: Yes. Lee Peddicord from the Board. In your slide on the panel closure time. It was number 16 on your presentation. But I wondered how sensitive are the curves to your drift spacing parameter as you stretch those out a little bit more? Do you see a big sensitivity to the panel closure time?

BONANO: Okay, so here, basically if we look at the two green curves, okay, this one is--the top one here is when the waste package spacing is twice as big as the one in the bottom here. Here is 20 meters between waste packages, and here is 10 meters. Remember when I said earlier when I was talking about the chart that has the thermal conductivity effect, the spacing between the waste packages is a little bit more important than the spacing between the drifts, which is a little bit more important than the diameter of the drifts. So when you come to spacing, the main parameter, other than thermal conductivity, is the spacing between the waste packages, based on the analysis that we’ve done so far.

EWING: Another question? Jean?

BAHR: Jean Bahr from the Board. How does the make-up of the overpack in the packages affect sort of the long-term stability of the waste, whether you have some sort of backfill within that overpack or whether that’s just an air gap or in terms of looking at a long-term repository performance and what does that do to the stability of the waste form?

BONANO: So basically what you have is a DPC with a disposal overpack, and the disposal overpack is the main interface between the waste form--let's put it that way--which is what you put in the underground and the surrounding rock. Okay? So the main interface is, what will be in touch with the geology, whether you have a backfill or not, is going to be the disposal overpack. So there is no backfill inside the DPCs. Is that--if I understood your--

BAHR: Yes. And I guess my question is: Does the lack of anything within that have some effect on how the waste form will behave if it's sitting in a hundred percent water rather than sitting in contact with the rock?

BONANO: Yeah. And one of the things that I mentioned is from the point of view of criticality is that one of the ideas that is being considered whether we can load through the watering holes in the DPC loaded up with fillers. We don't know what the effect of that was.

About 10 years or so ago--and Brady Hanson from PNNL is here. About 10 years or so ago PNNL did an analysis of basically putting, I think it was, concrete grout inside this waste package. They were looking not for disposal; they were looking for transportation. And if I remember correctly, one of the things that came out of that was that it was prohibitive in terms of the weight that it added by adding those fillers.

But it is one of the things that I think I showed in one of the slides--and I was going fairly fast--that we’re looking at whether loading them up with--but we’re looking at it primarily from a criticality perspective.

BAHR: Right. And I was asking less about criticality and about the release over longer periods of time from the waste form.

BONANO: We haven’t looked at that, no.

EWING: All right. We should move along, but thank you very much, Tito.

So from the next speaker, Dr. Thilo von Berlepsch, we’ll get the international perspective, particularly from Germany. He works with the International Cooperation Department of DBE Technology.

VON BERLEPSCH: Thank you very much for the introduction, and also thank you very much for giving me the opportunity to present to you the German nuclear waste management program. And, as you already said, the international perspectives mainly concentrate on the German program. And for one reason this is because I am German so it’s a bit easier for me to talk about this. And, secondly, I think, at least in my humble opinion, we’ve got a pretty good developed program. So I am very happy to show it to you.

It’s always good to get a bit of context when we talk about programs which are not very familiar to you. This is why I want to start talking about the history of our nuclear program--of our nuclear waste program. In fact, it started almost exactly 50 years ago when the decision was made to go into deep geologic repositories for radioactive waste, and already at that time we decided to preferably go to salt repositories.

Shortly after the work at the Asse mine in Germany started, this is a research mine where all of the knowledge was developed which we are using now for the development of our program. You might have heard about the Asse mine. People now say a lot of mistakes have been made, and I must say, yes, of course, they have been made because nobody knew exactly beforehand what to do in a mine. So we really learned quite a lot of these things and especially, I think, the colleagues from working for the WIPP repository--the results which have been made there.

And then afterwards we even operated some mines in the deep geological formations. The ERAM, the Morsleben mine, is in the former East Germany; and the Konrad iron mine was started to be developed in the ’70s, and right now it’s under construction. A very important milestone was in the end of the ‘70s when the regulators decided to put a new license condition on the nuclear power plant operators, and that is they had to prove that they survey for repository of nuclear waste. And this had two impacts, so to say.

On the one hand, it gave the possibility to the anti-nuclear groups to really find a new field of activities. They saw that the operation of nuclear power plants were fairly safe, at least in Germany, and now they found something where there is no solution yet. So this is why there was a very big opposition on repositories in Germany, and even the Green Party have got their roots here, which is also the problem when you go further down. I won't go into too much detail there, and all the troubles we've got in Germany with politics right now I think have got their cause up here.

The second good thing or the second important thing--it's a good thing, to be honest--the operators were forced to really develop some solutions for the final repository of nuclear waste. And this is when all the programs started to become more serious, so there were companies formed to work on the programs, and especially the work on the Gorleben salt mine started, which is now under big discussion unfortunately.

But this is very broadly the context of our nuclear waste program in Germany.

Before I go now into more details, I'd like to discuss with you some assumptions and definitions. I already notice that the term borehole concept is seen quite critically, at least by some of you people. When I would talk about borehole emplacement, that doesn't mean the deep geological boreholes. It is more a borehole within the mine just to use a certain engine. So, for example, Konrad has got a depth of homogeneous soil to almost about 3 kilometers, so when you have just one level of the mine repository, it just makes sense to go a bit deeper in boreholes to emplace the casks.

Then there are different types of casks we are talking about in Germany. The most famous ones, at least in Germany, are the CASTOR one, which was already mentioned today here, for transportation and storage and the POLLUX cask, which is a brother to the CASTOR and which is licensed for transportation or disposal. It's not licensed yet. The work stopped since the work in Gorleben stopped. Further casks are the BSK, Brandschutzkleber, it's called, so this is a small canister for the borehole concept. And we've got some casks and canisters coming from the reprocessing facilities, mainly from France and the U.K. coming back to Germany.

And when I talk about conditioning, I mean preparation for disposal. That means all the things you have to do when you want to put your cask finally into the repository.

And then the final thing is DIREGT, just to mention it. I will go into detail that this is a direct disposal of the transport and storage casks, CASTOR.

When we’re looking at spent nuclear fuel management in Germany, like always there are two different fruits in principle. And the one is going via reprocessing, and this was formerly the only way up until the ‘90s, while the direct disposal option, which means direct disposal of the fuel elements, is now the exclusive way to dispose of nuclear fuel. This option was allowed in the ‘90s, but people have been working on it obviously quite some time before.

In Germany we’ve been forced to work very early on the final repository program and also on the management of nuclear waste, and I think this is why we’ve got some advantages, at least now, and the concept was always to go via some kind of preparation for disposal and to the disposal facility. And that is why, for example, we designed all the program to have, for example, transport canisters and storage canisters at the same time, so we don’t have the issues of just having storage canisters at the nuclear power plant sites, which you then have to repack somehow or have to handle it in a different way.

This now introduces into the main concepts we’ve got, and there is lots of good work done by all the institutions in Germany, which mainly focused on the Gorleben site and its called preliminary safety analysis of Gorleben.

And most of these issues I will be talking about are captured there as well. Unfortunately, this is only in German, the safety analysis, but they will be in English, and some will be available hopefully by the end of this year for those of you who are interested in it.

And this safety analyzes and summarizes mainly the reference concept, and this is a concept we've been working on from the very beginning of our nuclear waste program. The reference concept is put at the nuclear power plant all the waste into CASTOR casks, transport them into an interim storage site, where then the fuel elements will be disassembled, put into the POLLUX casks, and then transported downwards and be emplaced there.

Additional concept is--this concept, by the way, is completely demonstrated, so we've built all the equipment, all the (inaudible). Even the hoisting system was developed and tested several times. And so I would say this emplacement is demonstrated. The one for boreholes is also pretty much been demonstrated, apart from the fact that we didn't have drilled the boreholes in the mine, but the emplacement procedure itself was tested at least.

So it starts quite similarly. You've got the CASTOR casks; the fuel elements will be disassembled and then put into a much smaller BSK canister. Because it's much smaller, the shielding is not as good as in the case of the

POLLUX canister, and that's why the transfer cask is needed to put it down into the repository. The advantage is that the transfer cask can be reused again, and we need a lot space with these smaller canisters.

Over the last years--and this has been just addressed by Tito--we also have been working on the direct disposal. That means direct disposal of the transport and storage carts into the repository. But here only paperwork has been done so far.

So let's start with the reference concept of the repository design. The mine itself has been completely designed. This is, by the way, the Gorleben site with the salt dome, the homogeneous part of the salt dome here. Here you can see the two shelves, which are already existing and which are built. And on top of this level, there is--how to say--a test drift already built to see how the ground looks like. All this is done in about 900 meters depth.

We will use the CASTOR cask for the transportation that's already set. There was a discussion earlier on the bolts. You can see here that the CASTOR cask actually really uses for closing the cask bolts for both the inner lid as well as for the outer one. And to the best of my knowledge, this was developed before my time, to be very honest, and this was done to really keep the flexibility and especially--and people already knew that the CASTOR cask was supposed to be opened again, and the fuel elements were to be taken out and put into the POLLUX container, so people thought of a way of easily closing the cask and opening up again for the later processes.

And this is the storage configuration. It looks pretty similar when the CASTOR is transported. It only puts some numbers on both ends of the CASTOR. And, just for information, this CASTOR weighs about 120 tons.

So when this is filled and then transported towards the repository site, then it was supposed to in the very beginning have a conditioning plant and at least near the repository. And, again, like the sometimes crazy Germans are, the date of complete pilot conditioning plant, which can do all the processes and handlings which are necessary for repackaging the fuel elements from the CASTOR cask into the POLLUX cask. And this is all done under dry conditions, a hot cell was built where all the handling can take place.

This facility is licensed. It’s far too small for the original purpose, but it’s also called just a pilot plant or pilot facility. But it’s in principle fully licensed. But at the moment it’s only allowed to prepare the casks. Up to now, nothing is done in the facility, mainly because all the casks are still intact. And if somebody decides to demolish this, to decommission this, it’s relatively easy because no hot stuff was used here.

So coming out of this pilot conditioning plant or this conditioning plant in general, the fuel elements will be put into the POLLUX canister, which I’m not a hundred percent sure, to be honest, but I think this one is welded at the top, because nobody wants to open it up again, and you can just put it down into the repository.

And this is still relatively heavy. This is 65 tons. And for the transportation of this POLLUX container you see here, a dummy, all the equipment has been developed so far. So all the locomotives, for example, even the hoisting system was developed. This is an 85-ton hoisting system especially for casks for radioactive waste. And here the emplacement machines all have been developed, and all this equipment has been tested I think about a thousand times in more or less real conditions. You can see it here. So this looks like an excavation inside the mine so that the people can really test how is it to work with these machines, because in reality everything is different than just on paper, as I guess all of you know.

So, for example, there have been some tests. You can see this on rails, and it has been deliberately derailed, and then it was put back on track again under these conditions, and people used this to get timing for it to see how long does it take, how long will the stuff be exposed to the radiation of the canisters.

So much to this.

And, finally, these are pictures from the Asse mine. There have been done some tests in the Asse mine to see if it’s really possible to close, to backfill the shafts. So they put the heater casks into the mine, and they backfilled it so the machinery was used, or at least the principles have been used, which were thought of for the final actual repository site. The heater tests went for about 10 years; and after these 10 years it was opened up again, and it looked very good. So there wasn’t a real difference between the backfilled material, which was pure salt, and the host rock next to it. So you can say this test has been successfully performed.

Nevertheless, from here there was done a step further to the borehole concept, so what we call borehole concept. The idea was, of course, like the concept before, both categories of waste, the vitrified waste from reprocessing as well as the spent fuel, shall be put underground. And emplacement technology, again, should be developed for the whole chain of activities. But the main idea is to use a borehole concept for its improvement of heat transfer to the waste canisters. And the big advantage is that only a relatively small borehole was to be used, so backfilling doesn’t take so much space and the host rock can creep very fast onto the canisters again.

This is slso the second point here, and also--I think I mentioned it earlier--the required footprint is a lot less than in the reference case, because you use a third dimension in the mine. The cask is relatively cheap, the borehole cost, so you save some money. And also the operation is a lot easier with this. And you use less metallic material, so you also have got less corrosion products in the mine.

And, if you remember--I'm not quite sure if you do--in the reference concept we've got all together 12 of these fields, and here you see two--let's say two and a half. But in principle, it's again in the repository on the Gorleben mine--it's not a repository.

And the canisters which are to be put down there are designed to be consistent with the canisters coming from the reprocessing facilities. They are mainly these CSD canisters. And so this has got the same width as the CSD canisters, and putting three of them on top of each other gives you around about the same height for the BSK canister. So what was done here, it was hard to develop for all kinds of ways to be used in the mine the same type of canister which eases operation in the underground mine quite a lot.

And, again, as I said before, all the equipment has been developed to each and every detail, so this is a transfer cask. And also the handling means for it have also been developed and tested. And also the emplacement machine for this concept also has been developed and tested. I don't know how many times, I think a thousand times, these tests have been running.

And underneath this machine there was a 10-meter hole, which the canisters were placed in. And there also have been some backfilling tests. Because the hole is relatively narrow, it wasn't sure if it's really possible to backfill these holes. And these tests so far have been performed quite good, and they even have been--how to say--they've been turned a little bit, these canisters, to see if this is also possible. And there also have been done the first tests of retrieving these canisters if something would have gone wrong. And this was especially challenged, because you can't guarantee that this thing at the top of the canister is always in the middle of the hole. But these tests have been working quite good.

And from there the next step was just the development of direct disposal of the transport and storage canisters from the CASTOR canisters mainly. And the idea was, again, just simplifying everything. And there is no real need for the CASTOR canisters anymore, especially not in Germany when we are thinking of phase out, and so you have to do something with them as well. And you also want to avoid handling as much as possible with the fuel elements, so why not just put them directly together with the CASTOR canister.

And there also have been done the first preliminary designs, and these have not been done in so much detail as the other designs. But, nevertheless, there have been done calculations on the spacing between the casks and also between the boreholes, quite similar to the calculations you've done in Sandia. So there already is for this type of design--design ready.

As I said, here mainly paperwork has been done so far. But, nevertheless, we've developed, at least on paper, concept for a hoisting system, which should carry--I'm not quite sure if it's by coincidence, but it also should carry 175 tons. And so far nothing speaks against the feasibility of this. Right now we are going into a bit more detail of this. We prepared some 20 years ago a probabilistic safety analysis for all the handling which was done on the repository site with special emphasis on the hoisting system, because people are quite afraid of transport of such a heavy weight inside the repository, and that's why we now want to start over this work again and started with some work on the shaft as well. And, again, also all the equipment is developed again, but not built yet at least.

And we are pretty sure that we can do this work, these horizontal boreholes here. There is machinery available for this, this is standard mining machines. And the differences what we are now doing is we also tried to simplify the processes underground. So, for example, in this case the transport cask will be turned directly, while in the older cases you would have to lift the transport cask and use very heavy machinery to really put it in the final position in the end.

Unfortunately, all the developments to go to a more simplified design also sometimes have got some drawbacks or issues at least, and so I don’t want to hide them. Before you the BSK concept, the borehole concept, is very nice; but it obviously only works when you’ve got a repository which is deep enough. When you only got a shallow layer, then you can’t drill some several hundred meters of boreholes into it. And since, I said, we haven’t drilled yet these couple-of-a-hundred-meter deep boreholes yet. It is also not demonstrated yet that retrievability is possible. For smaller distances, we show that it is possible, but not for the very deep ones.

Or to the proof of backfilling, we did it a couple of times, so it’s demonstrated but it’s not proof-ready yet for licensing. And the canisters are mainly, they only have got some steel wall around them, and so there’s no real shielding provided for the cask to put underground, and that’s why you need for all the equipment you’re using really relatively complex emplacement technologies. And we also got relatively high radiation impact on the host rock.

For the Diregt concept, it’s just existing on paper, so it’s hard really to say something about the main disadvantages, but I already know that some topics at least have also been discussed at least I guess in the whole community. So the handling of very heavy loads, of course, is a challenge. It works on paper, again, but it’s not demonstrated yet in reality. And the cask itself are designed for storage and transport but not for being underground for several hundred years. So also criticality is an issue. There have been some preliminary assessments for this, but they show it’s very, very, very unlikely that we come to a criticality issue. But, nevertheless, it has to be demonstrated, and we’re just talking about paper here.

Coming to my last slide, when you are going to plan something in more detail, you always discover some challenges, of course, and especially when it comes to operational and when you test some things, and I’m very happy that you have already seen most of these challenges as well so you are aware of these. I always thought that it’s kind of difficult when you’re handling some ten different casks with different lengths, different sizes, different centers of gravity, but what I heard today is that your challenge is a bit higher in this case.

We need some specific requirements on the hoisting system, and so we really need quite extensive and sometimes unfortunately also cost and costly development work. When you're going into the mine and the radiation issues are all so different than to the ones you've got above ground. So you've got (inaudible) directly adjusting to you, and so you very often got problems with back-scattering, for example, of neutrons by the host rock, and it might even become more difficult when you go into granite, because this has got some radiation by itself.

All the handling you're doing underground, again, you've got the advantage that you've got an underground facility, but all the handling underground is quite complex and time-consuming. So you just don't have got--and this is also the last point here is you just don't have got the space as above ground. It's very limited and it's very complicated, and you really have to test things first before you want to install it. And with this outlook and challenges, I want to conclude my presentation. Thank you very much.

EWING: Thank you. The presentation is open for questions or comments.

MOTE: Nigel Mote, Board Staff. Thilo, thanks for the presentation. Could you tell us how deep the concept is for which you've examined the emplacement of lowering of loads of 175 tons? Certainly within the industry here there has been discussion about limits on how far you can go down with those sort of weights because of the need for single failure proof designs or redundant lifting systems.

VON BERLEPSCH: This concept was developed for the Gorleben site, which is about 900 meters deep.

MOTE: Okay, thank you.

EWING: Jerry.

FRANKEL: Jerry Frankel, Board. You talked about the creep of the backfill salt. I’m just wondering, is there any concern that these very heavy loads creep up the host salt over time?

VON BERLEPSCH: You mean settling of--

FRANKEL: Yeah, the forces of the heavy load on the host salt formation.

VON BERLEPSCH: Well, I’m not a geologist, and this answer should be answered by them. But, to my knowledge, no, there is no real concern about this, because more or less you’ve got the pressure from all sides in the end of the host rock, and the salt is very, very stable, in fact. So, when you go--for example, you are invited to go to the Gorleben site, and you see that even the rails inside the--the roads inside the mine are just pure salt, so they can really carry a very high, a very high payload.

EWING: Just to follow up, you know, one of the attractive qualities of salt that’s often mentioned is that it flows. So if you have these hot, heavy objects, wouldn't the salt flow around the package?

VON BERLEPSCH: Well, I can't really answer that. I'm just an engineer, not a geologist. But it has been assessed, this issue. And as much as I was told, no, there is no real big danger. Maybe part of it is because we've got this very deep site in Gorleben.

EWING: Okay, thank you.

Other questions? Yes, please.

RESNIKOFF: This is Marvin Resnikoff of RWMA again. What is the maximum burnup of fuel that you're looking at in Germany?

VON BERLEPSCH: It's around about 70 megawatts. Yeah, around about 70 it is; at least there are some licensing procedures right now going on with this, this number. Up till now we are around about--60 was the highest burnups, and the operators wanted to extend it. I'm not quite sure what the current status is because of the phase-out. They are limited in time, so I think they really want to keep these fuel elements into the reactor.

RESNIKOFF: What are the units--

EWING: You need to--

RESNIKOFF: What were the units used, 70--

VON BERLEPSCH: Megawatts.

RESNIKOFF: 70,000 megawatt days per metric ton?

VON BERLEPSCH: No, sorry, 70 gigawatts.

RESNIKOFF: Per metric ton?

VON BERLEPSCH: Yes.

RESNIKOFF: Uh-huh. Thanks.

VON BERLEPSCH: 70. Sorry.

EWING: Okay. Other questions? Yes.

NIGAM: Hitesh Nigam. I'm from the Department of Energy. I'm just looking at your schedule over here. You had a ten-year moratorium. Could you talk about that? And for some reason there's nothing after 2013. What is your schedule for the remainder of the project?

VON BERLEPSCH: So the moratorium was--they discovered that a CASTOR cask--I think it was 14,000 becquerels at one point after it arrived at the Gorleben site, and after that all the process was questioned, and there was also big issue on using nuclear power in general, so the political discussions started. And that's why all the work has been stopped at Gorleben--all the exploration work. The mine was kept open, and all the data measurements were kept alive, but no real experiments or research for the mine was done in these ten years. And it was decided at that time of day that after ten years the process shall be reopened again.

And exactly at that time the Conservative government came into force in Germany, and they changed completely, and they went for lifetime extension at that point in time. And shortly afterwards Fukushima happened, and the same government made a turn back again, and this is now where we are. So this is a ten-year moratorium, and now we are again at the moratorium in Gorleben, which doesn’t look that good. So there are no times for Gorleben at least.

Concerning the schedule, we’ve got a law on site selection, which was put into force this summer in July. And the law now foresees that a special commission shall decide on special criteria for site selection again, and these criteria shall be agreed by the government in 2015. And then we’ve got a new law on the site selection with these criteria involved, and for the site selection there shall be a specific regulator and also the current--the former operator--the former authority for the repository shall be staffed with some more people. And up to 2031 there shall be a site ready, which then shall be licensed and developed.

But there aren’t any other numbers.

NIGAM: So you don’t have a projected operational date?

VON BERLEPSCH: No. There are some wild guesses. I think when you look at the schedule, we are now planning for 15 years for a site selection, but we really have to start with a complete wide net again, and this means you start with above ground surveys and then go into the mines and--no, there is no real schedule for this.

NIGAM: Sure. Thank you. The name is Hitesh Nigam.

EWING: Is it on the workshop topic?

METLAY: Dan Metlay, Board Staff. You’ve mentioned the new site selection law. Has any work been done about non-salt media?

VON BERLEPSCH: Yes. There actually is work on non-salt medias, so we’ve got a generic safety concept for clay, for example, because there are some clay formations in Germany. And there also has been some work on the Geologic Institute in Germany, just already some, I don’t know, 20, 30 years ago, on different sites in Germany where a possible repository could be. And they also did look at clay formations. And we are also involved in all the research, for example, in Belgium and France. But this is also true for granite.

EWING: So let’s leave site selection, and perhaps this will be the topic for another workshop by the NWTRB.

Other questions?

All right, let’s thank our speaker again. Thank you very much.

So it’s my pleasure to introduce the last speaker for the day, Allison Macfarlane, who is the Chairman of the Nuclear Regulatory Commission, and she’ll be giving us comments from the NRC perspective.

MACFARLANE: Good afternoon. It’s great to be here. It’s great to see so many familiar faces. I feel like I’m back with my people.

Also, I have to remark, the last time I remember meeting with the Nuclear Waste Technical Review Board was when I was on the Blue Ribbon Commission, and it looked an awful lot different than it does right now. I am very pleased to note that the majority of members of the Board are women. And being the only woman speaker of the afternoon, I just had to comment on that. I congratulate you all on that achievement.

And thank you very much for the opportunity to be the clean-up crew here. And I'll bring a bit of NRC's perspective to the discussion today.

And I just want to note also in starting, I think, to me anyway, the really important message of this afternoon and probably your entire workshop is on the need--the desperate need--to integrate our approach to the fuel cycle. And what I mean by that is you really have to take account for the back end early on; otherwise, you end up with the situation that we have in the United States where we're talking about repackaging canisters and all of that. I'm probably preaching to the choir here, but it's important. It's one of my issues that I find really important that I keep emphasizing to my nuclear engineering colleagues.

With that, let me talk a little bit about some issues. And before I get into the meat of the topics, let me dispense with some other issues that you might be interested in that are sort of a backdrop to our nuclear waste policy considerations.

You’re probably aware that in 2012 the D.C. Circuit Court of Appeals vacated the NRC’s 2010 Waste Confidence Rule and said that NRC in part hadn’t successfully considered a permanent repository, that a permanent repository would not be available. So the NRC has since then been working on revising its Waste Confidence Rule and developing an environmental impact statement, and we’re currently in the process of holding twelve public meetings--I think we’ve done--as of tonight we’ll have done seven of them--and collecting public comments on that draft rule.

At the same time, you’re probably now all aware that the court--that same court, actually--directed the NRC this past summer to continue and resume the Yucca Mountain licensing process. And today, this morning at 11:30, the Commission issued an order directing the staff to complete the safety evaluation reports for Yucca Mountain construction authorization application.

The order requests that the DOE prepare the supplemental environmental impact statement for NEPA review and also asks our staff to load documents from the old licensing support network into our ADAMS system so that the staff has access to them as they begin to complete the safety evaluation reports with the ultimate goal of making all documents available to the public, but certainly the documents that will be referenced in the safety evaluation report and the environmental impact statement will be, of course, made public.

So that’s basically what I have to say about Yucca Mountain. I can’t really say any more, because it’s an adjudicatory matter that’s going to be before the Commission, and so it’s not appropriate for me to go into any more detail on it than that.

Let me, though, be clear about one thing, and that’s NRC’s role in terms of a repository. NRC’s role is to ensure that a future repository is licensed consistent with applicable standards and that it’s operated safely. I want to note that there are a range of policy matters that were before the Blue Ribbon Commission and that the Blue Ribbon Commission considered that Pete Lyons referenced earlier and that aren’t specific to a repository and a repository site. For those matters, it’s the responsibility of congress and the administration to update the national policy for high-level waste disposal. So they are the policy makers on those issues.

Another related consideration right now is decommissioning of sites, and Jeff Williams talked a fair bit about some of the decommissioned or decommissioning sites in the U.S. And as more sites continue to announce decommissioning and shutdown, without a permanent disposal solution, a larger portion of spent fuel at the sites will be stored in some kind of long-term storage. And I'll focus on this issue a little later.

It's clear right now, though, that decisions made today--and this is really what we've been discussing today--made by the industry regarding the back end of the fuel cycle could impact storage, transport, and disposal in the future. I believe that looking at various parts of the fuel cycle in isolation will likely end up with unintended consequences.

So let me talk a little bit more about NRC's regulatory program. So I'm going to highlight NRC's role in overseeing storage, transportation, and disposal and some of our key regulatory activities. The Commission is charged with ensuring that commercial spent fuel is safe and secure during all modes of storage and disposal. We're responsible for certifying the packages that may be used to transport spent fuel from one facility to another. We don't endorse any particular strategy for the management of commercial spent fuel. Our job is to regulate the current technologies and practices employed by the industry.

At the same time, I personally believe that we should be cognizant of the impacts our regulatory decisions have on other aspects of the national waste disposal mission.

I think it’s--you know, we shouldn’t be doing this with a blindfold on.

We currently regulate approximately 60 sites that have deployed dry cask storage--Jeff talked a fair bit about this earlier today--including operating sites, decommissioned reactor sites, and two DOE facilities. As part of our regulatory program, we also anticipate and prepare for future strategies and scenarios that industry and DOE may choose for long-term management of spent fuel. So in terms of spent fuel storage, Jeff’s presentation earlier discussed in detail the population of storage casks used in the U.S. The NRC licenses spent fuel under 10 CFR Part 72 either with a site-specific license or a general license that’s been granted to all reactor licensees.

In total there are more than 1,700 loaded storage casks, and there are approximately 15 site-specific licensees with unique cask designs, including the G.E. Morris facility, which uses a pool. There are approximately 60 design variations that have been approved for use by reactor licensees. These design variations represent the continued evolution of cask technologies in increasing capacities and versatility and other changes that are tailored to meet the specific needs of reactor licensees.

Most of the loaded casks are canister-based systems, as we heard, and are dual purpose. Utilities and designers intend for the casks to be transportable under our regulations of 10 CFR Part 71 and do not plan to repackage casks at the reactor sites. However, as Jeff pointed out, there are a few vintage casks that aren't designed for transportation and will likely need to be repackaged.

Also, Jeff noted in his presentation, there are often cask designs that have been approved first by the NRC and loaded by industry for immediate storage but not yet approved by the NRC for transportation. The NRC does not currently have a policy that requires dual storage and transportation approval at the time of loading. The NRC performs license application reviews and routine inspections. We conduct regulatory research, and we develop rules and guidance to address emerging regulatory issues.

So let me talk about some of the technical issues. Along with aging management issues for storage, the NRC staff is in the process of evaluating potential technical issues relating to extended storage and transportation. In particular, the staff is seeking to identify areas where additional data and analysis may be needed to effectively regulate long-term storage.

So we have identified through extensive public engagement and research a number of cask degradation issues that require further analysis, and these include stress corrosion cracking of stainless steel in marine environments, concrete degradation, the effects of residual moisture inside spent fuel canisters after drying, non-destructive methods for inspection and monitoring of dry storage casks, and more realistic thermal calculation models.

The staff, in particular in regards to stress corrosion cracking--sorry--yeah--in regards to stress corrosion cracking, the staff demonstrated that chloride-induced stress corrosion cracking occurred in multiple stainless steel specimens exposed to realistic in-service canister environments and included stress states and chloride content and temperature range. They performed analyses to assess realistic canister weld, residual stresses, which promote stress corrosion cracking, initiation and growth, and the NRC performed a feasibility study to determine potential candidate, non-destructive, evaluation-based in-service inspection methods to detect stress corrosion, cracking in canisters. So this has been an area that's taken a fair amount of our focus.

We are also looking at high burnup fuel issues. Of course, there has been a fair amount of discussion about that this afternoon as well. We're interested in the long-term physical properties of high burnup spent fuel and the implications of high burnup spent fuel for storage. We've asked cask users and designers during consideration of storage cask license renewals to provide data on the expected behavior of high burnup fuel over long storage periods, and there is little data, really, that exists of similar type that’s available for low burnup fuel.

We’ve also sought additional information and analysis in improving transportation packages for high burnup fuel. Cladding integrity in terms of transportation is often credited for geometry control in terms of criticality safety analysis that’s required under our regulations. We just completed some research with Argonne National Lab to examine temperature ranges at which the cladding goes from a ductal to a brittle condition as it cools during long-term storage. And this Argonne research concluded that reorientation of hydrides, which you see here--these black lines here--into radial patterns--and this is cladding--into radial patterns during storage represents an additional embrittlement mechanism that can reduce cladding failure limits during storage as the cladding temperature decreases below the ductal to brittle transition temperature. So, as such, the effects of radial hydrides have to be included in structural analyses when cladding temperature is below the ductile to brittle transition temperature.

The research also observed that susceptibility to radial hydride formation and radial hydride induced embrittlement is highly dependent on cladding material--I guess that’s not really that much of a surprise--irradiation conditions, and predrying distribution of hydrides across the cladding wall, as well as peak drying hoop stress. DOE is supporting additional testing at Argonne to obtain information on this issue.

And the research does not necessarily conclude whether this phenomenon is significant enough to cause cladding failure and an inability to handle spent fuel after storage. So I think that licensees should consider this issue in the licensing of storage and transportation casks, noting that there is little confirmatory data to validate the predictions of high burnup fuel behavior in long-term storage. So, in general, this is an area that needs more research.

The NRC is also pursuing other research activities in order to get a better understanding of how spent fuel behaves in potential long-term storage environments and eventual transportation. This includes the development of a tool to determine whether fatigue or structural damage from vibration could affect high burnup fuel cladding during routine transportation.

Finally, the DOE and industry are implementing a long-term demonstration program to provide confirmation of high burnup cladding integrity during storage. The NRC is monitoring this program to make sure the information it provides is valid and is useful for us in a regulatory context.

We are also examining regulatory framework for storage and transportation. The staff at the NRC is working to identify ways to improve the efficiency of the licensing processes. They are also examining key regulatory issues such as the compatibility of storage and transportation requirements and regulating storage facilities at decommissioned sites.

So as part of NRC's evaluation of the compatibility between storage and transportation regulations, the staff is reviewing its policies, regulations, guidance, and technical needs in key areas such as the NRC policies for retrievability, cladding integrity and safe handling of spent fuel, criticality requirements for spent fuel transportation, and the aging management and qualification of dual-purpose canisters and components after long-term storage.

For retrievability the staff is still in the process of making a determination on whether NRC's guidance should remain fuel assembly-based or transition to allowing canister-based retrievability for storage of spent fuel. Additionally, the staff is still considering whether retrievability and cladding integrity should be explicitly incorporated into the transportation regulations to ensure that if spent fuel is eventually retrievable after transportation to a consolidated interim storage facility.

Another issue is spent fuel stored at decommissioned reactor sites, as I mentioned. As was discussed earlier, there are ten independent spent fuel storage installations at nine sites. This is the stranded or orphaned sites. And, as you know, additional reactor sites have recently announced shutdowns and plans for decommissioning. And at these sites the reactor infrastructure has been or will be largely dismantled, including equipment that can be used to individually handle or protect spent fuel. So it’s not going to be there anymore, as we’ve been discussing, and this includes spent fuel in associated facilities, I mean, pools in associated facilities. So the growing number of these sites like these is an issue that I believe we need to consider.

The NRC staff also plans to review the current regulatory framework and how it applies to stand-alone independent spent fuel storage installations, including consideration of long-term aging management needs and the applicability of general license framework to these dry storage facilities at sites that no longer have an operating reactor.

So let me add a caution that many of these research programs that I’ve been describing ongoing at the NRC are dependent on adequate funding. Yeah, I know. And these programs may end up experiencing further reductions or slowdowns as a result of further sequestration cuts if they come. So something to keep in mind.

Let me mention waste confidence again. So since September 2012 we've had a dedicated staff working just on waste confidence. This recent government shutdown did affect us. It forced us to postpone five of those twelve public hearings, and it also resulted in extension of the public comment period to December 20th. But we were able to reschedule all those meetings, and so we'll get them all in before the new year.

One key issue on which we're seeking comment is whether the proposed waste confidence rule and the related Commission policy should address the feasibility of a repository being available 60 years after the licensed life of a reactor. The related issue here is whether spent fuel can be safely stored on site during that intervening period until a repository becomes available, and I invite all of you to send us your comments on that issue.

So where do we go from here? I think that's my final slide. So the lack of a final repository solution and the evolving needs of interim storage and transportation is an issue that industry, the DOE, and the NRC has to consider within our respective roles. And we have to ask again how our actions now might impact decisions and technology choices later. It's, I think, a pivotal time right now for nuclear waste policy in this country; and, again, the onus is on congress and the administration to make it so. And Pete talked about some of these issues earlier.

However, we have to continue to do what we can at the NRC from a regulatory standpoint to prepare ourselves for any of the potential scenarios that may come down the pike. Our regulatory framework generally presumes that spent fuel may need to be directly handled while transitioning between the storage, transportation, and disposal phases of this process.

So the NRC encourages industry and the DOE to closely coordinate on the interfaces of the fuel cycle to ensure that safety is maintained and efficiency is optimized to the extent practical. This also helps to promote long-term efficiencies on the regulatory side as opposed to the NRC taking a piecemeal regulatory approach to new and unintended issues that occur because of past decisions.

We should also endeavor to engage actively with the public to foster understanding of how fuel is handled at each stage of the fuel cycle, particularly on the back end. People understandably have concerns about whether they are protected if casks of fuel remain for decades on a reactor site near their home or passing them on highways or on their way to interim storage. The NRC is working to strengthen public engagement to ensure that people have the opportunity to ask questions and get the information in plain language they can understand.

The NRC will continue to consider the interface of our regulatory regimes to potentially improve efficiency and effectiveness. I appreciate the NWTRB's attention to these issues and its role in providing technical advice to congress and the DOE.

So thank you. I appreciate the opportunity to speak with you today, and I'm happy to answer your questions. I want to note that Mark Lombard, who is the Director of the Division of Spent Fuel and Transportation in our Office of--and everything has a long name at the NRC--Nuclear Material Safety and Safeguards--and Mike Waters from my staff here. Mark is in the back somewhere. Yes, there he is. And Mike's here--are also with me to help answer questions if we get too much in the weeds, and I'm not a master of every piece of information.

So, with that, I'll take your questions.

EWING: Thank you, Allison. And the presentation is open for discussion, comments, questions.

GOTHERMAN: Brian Gotherman. Thank you, Chairman, for your remarks.

I had a question. Could you shed any light on the item on Slide 5 pertaining to residual moisture in canisters? What's the genesis of that? Maybe your staff. I'm sure you don’t know those details.

EWING: Can you pull up Slide 5?

MACFARLANE: Residual moisture in canisters?

GOTHERMAN: Yes. What’s the genesis of that whole effort?

MACFARLANE: Let me ask Mark to answer, but he needs a microphone.

LOMBARD: Lombard, NRC. Brian, it relates to the work that we’re doing at the Center to determine how much moisture is left in a cask after the vacuum drying operation is complete. And I’m not sure exactly what the status of that work is, but it relates to, again, how much is left in it after the vacuum drying. I think we’ve talked about it other--

SPEAKER: What started it?

LOMBARD: What started it? That’s a good question, and I’m going to phone a friend down here, Jim Rubenstone.

RUBENSTONE: This is Jim Rubenstone, NRC. And Mark’s right. We had a couple studies done by our contractor in San Antonio to look at the question, because while there are well-developed methods that are in use in the industry for drying, there’s not a lot of confirmatory information, because the number of canisters that have been opened after drying is very limited. So we had them look at some questions about how much water could be trapped within and then what would be the potential impacts of that.

So we're trying to do some follow-up work to see--just looking for confirmatory information. And that's another area where this demonstration plan that has been laid out by DOE and its contractors may shed some light on that as well.

EWING: Okay, thank you. Other questions?

CURRAN: Diane Curran, Harmon, Curran, Spielberg and Eisenberg. Thank you very much for your remarks, Chairman Macfarlane. And I want to--I just want to say how much the many environmental groups I work with have appreciated your commitment to open this in the waste confidence process. All the meetings you've held, your accessibility for help and information, very much appreciated. This is a hugely important issue to the groups I work with.

One of the things I'd like to ask you for is you mentioned some research that Argonne Labs has just yielded some results. Is there a way that that information can be publicly posted so that people who are commenting on the waste confidence EIS can have a look at it?

MACFARLANE: I imagine that--yes. And thanks, Diane, for your comments. It's nice to see you. I imagine it should be--if it isn't posted already, it should be. Is it posted?

SPEAKER: It's on ADAMS.

MACFARLANE: It’s on ADAMS.

CURRAN: Okay, terrific. Thank you.

EWING: Other questions?

GREEVES: John Greeves. And earlier in the year the staff put out a notice asking for comments on retrievability and cladding integrity policy issues; and I haven’t seen any results of those 17, 18 comments that have come in. Is there a status on when that’s going to come out and any follow-up with it?

MACFARLANE: Mark? Good thing I brought a whole bunch of people with me to answer all these questions, huh? That’s the problem when your agency covers tons and tons of things.

LOMBARD: As many of you know, the retrievability question and cladding integrity is a difficult concept to wrap our arms around, because, as the Chairman said earlier, we want to make sure we don’t make regulatory decisions now that have wide-reaching negative impacts going forward. So we are still looking at the comments.

We are taking into account all the environment that we’re in right now. And it’s a tough question to answer. It’s something that’s going to require a change in policy, because we did send up a letter to the Commission back in 2001 that defined retrievability on a fuel assembly basis. And as my colleague here, he’s in Team Canister, I believe. There’s Team Canister and Team Fuel Assembly. And we still haven't chunked through all the information that we have to date and made a decision and put it together. Again, it's going to be a letter that goes up to the Commission for them to help us make that policy decision.

EWING: Okay, thank you, Jerry.

FRANKEL: Jerry Frankel, Board. So we heard earlier from Jeff Williams that the dry casks can be recertified for 80-year lives and that maybe some manufacturers think they can last a couple of hundred years. So I'm just wondering if the work done by the Center here has influenced the NRC's plans for recertification of the dry storage casks, or do you think that those results still suggest that those casks will be fine for hundreds of years?

MACFARLANE: I think this is something that we're going to have to consider carefully as we go out in the future. And, you know, we have to consider issues beyond some of the few that I've talked about. We have to look at this holistically and carefully. And especially as we get into issues of high burnup fuel, I think there are a lot of unanswered questions right now.

EWING: Okay, thank you. Another question? Okay, Lee.

PEDDICORD: Lee Peddicord from the Board. On some of these technical issues that you've identified, the stress corrosion cracking, high burnup fuel, and so on, to what extent do you have a chance as a Commission or Commission staff to interact with the other regulatory authorities in other countries as they're addressing grappling with these same kind of issues, compare notes, and so on? We heard, for example, similar high burnups in Germany and so on. So do you have formal mechanisms of interactions that get right to these specific issues?

MACFARLANE: You know, there are a variety of issues that we work with our international regulatory partners on, and these are one of them. We work within the auspices sometimes of IAEA, sometimes with the Nuclear Energy Agency. There are committees on back-end issues, radioactive waste issues, in both of these; and so our staff will go and work with folks from other regulatory agencies on these issues. And the international component is a very important part of our work. We do a lot of learning from international partners, sharing of information, assistance work as well.

EWING: Okay.

HIGBEE: Hello, I'm Ed Higbee. I'm a Lincoln County, Nevada, Commissioner. And what I would hope--and I think a lot of us out in that area where we talk about it a lot today--is that we would like to kick the politics out of it. We would like to let these very smart people in this room work their way through it scientifically and then do the right thing for the American people.

MACFARLANE: Thanks for your comment.

EWING: Jeff.

WILLIAMS: This is Jeff Williams with DOE. I saw somewhere recently--and I'm not sure where--about 10 CFR 72 and how it seemed to be the NRC thought that for licensing of a consolidated storage facility, it was adequate for a storage-only facility; but if you were going to do some of these other things like repackaging, that rule may need to be revised. And I'm just wondering if you could comment on that.

MACFARLANE: I'm going to ask Mark to comment on that.

EWING: So we should leave the microphone--

MACFARLANE: Take it to the back of the room, right.

LOMBARD: So Part 72 wasn't designed for repackaging and other R&D activities that a site or a county or an entity might want to have in that type of facility, because just having a pad out there with a fence around it and a guard force for standard storage is probably not enough to entice an entity into actually going forward and investing the time, the money, and resources that it takes to actually get a license from us and to move forward.

Part 72, again, it was not designed specifically for that. There are folks who think that it might be tweaked to be able to handle that; but, again, it does have limitations. So we're looking at that Part 72 to see if it could handle an R&D and repackaging-type facility at this point. But the easy way to move forward on an interim consolidated storage facility is certainly just to do storage only. And Jeff has a follow-up question.

WILLIAMS: Just to come back, it seems that my recollection is 72 was passed around the same time that MRS facility was being considered that did rod consolidation, and I thought that 72 was adequate to address a facility that did rod consolidation. So I'm just--am I not remembering things properly, do you know?

LOMBARD: I think you are remembering things properly on what you were looking at to make sure what the extent of scope--how far 72 can go.

EWING: Another question, comment? Bret?

LESLIE: Bret Leslie, Board Staff. This is a question for both Jeff for DOE and NRC. There were two different time frames that were talked about today, one in the waste confidence and one in the scoping studies that Jeff has talked about. How do they correlate or coincide, or are they integrated? In other words, the time frames that the--not necessarily what Jeff did, but the other scoping studies that DOE has done, do they align with kind of the anticipated waste confidence timeline that is in the generic environmental impact statement?

MACFARLANE: Well, I think that's for all of you to comment on. You know, on the Commission we are--this is--

we're dealing with this draft document right now. We are looking for your comments on whether you think that they align and what you think might be reasonable.

The DOE doesn't want to comment right now.

EWING: All right. Any other last question?

Okay, let's thank the Chairman again.

Just a few orders of business before you disappear. We will reconvene tomorrow in this room at 8:00 o'clock to give you the instructions for the breakout sessions. I reviewed for you the topics for the breakout sessions, so be thinking about which session you would like to join. I hope that everyone can return, because it's been great that we've had such a turnout for this meeting.

And then, finally, I want to give special thanks to the NWTRB staff. A tremendous amount of work was required in order to organize the workshop. The framework document that was prepared, and it's available for you on the table outside, that's a staff product. The staff have really played a critical and driving force role in pulling this together. So as you see them during the next few days, be sure to thank them.

All right, thank you very much. Have a great evening. You're welcome to stay and keep asking one another questions.

(Whereupon, the meeting was adjourned.)

C E R T I F I C A T E

I certify that the foregoing is a correct transcript of the Nuclear Waste Technical Review Board's Technical Workshop held on November 18, 2013, in Washington, DC, taken from the electronic recording of proceedings in the above-entitled matter.

December 15, 2013 ________________________________

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