UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

FALL BOARD MEETING

September 23, 2009

Gaylord Hotel
201 Waterfront Street
National Harbor, Maryland 20745

NWTRB BOARD MEMBERS PRESENT

Dr. B. John Garrick, Chairman, NWTRB
Dr. David J. Duquette
Dr. Ali Mosleh
Dr. George Hornberger
Dr. Andrew C. Kadak
Dr. Henry Petroski
Dr. William Howard Arnold
Dr. Thure E. Cerling
Dr. William M. Murphy
Dr. Ronald M. Latanision
Dr. Mark D. Abkowitz

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Dr. David A. Diodato
Dr. Gene W. Rowe
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Linda Coultry, Meeting Planner

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Prior to the meeting, the Board provided each of the three vendors represented on this panel with a list of questions to be addressed in the presentations. The questions focused narrowly on the implications for high-level radioactive waste and spent nuclear fuel management of each proposal. Those questions are reproduced below.

I N D E X
(Continued)

1. What is the estimated mass of waste that must be disposed of per MTHM processed in each of the following categories? What is the proposed disposition or management path for each type?
  a. Vitrified high-level waste
  b. Low-level waste, including non-recycled uranium
  c. Intermediate-level or Greater-than-Class C waste
  d. Plant decontamination and decommissioning waste

2. What, if any, are the additional waste management process requirements for recovering and disposing of
  a. ^{85}Kr and ^{14}C gases?
  b. Separate handling of ^{99}TC, Cs, and Sr?
  c. Separate removal of ^{241}Am and Cm?

How significantly do these requirements affect the size and complexity of the reprocessing facility?

3. What, if any, are the technical constraints limiting the capacity or throughput of the proposed facilities? What factors cause those constraints?

4. What, if any, are the projected improvements in repository performance (radiation dose at the hypothetical site boundary) associated with actinide removal? What, if any, are the projected repository capacity improvements associated with actinide removal? What analyses support answers to these questions?

5. What are the appropriate metrics/measures that might be used to compare alternative technical approaches in terms of their implications for waste management? Why should the metrics be used?

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The Board asked each of these four panelists listed above to focus on a specific topic related to the vendor proposals described in the last session. Those topics are noted in parentheses following the name of each speaker.

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P R O C E E D I N G S

8:00 a.m.

GARRICK: We have a very, very busy schedule today, and because of the departure of some of the speakers, we have to make sure that we keep everything in accordance with our agenda. So, I'm going to be kind of tough on that issue today, so please, I'll ask for your forgiveness in advance.

I want to welcome everybody to this meeting of the Nuclear Waste Technical Review Board. As you will see today, it's certainly a departure from our usual agenda, and we're very much looking forward to it.

As to our Board, and as is our practice, at the beginning of all of our meetings, we like to introduce ourselves, and you should be aware that the Board is part-time. The staff is full-time, so they keep us honest. And, I will start with introducing myself. I'm John Garrick. I'm Chairman of the Board, and my background is nuclear engineering and risk analysis, and I spend most of my time doing consulting in those areas.

Now, in the past when I have introduced the Board, I have always noted the particular assignment of each Board member, and that is kind of in a transition right now, and we are changing the panel structure and the technical lead structure to be much more in line with the current role of the Board and the current emphasis of our activities. So, I'm not going to make any attempt to do that in the introductions. And, as soon as we make the assignments and as soon as we make the decisions on what kind of panel structure we want to have, we will post that on our website.

As I introduce the rest of the Board, I want them to raise their hand as I call their name, and we'll do this alphabetically and I will start with Mark Abkowitz. Mark is Professor of Civil and Environmental Engineering and Professor of Engineering Management in the Department of Civil and Environmental Engineering at Vanderbilt University. He is also director of the Vanderbilt Center for Environmental Management Sciences.

Howard Arnold. Howard is a consultant to the nuclear industry. He previously held a number of senior management positions, such as vice-president of the Westinghouse Hanford Company, president of Louisiana Energy Services, and engineering manager and general manager of the Westinghouse Pressurized Water Reactor Systems Division.

Thure Cerling. Thure is a Distinguished Professor of Geology and Biology at the University of Utah. He is a geochemist, with particular expertise in applying geochemistry to a wide range of issues, such as geological climatological, and anthropological studies.

David Duquette. David is the John Tod Horton Professor of Materials Engineering at Rensselaer Polytechnic

Institute. And, his areas of expertise include physical, chemical and mechanical properties of metals and alloys, with special emphasis on environmental interactions.

George Hornberger. George is a Distinguished Professor at Vanderbilt University, where he is Director of the Vanderbilt Institute for Energy and Environment. His research is aimed at understanding how hydrological processes affect the transport of dissolved and suspended constituents through catchments and aquifers.

Andrew Kadak. Andy is Professor of the Practice in MIT’s Department of Nuclear Science and Engineering. His research interests include the development of advanced reactors, space nuclear power systems, and improved licensing standards for advanced reactors.

Ron Latanision. Ron is Emeritus Professor of Materials Science and Engineering and Nuclear Engineering at MIT, and Corporate Vice-President and Practice Director, Mechanical Engineering and Materials Sciences with the engineering consulting firm, Exponent. His areas of expertise include materials processing and corrosion of metals and other materials in different aqueous environments.

Ali Mosleh. Ali is the Nicole J. Kim Professor of Engineering and Director of the Center for Risk and Reliability at the University of Maryland. Ali’s fields of study and practice are risk and safety assessments, reliability analysis, and decision analysis for the nuclear, chemical, and aerospace industries.

William Murphy. Bill is a Professor in the Department of Geological and Environmental Sciences at California State University at Chico. His areas of expertise are geology, hydrogeology, and geochemistry. Bill also serves as an administrative judge on an NRC Atomic Safety and Licensing Board Panel.

Henry Petroski. Henry is the Aleksander S. Vesic Professor of Civil Engineering and Professor of History at Duke University. His current research interests are in the areas of failure analysis and design theory. Henry is an accomplished author in engineering and science, as most of you know.

Okay, before discussing the agenda, let me make a few remarks about the role of the Board, particularly considering what’s happened in the last year. Under the 1987 Nuclear Waste Policy Amendments Act, Congress charged the Board with evaluating the technical validity of activities undertaken by the Secretary of Energy related to managing the nation’s spent nuclear fuel and high-level radioactive waste, and with reporting to Congress and the Secretary of Energy our findings and recommendations.

At the time the law was enacted, the Board’s “job description,” if you will, appeared fairly straightforward.

Virtually all of the Department of Energy's work in this area focused on the Yucca Mountain Repository Project. Times, of course, have changed, and the status of the project is in flux. Nonetheless, the Board's underlying mandate from Congress remains unchanged.

Our last meeting in Las Vegas in June, I provided three examples to illustrate how the Board views its role as it moves into the future. Since then, in an August 13th letter to Secretary of Energy Steven Chu, the Board more explicitly detailed its plans and objectives. In summary, the Board's plans and objectives are:

1. To the extent that DOE engages in technical work related to the management and disposal of high-level radioactive waste and spent nuclear fuel, the Board will continue to monitor and evaluate that work, and report on the technical validity of the work to Congress and to the Secretary.
2. The Board will continue to develop and compile objective technical information on the management of high-level radioactive waste and spent fuel to inform Congress and the Secretary of Energy. The Board believes this information also will be valuable to a Blue Ribbon Commission, if one is convened. In developing such information, the Board will look broadly at an integrated waste management

system and potential waste management alternatives.

3. And, three, the Board will draw on its experience, including knowledge gained from observing efforts in other countries, to develop and provide technical information and technical “lessons learned” about the U.S. nuclear waste management program, including the operational and safety risks of alternatives for managing high-level radioactive waste.

In short, the Board’s responsibilities under the law are unaltered by possible changes in the Administration’s approach to nuclear waste management. But, how we fulfill these responsibilities will, we hope, reflect and inform potential changes in national policy.

This meeting will be the first time that the Board has explored in great depth technical options other than direct disposal in a deep geologic repository for the very long-term management of commercial spent nuclear fuel. Doing so exemplifies how we are going to pursue the second of three objectives that I just mentioned.

More specifically, one alternative approach for management spent fuel from commercial nuclear power plants involves a so-called “closing” of the nuclear fuel cycle. In the most simple terms, what we mean by that is fuel discharged from reactors would be processed chemically to separate out plutonium and uranium. The variety of waste streams formed in the process would be treated in appropriate ways. Each stream would have its own disposition path almost certainly including disposal in a deep geologic repository. The extracted plutonium and, perhaps, the uranium would be recycled into other light-water or maybe into fast-reactors.

A number of countries, including France, the United Kingdom, Japan, the Russian Federation, and China, have adopted at least some elements of this approach, or are likely to do so in the near future. Other countries, including the United States, have processed varying amounts of spent nuclear fuel in the past. Although the U.S. developed this technical option, for economic and other reasons it has chosen not to adopt it, at least for the time being. In light of the uncertain future of the Yucca Mountain Project and the increased interest in closing the nuclear fuel cycle, the option is now being widely discussed.

We have a number of talks and panels that will explore the technical implications of closing the fuel cycle on radioactive waste management. After hearing from Chris Kouts, who will give us an update on the Yucca Mountain Project, Professor Ernest Moniz will talk about the MIT Fuel Cycle Study, which he directs. Following Dr. Moniz, we will hear from three invited vendor groups, who will discuss their proposals to close the nuclear fuel cycle. These proposals were developed with the support of the Department of Energy.

To avoid showing any favoritism, we will hear from the groups in alphabetical order. First up will be the group led by AREVA. Its spokesman will be Dorothy Davidson. Next up will be the group led by Energy Solutions. Its spokesman is Alan Dobson. And, finally, we will hear from the group led by GE Hitachi, and its spokesman is Eric Loewen.

Now, after each group has described its proposal for closing the fuel cycle, the Board and its consultant, Ray Wymer, formerly of Oak Ridge National Laboratory and the Nuclear Regulatory Commission’s Advisory Committee on Nuclear Waste, will ask questions of the spokespeople. It should be noted that about two months ago, the Board developed and distributed to the vendors a written set of common questions, which we have asked each group to address. These questions are printed in the meeting agenda, which is available at the back of the room.

The Board would like to extend its great appreciation to these three groups. They have accepted an invitation that probably required them to undertake at least some new work. This effort goes above and beyond the call of duty, and we wish to thank you many times for that.

Following lunch, a second set of speakers, whom we informally call the “commentary panel,” will take center stage. These experts received ahead of time copies of the presentations by the three vendor groups as well as the questions that the Board posed to the vendors. Each member of the commentary panel has been asked to focus on selected aspects of the vendors' proposals. The first panelist is Mark Peters, a Deputy Associate Director at Argonne National Laboratory. Mark has been a frequent presenter to the Board when he was associated with the Yucca Mountain Project, and we welcome his return. Mark will talk about the technical challenges associated with managing waste in a closed fuel cycle.

After Mark speaks, Professor Rod Ewing from the University of Michigan, whom Board members have heard from its fact finding meetings, will discuss the implications for geologic disposal of having high-level radioactive waste be the waste form rather than spent nuclear fuel.

Adam Levin, the Director of Spent Fuel and Decommissioning for Exelon Nuclear, then will talk about the implications of the vendors' proposals for waste management operations at reactors. Adam has also spoken to the Board in the past, and we welcome him back as well.

The last panelist is Dan Stout, the former Director of Nuclear Fuel Recycling in DOE's Office of Nuclear Energy. Dan now manages the Tennessee Valley Authority's federal programs and licensing efforts for new nuclear generation. He will describe what, in his view, are the regulatory gaps that have to be filled before licenses can be granted to those wanting to construct the reprocessing and other facilities needed to close the fuel cycle. Dan will also speak about regulatory needs connected to the safe and secure transportation of nuclear materials. This is a topic of special interest to the Board because, at some point, these materials will have to be moved, and because Congress called out transportation as a specific area requiring the Board's attention.

Now, we have some complications as far as the schedule is concerned. Because Professor Ewing was gracious enough to fit our meeting into a busy day's schedule, he will have to leave before the panel actually concludes. So, the Board, and its consultant, will ask him questions before he departs. Questions to the rest of the Panel will be asked once Dan Stout's presentation concludes.

After a break, we will reconvene to hear two colleagues from overseas. The first is Claudio Pescatore, who directs the waste management efforts of the Nuclear Energy Agency, a part of the Organization for Economic Cooperation and Development. Claudio will talk about trends in the evolution of radioactive waste management programs within OECD countries.

Following Claudio, we will hear from Tuija Hilding-Rydevik and Eva Simic of the Swedish National Council for Nuclear Waste, and then Willis Forsling also from the

Council. In many ways, the National Council is our counterpart, that is, the counterpart to our Board, and we have enjoyed a very close and productive relation with it for nearly 20 years. The two members will reflect on the Swedish site-selection process, actually the three members, which several months ago resulted in the choice of Osthammar as the location for Sweden’s deep geologic repository.

These two presentations will provide information that will be useful as the Board pursues its third objective, developing a “lessons learned” report that incorporates experience in a number of countries involved in the nuclear waste business. Incidentally, in response to several congressional requests, the Board intends to publish within the next few weeks a compendium of up-to-date information about the institutional arrangements and technical approaches taken by 13 different countries in managing their high-level radioactive waste and spent nuclear fuel. The report will first appear on our website, but you will have the opportunity to order hard copies if you wish.

Following the talks by our overseas colleagues, we have scheduled time for public comment, which is always an important part of our meeting, and it is important to the Board. If you would like to comment, please enter your name on the sign-up sheet at the table near the entrance to the room. And, by the way, we also have an attendance sheet back there, and if you haven't jotted down your name, please do so, and your e-mail address, if you would like to. If you prefer, remarks and other material can be submitted in writing and will be made part of the meeting record. These statements will be posted on our website along with the transcripts and overheads from this meeting. I understand that one or two individuals plan on doing just this.

Now, some of you have asked the frequently asked question about questioning during the course of the presentation. We do have sort of a pecking order with respect to that, and a time element is involved and determines how far we can go. First, Board members and Board consultants will ask questions. Then, if time permits, staff members will ask their questions. And, beyond that, members of the public, will be called to ask their questions. Frankly, we rarely get to the point where staff members can ask all the questions they have. But, we have other mechanisms to allow the people in the audience to question our speakers. You write down your questions and submit them for the record. We will read them if time permits.

Now, I should note in these meetings, that we as Board members, we kind of freely express our views and opinions, and we want to continue to operate in that fashion and to feel like we can comment however we wish. But, we have to realize that that's not necessarily the Board speaking. So, when we speak as Board members, we are indeed speaking as individuals, not on behalf of the Board, and we will try our best to make that distinction.

As usual, to minimize interruption, we ask that all of you turn off your cell phones, or at least put them on the silent mode. And, I also want to remind everyone that it is very important that you identify yourself, if you are speaking, and speak into the microphone. These microphones don't all have the same pickup capability, and we are very picky about developing a complete record of our meeting. And, when you do that, give us your name and your affiliation, and any relevant information that would identify your remarks.

Okay, so, with these preliminaries out of the way, I'd like to move quickly into our formal meeting, and ask Chris Kouts of the Department of Energy to lead off. And, I would also ask each speaker as they come up to just introduce themselves. I have telegraphed who it is, you have the agendas, we're not going to read bios, but it would be useful if each speaker would say what their role is in their respective institutions.

Thank you. Chris?

KOUTS: Thank you, Dr. Garrick. You took about ten minutes of my time, so I assume you want me to just give my summary in five minutes. So, I will try to stay with your schedule.

I'm very pleased to be here amongst the Board, Dr. Garrick and the members of the Board. It's been a while since I've been in front of the NWTRB, and usually it has not been as the Acting Director of the Program. Nonetheless, what I'd like to do is to kind of give you an update as to what we've been doing this fiscal year.

Our funding for this year started out at about $386 million, and it was adjusted about midway through to about $288 million. That caused a substantial reduction in our overall staffing of the program. We went from approximately 1700 people down to about 700 people we have now. About 18 months ago, we had 2700 people in this Program. I only indicate this to you just to give you a sense of the size of the program, and how it's evolved over time. But, I think it's very interesting that during the NRC license review process, from our perspective, we've been very successful in responding to the many questions that have been posed by the NRC. And, let me give you just an accounting of that.

To date, and again, these numbers change every week, we've had about 570 requests for additional information from the NRC. Approximately 260 of those were in the post-closure area. About 130 in the design area, about 140 in our preclosure safety analysis, and about 40 in the programmatic sections of the license application. It's very clear to us that the NRC is walking through the chapters of their SER, and filling in the blanks, their Safety Evaluation Report, and filling in the blanks with any questions that they may have. And, we're very encouraged by that.

By our perspective, we feel we're about, based on our interactions with the NRC, about 90 percent done with requests for additional information for the first round. And, whether or not there will be a second round will be up to the NRC. There have also been about 50 supplemental responses submitted to clarify earlier submissions that we had given to the NRC.

In the world of contentions, you may recognize that there were hearings in Las Vegas last week where a Case Management Order is being developed by the parties to determine how the discovery process and how the deposition process will move forward. My understanding of that process is that the parties are working very well together, and our expectation is there will be a case management order issued by the boards that will be agreeable to all parties.

So, from the standpoint of the licensing process, I think it's gone very well, and I think it's really a testament to the people who are still in the program that they have been able to maintain schedules and provide very high quality responses back to the NRC. And, also, I think it's indicative of the fact that a very high quality license application was submitted to the NRC last June.

For next year, and that's FY 2010, we don't have a budget yet, nor does the rest of the government. Basically, both committees have marked up at the Administration's request. Our expectation is that that will allow us to continue with about the same resources we have now. In fact, when we reduced the program from the 386 level to the 288 level, because that happened in the middle of the fiscal year, that actually caused us to take deeper cuts and got us down to a spend rate which is fairly consistent with what we expect from Congress for this next year. So, we don't expect very much staff reduction, if at all, for the next fiscal year. And, that budget will essentially allow us to support the Blue Ribbon Commission. It has about $5 million allocated for that, and also to continue to be an active participant in the licensing process. And, that's the guidance that we have, and that's what we will do.

Next question I think in most people's minds is Blue Ribbon Commission. Don't have any information to provide you. My expectation is that an announcement will be made sometime this fall. However, that's in the purview of the Secretary, and any announcement that the Secretary may make is according to his timing, and, again, I know he very much wants to get that underway. However, I don't have any information to provide on that. And, certainly, when that

Commission is empanelled, we'll look forward to any information requests that they may have that we can respond to.

You may also have a question in your mind as to Dr. Warren Miller, who has been nominated to be the director of this program. He was confirmed as the Assistant Secretary for Nuclear Energy. However, there was a hold on his nomination, it's no secret, in terms of who has the hold on him, which is Senator Lindsay Graham of South Carolina. I don't really have any new information to provide on that. That will resolve itself as appropriate. Nonetheless, I do see Dr. Miller a great deal. He's in the building. He's very hard at work in the world of his area of nuclear energy, and we do coordinate a great deal and talk a great deal. So, in fact, he's in Idaho, if you're wondering where he is today.

I don't know if some of you are aware of the fact that he has also brought in a new Deputy Assistant Secretary for the Office of Nuclear Energy, and that's former Commissioner Dr. Peter Lyons. And, he is the principal Deputy Assistant Secretary for the Office of Nuclear Energy.

Beyond that, I think I'm pretty much on schedule, I'll be happy to answer any questions that the Board may have.

GARRICK: Thank you. Questions from the Board?

KADAK: Kadak, Board.

Chris, are you saying then that you feel, based on the NRC questions that you've gotten, and the responses that you've provided, you are able to provide good technical answers of the kind of depth that the NRC would require for all the questions?

KOUTS: Well, Dr. Kadak, that's an interesting questions. We have answered the questions based on our submittal and on the technical basis that we submitted along with the LA. If there are additional questions that the NRC may ask, again, that's in the hands of the Nuclear Regulatory Commission. But, to date, I don't see any major disconnects in terms of the answers that we've provided to what the NRC has requested.

KADAK: Well, in particular, there were some issues that the Board has raised about corrosion. I'm sorry, I'm going into your area, Gentlemen, but some of them, as the Board has suggested, required additional work. Now, in order to answer the NRC question, is the DOE allowed to spend money to do that additional work to answer the questions?

KOUTS: Well, are you asking if resources are available in case we needed to do additional work?

KADAK: Yes.

KOUTS: Again, that would be dependent on the particular information that the NRC has and what level of resources.

It’s difficult to answer. It’s a hypothetical. And, again, without the specifics, I really wouldn’t be able to answer it.

KADAK: Oops, okay. I think you said you’re not going to answer the question.

KOUTS: No, I think the answer to your question is it depends. It depends on the level of additional work that we might surmise from the NRC questions that we may need to do, and whether or not we have the resources to do it. Again, that’s a subjective thing and all I can tell you is up until this point, we haven’t been faced with that.

KADAK: Okay, let me be more specific. If there is additional work required to answer the question in the technical depth that the NRC requires, does your department have the resources, and is it permitted to spend the money to answer those questions, given that the Administration has said that the project will be terminated, period?

KOUTS: We may or may not. I don’t know. It has to do with, again, exactly what the NRC asks us to do. We don’t have great flexibility in our budget to do additional research. If it was a minor issue, we might be able to deal with it. If it’s a major issue, we’d be more challenged. That’s the best way I can answer.

GARRICK: You may have answered this, but let me ask it. It’s kind of phrasing Andy’s question a little differently.

Can you kind of characterize what you consider to be your biggest challenges in moving forward with the license application in a manner as if nothing had happened?

KOUTS: I think our biggest challenge across the board is retention of staff, both in our national laboratories, in our M&O contractor, and in the federal staff. I think that there's an uncertainty associated with the Program, and I think people are reading about uncertainty and making personal judgments, and we just have to do the best we can with the resources that we have. But, I would say our biggest challenge at this point is staff retention.

GARRICK: The real issue here is are we going to get a really well scrubbed license application with the kind of technical information that is warranted based on the site characterization program and all the work that's gone on? Because, I think that much of the world is not particularly appreciative of the groundbreaking that was done in the preparation of the license application, and in the preliminary design work that has taken place. There are many first-of-a-kind analyses, and I just wonder if are we just going through the motions now, and spending the money, or are we really indeed confident that the process is going to generate a licensing package that is bona fide and for real?

KOUTS: Well, I understand the question, but there are also two sides of the coin. It's not just the resources the

Department has, it's also the resources the NRC has in order to go through all the things that they need to do. And, I think the NRC is going to be very challenged in FY 2010 to maintain their progress, because just, and I don't know whether you've gained this perspective before, but the NRC has essentially one pot of money, and that pot of money has to be used to support the staff and their review and development of the SER, and also to support the contentions process, the administrative law judges, the attorneys, and so forth.

In addition to that, we're right now in the process, or our venders are in the process of developing TAD designs, and those TAD designs are scheduled to be submitted later this fall. The pot of money also has to be used for that also. The NRC has also received a ruling from its general counsel that it can't use other than waste funds in order to do this work. So, it's not just the resources the Department of Energy has, it's also the resources the NRC has. And, I think what you've heard from the NRC is they're segmenting and they are perusing their review as we move forward.

In answer to your question about whether or not this is going to get a very good scrubbing, I think it will, depending on how long the process is allowed to continue. I think the NRC is doing a very thorough scrub of the license application, and I think that in a resource challenged environment, they've taken the approach that they're going to do it in phases, and we will take the lead of the regulator and respond in kind.

So, answer the questions? I think we are getting a very thorough review by the NRC. I think it's certainly been instructive and informative for our people, and I think also for the NRC. But, again, it's going to be in phases as we move forward, and the length of that will be dependent on the continuation and the amount of funds that are given to both organizations.

GARRICK: Yes, Andy, go ahead.

KADAK: Just to clarify again, is it, as far as you know, the Administration's policy to complete the licensing process to see whether or not Yucca Mountain is suitable or not, or in the termination of the project, is it really to stop the licensing process of Yucca Mountain? Which of the two is going on?

KOUTS: I'm not going to speak for the Administration. I recommend you to read is the language that was put in our budget for this coming fiscal year, which essentially indicated the intent of the Administration that in this budget, the intent of the Administration is to terminate the project. How future budgets and what they will say, you know, the FY 2011 budget is in formulation. I really can't comment on that at this time, and it will be revealed with the rest of the budget of the Administration in the February time frame.

DUQUETTE: Duquette, Board.

My understanding is there's some continuing work going on at Sandia in the corrosion area. You mentioned the TAD, that there's continuing work going on there. It would seem to be in support of the licensing application and not of the mountain itself. Are there other projects that are ongoing that we might be interested in that continue to be in support of the license application in addition to the corrosion work and the TAD work that's going on?

KOUTS: Our efforts internally are to make sure and to continue to review our technical work to determine whether or not there are any issues as we move forward. The REI process sometimes uncovers issues and technical basis documents that we weren't aware of when we submitted the LA, so there is some work to go in certain instances and modify, adjust, provide revisions to existing technical work that's the underpinning of the LA. Other than the corrosion work that you mentioned, you know, I can't think of anything else that we're doing substantively other than, again, responding to the REIs, and keep our technical basis updated as appropriate.

GARRICK: Howard?

ARNOLD: Arnold, Board.

Speaking as a veteran of several projects which were cancelled, and after the fact, people wish had been better documented at least, are you looking on the licensing process as an opportunity to provide a full dolcea of documentation for what this remarkable effort did?

KOUTS: Certainly, the licensing process provides that documentation. We're also very conscious of our need to have a very good record system and make sure that all the technical work is properly catalogued and retrievable, and so forth. And, we will certainly be making efforts this next fiscal year to make sure that our records are really up to date. So, there will be, you know, that work will be accessible and usable potentially in the future.

GARRICK: Any other questions from the Board?

(No response.)

GARRICK: David Diodato from the Staff?

DIODATO: Diodato, Staff.

Thank you for coming to present this morning. I was just wondering in light of the developments over the last year, is the Office of Civilian Radioactive Waste Management supporting any efforts to investigate alternatives to Yucca Mountain disposal? And, if so, what might those alternatives be?

KOUTS: What we're going to be doing is supporting the efforts of the Blue Ribbon Commission. I should also mention that Dr. Miller, I'm working closely with him, and we are making sure that we have internal coordination within the Department from our office, the Office of Nuclear Energy, the Office of Environmental Management, the Navy Nuclear Propulsion Program so that as information is developed, it's coordinated, we understand it, and it's consistent with our understanding. But, in terms of looking for alternatives, at this point, I think we'll look to support that Commission because I think that Commission will have substantial input into the policy process. And, you know, my expectation and Dr. Miller's expectation is that if there is a new mission for this program and a new policy path, that this program will be the one to implement it.

DIODATO: Thank you.

GARRICK: Any other questions?

(No response.)

GARRICK: All right, thank you very much.

I guess our next speaker is Professor Moniz.

MONIZ: Thanks, John. John, do you want to do a bio? Well, forget it.

GARRICK: A sketch, yes.

MONIZ: A sketch? Okay, well, all right. A few things, I've been on the faculty at MIT for, embarrassing, 36 years. I co-chaired with John Duitch a 2003 report on the Future of

Nuclear Power. Currently co-chairing with Miche Kessemee (phonetic), a study on the nuclear fuel cycle. Your colleague, Mr. Kadak, is a member of that study. Other bio significants, John and I served together on a nuclear transportation study for the Academy, and during that study, I just note things that might be of translational relevance here, such as safety issues in terms of transportation, no big differentiator between distributed and local storage, issues about institutional arrangements, government arrangements for managing very complex logistical programs. That was all in the context of transportation. You can translate that as you wish into the subject at hand. I'm currently a member of the President's Council of Advisors on Science and Technology. So, those are a few issues.

So, I was asked to come talk about where we are, what it is and where we are on this study of the nuclear fuel cycle. I will do so, but with a caution that we really are not finished with the study. We intend to finish this year, and hopefully that will be quite timely for the Blue Ribbon Commission already discussed. But, the fact is we do not have full consensus on the full set of issues today. So, if you think I issued a consensus you've misunderstood me, and you can take those as just kind of personal remarks.

So, again, a little bit of this history. Again, in 2003, we issued what has proved to be the first in a series of future of reports in which we look at specific technology areas, not exclusively, but strongly motivated by the needs for carbon-free or low-carbon technologies in a future carbon constrained world, and nuclear power was in fact the first that we studied, among, I would say, and I'll come back to this perhaps in a bit, what I think the group would agree is that when all was said and done, the primary finding, if you like, and ensuing recommendation was that when it comes to the future of nuclear power in this context, the number one issue was certainly not, in some sense, need for new technology. It was about getting some new nuclear power plants built, and we made a case. I think we were kind of a first mover in making the case that there was a sound public rationale for public support for that first mover.

By the way, in the bio, I just forgot one little detail. I was Under-Secretary of Energy. I was not trying to suppress that because February the 1st of 1998, a date you may associate with something relevant to this, but I do remember working with Chris, of course, colleagues, and the TRB in those years. Sorry.

So, another point that I would make is that that report, when it was issued in 2003, I would say eventually was well received, but even more importantly, started out by having everybody shooting at it until they noticed that people they didn't agree with didn't like it either, and we can aspire to that in this report, I think we have done well.

We were motivated, again, to pick up this theme again for a variety of reasons, as we'll go over, many of you know, since 2003, there have been a whole bunch of changes relevant to this subject including those that were just discussed in Chris's presentation. So, we are looking at what has changed. We'll discuss the report objectives, and what we consider to be some of the critical questions.

I want to acknowledge our sponsors, EPRI, Idaho National Laboratory, AREVA, GE, Westinghouse, and NAC in-- they are listed in order of our level of gratitude, and I should say that NEI has also played a very helpful role in facilitating and in providing information for our study.

So, again, a little bit of background in terms of an update. By the way, if you haven't seen it, a few months ago, this was on our website, web.MIT@EDU/nuclearpower, we did publish a short update, which I will come back to, which probably had its most useful piece, a completely redone look, given new realities, on the costs of various baseload power options. I'll come back to that explicitly. But, certainly, compared to option three, certainly this context of climate change as a driver of why public policy would support first mover nuclear power plants, is of anything elevated in importance. Public acceptance of nuclear power in the United States, and one would say in many European countries, is greater. Performance of nuclear power plants, of course, has continued to be excellent. We'll come to this in terms of costs. The bottom line conclusion here will be that especially given the uncertainties in policy space, in the financial sector, et cetera, nuclear power is certainly in the mix in terms of cost. We'll come back to that in more detail.

Regrettably, to date, the government first mover incentive program initiated in the 2005 Energy Policy Act has not been effective in leading to firm commitments. We're always just about there. We hope we will see if that's true over the next months. And, obviously, in the context of the discussion just happened, there is a clear need for a long-term robust waste management policy. This involves questions of interim, or I prefer the term managed storage. It involves fuel cycle alternatives. It involves different disposal options. It involves, as John talked about in your agenda, a much stronger degree of integration of back-end choices fuel cycles, waste management, et cetera.

So, that's kind of the motivation there, and this kind of repeats some of that. So, after six years, no new plants under construction. Government assistance programs not effective, et cetera. And, the reality is while there can be a lot of happy talk about all the things that are just about to happen, if you just take a hardnosed view and say what’s the ground truth, the ground truth is that nuclear power will diminish as a timely and practical option at a scale where it matters for climate change mitigation. I would argue that my person view is I would say we are farther behind the 8-ball than we were before, despite the promise of various steps forward, because the climate clock has a clock, and timing of moving towards scale-up is critical if one is going to be part of the solution. So, that’s kind of our perspective, broadly speaking, in terms of motivating the study.

So, a couple of the questions kind of obvious, but, you know, what are the long-term nuclear fuel cycle choices that have desirable features? Desirable features includes, of course, issues of waste management. It can include issues of resource extension. It can include issues of safety. It can include issues of non-proliferation. But, what are the long-term nuclear fuel cycle choices, and what are the constraints it puts on timing and nature of paths forward, and particularly, what are the implications for near-term policy choices?

So, in the study, a couple of the framing issues that I think are worth mentioning. First of all, we will talk about, or we will frame the study in the context of three different growth scenarios. And, very originally, one is more or less flat. One has kind of decent growth, and one has very strong growth, novel approach.

But, the real point is that obviously, we really have no clue today which of those kinds of growth scenarios is going to be realized. Whether we have scale of hundred gigawatts, I mean, within a factor of Pi, terawatt, or a few terawatts in this century, who knows, and that has enormous implications for how you would like to see the fuel cycle evolve over the century. This is a way of leading into, and I'll come back to, is a major perspective that we take in the study.

If you're in the business world, you understand the considerable value of options. There's a science of evaluating options. This does not seem to be characteristic of a politically driven system. So, just again, and you can connect some dots yourself when you consider options to be a key determinate of how you would structure fuel cycle growth, how you would structure policy in the near-term. This may sound trivial. I think it's a very, very important way of framing the discussion.

We will analyze several fuel cycles with some baseline cases and some alternatives. Clearly, once through is an issue. Physical fuel recovery, waste management implications are clearly important. What I emphasize, the baseline scenarios that we will be evaluating again will not surprise you. Once through, MOX, and let's say plutonium loaded fast breeder reactors. That kind of the canonical set for a long time.

I think another of our perspectives is to go back and say that, you know, a lot of how we think about things tends to be rooted in the assumptions of those early days. It’s not saying the conclusion is wrong, but for example, that set of canonical fuel cycles emerged from the period where there was no uranium. Well, we got roughly speaking, this is part of what we will discuss, but, you know, I don’t think it’s a big secret, take leadbook and other issues, you know, roughly speaking we’ve got uranium coming out of our ears for a long, long time. It was a period in which LWRs were kind of a short-term transitional technology. Certainly, by the way, on the flip side, the history of, let’s say, sodium cooled fast breeder reactors to date, the limited history, would not encourage one to have thought about that original bounding condition as being reasonable.

And, no matter what you say, it’s obvious the ground truth is LWRs are going to be here, they’re going to be here in greater numbers for a long time. We will talk about that briefly later on. So, in that context, where we will be going in our framework is to say that, you know, we’ve got to think about lots and lots of alternatives, some of which we understand relatively better today, some of which we do not.

But, again, we'll come back to this maybe if we have time later on, but one of the conclusions of this, without saying where we go in the end in terms of specifics, but we would argue in this context re-examining the fuel cycle options in terms of today's bounding conditions, and not those of 35 years ago, leads one, for example, to not knowing whether or not irradiated spent fuel from LWRs is a resource or a waste. We just do not know that today in terms of the uncertainties.

For example, I don't think it would take anybody in this room too much thought to think that if nuclear power ends up not having a robust growth scenario, that would very much limit one's desirability for certain more advanced technology, let's call it, fuel cycle. So, again, this is the context which will be a very strong flavor of our report, re-examining bounding conditions, and emphasizing what we would call just a hard-headed preference for well-chosen optionality in the public and private arenas with, of course, a concomitant need to use any period of optionality effectively. Otherwise, you're not seriously in fact utilizing options if you're not using that time period seriously. And, again, we will discuss that.

Primary emphasis will be on the United States, but certainly within the global context, the same as our 2003 report, and we do think, as with the 2003 report, we do think it will certainly attract attention in other places, as well as the United States. Also, however, recognizing that other countries do have different bounding conditions. It's not like if the same choices are in fact appropriate in all places.

And, finally, in terms of the current ground rules, another thing that we will emphasize, particularly in growth scenarios where different fuel cycles, the choice of different fuel cycles really is an important issue, that we will emphasize not just the usual discussion of the equilibrium states of where we are now and where we will be in 2300, but what are the dynamics in getter from here to there, you know, in the baseline fuel cycle. So, when you need decades of gigawatt years to fuel one fast reactor with plutonium, how you get from here to there puts real world constraints, in fact, it's not hard to figure out without going through all the modeling that we've done. Again, I'll save the details for the report, but, you know, fundamentally, it's trivial to say that with that kind of bounding condition, if you're going to build up that kind of a system, let's say with plutonium fed breeder reactors, with a significant growth rate, you've got to build a lot more LWRs while you're building up that fuel cycle. So, this question of dynamics will be a very, very important issue, again, in our consideration, and as I said earlier, the value of options will be emphasized.

So, let me just go back now, circle back and talk about first of all the quantitative results in terms of our levalized cost results for baseload electricity generation. Again, if you look at, and this is published on our website, as I said, the little update, and also there's a reference in there to a full paper, 60, 70 page paper that is very explicit in terms of the methodology, the assumptions that go into it, et cetera. It's basically the same methodology used in 2003, but updated, and it turns out there are always time lags that, of course--now, these results kind of were using data at the peak of construction cost curve. So, you know, you always have to judge that appropriately.

But, the bottom line is that the pattern of comparative levalized costs for nuclear new super-critical coal without carbon capture, and nature gas combined cycles, leads to the same kind of basic conclusion as we had in 2003, which is that nuclear power with no carbon policy, with risk premiums of the type that, what we used to call Wall Street, might have on new merchant plant construction, you know, nuclear power probably has a levalized cost then above those of the other two, but certainly with the issues of carbon prices, of changing in financial structures, nuclear power is very much in the mix. Specifically--oops, I'm sorry, this is a little bit of maybe a translation from mack to non-mack.

Okay, but anyway, the first column are the base case results, nuclear coal and gas. Note that the gas cost here is $7 per million BTU. Obviously, well, roughly twice the current cost, but these costs for natural gas do go all over the place. Right now, the combination of new shale gas and of the economic downturn have that price lower. If you add then a pretty modest $25 per ton--the CO2 belongs in the second column--a CO2 cost, then you see the coal, and to a less extent, the gas of course jump up.

The third column, the 6.6 cents, is what happens if the financing charge for nuclear power plant is the same as that for a coal and gas plant, because in the first column, there is a substantial risk premium for the nuclear power plant.

And, as you can see if you look at that, certainly if you go to the right-hand columns, then nuclear is more favorable, and certainly in terms of risk management, the carbon price, particularly for coal, and the fuel price, particularly for gas, give you a hell of a lot more uncertainty than that row does for nuclear power costs. So, that’s kind of the revisit of the economics. And, I do recommend, John Parsons in our group, who comes from a financial background to MIT, was the lead author of this, and again, I have a very, very long paper on this. Including, by the way, I think it’s kind of a nice pedagogical piece, I might say, going through the specifics of why nuclear power costs that you see in the newspapers can seem so dramatically different, and yet be essentially identical in terms of overnight costs because of what’s quoted, particularly in different regulatory structures, different costs tend to be quoted.

Okay, so with that, a few other features of our study, and John, I forget, you want me to go a quarter past, something like that? Is that about right? Okay. I was going to say something and I forgot.

Oh, I know what it was, just before leaving that cost issue, I wanted to add that again, I think I more or less said this, but in the 2003 report, when all was said and done, we viewed our most important and consequential recommendation to be the one that said there was a, in our view, compelling case for public subsidy of first mover nuclear power plant construction. I believe the report was very helpful, in fact, in having first mover incentives in the 2005 Policy Act.

And, what I want to say is that although this study is, again, principally aimed at fuel cycles, wastes, back end, et cetera, we want to emphasize that in the context of the future of nuclear power, particularly with the climate change risk mitigation as a presumed policy instrument in the future, that that remains the most important recommendation.

I mean, if you don’t start building some nuclear power plants, seeing if that dog hunts in terms of the economics and the construction, the regulatory procedures being exercised in the United States, a lot of what we’re doing in this report is not terribly helpful. So, I don’t want to leave any uncertainty in that.

So, again, we will be talking certainly about the implications of fuel cycles for repository and other waste management facilities. Uranium resource implications, as I already hinted, is a very important question, and clarifying that and leaving no doubt about where we stand today in our understanding of uranium resources, but also about what looks likely and what are the options for acquiring more data is very, very important, again, because a lot of our implicit thinking stems from very, very different bounding conditions.

We will talk about non-proliferation implications of different fuel cycle choices, and I would just say that here, we will probably place a lot more emphasis on the threshold state issue than a lot of the more traditional discussions in terms of kind of safeguards in national facilities. The threshold state issue, of course, would be, an example would be today’s focus on Iran, and we will, of course, talk about the technical challenges of alternative fuel cycle options.

In terms of technical challenges, we again will emphasize the need to look at the complete fuel cycle. And, here again, in terms of kind of the factual basis, we will emphasize what is often not really focused on. Too often, the debate tends to equate irradiated fuel partitioning with recycling. And, the fact is that let's say the cost of a real reprocessing plant has very little of it in the separations technology. And, really, the system cost will be dominated by the nature of the multiple waste streams that one produces, and the often unclear fate of those waste streams.

Frankly, in the context of, and this is no secret, even our classification scheme for different wastes is, what's a nice word, needing maturity. I mean, a classification scheme that, for example, has the origin of the waste as a criterion as opposed to the composition of the waste, sounds a little bit peculiar. But, in any case, we will again be I think elucidating these points, and talking about in fuel cycle choices flow sheets with boxes on them don't really help you to understand the risks, the costs, the disposition of these wastes. So, if nothing else, I think, again, whether you like our answers or not, I hope you will at least appreciate in the report the framing of these issues, and the importance of getting them into the discussion.

And, certainly in this context, commercial reprocessing, you know, when you think about it is a very fair price, again here, by the way, a thing which is not given sufficient emphasis in our view, is the whole issue of what are the safety and operational questions. If you move at large scale to these kinds of advanced fuel cycle facilities, what is the real value for long-term waste management. In our 2003 report, we did not look at this in the same depth as we do now, but we did say there that, let's say there were a lot of exaggerated claims for nuclear waste management, a lot of use of unimportant criteria in characterizing alleged benefits for nuclear waste management. We will address that, and you can extrapolate as to whether or not that fundamental conclusion will be changed.

We will make a set of explicit R&D recommendations. Chris, please take these back to our friends the Peats, although we will be briefing them shortly. These are areas certainly that we will be looking at. And, I think what I want to emphasize is that, and we will make specific recommendations, as we have in our past reports, Nuclear Coal and others, about what the R&D focus should be, and at least notionally, what kind of resource level is appropriate for each component of the R&D program.

Well, without going through all the details, I mean, global uranium resource assessment, enhancement of life extension of LWRs, new built LWRs, brand new kinds of fuels, claddings, et cetera, advanced materials, things like reviving a look at engineered barriers appropriate to different geochemical environments, technologies for long-term managed storage, et cetera, et cetera, there's a theme there that we feel that the program, over the last years, has been frankly poor aligned with the strategic realities of where nuclear power is going. That is, we need to have a serious R&D program around what the fuel cycle on the ground is going to be for decades, roughly speaking, what you see now. And, frankly, we have had, it's exaggerated perhaps, close to nothing in that context.

We've had enormous focus certainly in recent years on advanced fuel cycles. We support a strong program in advanced fuel cycles. Indeed, at least the legendary Vic Reese claims that, you know, that our 2003 report was in fact a major motivation for what became GSEP, but I want to state that the program implementation looked nothing like what we had recommended. So, we will be supporting a strong and robust program of looking at advanced fuel cycles, of developing the appropriate tools.

There was a workshop in the spring, I was a co-chair with Bob Rossner on Exiscale computing, modeling and simulation for nuclear technologies. So, developing these tools, doing a lot more basic research in terms of advanced separations ideas, et cetera, not being--basically, this is what we will put in the context of using the options period, if you like, wisely and aggressively to understand what the options are in a timely way to get to the dynamical transition from our current deployment, our current nuclear power deployment, to whatever is the appropriate fuel cycle, in whatever is the growth or non-growth of nuclear power.

I skipped over this. Again, another thing that we have not really spent a lot of time on at all, on alternative disposal options, one of our favorites remains the possibility of kind of minor actinides and deep boreholes as a kind of a strategy. You can have your own, but there are clearly strategies that we have really not had on the front burner at all, and we believe we need to spend some time researching these RD&D to move forward.

We'll have discussions about nuclear material security, again, especially in this context of threshold states, and proliferation.

Another issue is a big open question that we will make some recommendations on, the questions of large scale demonstrations. Again, I basically said it just now. Within the last few years, I think that the Program got rather unbalanced and unwise, and there is now the opportunity to re-evaluate that Program. But, the issues of demonstrations are not just the kinds of things that have been discussed in the last few years. I mean, for example, we will certainly, I'm going to say, will be talking about things like demonstrations really of advanced fuels that can make a big difference in new built LWRs, for example.

So, again, I just want to get--the spirit will be certainly we're not stuck into the focus, the narrow focus, in our view, of the last few years. Quite the contrary, we believe, as we did in the Coal Report that we did in 2007, the RD&D program should be aligned with the strategic realities of moving these technologies, be it nuclear power or carbon sequestration or solar energy, to scale in a timely way with respect to the climate change risk mitigation challenge. That is the basic mantra, and our view is, again, we have been very misaligned in that context over the last years.

So, anyway, just kind of a summary, so again, we'll focus very strongly on the need to rethink fuel cycle strategies in the context of the various changes since 2003. Now, this time to assess alternatives, and that time again should be used to emphasize the good value in optionality. Major questions need to be addressed. We outlined some of those. We want to help in developing those, and we will, as I said, also identify RD&D aligned with the strategic choices for fuel cycle options.

And, with that, I'll be happy to take some questions.

GARRICK: Thank you. Ron?

LATANISION: Latanision, Board.

Well, there is no doubt we had--yeah, we did have a--there is no doubt we had a genuine physicist before us because when someone talks about issues as a factor of pi, we know that you're speaking physics language and not something else.

MONIZ: And, pi equals one in dimensionless units.

LATANISION: Yes. Well, it's good to have you here.

I have one short question and one perhaps more philosophical question. You expressed some concern that federal incentives do not seem to be working. Maybe I'm not using exactly the language you had on your slide, and I don't remember which slide it was, but utilities have in fact been beneficiaries of the federal incentives. Some have filed license applications. There is, of course, a natural lag time in the regulatory process before construction will begin. So, I want to understand your comment in that context.

MONIZ: It's very simple. There are those, like you, with sunny dispositions, and there are those who are former government cynical hardened people, so we acknowledge there's been a lot of, the word I use, I think it probably isn't appropriate for this particular audience, there's been a lot of preliminary actions taken, I would say, very important in terms of moving on site identifications and licensing. But, again, we say that that's all great. Keep your eye on the ball. Where is the spade in the ground? So, it's very simple. You can focus on the cup half full. We have a habit, I'll remind you, of getting to the brink and not getting over the edge. So, just because all that stuff has happened, does not mean we're going to have a spade in the ground soon.

And, of course, there are externalities like, for example, the less than robust demand picture right now, difficulties with financing. There are all kinds of issues that could stop you from getting there. But, in the climate clock context, maybe it's an aside, excuse me for getting into my pedagogical mode, but, you know, the--if we think about CO2 in particular as a long residence time greenhouse gas, characterized by centuries, and at least for the CO2 component of climate drivers, you can think of this as a budget. It doesn't matter if the CO2 molecule is emitted in this room, and quite a few have been today, or in Indonesia in ten years, it's the same in the accumulative budget.

So, we know what the budget is if you tell me where you want to stabilize concentrations. Let's take the now allegedly international consensus on 2 degree centigrade, let's take the probability distribution of what concentrations are for 2 degree centigrade, and the point is if we continue on our current trajectory with that budget, the budget runs out 2030.

Well, if we delay the spade in the ground five more years, you know, we're not serious about getting into the business of needing that kind of, not of, and I want to be very clear, we are neither advocates, as a group at least in our study group, we are neither advocates nor enemies of any of these technologies. Our view is what does it take to position them to be viable options for low carbon future. That's what the first mover incentives are about, and it's just not happening.

LATANISION: Well, let me make, I guess as it's turned out, let me just follow it up, because the philosophical question has to do with your comments about options. And, the fact is the clock is ticking, and if we look around the globe today, we see that, for example, wind energy is getting tremendous traction all over the planet, and yet it probably has the capacity, even under the best of circumstances, to meet only a small fraction of our energy needs on the planet. Where is a study which puts in perspective the potential that all the energy options, to use your language, have to meet the energy demands of the planet?

I mean, there are recyclables and other options that maybe should in fact be part of the equation, but they're not going to meet the kind of demand we have for a growing economy on the globe. Where is that study? I mean, is someone doing it? Is someone putting in perspective the fact that the investment and the time and the lag in terms of nuclear build-out and construction, and so on, is a slower process than building essentially a windmill, the technology for which exists today. And, so, people are investing in that technology because it's available and we see the consequence. But, is that going to be a solution to the global energy and climate needs?

MONIZ: There are a variety of models that address that issue, and I would say that one of the programs worthy of your attention, and I will apologize, I'll use another MIT program, there are clearly programs elsewhere, but we do have, for example, at MIT in our global change group I think a pretty sophisticated almost 20 year old global general equilibrium model of the global economy that's been built up with the globe divided into 17 regions, and there's trade between the regions. There's a lot of input obviously to this.

So, for example, in that kind of a model, in contrast to some of the bottom-up models, this is a so-called top-down economic model where you put in production functions that characterize the economic engineering performance of different technologies, but you also have interplays between different sectors, things like fuel prices are indigenous to the model. Okay? So, in that kind of a picture, you can constrain various technologies and see how they play.

There will be a lot of that in another report that we are doing called the Future of Natural Gas. The reason why it’s more prominent in that is because natural gas, compared to nuclear or coal, is so much more multi-sectoral in its uses. Okay?

However, if you go to the Coal Report in 2007, you will see one illustrative result of the model that kind of makes your point. Now, that was the future of coal report. So, in that model, that particular model run that we showed, arbitrarily, nuclear was held constant. There were other runs where nuclear grows, but in this particular run, nuclear was held constant, whatever waste management isn’t resolved, you know, globally.

Secondly, there was no magic cost reduction in the renewable space. So, it grew a lot relative to where it is, but still was not dominant. Fundamentally, that model forced you into a situation where coal and carbon sequestration was close to the magic bullet for the power sector, and biofuels were close to the magic bullet for the transportation sector in that particular model. Okay? And, the model was constrained by variable carbon pricing to reach a 550 part per million stabilization. You put all that together, and what it says is there is no law of physics that prevented that being a solution. However, it did require 200 million barrels a day of super critical CO2 injection into the earth.

LATANISION: Well, that's a problem.

MONIZ: It did require a 50 to 60 million barrels of biofuels a day and certainly at today's conversion efficiency of a half a watt per square meter, that required several tera square meters of biofuels, i.e. it doesn't violate a law of physics, but it sure as hell isn't going to happen. And, I think what that kind of modeling does is it emphasizes this idea of needing a portfolio of solutions. We need all of these technologies, frankly, to contribute. I think that was the conclusion we drew from that, as opposed to wow, isn't CCS a great thing.

So, I think that's the kind of model that does explicate that. I don't think it is penetrated into the popular kind of views. But, I can see Matt Wall will take care of that in the next Wall Street Journal. That was a promotion, I'm sorry.

GARRICK: Are you through?

MONIZ: Yes. Thank you.

GARRICK: Mark?

ABKOWITZ: Abkowitz, Board.

Ernie, I am an MIT alum, but I'm not here to welcome you for your MIT connection. If you've been up there for 36 years, I'm here to welcome you as a member of the Red

Sox nation.

MONIZ: And, then, blowing a 6-1 lead in Kansas City, just before the Yankee series, too.

ABKOWITZ: Okay. Well, I can tell that we share that passion.

MONIZ: Do you want to talk Dice K for a while?

ABKOWITZ: Later, off the record.

Given that we are a waste management board, I want to talk a little more about the types of tools you're using to understand the temporal and scale issues with regard to the wastes that may be coming out of these different strategies. Could you talk a little bit about the extent to which you're modeling those types of activities and the fidelity of that, or does that fall under the category of the tools that you're recommending that we need to develop more in the future?

MONIZ: Well, clearly, what we do in terms of the modeling, et cetera, it's pretty high level. But, let's say as one example of the kind of thing that, I mean, this is kind of factual as opposed to a conclusion, which I would have to deny anyway, if you look at, let's say, the baseline fuel cycle that I discussed, let's put the MOX aside and let's talk about once through versus the more or less canonical breeder path. In a, let's say, two and a half percent per year growth scenario for nuclear power, as an example, so we have the dynamic modeling that we, in those kind of mass flows, we clearly track inputs like uranium resources and outputs like the various waste streams in a kind of, you know, aggregated sense. I mean, basically uranium, fission products, plutonium, and minor actinides.

And, so, we track those. It’s not like we have them detailed, modeled as to where they all go, et cetera, but we track those respective--and, there’s an example, by the way, of that particular set of conditions I mentioned, where, if you think about it, you’re not going to be terribly surprised. There’s not a huge impact on uranium resources in this century. There is essentially no impact on the amount of transuranics. There is a substantial difference in where those transuranics are. Are they in a hole, or are they in various fuel cycle facilities and reactors, and that’s kind of the balance. So, we will kind of explore, and hopefully explicate that kind of choice.

ABKOWITZ: Okay. Let me just follow up with a question that may look at scenarios in a little more detail, and perhaps you can tell me if that’s where the level of fidelity kind of cuts off in what you’re looking at.

Are you considering differences in scenarios such as when recycling or reprocessing might come on, what the capacity of those facilities might be and the mass balance issues that correspond with those?

MONIZ: Yes. Now, we have a set of floors that will be transparent about when we believe these technologies are available, for example, particularly, let’s say, fast breeder reactors for actual deployment, et cetera. But, within that, then the answer is yes, all those issues will be looked at, the infrastructure needs, et cetera.

KADAK: Just let me explain a little bit. The big fuel cycle model is a bunch of boxes where inputs and outputs are tracked. But, the input to those boxes is based on analysis of different reactor types, different fuel cycles, different reprocessing scenarios and systems. So, the question is do we have it detailed enough to be able to understand what’s going on? Yes. Have we timed the implementation of the various technologies based on what you can physically build in time, how long it will take, what the inventories of plutonium may be to support, say, a breeder fleet, if you consume the MOX--if you consume the plutonium for a MOX recycle, what does that do to delay, if you will, the deployment of fast reactors? So, all of that is attempted to be modeled in I think a very serious way. So, it should be useful.

MONIZ: I should also say that the study is also part of a slightly broader project, and in the intersection of it, for example, also the nuclear group has been heavily involved with benchmarking the model against EPRI models, French models, et cetera. So, that's also another important part of that.

GARRICK: All right, we have several that want to ask questions. Howard, Thure, David Duquette, Diodato, and I'm hopeful that I can get a couple of questions in. But, we will terminate this on schedule, which is 9:50. So, make the questions as efficient as possible. Howard?

ARNOLD: Arnold, Board.

You may have been joking about the use of pi, but I've found over the years that it's a pretty good accurate number by which to multiply an estimate of something new to be done. It goes back to my own experience as a graduate student in physics in the 1950's building cosmic ray apparatus, and a British physicist named Blackett coined the phrase, and we always called it the Blackett Pi Factor.

MONIZ: Physics is a cow, not a chicken.

GARRICK: Thure?

CERLING: Cerling, Board.

You may a couple of references with respect to several different things about the need for some maturity on a number of these issues. And, so, as your experience both as an Ivory Tower optimist and as a hardened Washington bureaucrat, where do you see the maturity developing or coming from? What's needed to develop the maturity to deal with some of these issues?

MONIZ: Oh, I think the TRB. Next question?

GARRICK: Okay. David?

DUQUETTE: Duquette, Board.

We've got too many MIT graduates here, I can see that. That's going to create problems somewhere along the line. The question I had was I gather from your presentation and from other comments I've heard from Andy, actually, that some of your recommendations indicate that what you called management versus interim storage of the current waste and the waste that's being developed is an option for some time in the future. I'm not sure your report will address this, and perhaps you have a personal view on how long do you think we have before your solutions, if you will, will bring us to the point where we absolutely need some kind of a long-term disposal?

MONIZ: Well, first of all, I think just in terms of data, century scale in dry cask storage is not looked to be like an overly taxing challenge. I want to emphasize that it's important to say that we will not suggest that the length of time, whatever it is, for which one can safely, easily, economically manage let's say surface or near surface storage. I mean, that should not be the determining factor as to when one does something else. It just gives you the option, and I would view it certainly, maybe I'll speak now, let's say, for myself, I would say that in my view, the challenges of managing irradiated fuel storage, I will be a little bit extreme, for as long as you want are not the controlling issue for future fuel cycle choices.

By fuel cycle choices, I also include in that when you put something into a repository, when you don't, but this is a problem, in my view, that just gets easier with time as long as you take a few precautions up front. And, we should view managed storage, the approach to storage, the approach to managed storage, whatever your choice is, the first thing we would emphasize is in contrast to kind of the default option, it's in our thinking for decades, your choices there are a critical fuel cycle choice. It has major implications for how you think about the repository, major implications for how you think about fuel cycle facilities. We would argue that it's not been in the foreground of one's thinking.

I will certainly make a statement that is not part of, I think will not be part of our report, but whatever the case, I'd say it's a personal view that again, as I say, I think one can--the limits on what one does here are not technical. It looks pretty easy. As, by the way, does the fundamental science of geological isolation continue to look like a perfectly viable approach.

But, you know, there's a lot of discussion, I would say, and again I want to stress this is a personal view, there's a lot of discussion for years around issues of intergenerational responsibility. And, we've got to put the stuff into a hole as fast as possible, and take care of our trash. I don't agree with that position. I think it's a very, very limited view with intergenerational responsibility. If one is convinced that one has a safe and secure approach, that preserves options for other generations, particularly when we don't know today whether it's a waste or a resource. That, to me, is a richer approach to intergenerational responsibility.

GARRICK: Okay, very good. Henry?

PETROSKI: I was glad to see that demonstration was added to R&D. Will your report, or would you care to personally make a recommendation about how much budgetary resources should be devoted to basic research, development and demonstration? What kind of break-down would you give that?

MONIZ: That will be in our report.

PETROSKI: That's good.

MONIZ: We will have numbers rounded off to the nearest hundred million, or so. Let's just say that we literally have not had a full group consensus on this. A sub-group of us has a very specific proposal to make to the whole group. But, let's just say that very basic research, I mean basic research will have a prominent role. It will include explicitly the self-serving assertion that we need to rebuild a lot more opportunities in universities. But, there is a great opportunity, in our view, for university based research, with all of its concomitant benefits. Certainly for advanced fuel cycles, my personal view remains that we need to go back to more basic--by basic science, I don’t mean the round cow joke, I mean basic science, basic engineering, certainly laboratory scale experiments, maybe pilot scale, but I think a very judicious choice about when we move to large scale demonstrations, and how they fit into the strategic view needs to get a lot more emphasis.

PETROSKI: Thank you.

GARRICK: Okay, let me throw a couple of questions at you. I understand, Ernie, that there’s going to be--there exists some sort of advisory group that works in an oversight capacity. Beyond that, is the study going to go through any what I would call rigorous peer review, particularly with respect to industry input?

MONIZ: First of all, John, just to clarify, I should have said this earlier, that in all of our studies, we have an external advisory board with a pretty diverse set of perspectives. It’s not surprising that, for example, if we go back to the 2003 report, the interactions or the lively discussions of, say, John Sunnunu and Tom Cochran were quite informative. Phil Sharp, former councilman Phil Sharp, by the way--

GARRICK: Yeah, but I'm thinking of--I know those people and I know that they are very top quality, but I'm thinking of real technical expertise.

MONIZ: So, now, we have throughout the study stayed in contact with industry, certainly EPRI, NEI. We've had a whole bunch of seminars coming from industry. We had a meeting two weeks ago, I think it was, something like that, that involved some of your speakers coming up next in the program. We have to take their input clearly, and either support it or say why we don't, in a certain sense. I mean, there clearly are, as your program has, there clearly are at least three groups who have thought pretty hard and done a lot of work on this. So, the answer is yes.

On the rigorous peer review, I think the answer would have to be no, frankly, that is we will--we use the Board, we use the input from the Committee, but we're not going to mail it out to anonymous reviewers. That's the way we've done our studies in the past. And, I should say a characteristic of our studies, and this is partly why this process we have is, you know, I would say we use the advantage of being a university group doing this in the sense that, let's say, in contrast to the guidelines for an Academy study. We are not constrained from making very explicit policy recommendations, and we take that opportunity and do so.

GARRICK: Speaking of the Academy relates to my second question. About ten years or so ago I was involved in an Academy study affectionately known as the Stats Report. And, I don’t know if you were involved directly or indirectly, but as I hear the results--

MONIZ: I was occupied then.

GARRICK: Yes, I think you were. But, I was curious because I’ve heard a lot of leaks from your report that sound very similar to the same conclusions that were reached in that report. Has that been any kind of baseline contribution to your thinking? Has the Stats Report been a part of the background?

MONIZ: Well, to be honest, I wouldn’t single that out, but, I mean, there’s been a lot of reports obviously over the years from the Academy, and from elsewhere, by the way, including, you know, NEA, and others.

GARRICK: Right.

MONIZ: All of those we consider part of the baseline. And, I want to say that, you know, we are not--it certainly is not a principle to invent everything new. It’s to relook where we are today, analyze, and the extent to which we come out with findings, conclusions, recommendations that support previous reports maybe actually adds to the credibility and value of it. So, that’s how we approach this.

GARRICK: All right. Yes, Ali?

MOSLEH: Mosleh, Board.

So, your study, of course, is looking at many factors, parameters, some of which probably controlling parameters, with a lot of variability and uncertainty, both in decision space as well as technology space. Are your conclusions or recommendations based on some global optimization, finding some strategies that are better, superior to others, or what are the criteria that you’re using to kind of identify what your recommendations might be?

MONIZ: Well, first of all, as I said earlier, our approach does have a particular focus on the United States, with an eye to the global context. But, you know, mainly we are being driven U.S. situation. The criteria obviously includes our judgments at least on technical status, cost status of different technologies, and criteria, as I said earlier, like optionality, so then we use our judgment in terms of what we will recommend in terms of near-term policy options to at least at a minimum not preclude useful pathways.

MOSLEH: You’re running obviously an abstracted model of some of the various ingredients, such as technology option and other characteristics of the assessment.

MONIZ: Right.

MOSLEH: Your conclusions are based on running models and then selecting from the results that are coming out of the analysis, or are you running an optimization on that?

MONIZ: I would say it's modeling the mass flows, et cetera, in our different baseline and alternative fuel cycles. There are in there, again, assumptions about, let's say, availability of fast reactors, et cetera. Those will be--apparently, if you think they're wrong, well, maybe our graduate students can rerun.

Andy, you wanted to comment on this?

GARRICK: We're going to have to make it brief. I've got one more question from the Board.

KADAK: It's more of a--it's not a TRA, it's a sensitivity analysis of various scenarios and options off those scenarios. So, from those scenarios, we kind of say what is this telling us, and then from there, we kind of reach a conclusion.

MONIZ: Reach a big picture kind of conclusion about what's the right policy direction.

GARRICK: Ron?

LATANISION: Short question. Ernie, given your experience in the Department, how do you see 100 years of dry storage on site impacting the lawsuits that have been filed, breach of contract lawsuits that have been filed by utilities? How does that play out?

MONIZ: Well, it's no secret that in 1998, we offered to have government ownership on site to resolve the ownership issue, and then essentially pay the vendor to keep managing it on site. So, there would have been no on the ground change, but a title change to resolve the lawsuit. That obviously has not been implemented. And, the exact dynamics that occurred in ’98 are only good for the posthumus--but I think I go back to my comment about the transportation study, and you can make analogies as you want that the issue of distributed versus consolidated storage does not have a lot of major technical or economic differentiators.

So, I think in the end, that comes more to a question of judgment than politics, and what’s easy to do, et cetera, et cetera, with one exception. Well, again, in my view, and I think in the view, frankly, of the members of our group that without getting into specifics, it is very hard to justify keeping spent fuel at shut-down reactors.

GARRICK: Very good. I want to truncate the meeting right now and take a recess, and reconvene exactly at--and, I apologize to staff for not getting to their questions, but we’ll have to handle that some other way.

So, let’s take a break and we’ll reconvene at 10:00 sharp. Thanks, Ernie.

(Whereupon, a brief recess was taken.)

GARRICK: Can we take our seats, please?

I think somebody once said that it is impossible to have only a ten minute break, and I think they were right.

Ladies and Gentlemen, please take your seats. Okay, we're now going to hear from AREVA, Energy Solutions, and GE-Hitachi, and I would appreciate it if each of the speakers, as they get up, would tell us a little bit about who they are and what they do.

So, Dorothy, you're first.

DAVIDSON: Thank you.

I'm Dorothy Davidson, and I am the vice-president of strategic programs for AREVA Federal Services. What that means is I'm responsible, I have responsibility for things having to do with fuel cycle studies, anything having to do with advanced reactors, even on the renewable side, as well as some of the things on non-proliferation.

Okay, I wanted to talk, as everybody knows and was mentioned this morning, a number of industry teams have actually done some studies over the last almost three years now. So, I wanted to talk about some of the results, especially trying to answer the questions that we were given specific to waste for this topic.

First off to introduce, this is not just AREVA, there are six international teams, large teams, or large companies, that were involved in this INRA team that we call it, the International Nuclear Recycling Alliance, AREVA, Mitsubishi, Battelle, Babcock and Wilcox, JNFL, and the URS Washington Division.

In addition to the team that we set up, a couple things I just want to point out on the side over here are these advisory panels. Again, we were doing studies on should you close the fuel cycle, and if you do, how do you do it. It was easy enough for us to say, you know, give our opinion as industry, but we really wanted to try to do a reality check on this both with the utilities, who could be the end users if you did close the fuel cycle, and with the financial institutions to see if you could privately finance.

So, we have two advisory groups, the first one being the utility advisory board. There were 15 utilities that represent a little over 75 percent of the U.S. Nuclear Generation, the FEPC and 11 Japanese utilities, plus EDF and France that participated.

Again one of the questions--we went through all of our results with them, but one of the questions we asked is whether we should consider recycling. The answer we got was it does make sense. What they said is we ought to be able to pay for it from the Nuclear Waste Fund. Also said that if you did an integrated solution, it ought to be moved outside of the Department into a new entity to actually do this, and that the utilities wanted some say in this. So, these are some of the feedback we got, in addition to the technical feedback.

On the financial advisory group, we worked with two large banks in New York and really trying to find out what would it take to privately finance. Again, I can tell you it’s going to cost, you know, $20 billion, or whatever, but it’s going to be important is could you finance that was the question that was asked to us.

They came back, and I think it’s important because it’s the basis of some of the parts of our studies, or the assumptions. One, for it to be privately financed, you have to have a commercial model with existing fleet. What that means is you have to have a customer for the recycled fuel. And, now days, since all we have is light water reactors, that means light water recycling, and that is different than the assumption that we went into the study with.

They also said it had to be investment grade with guarantees. They were very clear it had to be proven technology if you wanted to do private financing. And, thirdly, rule-making is critical, and the particular one-step licensing was important because nobody wants to actually go through finance of a facility, you try to get it licensed to get to operation, and you can’t operate. So, there’s just too much risk there. In addition to that, we also have a number means to the national labs. We have met with NRC.

When we talk about--I want to just briefly, just to kind of lay the groundwork for what the study results were, so you know what kind of facility we’re talking about.

First, the consolidated recycling facility, or CRF. What we concluded is that we believe that technology is available, that could be done, it's mature, based on 50 years of experience from several countries. What we proposed was a COEX process that does not have separate plutonium, and that was one of the assumptions that was given to us. Co-location of separation in the fuel facility. Again, this was more from production from adjusted time production. And, a capacity that's based on the market of the recycled fuel. And, then, last this, this flexibility to allow deployment of new technology.

It's going to take, we estimate, 17 years from start--from design through start of operation. So, we're talking a long project to get this going. We fully expect that there could be developments in that time, in the next two decades.

As far as the capacity in the market, we think that's really important. We're not advocating starting something just so we can store separated material. Even separated material has uranium and plutonium. It should be market driven on that.

With this process and what we did, one of the questions you asked is is there anything on capacity that would actually affect--technical issues that would affect capacity, and the answer to that is no on that. It really is going to be how you design the facility.

On the recycling reactor or the sodium fast reactor, what we concluded there is there really is a lot of work to be done. Can you build a fast reactor? The answer is yes, there's a couple of them that exist, prototype type reactors or test reactors. On the other hand, if you wanted it to be commercial, there are things that need to be done as far as to make it cost competitive with some of the sites, LWR, and to enhance reliability and safety in particular. We looked at a whole host of things, whether you do oxide fuel, whether you do metal fuel, you could do either. We looked at whether or not you use homogeneous transmutation fuel, whether you make targets, and what impact that all had both on the repository and the material balances that we tracked, as well as what impact it had on the economics.

This is just a slide just to kind of show you the 50 years experience, commercial experience that's out there, all the way back to UP 1 in 1958, all the way through Rokkasho, which is starting up now. And, then, there's some things of, you know, we kind of had to put a date on ours. My guess is that 23 is way below, if you're talking, that's not even a realistic date right now. But, the big thing, just to say again, is that we did the study based on assumptions, you know, and the things, the lessons learned that we have so far as far as our experience.

The big thing, mitigating risk was the important thing, guarantee the process efficiency and reliability, minimize the impact on the environment, and then, again, this flexibility. That was carried out throughout.

Some basic assumptions I want to go through quickly on the technical. We did assume that the repository was Yucca Mountain, and that does have an impact on the waste and your assumptions because of the heat constraints that Yucca Mountain has. So, we took that all into account. If you choose a different repository at some time, or we consider that, that could have an impact. But, again, that was the assumption for the study.

We had a reference fuel, it was PWR, it was 50 gigawatt days for time. The thing after that, the four years cooling time, that again was an assumption we made and it has a direct impact on the minor actinides that are produced and the used fuel. This facility, though, could treat any burn-up. That was just the one we did for our test case, and partly, again, from input from the utilities because that was the fuel that they would like to move first operationally is the fuel that’s actually just being discharged.

No pure plutonium stream, mature technologies to reduce risk, had to be light water and fast reactor fuels, and advanced processes implemented when mature. And, then, the last assumption, again, that’s very important is you’re talking a commercial facility.

Looked at scenarios all the way from a demo, and there was a mention by Dr. Moniz before, all the way from 100 metric ton demo, all the way up to a 2500 metric ton facility that could handle not only about 2000 annual discharge in the United States, but also start working down some of the legacy, and looked at all of the variations of that as far as cost and any kind of technology or design.

Now, I want to go over basically just at a high level, what the flow was, so you'll know where the waste streams are. First, I'll tell you the waste streams are the ones with the little double blue boxes around them. Used fuel comes into the facility here, goes through chopping and dissolution--this is a process that's been used for decades--from that, and then it goes into separation. This is where the coextraction is. And, then, it actually can be the recycled fuel, both the U,Pu, there's no separated plutonium, and then the RepU, or the reprocessed uranium, that could be then made into the fuel and recycled. At the chopping and dissolution, this is the major place that you see it, this is where, when you do this, that you get the gas releases, primarily, your Iodine-129, Krypton, and your Carbon-14.

What we have looked at in the study was actually going through, trapping with Iodine, and then conditioning it. The Krypton and the Carbon are actually monitored, and then they go up the stack and they're released. And, the chopping and dissolution, the hulls, end pieces, metallic waste is rinsed and it's compacted, and you actually have a canister with compacted waste in it. And, the separation, you get the minor actinides that are in there in the waste, liquid waste, then you have the fission products and your Tritium. The Tritium is again taken off and it's treated, and this is different than what's actually done in LaHague right now. And, then, we condition that Tritium. And, then, the minor actinides and fission products are vitrified into a robust glass waste.

(Pause while new slides are being put up.)

ARNOLD: I've got a question for you while we're waiting. You don't show any recycled uranium going into a waste stream. I'm concerned with the uranium that comes out of the recycled plant from a couple of standpoints. One, when you re-enrich it, you're also building up the U236 and the U234, and it becomes less and less useful as reactor fuel. And, also, you have changed the disposition path for tails from being clean, depleted uranium, which can be handled, you know, without radiation protection issues, to something that is now contaminated, and it's going to be in large quantities. So, every time I listen to a reprocessing scenario, I become concerned with the issue of the recycled uranium.

DAVIDSON: You're correct. What we looked at was, and the assumption was that on the uranium, the reprocessed uranium that we recycled, so we did look at that, you're right, there is an ingrowth of some of the even isotopes and uranium in there.

ARNOLD: Yes. It makes it pretty useless in a light water reactor.

DAVIDSON: Well, actually, it is being used right now after a single recycle in the light water reactors.

ARNOLD: But, after two or three, it becomes pretty bad.

DAVIDSON: That's correct, and we did not go into multiple recycles and looking at any of the, actually, the contamination on that. We only went through the first recycle.

ARNOLD: Well, if you don't go through multiple recycles, then you end up with it as waste, and it is now difficult to handle compared to clean UF6, clean depleted uranium.

DAVIDSON: Okay. I'm going to actually ask someone who is technical, better at chemistry than me to answer that. Is that acceptable?

SPEAKER: Yeah, (inaudible) with AREVA. Your question is very valid. The answer is that we, in the blending of the reprocessed fuel, uranium with natural uranium, in order to come back to acceptable and usable--because there is a very small amount of reprocessed uranium as compared to the natural uranium stream in the enrichment--

ARNOLD: Well, you know, every metric ton of uranium that goes into the process, minus a few percent that's fission, ends up somewhere, and it is now contaminated.

SPEAKER: You're speaking about the depleted uranium?

ARNOLD: I'm speaking of whatever stream is coming out of your reprocessing plant.

SPEAKER: Yes, but the answer is that we do recycle reprocessed uranium, and if we have problems with the isotopics, we--

ARNOLD: You recycle it once.

SPEAKER: No, we blend it. If you have problem isotopics, you can blend it with natural uranium.

ARNOLD: Okay. I think I'd like to see a mass balance.

DAVIDSON: On solid waste, again, just to show very quickly, and I apologize because the ones that came across on the e-mail were incorrect, there's been a lot of work that's been done over the years, again, trying to figure out how do you keep producing the volume of the waste, how do you make them a more robust waste form.

We talk about the waste, and what I'm going to talk about especially with the solid one, two different kinds, your conventional waste, your non-nuclear, and then there's two kinds on your nuclear waste, both the processed waste and the maintenance or operations waste. And, there are a number of different types of, as you can see below, of different techniques for treatment, and conditioning of the waste.

Some of the general things, and when we talk about a facility, if we are to do recycling in the United States, we think are important, one, it has to have the assumption right up front that final conditioning for every waste stream, you want a robust waste form, you want to minimize the amount of waste, the volume and the radiotoxicity you're generating, and you want to have defined disposal paths. So, we would agree on that.

Some of the principles of limiting the waste volumes from the very beginning, even the design of the facility, it's modular equipment, we need to have equipment reliability so we don't have to replace out a lot of equipment. We maintain the equipment as long as possible, if we can decontaminate and repair it, rather than pull equipment out and actually have to replace it. A lot of sorting, based on waste classification, right at the source of the waste, and then we choose the right treatment process, and then in cases where possible, you're going to recycle liquids as much as possible.

As far as waste volumes, when you look at the recycling for the high-level waste, direct disposal at 45 cubic feet per metric ton. What we believe, based on experience, is that with recycling, if you take into account both the vitrified fission products, minor actinides, and the compacted hulls and end pieces, you get factor of four and a half. There are things that can be done that people are looking at to actually improve that further. If there were some way to actually do something to reduce the radioactivity of the compacted hulls, and not have to put them into a geologic repository, that would also help.

Some of the different types of waste that we have, you will see that on the vitrified fission products and minor actinides and the compacted hulls and end pieces, they are in the same type of canister, is what we would propose. It makes it much easier for handling purposes. There's also some alpha waste that is actually recycled, there's less than 100 canisters in there, per metric ton. And, then, the high integrity container, which is a cemented container, and there's only a few of those in there. In the backup information, there's actually a flow diagram that shows all of these and the process, ties it to the process.

One of the questions that's come up is not just on the high-level waste, it's what about the low-level waste. There is low-level waste that's generated primarily from the actual operations and maintenance. What we estimate and what we believe, based on the process that we're proposing, is that there's about 50 cubic feet per metric ton of low-level waste that is generated. These are 2007 numbers. The total low-level waste generated in the United States is approximately 2 percent of the U.S. market, is what that equates to.

Again, there are specific containers that have been used that we would propose for this. There are some, all the way up from 120 liters, all the way up to this high integrity container, and there's some cemented waste and then other ones that have multiple different items that are placed inside of it for mobilization. You can see some that are mobilized, some that are encapsulated. The total waste there, you know, the 50 cubic feet, and most of that is A, B, or C waste.

I'll make one additional comment, and we can talk about it now, is we talk about the vitrified waste and the compacted waste containers. Remember, in this case, the end pieces, the hulls and end pieces, when we actually look at just the activity of the waste, what we concluded is by standards now, it's greater than Class C. We are proposing it needs to go into a geological repository recognizing there's not a greater than Class C repository right now, but believe that since this is actually the waste that comes from the fuel assemblies, it can also be disposed of with the vitrified waste, the glass. That would take legislative changed. But, then, there are a number of things that are going to require some legislative changes.

On the TRU waste, as I said, there's a small number of containers that are TRU waste. Potentially, a site such as--a disposal site such as WIPP, or an NRC licensed disposal site, again, that's going to take--there are some requirements, changes that would have to happen legislatively to allow something like this to go to WIPP if they accepted it.

The mixed low-level waste, the iodine traps, there's some additional treatment that we're doing some R&D on right now and looking at. Have not defined what that disposal path would be. It will depend on whether or not it's classified as low-level or high-level waste, and that's still to be determined because we're still looking at how we condition the iodine waste. And, then, the low-level waste we believe could go to a DOE or a commercial low-level waste disposal site.

Gases and liquids, this is another area where it's important, we're continuously looking at, how do you do continuous improvement on this. This is just kind of from 1976 until 2007, just to show briefly, you know, what has been done as far as affluence, and this is from the LaHague plant in France, what's been done over that time. What you see is that there's still, even though the capacity and the through-put of the plant has increased, what you're seeing is a significant drop in your alpha and your beta gamma. As far as your discharges, the one you see that is actually rising is Tritium because it’s not captured at LaHague.

When we went through and we looked at all what we believe, based on the capacity that we were looking at, and then actually the process, we looked at all of the releases, we tried to compare them to what the regulation says now. In the case of 40 CFR 190.10a where we have dose limits, both for air and liquid, in all cases, it was significantly less than what was allowed. So, there wasn’t any problem with the dose limits for that.

In the case of 40 CFR 190.10b, this is a quantity limit on gigawatt year of electricity produced, and it’s for the whole fuel cycle. Granted, the majority of it will come from the reprocessing plant. What we did conclude there is that for recycling, it does exceed the current limits for Krypton 85 and Iodine 129. Now, I have to say in our study, we made an assumption right up front that we would actually do preferably, the fuel that was within four years, newly discharged fuel. So, the hotter fuel that was coming out of the reactors, that has also a higher content of Krypton in it. If you decide to do cold fuel, and especially fuel that has low burn-up, the colder fuel will have almost no issue with the Krypton in there. So, there’s a lot of trade-offs of whether or not you do old fuel or new fuel, what impact it has.

Again, if you’re looking at Yucca Mountain and you’re concerned about heat, and you want to minimize the Americium, you’re going to do your newly discharged, or your low burn-up fuel. If you want to minimize the amount of Krypton that’s produced, then you want to do, again, your older fuel. Iodine is still an issue. We’re looking at that and I’ll talk about that in a minute.

So, we’re looking at kind of two solutions, or two possible paths forward on that. One is that you could revise or update the regulation so it’s more risk based, consistent with International Commission of Radiation Protection, or you could update the current cost and the dose basis. Back in the late Seventies when they actually set up this rule, there were some assumptions of how much nuclear generation there would be. Significantly, significantly higher than what we have anywhere worldwide right now, because we’re looking, remember, on a cumulated dose. So, there are some things there, again, there’s some updates that could be done that have significant impact on this.

And, then, the other thing is we are working between industry and the national labs to look at new technology to capture Krypton 85. But, for sure, there’s going to need to be a risk and a cost benefit analysis on that.

When we start talking about the gas release and the challenges, you know, that we want to capture everything, there are some really engineering challenges. We could be talking very, very, very small trace amounts inside a very large gas release, you know, from the stack. We could be talking, you know, when we start doing these things, we also have to define, okay, what is the stable form that we want to put this in, and we don’t have all the answers to this part yet.

We also need to consider that if we are going to concentrate, whether it’s Krypton or Iodine, or whatever, you know, that this also could potentially pose some additional risks of exposure and contamination to the worker. So, all this needs to fit into a definition or into your analysis of what do you want to include as far as the facility.

First off, and I’ll go quickly through these, the first one as far as the Krypton, we believe this one has a very, very low dose impact from the Krypton. As I said, what we had proposed in the study was that it should be released from the stack. What you’re talking about in a worst case scenario is about .5 millirem per year, is what you’re talking about the dose that comes from this.

We looked at a couple other things, cryogenic distillation, and some other waste conditioning. Again, they could be done. They’ve actually been demonstrated at the

Tokai facility in Japan, very costly. And, so, that’s one of the things that we kind of pointed out. This was one of the areas where we said that there is R&D needs, and to actually look at this some more in the future.

Iodine 129, we’re already looking at, and what we proposed was a process that is actually being implemented at Rokkasho Recycling Plant, where they’re trapping the Iodine 129 on a solid media, in this case, silver beds, and they’re actually trying to trap it in the out-gas process. They can capture about 98 percent of the iodine, so there’s only about 1 percent that is released in the air, in the stack, and another 1 percent that’s left that’s released in the water. So, we are still looking at conditioning of that solid media, deciding how you would dispose of that, what would be the best path. And, is there another way to go after that other 2 percent, and whether it’s reasonable. Again, all of this was within our ALARA goals for the facility.

Carbon 14, this one already complies with all the current regulations. We just put it up there and saying that there is some that, especially during the dissolution, that Carbon 14 is released as carbon dioxide. You could try to go in and try to capture that Carbon 14 if you wanted, again, to capture everything. The problem is what you’re going to do is you’re going to capture a whole lot of the carbon dioxide that’s not radioactive, and now we have a very large waste stream that we have to figure out what we’re going to do with. Because it met the regulations, we just propose that they ought to just leave it going up the stack. And, again, if you look at what the real impact was, it was very low on that, and we have all the numbers, in fact, we have all the dose limits from all these radionuclides.

The last one to look at is Tritium. In this case, in the case of LaHague, it actually is released to the sea, and it can be dispersed, and, so, it is well below any of the requirements as far as dose limits. The facilities we’re looking at here, they’re not going to be on the ocean, or anything, they’re going to be inland, we went back and looked at ways that we could actually capture and condition, again, the Tritium there. About 96 percent we believe can be actually removed and conditioned as a solid waste. We’re looking at, again, the other additional 4 percent, and what’s reasonable there. Right now, the technology does exist to do this capture. It is an engineering problem there. It’s not a technical issue. It really is an implementation issue at this point. It will be very energy intensive just to do this process, though.

The last category that the question was asked is what about D&D. One thing that we found, and we’ve almost completed the D&D of the UP 1 facility that was down in--we’re actually working on D&D of one of the facilities, the early facilities up at LaHague, so one of the things that we considered is that it’s really important, and I think one of the timely--we’ve talked to some of the communities that said, you know, if you’re going to design a facility, you’ve got to take this into account right up front. Don’t, again, try to fit this later on and figure out what are you going to do about D&D? So, from the lessons we’ve learned, we think it’s very important to actually look at D&D, and the wastes you’re going to generate, and make sure the disposal casks right from the very beginning.

As far as if we take the 2500 ton per year recycling plant, and again, I use that because that would take care of all the annual discharge, plus some of the--work off the legacy, and we looked at it at the Summa plant, the lifetime of the plant is 50 years. What we create as far as low-level waste, we actually generate less than 20 percent of the accumulated low-level waste that we generate during operations. So, we actually compared it back to the operations part.

There is some greater than Class C, and I didn’t put it up there because I didn’t have the information at the time. You will have some greater than Class C from some of the piping, and then some of the decontamination operations that you have. It’s about 10 percent, or so, about 9 percent is what we calculated. But, there is some greater than Class

C that's generated during D&D.

Last topic that was asked was advanced separations, what do we do about the other radionuclides out there, especially the minor actinides? As I said earlier, the criteria for this is really going to impact what you want to do. It made a big different at Yucca Mountain because of the heat generation, and we wanted to minimize especially things like Americium. We also looked at Neptunium and said okay, can we do something with Neptunium for other reasons. So, if it's something different in Yucca Mountain, it could have an impact as far as the criteria.

The other thing, and Dr. Moniz made the comment, is, you know, if you look at this, and I'll show you a picture in a second, if you look at the whole facility, the processing is a small part of this compared to the whole operation that you have for recycling facility. If we start adding additional, you know, multiple waste streams, and we're going to do multiple processes instead of just what we're proposing here, it is going to affect the complexity. It's going to affect the process, it's going to affect the design, it's going to affect the cost, as you would expect.

On Cesium and Strontium, we did not propose to separate that. We didn't see any real advantage to that. We thought it was just as well to leave that in the glass and allow it to decay at the site, so that, again, because it's a short enough half-life, it’s something that you could decay. And, we looked at anywhere from 20, if you allow it to sit and decay for somewhere from 25 up to 100 years, and what that impact again, in this case, on the heat generation, would be.

Technetium, the correct plan is to send it to the vitrified waste. I know there’s lots of discussions whether or not they form another alloy with this, or something else. It can be done. It can be added to the facility. It’s just something that we had a technology, we believe, that was mature enough to add at this point.

Americium and Curium, this is the one area we think it is important, and particularly with the Americium. The Curium, there’s some complexities with handling Curium. Again, because of the half-life that you’re talking about, principally Curium 242 and 244, we thought again it was better just to send it to the vitrified waste and allow it to decay. It’s not one of your very long half-life radionuclides. The Americium is another case, though, we thought that it was important that we would like to be able to recycle that in transmutation fuel or even better from a cost standpoint, possibly using targets. And, that’s still a lot of work on transmutation fuel that needs to be done before we come up with a conclusion on that.

The one thing I will note is in order to actually really burn that Americium, you are talking multiple recycles. We're not talking just one recycle. We went through and looked at how many recycles it was going to take. We also looked at the sodium fast reactor and said when we do this, the principal purpose of a fast reactor is to generate electricity, and then, oh, by the way, it does burn some of the minor actinides from a waste standpoint, or do we want to optimize the whole fuel cycle that we're looking at and actually just make a few fast reactors, and use them as true burners as part of a waste strategy. So, we looked at it in both ways, and tried to determine again on the cost and looking at the material, and how many times we would have to recycle.

This is just a plant layout of the facility. What you see, the part that's in gray here, all of this here, this is the part, the technology that we believe is mature enough that does exist now. The part that's in red here, that's Neptunium separation. That's actually been demonstrated before. I think you could do that in the first facility. The utility input that we got was if you're going to put MOX in LWRs, we prefer not to have Neptunium. So, we kind of said okay, we can do this, but we're not proposing it.

The important thing in working with the laboratories, these blue facilities right here, if we're talking about the separation, and especially if we're talking about Americium separation, we sat down with the national labs and took out flow sheets and took their flow sheets and what they thought you would have to do for advanced separation, and figured out how you could put them together and literally came up with where there’s an additional tank that would have to be added in the process line, and then you could add on these buildings, both the separation in this case, so you could separate out the Americium, and if something happened and it didn’t work right up front, it still allows you to keep running the rest of the plant. And, in this facility is where you would make either the homogeneous transmutation fuel, or the targets, Americium targets. And, again, you still have the MOX fuel in here.

The important thing is we don’t believe that, you know, again I said 17 years to build this kind of facility, design and build this facility, and get it to start-up. We don’t believe that you’re talking about a facility that it’s going to come online and you’re never going to change this. There’s still going to be developments and things that we have to work on. We also believe that from the very beginning, if we decide and when we decide to do this in the U.S., we need to be working together, and this needs to be a collaborative type thing between industry and the national labs. And, I will say we have a number of projects that are actually going on in the universities right now, in looking at some of these very specific R&D areas. So, it's important to work together and continue to work together and to look at how do you bring those best technologies, you know. If there's something in Krypton that's reasonable, then we ought to deploy it, and we ought to do the right analysis to determine whether that's the right path forward. So, we believe that's possible and that's kind of included.

I will summarize and say that I agree with what Dr. Moniz said. First thing we ought to do is new reactors built, and we just need the first one to start. We need to be convinced that there really is going to be a renaissance in the United States. Let's assume that that's true and that does happen, and I'm hopeful, the real conclusion we have is we really do think we need an integrated solution in the United States. We believe that recycling should be included as an option. We are not saying let's go put a shovel in the ground right now. It's obvious there are some issues that we've left open that we think we need to work--that we want to work through, and there's not even some of these things, these enabling steps near-term. In some cases, the rule-making is not done. NRC is working on that and we fully support what NRC is doing on the GAP analysis and the rule-making.

There are some regulatory issues, obviously, on affluence that we, you know, we've kind of had some initial discussions but not decided. Legislative changes, and obviously financial things on how you would finance something that's this large and this long a project. But, we do believe that there are positive enough advantages even from the waste from the--we even believe from the economics on recycling, that it should be included as an option.

The one thing I would point out is that no matter what back-end strategy we choose, we have to have a repository. So, this isn't an either/or type situation. It may affect timing, but bottom line, there's still going to be a need for a high-level waste repository.

Thank you.

GARRICK: Let's do them now. Go ahead.

KADAK: Kadak, Board.

One of the things that Ernie was trying to explain, and that is the role of demonstration projects. From what I gathered, you feel that this is ready to go commercial. Would you have any recommendations for pilot proof of principle on a scalable size for some of these technologies that you're talking about, or are you ready to build it if you had the money?

DAVIDSON: Well, okay, I'll qualify it. If we had the money, but I'm assuming the politics and legislative--

KADAK: Yes.

DAVIDSON: Let's assume everything is aligned and that is the decision. Are we ready to build a recycling facility now in the U.S.? The answer would be on the separations part, yes. So, on that part, I would say yes, with the technology that we’re proposing. Again, like I said, on the waste side, and in particular on Krypton, Iodine, Tritium, there’s still some discussion and things that need to go forward, and probably that’s regulatory, because we’re not really sure what we’re going to actually strive for. So, I think the technology is there.

Now, I will take one step back. We already went through and looked at all of the flow sheets if we were to do a facility in the U.S. And, what we concluded was we don’t think there’s any technical show-stoppers. Okay? And, I’m putting Krypton aside because I don’t know what that decision will be in the separations. But, we do think that there are some things we have identified, a significant number of things where we think that we could do demonstrations, and they really are technology demonstrations, not the real R&D side, that could simplify the process both cost and the licensing process.

KADAK: So, I think--

DAVIDSON: So, I think there are some demonstrations that could be beneficial, but not absolutely necessary, because we have backup plans if they don’t, and they will meet the requirements.

KADAK: So, in the sense of putting it together, you call it a consolidated something facility?

DAVIDSON: Recycling facility.

KADAK: Recycling facility. So, it would be helpful, I think, if we knew where the technology gaps were. And, you seem to suggest it’s only in the Krypton or maybe Iodine process that would be a challenge. But, without having some of those things clarified, I can’t see how you’ll design a facility and be willing to put up your own money, assuming it is your own money, not knowing what the ultimate cost of the facility would be, since as we now learned, it’s mostly waste management.

DAVIDSON: You’re right. And, again, that’s why I say I would not say we would go do this now, because, like I say, I don’t even know what the regulatory requirement is going to be on a couple of these. We need to finalize that. So, there are some things that need to be done. On the demonstration, as you said, could you start it now without demonstration? I think there are other things now, the Americium for sure, you need to have a demonstration, and we have actually talked with the national labs and said how could we actually take this--a commercial facility, we have all the rest of it done, you know, all the waste, all the input, you know, the MOX fuel and everything, and how could you actually use that as a demonstration platform. We’ve also tried to look at how we would do that, again, a possible demonstration.

KADAK: Could you just briefly explain the difference between COEX and NUEX?

DAVIDSON: Between COEX--

KADAK: And, NUEX?

DAVIDSON: I could--I'm sure--the difference is COEX is actually--it's looking at the uranium and plutonium together, and the NUEX, you actually have neptunium together--is that fair, Al?

DOBSON: It's not quite fair, Dorothy. But, I will speak to that when I, okay, give my presentation. But, you each have chosen different ones, and I was curious as to the basis for the technology selection.

DAVIDSON: Again, we chose it based on technology and maturity. The COEX process, probably not for this study, but AREVA has been working on that with CEA since the Nineties, and again, not because of those reasons. It really had to do with the MOX fuel. They were looking at kind of optimizing MOX fuel. So, we believe that the technology is mature enough. Again, we've already done demonstrations on Neptunium, so that's doable at any time, as long as we have, again, an end market for the product.

KADAK: Okay.

DAVIDSON: So, we have no problem with that.

GARRICK: Ron?

LATANISION: Latanision, Board.

I'm sorry, I may be missing a subtlety here, but recycling is being practiced today in France and Japan. This is a follow-up to Andy's question. So, what is the short description of the distinction between what you're proposing and what's being practiced that would lead you to say that you're not ready to start building today, if we've already got operating successful?

DAVIDSON: There's different regulations in the United States as far as that. That's the only difference. It is not the process. The concern is on 40 CFR 190.10b, and it has to do with the Krypton and Iodine, which we don't have those same regulatory constraints in France. And, because France has also, it's actually built on the sea, actually they're doing--can do discharge to the sea, and we're assuming we would not have that kind of facility or siting in the U.S.

LATANISION: Well, are those regulatory concerns issues that ought to be discussed, negotiated, what? So, what stage are we at in that context?

DAVIDSON: There has been very preliminary discussions with the EPA in particular on that 40 CFR 190.10b. So, very early stages on that, in looking at whether this ought to be risk based, whether we ought to update the assumptions over what was made as far as nuclear worldwide back in the Seventies. But, it’s still very early on that part. And, so, that’s the biggest thing. As I said, as far as the process, as far as the fuel fabrication, as far as all the shearing, everything, I think that is not an issue. I think it’s the things that are very specific to the regulations in the United States that we still have questions on.

LATANISION: Thank you.

GARRICK: Howard?

ARNOLD: Arnold, Board.

I’m still not satisfied that a substantial fraction of the uranium does not end up as waste, but I’m willing to pursue that separately. We don’t need to drag it out here.

DAVIDSON: Okay.

ARNOLD: Thank you.

DAVIDSON: I appreciate your comment. I will gladly talk to you afterwards, whenever you like.

GARRICK: All right, we’re right on schedule. Thank you.

DOBSON: Good morning. My name is Alan Dobson. I’m with Energy Solutions. I’m responsible for fuel cycle and spent fuel management within that company, and as part of my responsibilities, I led our efforts on the GNEP project, which began a couple years ago, and we’re just in the process of submitting our final reports.

Before I go on to talk about the impact of recycling on waste management and disposal, I would like to introduce our team. Energy Solutions, former team for the GNEP project, and our principal partners, Westinghouse Electric and Shaw Environmental, they're very prominent names in the U.S. nuclear and on the world stage.

An additional international dimension was brought by Atomic Energy of Canada, Toshiba and the UK's National Nuclear Laboratory. And, then, last, but by no means least, bringing up the rest of the team was NFS and Bozz Allen Hamilton from the United States.

This team was actually created to address the challenges given by the United States Department of Energy, and that challenge was that they asked industry to advise how and what needed to be done in order to commercialize the full range of GNEP facilities. So, those are facilities involving LWR recycling, involving producing advanced recycling reactors, involving recycling advanced fuels for advanced recycling reactors. And, we covered the whole spectrum of those requirements, and we did it against meeting the goals of GNEP, which were stated very broadly by the waste management goals. They were goals relating to non-proliferation. They were goals related to economics, and they were goals related to energy security and public accessibility.

But, there is a much bigger question that has to be answered, and it kind of hangs in the air in any discussion like this, and it is why would you close the fuel cycle? And, Energy Solutions team believes that there are some significant benefits from closing the fuel cycle. We do believe that it enables you to put forward a particular solution to the waste disposal problem. There are benefits to be taken with regard to volumes and amounts of waste to be disposed of. We talk about the heat problem, and all the rest of it.

There are other benefits. There are benefits with regard to the non-proliferation issues that are raised when people talk about recycling. But, I just really want to focus on one of the points that’s on this slide, and it is that we believe that having the option to close the fuel cycle, provides an additional measure on waste confidence with regard to the factors affecting new growth. And, we wouldn’t argue with anybody with regard to the economic issues surrounding new build. They are all major questions. But, as a colleague used the expression, Jack Bailey from Tennessee Valley Authority, a couple weeks ago when we were receiving feedback from Dr. Moniz and his team on the NRT study, and Jack used the expression, “certainty of solution,” and I think it really captures the whole spectrum of things that emerge when you consider closing the nuclear fuel cycle.

You'd have to use one word in describing our approach. It was incremental. I'd just like to set the context of that approach, at least set some parameters for the team. We said that we need to look at the U.S. nuclear situation from now to the end of the century, and we modeled various scenarios with increasing share of nuclear, from the generation of electricity point of view. And, we assumed very conservatively, that the nuclear share would remain, it's about 20 percent, and then increase in a few years, in a few tens of years, to about 25 percent.

We also include in that scenario the deployment of fast reactors, fast reactors not for breeding, but fast reactors to be used as advanced recycling reactors for the destruction of transuranics. We also had set the parameter that we would not dispose of used nuclear fuel. We took the view that used nuclear fuel was an asset. We also said that in this picture, we would not accumulate plutonium or uranium, and we would look to see how we were able to recycle the uranium and the plutonium back into the thermal reactor fleet and eventually into the fast reactors, should they be deployed. And, whether or not they are deployed is a key issue that we'll, if we get a chance, speak to this morning.

Initially, the first step could be closing the fuel cycle for LWR fuel. We believe that some development work is required, but it's not substantial compared to the development work that is required to bring to commercial fruition a fast reactor for the fuel cycle. There is correction needed now, though. Dorothy has already spoken about the legislative changes that are required, the regulatory changes, and we fully agree with that. I just emphasize it’s really important that industry and the national labs continue to work together on the development.

We believe the incremental steps, the initial steps, industry should lead. We think that industry is best qualified to lead that work, we think with the national labs being an integral partner. We think that the national labs, as an entity, for instance, and I’m not deliberately leaving out universities, but we do believe the national labs as an entity are best qualified and should lead the development of the fast reactor in the advanced fuel cycle work that needs to be done.

I would say that one of the things, it’s really important today to continue the quest to find sites for managed used fuel storage, for eventual recycling, and it has to be done in a manner where the states, the communities and the states in which those sites are both found on a volunteer basis, and with the full blessing of the state, because at the end of the day, as history really shows us, we get nowhere if we cannot trust that bridge and be able to get those parties involved in that decision.

From a technical standpoint, our approach was to use advanced, but yet proven, and we will speak about what that means, processes. But, we would use, wherever possible, commercially proven, and would deploy those processes on commercially proven equipment across the whole range of facilities that are required for fuel recycling and fuel fabrication and reactor deployment and advanced fuel recycling and advanced fuel fabrication.

And, the key reason for doing that is that you significantly mitigate the technical and commercial risks. It will become clear, I hope, we're not saying do just what has been done in the United Kingdom and France and Japan and Russia. We need to move on from that. There is something different that needs to be done. We believe, however, that this approach does allow progress, real progress without prejudicing the future of nuclear power in any way.

In our approach, it may quickly become clear, by the way, that we would not be ready to deploy on a commercial basis fast reactors. And, therefore, if you're looking to meet the condition that we gave of not leaving uranium unused, in other words, regard it as a resource rather than a waste, you need to find a route for the uranium. And, the Canadian CANDU reactor, as a first and significant step, I might add, provides an excellent route for reuse of recycled and recovered uranium.

We also looked what could we do with the transuranic elements, Americium and Curium, pending the availability of the fast reactors to burn those elements, and, again, the CANDU reactor really features that. It is possible to fabricate targets and irradiate them and destroy the Americium and Curium in CANDU reactors.

Now, that's not a statement of--that's not with 100 percent certainty, I couldn't say that we can get the satisfactory yield at one pass, and all the rest of it. But, the possibility is very real, and we identified a program of development work in conjunction with the ACL members of our team to explore how best to do that.

In our final report that we will submit at the end of this month, in fact, next week, we have also been working on burning Americium and Curium in light water reactors, although we have not discussed that with any utility whatsoever, technically our studies show that that is feasible. So, a key feature of our approach is that we would train to take care of some of the problem species and the valuable material from the get go. And, our model for the whole nuclear scenario required us to demonstrate that we were not accumulating either plutonium or recycled uranium, and we were consuming, or we would consume all of the Americium and the Curium. There's a big technical question about the Americium and Curium from the point of view of the target fabrication and burning in the reactors. But, we think it’s possible.

This is what our facility would look like for LWR recycling. And, I have brought, although I don’t propose to discuss this in detail at all, I have brought along a DVD, which I will be very happy to present to the Board, and we can get multiple copies, and it will take you on a virtual tour through the facility. You will see the technology that is being used, and you will see the advanced processes and where they’re being deployed on currently commercially proven equipment.

Although there is rightly a focus, and this Board is really concerned with waste issues, you have to look at the separations technology. And, if I could answer Dr. Kadak’s question, the NUEX flowsheet is specifically designed at all times so nowhere in the facility would you separate plutonium from uranium, nowhere. So, it’s not only co-extracted like uranium and plutonium. If there’s any solid extraction people in this audience, you will know that uranium and plutonium is co-extracted in any reprocessing facility. The key, though, is can we co-strip it in separation, and the NUEX flowsheet, the essence is the chemistry is such that you can co-strip the uranium and the plutonium from that primary separation cycle. You never, never have to blend back uranium to get the uranium/plutonium mixture.

And, as you can see on this diagram, one of the areas we looked at for Americium and Curium, was to the national labs because we looked at the processes that are being developed for Americium and Curium extraction, and we felt that the national labs were not completely onto a winner, but they had a very good process for Americium and Curium extraction. We believe it requires development work, but it can be industrialized. That’s the key, it can be industrialized.

Solvents present a bit of a challenge, but it can be industrialized. And, to go to your second point with regard to pilot scale--I’m sorry, I’ve clicked the button too often, I’m sorry about that. If we went to pilot scale and deployed this facility, you would only need to use very small scale fully radioactive facilities. We’re absolutely confident. The full-scale facilities will be to demonstrate physics flow, would be really to demonstrate the physical processes to do with chemical engineering in some parts of the facility. Fully radioactive, you would go no greater than 1/5000 scale--no greater than 1/5000 scale.

KADAK: Kadak, Board.

Has this NUEX process been tested in any scale?

DOBSON: It’s been tested in the laboratory. The actual chemistry of the separation--

KADAK: Could you go back to your flow chart? What is it that you have actually tested? Is it that pink box?

DOBSON: The top pink box. The primary separation box. What I have to share with you is that when we developed the process--in the United Kingdom, we looked very carefully at the Neptunium, and technetium in particular. Let's put the technetium to one side for a moment. Our studies showed that if you could work on the valiancy of the Neptunium in that primary separation process, we were able, and our focus was out to get Neptunium out, by the way, but we realized that we could co-strip the uranium and the plutonium. And, the work that we've done in the laboratory absolutely confirms that that chemistry is viable and can be controlled, and it would take place on the proven equipment, we're also confident of that.

KADAK: Thank you.

ARNOLD: Arnold, Board.

How do you have the yellow arrow and the blue arrow come out of that primary separation?

DOBSON: Well, that's a gross simplification of the flow dynamics, and the uranium product, we would just take, and after purifying uranium, we might take some more uranium and blend it back into the uranium/plutonium stream. And, let me explain why.

ARNOLD: But, I thought you were co-stripping, so there wouldn’t be any straight uranium stream.

DOBSON: Oh, there is absolutely because you don’t take all the uranium. Our initial approach was to take about an equal amount of uranium as plutonium, on the blue line going down to the mass prediction box. And, the rest of the uranium would go down the normal routes and be purified. But, from a proliferation point of view, we’d be asked to consider what amount of uranium could you actually get out in order to satisfy the various criteria for the material not being weapons usable. And, with this process, we could get it to 3:1 ratio of uranium and plutonium, so we’d have to add back a second pass in order to meet that. That would be the requirement that the national labs have created.

So, moving on to the wastes, obviously we focused on the volume of high-level waste. There is greater than Class C waste produced, and recycling also produces some low-level waste. But, the important other criteria that we set ourselves was to try to have zero of the discharges, and particularly zero radioactive liquid discharges. And, while we can’t quite make that, it’s fair to say that we’re very close to zero, and it is very, very clean from a radioactive point, and similarly, with near zero, aerial discharges. And, as I’ve already said, that requires a significant advancement from what is known today in Europe and Asia.

So, the kind of advances that we’re talking about, in high-level waste management we would use the latest, the most advanced stage of the process, and we have chosen, from a vitrification process point of view, to use joule ceramic melters. They're used in the United States. It's very self-serving for Energy Solutions, because we own the technology. But, we're also looking at compatibility with other similar products already created in the United States. And, so, we chose to design our facility to produce the ten foot large U.S. containers of vitrified waste.

We have gaseous effluent treatment, Krypton, Iodine and Carbon-14. Carbon-14 captured is already a well proven and commercially used process. It is used today in the nuclear business, and there's no issue with that.

Krypton, we would have to use the cryogenic process, and we factored into our cost line, the cost of the development work to confirm, but some very substantial demonstration work was done in Europe over 20 years ago, and I can speak from a licensing point of view, the UK facilities, it was expensive and absolutely was no cost benefit from removing Krypton.

However, we were going to consider that, but we did in fact come across a serious issue, and that was the balance of risk. There is the Krypton process removes the Krypton, and there is no process for disposal. You have to store it and decay it for a few tens of years. And, that means that you're storing it at the site of the reprocessing facility, and you've, therefore, increased the risk to the work force. But, we decided in the United States to meet the regulation rather than opting to try to change the regulation. We would incorporate that in our facilities, similar to the Iodine capture.

And, Tritium capture, our approach is to drive all the tritium into the liquid stream. Bear in mind what I said about recycling to get near zero or zero liquid discharge, and that means that you've got to get the Tritium out of that recycle, and that's the principal volume of low-level waste that we would produce in our facilities if we were to co-strip these facilities.

And, as everybody does today, we would volume reduce all the low-level waste, greater than Class C, and the Class A, B, and C.

This is a picture, it's been around for a few years now. But, what it shows is really the extent of technology that's ready to deploy, and that's the green piece of the picture. The brightly colored pieces, the magenta, the red and the yellow, they're to do with Americium and Curium. And, the design of the facility is such that you could take this facility fully active, and incorporate those features down the road if you wanted to. We're confident that we can industrialize that extraction process, and we built in the cost of our design process, we would actually complete that development work with the various agents that we would deploy, the agents for doing that development work.

I'm going to move on a little bit faster. No surprises on liquid effluent, pretty standard processes. And, I've already talked about the aerial effluent and the solid waste, so I'll move on.

But, I will look at the greater than Class C, because it looks and smells like what is called remote handle TRU today. Those hulls and ends look, and we believe they could be disposed of as remote handle TRU. Now, of course, there is no commercial repository for greater than Class C or for remote handled TRU. In part of our report, we suggested that you would consider a commercial repository in salt, it might just happen to be in New Mexico, but it would be commercial. But, New Mexico is not the only location that is suitable, I might add that, but there is a very willing host community. People have asked about the wastes that are actually produced and the volumes and what would we do with them. So, our approach is to say, well, there's a disposal canister of spent fuel. The package looked like, people thought it was going to go into Yucca Mountain. It's volume is about 11 cubic meters, it cost to dispose is about $6 million, and that's using some fairly recent Department of Energy numbers. Radioactivity content, of course, is 100 percent.

If you recycle, you get some high-level glass waste. Its actual volume would be about .8 cubic meters, and the cost to dispose, if it went into a repository that looked like Yucca Mountain, and, therefore, cost the same as, would be $1.2 million. And, it's because you have to allow for the fact that in disposing in the Yucca repository scenario, you can't just put the canisters in as they are, you've got to pack them as well, and you get about a five fold reduction in volume.

You also get the greater than Class C waste, what we think is remote handle TRU. As I say, it looks and smells like remote handle TRU. But, on this picture, the remote handle TRU would be the two vertical casks, but it would also be some contact handled TRU, and that's in the drums. And, for figuring, we decided that our disposal canister would be an RH72-B, because it's licensed for defense waste. We know it's not licensed for commercial waste, but we do believe that it's real, it's proven, and there's some real numbers available for it. We would actually redesign that cask. It's not commercially effective. There's a better design for that cask, and it would require licensing.

Then, there is a significant volume of low-level waste, and the way that we configure that flow sheet, it's all Class A waste, and you might say that's also self-serving, given Energy Solutions' business portfolio. It would be about 70 meters cubed. If we didn't capture Tritium, it would be just a small percentage. It would certainly be less than 5. It might be as low as 3 percent, even on our flow sheet.

But, I would say one thing about these costs. You do open up alternative repository options, and the high-level waste and the GTCC could go in a salt repository, and those costs would come down. They would have to go in the repository, but you're not confined to a retrievable repository. Put it another way, we were talking about the energy for a family, they're the actual volumes.

In answer to some of the specific questions, and I don't propose to go through this table, but there's a table, this table gives you the quantities and the disposal routes. Now, of course, we would have to establish and license a commercial repository for greater than Class C, and that's a challenge facing the nation. We think that salt is a good answer, but it has to be done.

On throughput and in our model, we decided, obviously, anybody that's done reprocessing is very familiar with the 800 ton a year facility. We've got them in France. We've got them in the UK. We've got them in Japan. But, we looked to see what could we do on more or less the same footprint to get that to--and we went back to the lessons learned and what we learned in that reprocessing history with regard to improving capacity, and we built an operational research model and, you know, I once was of the persuasion that all our models are rubbish in, rubbish out, but I have to say this, that when the input is based on actual measurement from real operating plants, the OR model is worth its weight in gold.

And, there were three areas, all in the mechanical handling in the head-in processes, and that's why, and I forgot to, and I'll mention this in a moment, that's why the virtual tour through the facility is so interesting, because our model is in both two dimensions and three dimensions, and we have actually modeled the three dimensional--the mechanical handling processes, and put real data in on what we know from the actual plants in the United Kingdom. And, that's enabled us to significantly improve the efficacy of the facility, and the throughput.

And, our starting facility would be a 1500 ton facility. You would need much more than that to do what I said, leaving no used fuel unrecycled, and leaving--having no used fuel to connect to the repository. And, we would have to go from 1500 tons to a 3000 ton facility.

We also looked at the burn-up of fuel. In our model, the starting point was 50,000 megawatt days. But, it was any fuel. It didn't have to be old or new, it could be any fuel. And, we certainly would target getting the fuel away from shut-down reactors. But, then, if you consider higher burn-up fuel, you have to make certain changes to the approach, and that’s why the second facility would be the one that could take the higher burn-up fuel.

So, in our model, we went from 1500 tons to a 3000 ton a year facility. They’re both operating in parallel, within about ten years of each other, but the second facility can take the high burn-up fuel, and it would process the MOX fuel. Yet, you can recycle MOX through existing facilities, but to do it efficiently, you need to make some changes.

That’s just a picture, that’s the two dimensional picture of the model, and we tried to run it before, and we always get egg on our face, so we’re not going to try and do that today. But, I really commend that you take a look at the DVD and you will see some of the modeling action.

Now, in conclusion, we do think that closing the fuel cycle is an important additional option. There are benefits. There’s a great debate about the benefits. We believe that reducing the volume, reducing the cost of disposal is important. We do think it’s important, particularly over into generational periods of 100 years or more, to think about whether or not that result is valuable. You know, people have said, well, you know, the price of uranium has come down. It’s now only $45. And, that’s absolutely correct, and we featured all of that in our financial model. The model is sensitive to the price of uranium. But, the bottom line is the actual cost of recycling is not even close to being the significant factor in the cost of nuclear power.

And, if, as we believe, closing the nuclear fuel cycle allows you to increase and answer the waste confidence issue, that's really, really use of the United States, particularly with regard to carbon emissions.

Thank you.

GARRICK: Howard?

ARNOLD: Arnold, Board.

Alan, you mentioned CANDU reactors. I presume they would have to start recycling also, which I understand they don't do now.

DOBSON: We didn't make that assumption. We actually didn't make that assumption, because our approach with the CANDU operators was that they were getting an asset, and when we looked at the economics, their numbers, not ours, we could sell the RU at a premium--

ARNOLD: Okay, so, they'll continue to have a throw-away fuel price?

DOBSON: They will continue to have a throw-away facility.

ARNOLD: Okay. The second question I have is you use a key word, which was that uranium would not be accumulating as time went on.

DOBSON: I meant in the small fuel, you know, there will be amounts of those quantities accumulating. There wouldn't be tens of thousands of tons accumulating. We were able to demonstrate that we could recover and recycle all of the uranium. Now, there is the challenge that you made about the--is absolutely correct. And, there's a similar challenge with plutonium in the MOX.

ARNOLD: Yes.

DOBSON: Recycle. And, we did a lot of work on the MOX, and we came up with the numbers over three times, and then you've used all the usable MOX. And, then, the question is what do you do with that? Well, here's what you can do with it. You can get rid of that plutonium in the same way that I talked about Americium and Curium. We have not completed the work and, if we have, and I was hoping that I might get some inspiration by a Blackberry while you were asking that question, but I didn't get that inspiration by Blackberry with regard to the uranium. I will make sure I can answer that question on uranium before the day is up.

ARNOLD: Yeah, I'm afraid uranium is the elephant in the room here.

DOBSON: Well, our models show that we could recycle all the uranium, and we looked to--there are three enrichment processes today--sorry, there are two. There’s diffusion and there’s centrifuge.

ARNOLD: Right.

DOBSON: And, in actual fact, there had to be a constraint, yet you would have to want to operate your facility, and I can’t imagine that LES would want to put recycled uranium into their shiny new facility. That’s not to say that it cannot be commercially--

ARNOLD: Oh, no, a centrifuge plant can be built in segregated parts, so only a piece of it--

DOBSON: Absolutely.

ARNOLD: Yeah, that’s not an issue, no.

DOBSON: The details then becomes the issue, but I think you can deal with that also.

ARNOLD: Okay.

DOBSON: And, who knows what laser enrichment is going to give us with regard to that isotopic distribution. And, you know, I’ve explored my model.

ARNOLD: All right, so we stay tuned in. Thank you.

GARRICK: Ron, then David.

LATANISION: Latanision, Board.

Your conclusion is that recycling will be paid for by the nuclear industry.

DOBSON: Absolutely.

LATANISION: Are you envisioning something like a recycling fund, which has an eerily familiar and yet unhappy track record, or how do you envision this playing out?

DOBSON: In our discussions with the utilities, and we didn’t do that as an extensive group of utilities, but we had some very significant utility players. They were interested in well, what’s it going to cost, and the actual cost was very--there was very little difference if you didn’t built inflation into the figures between direct disposal and recycle. And, I’d just have to disagree with NRT, and I’ve given that feedback to NRT. You know, their focus is on the value of uranium. That’s not the issue. What you’ve got to look at is the total cost of recycling. But, we do envision that a fee would be levied, that if a utility did not want to buy that service, then there’s no case for reprocessing. There’s no case.

And, a fundamental premises, it’s economically attractive to the utility for a number of reasons. If it isn’t, then we don’t have this discussion. There’s no expansion in nuclear power, significant expansion in nuclear power, there’s no point in having this discussion. We’ve just got to think about what we’re going to do with the used nuclear fuel.

LATANISION: Latanision. Just to follow up. I mean, have you had conversations with utilities, people that feel as you do?

DOBSON: Absolutely. And, we have presented to the very top management, my boss and I have presented the business model to the very top management of several--

LATANISION: Okay. This is why--

DOBSON: Three utilities.

GARRICK: This is why I raised the question about peer review, especially from industry.

DOBSON: They've actually run the model themselves and tested the assumptions, et cetera.

GARRICK: David, and then Andy.

DUQUETTE: Duquette, Board.

How much time would you be buying from the time you first installed new fuel into a reactor to the time when it would actually have to be--what was remaining would have to be disposed of? Are we talking 50 years, 100 years, 150 years? What are we buying for time?

DOBSON: I haven't got a precise answer to that question, but it's in the several tens of years. It's of the several tens of years because we do, in our model, multiple recycles, and the limit was the plutonium, and that was three cycles of recycling on the plutonium for recovery as usable MOX. That doesn't mean to say that you cannot continue to do that, but from an economic standpoint--and, it fit very nicely, in our model, we envisaged that we would get a demonstration fast reactor in the next 20--we could do a demonstration in about the next 20 years, but we couldn't even begin, and we were having to force the model, to be honest, to get to the commercial deployments of the fast reactor. And, we actually force fit the first module for reactors in about 2050, but we didn't get--it was more attractive not to build a fast reactor, is the plain truth, this century, but to wait until close to the end of the century.

GARRICK: Andy?

KADAK: I guess that last comment was consistent with our conclusion, by the way, on the need for fast reactors.

I'm stuck on the economics again. I'm sorry. It depends on who pays for the disposal, and right now, the structure is the utilities pay for it through the waste fund, and you're asking the utilities to also pay for the recycled fuel going through all this process, which is incremental on top of the waste fee. Unless you negotiate something with the DOE about taking the waste fund money to do this, I don't see how it's economic for the utilities.

DOBSON: Well, that wouldn't be the way we would do it. We did actually propose to create a new entity. It would be a new government entity. It wouldn't have the same chance as the Department of Energy, but it would be an authority that could act like a private enterprise. And--that was created back in the Thirties, and, you know, they've had a long history, that when they created TVA, it was the same thing. It could act with the authority of government, but also with the flexibility of private industry. The waste fees would be collected by that entity, and it all depends how much is that waste fee. That’s the first question the Utility Commission wants to know, a utility operator wants to do, and does that make sense.

KADAK: So, you are using those funds. I have a technical question as well. As I am trying to understand the difference between the COEX and the NUEX, and I was trying in my brain trying to understand waste streams, I couldn’t. I couldn’t correlate what Dorothy was saying and what you were saying in terms of what actually has to end up in a repository, or can be released, or isn’t released. I think one of the things we’ll probably end up doing as a Board and Staff is to try to put those all on the same page so we can understand waste streams and what processes are, in fact, minimizing those waste streams.

DOBSON: In the NUEX approach, high-level waste, which would be glass, and greater than Class C waste, and the content which we think looks like transuranic waste today, would go in a big geologic repository.

KADAK: That’s a factor of four or five?

DOBSON: The volume--if the high-level waste went to somewhere like Yucca Mountain, the factor would be five.

KADAK: Five? Okay. Now, how about all this other stuff, like Krypton, Iodine, Tritium?

DOBSON: The Krypton, as I said, we do not have the process for converting the Krypton into something that you could dispose of. We would be storing it. We would capture it and then decase, store it.

KADAK: And, I’m hearing similar proposals?

DOBSON: There is a process, and it is being demonstrated.

KADAK: Okay.

DOBSON: The reason it wasn’t adopted in Europe was on that risk/balance argument in the debate with the regulator. It was that section, the regulator community in Europe, it was better to release that Krypton than to capture it because you concentrate it. You turn some of this very small innocuous dose into a concentrated dose. And, all of the solid waste would actually be low-level waste. We deliberately arrange it to be Class A low-level waste.

KADAK: Okay, thanks.

GARRICK: Go ahead.

MOSLEH: Mosleh, Board.

Just to follow up on what you just said about the volume. I’m looking at the AREVA slides and your slides, particularly Slide 14, can you explain the factor of five--

DOBSON: Yes. For the rest of the audience, that’s the slide that's got the canister of fuel, the high-level waste, the greater than Class C, and the low-level waste. And, the factor of five, if you look at the cost line, it shows a picture of a canister, and that's its actual volume, 8 cubic meters, that's the high-level waste. So, .8 compared to 11 is a factor of, you know, I don't know, 15 or 14, or something. But, in actual fact, when you put that canister into its configuration for disposal in Yucca Mountain, you lose some of that benefit by a factor of two, actually, and it becomes a volumetric reduction of five. And, so, the cost gives the real clue. If it went into Yucca Mountain, the cost would be one-fifth.

MOSLEH: Right.

DOBSON: If it went into a solid repository, it would be at least a factor of five lower.

GARRICK: Gene, you have a question?

ROWE: Yes, just a quick question. You indicated that you could recycle the MOX fuel two to three times?

DOBSON: Three times.

ROWE: What kind of burn-up do you get out of the MOX fuel?

DOBSON: Well, in the range, 55 to 60,000 is what we assume, 55 to 60,000 gigawatt base--megawatt base.

ROWE: Yeah, that's going to give you a quality of like 50, 55 percent, something like that?

DOBSON: And, that was the limiting factor. Eventually, the quality is such that you do not wish to do it. And, that was when we made the cutoff. We looked very carefully, and we published, and I'm pretty certain that that report is available, but if it's not, I could certainly arrange for an excerpt of the report that deals with that to be made available.

ROWE: So, what's the impact if the utilities go to 70, 80 gigawatt days per ton?

DOBSON: We have not modeled 80 gigawatt days.

ROWE: Okay, thank you.

GARRICK: Any other questions from either the Board or the Staff?

KADAK: Just one.

GARRICK: Oh, okay.

KADAK: Kadak, Board.

Could you explain the CANDU, why CANDU reactors are so unique in their recycled uranium business?

DOBSON: Well, the CANDU reactor that uses natural uranium, so there's no enrichments, that's about .7 percent. The recovered uranium is about .9 percent, and if you're familiar with the CANDU program, they are looking at getting a slightly higher enriched uranium fuel. It's kind of lower enriched uranium fuel that they're looking at. That's in their context, not the--concept of lower enriched.

KADAK: All right. So, you're saying that you could take the .9 percent enriched, and put it directly in a CANDU?

DOBSON: Yes.

KADAK: I thought they were going to little bit higher numbers than that, too?

DOBSON: They have indeed looked at 1.2, but our work was, you know, this is going to be .9 percent, from a financial standpoint and a technical standpoint, does it work, and the answer is yes, and there was sufficient premium in that recovered uranium to be able to get some benefit into the recycled economics, and for them to get some benefit in the use of that uranium.

KADAK: And, does that include the operational difficulties associated with having a radioactive fuel?

DOBSON: Yes.

KADAK: It does? So, this is not the DU Pick process?

DOBSON: No, we just take the used fuel and chop it all up.

KADAK: Right.

DOBSON: We took uranium, not even in the same category. No, no, no, it has to be dealt with differently because there are additional radiological controls. But, they're not significantly different from what they're doing already.

GARRICK: Okay, a final question from our consultant Ray Wymer? Final questions.

WYMER: This is sort of a general question that I think applies across the board to all three speakers. I appreciate your comment about the cost of recycle being a relatively small fraction of the total cost of energy produced. That's certainly true. But, I know we had a cost--nuclear or chemical if we didn't worry about the individual cost factors, and so it's in that context that I ask this question.

There's a study out by a group of people, and the report actually came out from Oak Ridge National Laboratory, that was along the lines of the additional cost required by the additional waste streams. If you separate out Cesium and Strontium, if you separate out Americium and Curium, if you separate out Krypton and perhaps Carbon 14 and Tritium, that says that eventually that waste treatment part of the plant, it becomes the tail that wags the dog, that it's a very significant addition to the cost of the plant. What's your--

DOBSON: It's really important to recognize that, and I thought it was so obvious I didn't dwell on it. But, a key issue is we do not separate Cesium and Strontium. Why on earth would you do that? There's a well-defined route for dealing with Cesium and Strontium, and although Cesium and Strontium presents the short-term heat problem in the current Yucca model--and I would recognize right from the outset, there's a lot of debate about the heat model for Yucca

Mountain, and I don’t really want to get into that today. The way to deal with the Cesium and Strontium is to leave them in the high-level waste and decay store it on the surface. It’s a small volume. There’s 50,000 tons of fuel in glass in a facility in the UK. There’s a fuel from 50 years of reactor discharge that’s been reprocessed, and it’s in glass today, and it doesn’t occupy a building as big as this actually.

WYMER: Well, that was the other aspect of this study I mentioned, that they talked about storing the Cesium and Strontium, which is essentially what you’re saying, store it 100 years, it’s vitrified waste.

DOBSON: But, don’t separate it.

WYMER: I know, but you’re saying store it, and the actual cost of storage is a significant factor as well.

DOBSON: Only if you take the Cesium and Strontium out.

WYMER: You’re storing the high-level vitrified waste, which is equivalent to storing the separate Cesium and Strontium.

DOBSON: Well, no, because you’ve got to do the high-level waste as well. So, you get at least twice, and I think there are additional issues with the separate Cesium and Strontium.

WYMER: There are.

DOBSON: Right. All I can say is that in our model, all the cost of the waste streams and their disposal were factored into the model, and the cost of the vitrified waste storage above ground is insignificant compared to other costs in the process. It really--if that was the conclusion, we would have to look at the report from the circumstances.

WYMER: Perhaps I could refer you to this report. It’s a report that just came out this year, and I think the principal author is Kent Williams. So, you might want to take a look at that.

DOBSON: We absolutely will talk to Kent.

WYMER: Thank you.

DOBSON: But, we couldn’t agree with that.

GARRICK: Okay. Well, thank you very much.

DOBSON: Thank you.

GARRICK: Our final speaker for this morning is Eric Loewen.

LOEWEN: Good morning, Chairman, members of the Board. Thank you for the opportunity to speak. My name is Eric Loewen. I work for GE-Hitachi Nuclear Energy Americas, LLC.

We do three major things in the nuclear industry. The first is we design new nuclear power plants, second is we make components and fuel for our existing reactors, and we do services for our existing customers and plants. If you add them up here, it represents that we are a technology company, and we recognize that customers and society have difficult issues, and, so, GE brings a lot of breadth and depth to solve those sort of issues. And, so, what I’m here to talk to you about today is what our vision is, our approach is to closing the nuclear fuel cycle.

To close the nuclear fuel cycle, it’s two technologies, linking a sodium cooled fast reactor, which we call PRISM, and linking it with a separations process called electrometallurgical separations, or pyro processing or electrochemical. The picture on the left shows our current fuel cycle where we dig up uranium, we fabricate fuel, and we sell it to our customers, and they produce electricity that is safe, it’s economic, and it produces 20 percent electricity in this nation. The question before this Board and before our nation is is this a resource that you can do some sort of separations, generate electricity to cover your costs, and the system that we looked at, our modeling shows that it is economic.

Briefly, I’m going to talk about the two technologies that make up our advanced recycling center. One is the separations. This started when we deployed as a national experimental breeder reactor Number 2. And, so, the way they initially processed the fuel is a metallic fuel. They threw it into a crucible that was inductively heated. The volatile fission products came off, the actinides stuck onto the skull of the crucible, they poured that back and made fuel. That wasn't applicable if you went to higher and higher burn-ups.

So, then, in a program started in the integral fast reactor program in the mid Eighties, they looked at electrochemistry, which is similar to what we use in the aluminum and the titanium industry. And, so, that process was then funded by the Japanese. We had a lot of activity. When that program stopped in 1992, '93, then from the National Academy of Sciences, EPA, and a record decision by the DOE, they still use that technology to treat experimental breeder reactor Number 2 fuel today.

The other technology that we're linking together is the sodium cooled fast reactor. The genesis of this was in 1981 by General Electric. We realized that at the time for scaling up sodium cooled reactors going bigger and bigger for economies, was fundamentally wrong. For sodium cooled reactors, because of the high heat transfer, because of the properties within the pipes, probably the best way to scale the economics is through replication. So, we are pretty good at making washing machines, we're good at making jet engines, we're good at making gas turbines in a factory because of the control cost, the control quality, so why not design a reactor to do the same sort of thing. Modular construction and passive safety.

This got picked up as a national program in 1985, what was called the advanced liquid metal reactor program, where we had eight other industrial partners with us, and that development went through 1995.

Some milestones along the way were in 1987, we submitted to the DOE and then to the NRC that conceptual design. Then, in 1994, the Nuclear Regulatory Commission issued NUREG 1368 that said we don’t see any safety impediments to deploying this sort of reactor. Another milestone is if you look at the 1992 Energy Policy Act, there is authorization language to build what I would call is America’s fast reactor, which we call a GE PRISM.

After the program stopped in 1985, we did get some external funding from ’85 to 2002 from Korea and from Japan, and then we put that product on the shelf because we didn’t see a market. So, with the change in government policy in 2006, we put that back on the shelf and like our AREVA and Energy Solutions, we put that into the study, funded under a Global Nuclear Energy Partnership grant.

So, why is a technology company like GE pursuing this sort of technology? We looked at four things, the environment, the economics, engineering safeguards, and the National Academy of Sciences endorsement. I’ll talk more about this, but it comes down to heat load, and we see that as a driving metric as a long-term heat generation rate as far as environmental performance.

Also, when we look at pyro separations, it’s a dry process. You don’t have liquid and fluids. We see that as an advantage. We’ve had our share of experiences with aqueous processing, and we no longer do that. Our facility at Illinois and a facility down in Wilmington, North Carolina, we have shifted to a dry process.

As far as the economics goes, this is a very old report done by two national laboratories that were proponents of the two different technologies, and the important thing when you look at the cost at the very bottom, the cost is greater than a factor of Pi, difference between electrometallurgical separations and aqueous separations. And, there’s some recent work that’s done by Idaho National Lab, the lead lab for nuclear energy in this country, by a person named Dave Hebdidge (phonetic), which talked about the cost of aqueous processing, which they still see as excessive.

When we look at engineering safeguards, there’s three signatures when you look at proliferation. One is the thermal heat that’s generated. Second is the spontaneous neutrons. And, third is the gamma rays. And, so, when you look at weapons grade plutonium, you can see that signature is very low, so it’s difficult to detect. When you look at reprocessed reactor grade plutonium, you see those signatures go up. If you look at the full recycle that we’re talking about when we take all of the transuranics, neptunium, plutonium, Americium and Curium and some earthal actinides, you can see you have a significant signature of thermal heat, a lot of spontaneous neutrons and a lot of gamma rays. So, even if you have overt or covert acquiring of that material, you can see that you have a signature that would be easier to detect.

Then, finally, the National Academy of Sciences, this was a report or efforts that were done in the early Nineties, and there were ten reports that were issued. The final one is in 2000. It’s up on the National Academy of Sciences web page, and they had a lot of findings and a lot of recommendations. But, what I want to call the Board’s attention to was a recommendation that this electrometallurgical separation should be looked at as an alternative to PUREX processing for the United States.

So, let’s get to your questions. We started this in 2006. We inherited this flowsheet from Argonne National Laboratory as approach for pyro separations. Then, we, as a business, used flowsheets with block diagrams to help us understand the process, and so we know what sort of constraints, what sort of waste forms can be developed. And, so, this is how we applied our six sigma sort of processes to look at this process.

We went further in a mass balance, and I apologize, it’s difficult to read, but just to give you a scale, the modeling and what we looked at for the answers that you have for this Board.

And, we used this model similar to what AREVA and Energy Solutions did, to quantify the waste packages that we developed, what sort of process parameters you should be concerned about, and how to best run that factory.

So, let’s go to your questions. So, these are the questions that you provided us, Dan provided us about a month ago. So, we’ll go to the first one. The question is what was the, for vitrified high-level waste, so the answer is that we produced 0.5 to 0.8 metric tons initial heavy metal. That range is dependent on the burn-up of the fuels, and it’s dependent on how you run the factory. So, that’s the number that we can give you.

As far as excess uranium, the elephant that’s in the room, we see three pathways for that waste stream, or that resource. First, it would be clean to an RU standard. So, the first way you could use that is through re-enrichment. And, so, the technology that General Electric is developing down in Wilmington using laser enrichment, we do not concentrate the lighter elements of uranium, and, so, you could put that back in light water reactors. The second way is to put it back in a PRISM reactor because predominantly, the fuel is using uranium. And, then, the third way is also to put it into CANDU reactors.

General Electric, a lot of people are not aware that we provide 50 percent of the fuel that fuels the CANDU reactors in Canada.

The second is the low-level waste. We consider that to be small because we are a dry process.

The intermediate level or greater than Class C, we're going to have that. There will be some equipment that's going to be needed to replace, electrodes, crucibles, and those sort of things. At this point, we don't have a process flowsheet done to give you an actual number.

And, the last one is what is the volume of the decontamination, or when you do D&D. And, that's going to be driven by the licensing process. At this point, since we haven't got a license, we don't fully understand what constraints or requirements the Nuclear Regulatory Commission will have on this new facility. I can tell you how much concrete we're going to have.

Your next series of questions, Question 2, we'll get into those. Let's talk about Krypton 85. Again, I think we're consistent. It's a cost benefit analysis. If you want to capture it, there's going to be a source term at the factory that's going to be different than if you release it. And, that's something that needs to, you know, look at a cost benefit analysis. Some differences, though, we process an inert cell, so that capture of Krypton is a little bit easier through cryogenic separations. And, so, our initial flowsheets that we inherited from the Advanced Liquid Metal Reactor Program, they are showing that they would do Krypton 85 capture.

As far as the separation of Technetium, Cesium and Strontium, what is unique about the pyro process is that it separates based on how nature separates things, or follows the laws of physics. So, your active metals in Group 1 and 2, and your halogens end up in the ceramic waste form, and, so, they stay in the salt, and that's what gets vitrified into a ceramic waste form.

The second product, the technetium, or other noble metals, you pull out and you alloy those and put them in a metallic waste form.

So, when we look at, you know, we think that the chemical, physical, the host rock, all those things play into what is the source term, and we think by separating elements based on where they're at in the periodic table is a better way to look at those--or is a better way to have a better waste form.

Then, the question came up about the separate removal of Americium and Curium. My second slide, I talked about this as full recycle. So, when we do the separations, we really have three streams, uranium, fission products, and the transuranics, Neptunium, Plutonium, Americium and Curium. So, those are all a fuel in a sodium cooled reactor. So, we’re not separating those out. The electro-negativities don’t allow that, and they would be used as a fuel.

What I have provided here are backup slides as far as the metallic and waste forms, because Dan was concerned that I wasn’t going to make it all the way through these slides. He even called me, or sent me an e-mail. But, the take-away here is, you know, we need to look at the transparency of the analysis, and look at the thermal, chemical, nuclear, mechanical properties of those two waste forms within a host rock.

So, I’ll give you some details of metallic waste form, what sort of eutectic or alloy that you would use. So, if you’re predominantly a lot of iron, like from a fast reactor, you would use this. If you’re using it with a lot of zirconium, you would do it the other way. Some about the ceramic waste form, using the zeolite.

And, now, to your third question, the issues of scale-up of this process. I put it up to you pictorially upon the chart here, when you’re scaling an electrometallurgical process, it’s done on two things, surface area and current density. When you’re scaling up a chemical process, like we did at Morris, Illinois, you’re scaling on three things, thermal dynamics, chemical kinetics, and mass transfer.

So, we see this issue of trying to scale it up as that we need to understand that process. But, if you look at that top picture, that's an aluminum smelting mill in the United States. And, so, they are doing electrometallurgical separations, if you will, in a fluoride salt, by adding bauxite or, remotely, and I realize it's not radioactive, but they do that day in and day out on hundreds of tons per day sort of production. So, as a technology company, we want to take that technology that's been developed in our national laboratories, and take it to that industrial scale. And, so, we don't see the scale-up issues, you know, there are criticality issues that we are fully aware of, but we don't see the issues as insurmountable.

These two questions, I grouped together. We really look at this as, you know, it's the heat effects. It's the long-term heat generation rate, and so I grouped these together with two slides to explain the analysis that we have done.

This is some work that we did for our technology and development plan and for our business plan. And, we looked at if we took used nuclear fuel and put it in the ground, the thermal properties, the long-term heat generation rate is on this curve.

If we assume that we had a 99 percent removal factor, only two nines, and you did a MOX process, our assumptions were that you would follow this pink line, and you would remove 50 percent of the long-term heat generation rate.

If you went to a full recycle, as we are talking about in the advance recycling center, you see that this would follow this yellow line to where you're putting in fission products, and, again, this is a 99 percent efficiency, so we're assuming that, you know, it's not five-ninths, or anything, you will see that this long-term heat generation rate significantly goes down.

So, now, when society is faced of making decisions with a lot of uncertainty, we've taken much of that uncertainty out from millions of years down to hundreds of years. So, when you ask society can engineers build something that can last underground for 300 to 500 years, I think a reasonable person would say sure. Because there are things that have been above ground longer than 300 to 500 years, pyramids, Great Wall of China, et cetera, et cetera. So, that's how we look at the long-term heat generation rate.

The flip side, though, is the short-term generation rate. And, so, this is a paper that we presented two weeks ago at the Global Conference in France. And, so, we looked at the short-term heat generation rate that's in used nuclear fuel. So, the line right here is if you took a used nuclear fuel bundle and stuck it in there, you can see that it has, based on this thermal limit of Yucca Mountain, as far as kilowatts per meter, that it could be, you know, pretty much put in the ground whenever it was ready to go.

If you do concentration because you're trying to do volume reduction, which is a benefit, but if you do that, if you do this factor of ten up here, you can see that your heat generation short-term is a lot longer than what the repository can take. A review board, you know, that's one of the constraints that, as you well know, that Yucca Mountain is thermally limited. So, when we look at different options in the future, we think the metric should be long-term heat generation for the amount of transuranics you're putting in.

So, John is scratching his head, looking for me to get done. I have two more slides.

So, this is a kind of a summary of what we see the nuclear fuel recycling center, I focused more on that, and it separates three products, uranium, fission products that go into different waste streams, either metallic or ceramic, and, finally, it gets transuranics, and that's what we use as a fuel for the sodium cooled reactor, which we call PRISM. It has unique design features, and it doesn't have any salt-- or, it doesn't have liquid waste. It's module and scalable because you're just scaling these unit operations. And, it has had extensive component testing that has been done, because we’re using it today in Idaho to process UBR-2 fuel.

So, I leave you with this slide as kind of the ending point. How do we go forward? How do you license? And, so, what we put into our plan is we see that we could use this electrometallurgical separations for the processing of off-spec uranium that we have at our fuel facility at Wilmington, North Carolina.

So, what we’re proposing is that we build some of these components to clean up that uranium. We would use our existing license that we have from the NRC, a Part 70 license, and that allows us to do what is called integrated safety analysis. And, that safety analysis, we would say we’re going to treat spent nuclear fuel, but for our treatment, we’re only going to use 5 percent enrichment of uranium of what we are licensed for.

So, now, when we go and put that into simulations, and we go before the NRC and say we’re ready to build a fuel separations plant for spent nuclear fuel, we have an empirical data and we have that process experience, because we see that as a viable way of cleaning up our off-spec uranium.

So, the story is very simple. What GE is trying to do is commercialize the technology that was developed in our national laboratories to close the nuclear fuel cycle. It’s the same story we did in the 1950’s, when out in Idaho, they had three reactors, Borax 1, 2 and 3. 1 and 2, they blew-up on purpose. Okay? The third one, we decided to take that technology and go commercial.

And, so, we took that technology and we built a first plant at Vallecitos, and then you've seen, you know, 30 percent of the reactors in the United States today are boiling water reactors, 70 percent in Japan are boiling water reactors. So, that's the story that we're trying to do.

And, with that, I conclude, Mr. Chairman.

GARRICK: Thank you. Howard first, then David and Ron.

ARNOLD: Arnold, Board.

I'm just trying to fill in the systems implications. Basically, you're not then recycling at all in light water reactors in this scenario?

LOEWEN: No, sir.

ARNOLD: Right. And, you're storing the fuel and waiting until these PRISMS are ready to go?

LOEWEN: No, we're not separating for the sake of separation. Our business model, we'd--the sodium cooled reactor. And, so, that reactor would be put down and built first. It would start up on known fuel, either uranium, zirconium or plutonium, uranium, zirconium. Then, through the support of the national laboratories, you would put in lead test assemblies that would have all the transuranics in them. And, then, you start the separations.

ARNOLD: Right. Yes, I understand. So, there's, again, just to repeat the obvious, there is no recycling in light water reactors in this scenario; right?

LOEWEN: No.

ARNOLD: All right, thank you.

GARRICK: David?

DUQUETTE: A couple of technical questions. This is curiosity more than anything else. What salt are you using for the electrometallurgical process?

LOEWEN: In the electro-reducer, we use lithium chloride. In the electro-refiner, we use a mixture of lithium and potassium chloride.

DUQUETTE: And, what temperature do you have to go to?

LOEWEN: About 500 c.

DUQUETTE: That's not too bad. The other question I had really pertains to all three programs we've heard about. Are all of these programs being funded by the companies involved, is it all private funding that goes into this, or is the government also funding some of this work?

LOEWEN: General Electric received a grant from the Department of Energy in 2007, along with three other industrial teams, to provide a business plan, a technology development roadmap, and a conceptual design of how you close a fuel cycle. So, our grant ends the end of this month, September 30th is when the grant ends.

DUQUETTE: Okay. The last question has to do with do you perceive these three different programs being sold separately, or do you think they’re going to be in competition, and somebody, whether it be the industry or the government, will choose one?

LOEWEN: We’re competitors. We compete on a lot of different things. And, so, I think that’s a good thing for America, that you have three different options to pick from.

LATANISION: A couple of questions on the electrometallurgy. As I understand, you’re basing the separations on potential control, which presumably means that you’re co-depositing uranium and plutonium on the cathodes during this process; is that correct?

LOEWEN: No, that’s not correct. We do the separations, so initially in your--

LATANISION: This might have a slide number on it. Maybe you could walk me through this so I understand how you’re doing it.

LOEWEN: Sure. We’ll skip this step this is oxide reduction, this is electro-reduction. So, electro-refining, what you’re doing is you’re initially providing a potential, and because of the electro-magnetivity of the uranium, that is coming out first. So, you gather uranium because that’s 75 percent of your--or, 95 percent of your mass. And, at some point, then you’re starting to concentrate transuranics in the bath. You switch to a liquid cadmium cathode, and then you apply potential, and then you get uranium plus all the transuranics, and that's what you then extract. You boil off the salt, and that's what you fabricate into fuel.

LATANISION: So, you're saying that plutonium is coming out in that second step?

LOEWEN: Plutonium, Americium--

LATANISION: And, others.

LOEWEN: --because they're electro-negativities are so close together, it's a group separation.

LATANISION: And, how do you control the potential? How is that controlled? In principle, you would need to be able to monitor the potential and control it. How do you do that?

LOEWEN: You measure the potential and you control it.

LATANISION: You need to know what the reversible--thermodynamically, you would need to know what the reversible potentials are for the reactions of interest. If you want to separate uranium and not deposit all of the other transuranics, you've got to control the potential. Otherwise, you're separating everything. So, there must be some means of controlling potential in order to--it's like a still, you want to separate some things and leave the others in solution until you want to separate them. There's got to be some control. That's the point I'm missing.

LOEWEN: That's the point that I'm not versed on. We are trying to commercialize that technology from the national laboratories. The National Academy of Sciences was convinced that it did work, and that's why they gave their approval or recommendation to use that for the treatment of EBR-2 spent fuel. So, what I can tell you is that they control it. There's different ways you can do that, and they get the separations that they want.

LATANISION: And, I accept that. One final question. These, uranium and ultimately plutonium and the other transuranics, they're coming out on a cathode; right?

LOEWEN: Yes.

LATANISION: I mean, they're being plated out?

LOEWEN: Yes, they're being plated out, so you're putting them in a basket and you're migrating across the salt, and you're taking those out.

LATANISION: Yes. And, what is the cathode?

LOEWEN: There's a couple different variants. The default was platinum, because of its properties. That's a little bit expensive, so we've been looking at some other options rather than platinum.

LATANISION: Yes. Okay, thank you.

GARRICK: Eric, there's been lots of work in this field for many, many years, off and on, and for a broader application than what you're proposing here. What's the driver for this somewhat limited application?

LOEWEN: I don’t understand your question.

GARRICK: Well, electrometallurgical process has been considered for an application to all kinds of nuclear fuels in the past from time to time. And, your presentation is limited to, as Howard said, to--it does not include light water reactors.

LOEWEN: Why we are not doing light water reactor recycle; is that the question?

GARRICK: Yes, or other reactor types as well, yes.

LOEWEN: Okay, now I understand your question.

We don’t think it’s economic. All right? Now, the reason why I say that is because when you go back into a light water reactor, you have to put those transuranics into an oxide.

GARRICK: Right.

LOEWEN: We make oxide fuel down in Wilmington. We make it with one element called uranium oxide, and we do put some burnable poisons in there. And, to this day, sometimes you will get off-spec. To this day, it’s very difficult. So, now when you start making an oxide that can’t be built in a factory where you can have hands-on people, it has to be in some sort of remote facility, it makes it very, very difficult. So, we think it will be tough to make an oxide fuel that you can put back into light water reactors.

GARRICK: Okay. So, it’s strictly economics. It’s not necessarily technology.

LOEWEN: Well, I would say it is technology. You know, how do you figure out the O to M ratio in a fuel pellet that has uranium, neptunium, plutonium, Americium and Curium? It's tough.

GARRICK: Yes.

LOEWEN: It's been done, you know, when we took, like the rest of the industrial teams, and went to the national laboratories, we got down to Los Alamos, and they're making actinide oxide fuel pins, and I said well, how do you measure the O to M ratio, because that's how we control a lot in our factor, and they go, well, we haven't figured that one out yet.

GARRICK: Oh, okay.

LOEWEN: Okay? So, there is technology. It's not just all economics.

GARRICK: Okay. Last question Andy?

KADAK: In your scalability, I wasn't really sure. You said that the cost of your facility versus an aqueous process was about a factor of what, five or so?

LOEWEN: Greater than Pi.

KADAK: Greater than Pi.

LOEWEN: Well, I had to use that.

KADAK: Okay. And, I'm trying to say well, that's just the cost of the facility. How about the costs of the process and product and the whole, you know, whatever it is you're going to make to recycle. What are those costs comparatively speaking?

LOEWEN: We did our own business model looking at that, and so once you have a qualified field form that you can put in a sodium cooled reactor, we are showing that through the generation of electricity, that you will cover the costs of separations and the capital cost of the plant to where you have a positive cash flow. You will not need a subsidy or a mill per kilowatt fee to cover the operation of the plant.

KADAK: And, that gets me to the last question, and that is the sodium cooled fast reactor as the driver for all this?

LOEWEN: That is correct.

KADAK: It is, as you know, we're also doing some studies at MIT about trying to figure out how we can make them more economic, and we're having difficulty. And, I'm wondering how, in your modeling of best PRISM or your latest version, that cycle works relative to LWRs?

LOEWEN: Our analysis of the PRISM reactor, realize the genesis of this reactor started in '81, that we realized as a company back then that nobody was going to buy a sodium cooled reactor because they like table salt. We realized that it had to be on par with the light water reactor. So, that's where we got the modular construction and we can get cost out. We also looked at how do we get rid of active systems. So, if you look at the lineage of passive safety that we now have a light water reactor, is it really came from the early work that was done in the LMR program. So, the passive safety, the last active systems, we think this is an economic approach to sodium cooled reactors because it's small, it's pool type, and it uses metallic fuel.

GARRICK: Okay, Ray, you have some questions?

LOEWEN: I gave Mr. Wymer my business card hoping he wouldn't ask me any questions. He can e-mail them to me.

WYMER: E-mail them to you? A couple observations and then a question.

LOEWEN: Sure.

WYMER: First observation is that the process is basically a process for metallic fuel reprocessing. And, in order to process light water reactor fuel, you've got to convert the fuel to a metal to make a cathode that you then use in the reactor--I mean, in the electro-refiner. It's basically a batch--and, additionally, you can't play out, is my understanding, plutonium and Americium on the single cathode because of the electro-potential differences between uranium and plutonium. Plutonium, if you produce it to the metal immediately, it goes back to plutonium three valence into the meld. So, the way you remove the plutonium is reducing it into a liquid cadmium cathode at the bottom of the electro-refiner, and that works because you form an inter-metallic compound between the plutonium and the cadmium, which greatly changes the EMF required to play it out. So, those are comments.

This is basically a batch process, both in the electro-refiner and in the cathode processor. So, my question is how many of these electro-refiner units, and the paired up cathode processor, would be required to process, say, 1500 metric tons of heavy metal per year? It seems to be quite a few.

LOEWEN: As I put in one of my slides to talk about the modular construction of electro metallurgical process, so they’re currently in the national laboratories on the scale. So, we’ve done with our own funding, is asked the national laboratory to design us an electro-reduction unit at 50 metric tons per year. And, so, we feel like that’s a pretty good size to get our--50. Okay? So, that’s your base unit, and then you divide 50 into the capacity you want in your plant.

WYMER: You get 30.

LOEWEN: That is correct.

WYMER: It’s a lot.

LOEWEN: That is a lot. But, if we look at how we do other processes, so one of the things that we get brought up a lot is that we’re a batch process, and aqueous process is continuous, when you look at a lot of the ways factories are worked, especially for material, the accountability, you're in a batch process anyway. So, we don't see the argument that pyro process is a batch process is necessarily a negative. A lot of cases, it helps you with your material and accountability.

So, our first step is to take 50 metric ton, you know, share an anecdotal story, when we went to Saluda Manufacturing in this country to see if we could partner with them to talk about scaling up this process, because obviously, they had the experience of doing that electro-reduction, so we puffed up our chest and we said we wanted to do something at 50 metric tons. They laughed at us. They said that we weren't serious, and they said we're not going to work with you.

Now, when we say that we want to do 50 metric tons in a national laboratory, they see us as being too aggressive and overly optimistic on the technology. And, so, we're back again to the boiling water reactor story. How many experiments would we have done before the national laboratories would say it's ready for commercialization? So, we're ready to take, you know, try to make that, fill in the gap as a technology company to try to commercialize this to take it into a bigger scale, commercialize it. We obviously want to get our things greater than 50 metric tons per year. That's a step we've taken. But, we're in the right order of magnitude measuring it in tons rather than kilograms.

ARNOLD: Your criticality is a constraint.

LOEWEN: We are criticality constrained, but since we're not aqueous, we do have the ability to concentrate a lot more than an aqueous process because we can take credit for that. And, so, that was some analysis that we did internally using our criticality engineers to look at the process.

GARRICK: Okay. I think we're to the end of the morning session, unless Andy has a burning question. It better be short.

KADAK: Just a clarification. Based on Ray's comment, you need to convert the oxide to a metal before you can use this for LWRs. Is that what I understood him to say?

LOEWEN: This is what he said. The used nuclear fuel that we have is oxide based. So, our first step, we have to do an electro-reduction. And, that's what we do in a lithium bath. So, we reduce that to a metal. Then, you take that to the electro-refiner.

GARRICK: Okay, thank you very much. We will reconvene sharply at 1:30.

(Whereupon, the lunch recess was taken.)

AFTERNOON SESSION

GARRICK: Please take your seats, everybody.

Ladies and Gentlemen, we need to get underway. We have a very, very tight schedule this afternoon. We don't want to miss a thing.

The way we're going to conduct this panel is that we're going to hear from all of the panelists, and then ask questions, with the exception of Rod Ewing. And, for Rod, we're going to ask him and interrogate him immediately after he speaks, as he has to leave.

So, with that, and without further ado, I'm going to let Mark Peters start us off.

PETERS: Thanks, John. So, you want a short bio?

GARRICK: Yes.

PETERS: It's great to be back. I only have, since you all know me, I think, I only have 50 slides today. Let's see, so a little bit why maybe I'm here. I spent eight years working out at Yucca Mountain on the Science and Engineering Testing Program, and then spent a couple years when Margaret Chu was RW-1 on her staff, and was involved with establishing the Yucca S&T program. Rod and I worked the source term area together. And, since then, I've left and gone to Argonne, and I've actually gotten more involved in fuel cycle R&D. So, I was part of expanding the waste form R&D program for the Advanced Fuel Cycle initiative for DOE NE, and I'm also involved with them in thinking about disposal alternatives.

So, the slides I put together are fairly general, just to try to get some thoughts out on the table, and then I imagine we'll get into a lot more details in the discussion. There was a lot of detail provided by the three industry teams this morning, and I don't intend to hear any short remarks to go through those in any great detail.

So, I was assigned the topic of technical challenges, so I'm going to try to articulate high-level technical challenges, and really try to emphasize the role of science and technology R&D going forward, and how that fits.

So, what's the grand challenge for nuclear waste disposal? First off, let me start by saying there continues to be the scientific consensus that disposal of spent nuclear fuel and high-level waste in deep geologic formations is feasible, safe, provided you find the right site, it's characterized well, and you have the right combination of engineered and natural barriers.

The grand challenge is that you have to be able to characterize these sites, develop models for the processes, and make those feed into risk assessment models, that you have to be able to demonstrate that the geology and the materials that you put into the repository, both the packages and the waste form, can perform for very long time frames. In the case of the United States regulatory framework currently, we're out to a million years, and you have to deal with impact of climate change, extreme events like seismicity and volcanism, et cetera. And, the engineered barrier needs to work with the natural system.

And, this is relevant to the waste form area, because one of the things I will say, and what I'm going to try to emphasize here, is that the waste form is, I would argue, an under emphasized barrier. And, so, I think part of what we have an opportunity to do going forward is think about the waste form in a more serious manner vis-à-vis how it fits into the disposal environments that we would be exploring for the future.

So, first, I think it's important--I think we're at a stage where we're going to need to be looking at disposal alternatives, and I think there's some move afoot within the Department to do that, by myself and other folks from the national labs, and we hope the universities will start to get involved in this thinking. But, we need to really take a step back, so this is just the table, you all know this already, but it just gives you a sense for the different kind of rock types, geologic settings that are being looked at domestically as well as internationally, and what different countries are considering in terms of their options.

As you all well know, some countries are further along in terms of actual repository development. Some are still in the site characterization phase. But, there's a variety of different rock types in the saturated setting, granite, clay and salt. This doesn't talk to I'll call it concepts vis-à-vis could we think about boreholes versus mine shafts, shafts rooms, or ramps like we had at Yucca Mountain. I think all those need to be put back on and should be evaluated as part of our efforts going forward.

So, I don't want to dwell on the research needs or the technical challenges with the natural systems, but as you think about alternatives, you have to think about all this. What we've been thinking about in the context of advanced waste forms, is you have to think about the near-field effects. So, one of the things that we've been doing as part of our DOE nuclear energy efforts is starting to think about how to model near-field environments, understand and model near-field environments in a range of settings so that we can get a better understanding of how those different waste forms might perform.

Of course, engineered barriers and the waste forms go inside some of these waste packages, the U.S. concept, the Swedish concept I've shown in the upper left, different kinds of concepts. So, we really have to develop tools, predictive tools that allow us to look at these range of options.

What are some of the research needs, challenges for the source term? Again, enhancing the understanding of the performance of spent nuclear fuel, and for that matter, advance waste forms, trying to strive for a basic understanding of the fundamental mechanisms. And, there's a lot of different processes that one has to understand in the case of spent fuel and/or other kinds of waste forms.

So, specifically to waste forms, and I think this is relevant to this morning, one of the things that I would say is that the industry teams thought about the problem from the perspective of developing a business case and a technically defensible case for developing recycling facilities using flowsheets that they either had or were imagining could be in place down the road. And, less of a perspective on ultimately where it would go in terms of disposition, and that's not a criticism, because they weren't asked to do that. But, I think one of the things that we need to do going forward is bring that perspective more into, and I think that's relevant to this Board, bring the waste management perspective into our thinking.

And, so, a lot of the things that you think about when we think about waste forms, perhaps more from the perspective of ultimately as something that you have to dispose of, and it could be a potential barrier as well, is you have to think about performance, the second, cost effective, that does tie into what you heard this morning. So, you have to think about being able to generate more disposal volumes, what economic processes, also flexibility in terms of waste composition, loading, process ranges. A lot of those things play into making the design as effective as possible, cost effective as possible, able to be implemented safe, secure, et cetera, et cetera.

Also, need to think about developing forms that have predictable performance. And, this is, again, a perspective more about the fact you have to isolate these for a millennia.

And, then, finally, this morning, there was some discussion about the flowsheets, and you can look at multiple waste streams coming out of these flow sheets. There is an opportunity to match the waste stream to the waste form, not only to optimize the design for the reprocessing facility, but also to optimize and think about how one could match it to disposal environments. So, as you think about disposal alternatives, you need to think about waste form alternatives as well.

So, I think what the opportunity is, and I think there’s an R&D component to a lot of what we were talking about this morning, more than just the near-term, I’ll call it near-term R&D, or driven by what industry needs now that’s important. But I think there’s also a longer term component of an integrated program, and it’s not so different than what you heard Ernie Moniz speak to this morning. I think there’s a lot of similarity here--I'm speaking specifically about the disposal alternatives in the waste forms here--is a combination of systems analyses, experiments, modeling and simulation. And the future directions would be to go after advanced more durable waste forms, think about developing advanced geologic disposal concepts and range of settings, and developing the tools to be able to do that.

It could also ultimately inform our policy going forward, ultimately striving for a better understanding of repository performance, but also putting the repository part of this within the context of the overall fuel cycle. So, there's a lot of tool development, a lot of fundamental R&D, that I would argue needs to go on in parallel with some of the work that we heard about this morning, as we go down the path as a country, thinking about where we're going to go in terms of dealing with the existing legacy problem, as well as what we hope will be a renaissance and future waste that we have to deal with.

So, with that, I think I'll stop, just leave that as context. There's a lot we could talk about, the details of the different waste streams, and what we've been thinking about in terms of some of the R&D in that area, and some of the challenges. We could probably talk about that during the discussion.

Thanks.

GARRICK: Okay, thank you. Rod, tell us what you're up to now.

EWING: So, I'm Rod Ewing. I'm a Professor in the Department of Geological Sciences at the University of Michigan. I'm a mineralogist, material scientists, and my entree into this field was an interest in materials that might be used for incorporating various radionuclides, radiation effects in these materials, and over the years, this has evolved into even looking at inert matrix fuels, and so on. And, I've been involved in reviewing various aspects of the United States waste management plan for Yucca Mountain, WIPP, and so on.

When they asked me for my slides to load, they were surprised, disappointed, I don't have any. I did that on purpose because if I had made them, then I would simply be giving my bios without having to listen to the talks. So, now, having listened to the talks, I'll simply give you my bios, and we'll move on from there.

Well, the morning was--and, so, I think my job is to give not only my perspective, but to make comments and suggestions as to what we listened to this morning.

I begin by giving you the good news, and I think it is very good news, at least to me, is that this isn't the first meeting, but it's only been within let's say about the last year that groups have gathered to discuss and connect what goes on in a reactor, with what can go on in a reprocessing plant, with what goes on in a geologic repository. I call that the three R’s.

This is a big difference than in the past where from the waste management point of view, we were just given the waste in a bucket and say work with that. Now, we can think about what we could do with a reactor, maybe burning up, as a function of burn-up, something very simple. We can think about possibilities with reprocessing, the subject of this morning’s presentations. And, we can talk about the repository.

The bad news, it’s not bad news so much--and, I should say it this way. I understand the constraints that the speakers had. But, taken as a group, I would say is the approach in linking these three areas, namely is to say--it’s not said explicitly--the repository has failed for certain radionuclides, what can we now do with reprocessing. And, I think that’s a mistake. I think we have to look carefully at each radionuclide, and ask ourselves where is that best handled, in the reactor, by reprocessing, or in the repository.

As an example, with the actinides, certainly with uranium, but also with plutonium and the minor actinides, changing the redox conditions within the normal range available to us in repository environments can give us three, maybe four orders of magnitude reductions in solubility, and, therefore, limit the mobility of some of these radionuclides.

So, I think in weighing the possibilities, it’s very important to look back at the geology, the geochemistry, the geologic barrier and ask if there’s not a simpler way, better siting, better use of engineered barriers, to solve some of these problems, short of reprocessing, or something that goes on in the reactor.

The other general point I want to make is the fuel cycle, there are no closed fuel cycles. That gives you a feeling that everything stays in the room, that nothing is coming out of the closed fuel cycle. For all of these fuel cycles, you have the mining of uranium. This is a huge impact. Maybe reprocessing reduces that impact, no one has made that point. During whatever the process is, there are releases, some by design in the past, some not by design. And, then, all of the options need a geologic repository, as far as I could see. And, so, this closed fuel cycle, or open, actually has a lot of communication with the outside world and, in particular, the biosphere.

Now, I’ll give you very briefly my impressions as I was instructed, that is, to comment on relationship between reprocessing schemes and the impact on a geological repository. Then, I want to make a few points on the talks, mainly just raising some small red flags about things that maybe need more attention and shouldn't be looked at in such a general way. And, then, I'll go beyond my charge and make some broader comments on reprocessing as a strategy.

First, as far as the impact of what we saw this morning on the geologic repository, most of the discussion of the impact is in terms of volume and heat. Okay? We want to reduce the volume and we want to reduce the heat. To me, this is a little bit strange because actually, what we're disposing of is radioactivity. And, the volume, concentrated or not, can wreak havoc with you in a performance assessment. Sometimes having high concentrations is not the best deal in terms of the final environmental impact.

Also, with heat, looking at the flow diagrams as you follow through, there are important details that need to be addressed, that is, the heat generation from MOX fuel is much higher than from normal fuel. So, this has to be calculated into the assessment of whether you have reduced the heat. And, also, I would say, with both volume and heat, reprocessing isn't your only tool. There are ways to engineer a repository so that heat becomes less important, and I would refer you to the Swedish and Finnish programs. Here, the temperatures are much lower. They have these actinides such as Americium, and they're not talking about the thermal bump over the history of the repository.

But, I actually need to comment intelligently on the relationship between reprocessing and the repository, is I need to know the composition of the waste in each of those streams, the isotopic composition. It makes a big difference. It makes a big difference because I have to put that composition in the context of possible waste forms. Glass isn't the only possibility, although it appears prominently, usually modified by the adjective robust, whatever that means.

There are many possibilities, depending on how far you want to extend your reprocessing. So, I need the exact compositions, which were not given, and I understand these were pretty high-level reviews, so it's not a criticism, but that's what we need if we're going to weigh the strategy for technetium, whether it goes into a metal waste form under certain redox conditions, or whether you want to handle it with some reprocessing scheme.

Another reason the isotopic compositions are very important is, an example would be Cesium and Strontium, sometimes less in glass, sometimes incorporated into a called low-activity glass and left for near surface storage. There's a Cesium 135 is present. So, that's often raised. I don't know in the long-term whether that's an important issue, but I do know in European performance assessments, over extended periods, you see a small peak that's attributed to the Cesium 135, which has a half-life of 2.1 million years.

In a certain way, listening and thinking about waste streams, waste forms, and repositories, the message I took away was what if this doesn't work. You have a pretty elaborate scheme that has to be balanced. You're separating waste streams. In some cases, in some proposals, you're waiting for fast reactors to become commercially available, and then you go to the next step.

From a waste management point of view, actually, I think my main responsibility is to begin to plan for the failure of these grand schemes, and to plan for what we'll do with the orphaned waste streams.

A good example would be the Cesium and Strontium capsules at Hanford. They're separated. They're sitting there. If you visit and look, it doesn't give you a warm and fuzzy feeling that that's the best solution for that material.

And, so, I think, and this will be a general comment for all the talks, as we look at reprocessing, what would be most helpful to planning would be for every scheme, to ask the question, well, what's your worst nightmare? What happens if things don't happen on time? What happens if the technology doesn't develop in the way that you expect it to? What will be the waste streams that we'll be left with that we have to deal with in a geologic repository, and what will be the forms? It makes a big difference, you know, if someone potentially would be asked well, what are you going to do with that, I'd like to have some say in how that is developed, what the total activity is. I'd like to know what the volumes are. I'd like to start planning in that regard.

Some of the examples I would cite, some of the experience that will be the basis for moving forward, hasn't been as positive as portrayed. The reprocessing facility in Rokkasho, Japan, I looked, it was supposed to open in 1997. Proposals for how long it would take to bring certain schemes on were in the scale of 10 to 20 years. Plus ten? Well, that's a long time, and it's a long time to sustain a complicated technological process.

So, those are the main points I would make from listening this morning to the presentations. What do we do if something goes wrong? What will the orphaned waste streams look like that we have to deal with? And, we'll be dealing with them in a geologic repository.

Some more specific comments. I don't want to--I made a number of notes, but just some of the major points. A lot of people inside and outside of this room dream of WIPP as the final resting place for intermediate-level, low-level, hulls, et cetera. I was in New Mexico in an Academy Panel for over a decade kind of shepherding that through the process. There were a lot of compromises made, and a lot of understandings arrived at between DOE, EPA and the State of New Mexico. By the way, it's not regulated by the NRC. It's by the EPA. It's an operating repository, things are going well. And, so, I think I would be very careful about raising or putting more things into WIPP.

Every five years, EPA redoes the performance assessment. When I last looked, in terms of total plutonium content, well, it's a lot different than when it was approved. And, so, realize that politically and technically, we can't all dream of putting intermediate or transuranic or low-level waste into WIPP. I think you run the risk of ruining one of our--well, our only operating repository.

There are other words on slides, incineration. Actually, that's an idea that's very attractive to me. But, in the United States, we have a track record, mainly at Idaho, with trying to move forward with such ideas. And, looking at our real experience, and seeing where we got or didn't get, and how long it took, I think we will need to recalibrate some of the expectations for how things will go in the future.

Finally, how much time--okay, then I won't talk too much longer. So, those are comments directed at the presentations, a little bit of advice. Now, with the Krypton 85, I would remind you that at Idaho, they captured it in a zeolite. There's experience there that wasn't mentioned.

So, there are a number of small technical suggestions I would make in terms of filling out the experience that's relevant to some of this planning.

With my final comments, I would like to make some broader points, but I think they're important to these discussions, and I will be repeating, actually, what Ernie Moniz said, some of his points earlier this morning.

My first advice--but, I'll say it maybe a little differently--is if the justification for the nuclear renaissance is to reduce CO_2 emissions, and I think that has to be a major driving force in the grand scheme of things, otherwise, it's not so interesting, I'd commend you all to set with the carbon cycle for a good long time, the short-term carbon cycle, the long-term carbon cycle, and try to develop, or develop an appreciation for its complexity and the scale. And, if you do that, and think about risk mitigation of climate change, what you will see is that timing is everything. Okay? And, there's not a lot of time.

And, so, if you're looking for a strategy for nuclear power to have an impact, which I think it can, on reducing CO_2 emissions, it has to have that impact at the right scale, and even at the expanded scale, it will probably be modest. At the expanded scale, it's probably not resource limited for the next 100 years. But, timing is everything.

And, so, if you lay out a plan that takes 20 years, and experience tells us to double that number, then probably you're too late. So, whatever the strategy for reprocessing, looking down the road, whatever the justification, there has to be, if nuclear power is going to be part of the solution, there has to be a real push under things that can be done today and that can be done in a timely way.

And, we can wait for the MIT report and the models, but I think from my point of view, generation three plus reactors, light water reactors, we now have interim storage, so we should think about how best to do that, centralized or not. That's a fact, we have to address it. States that are stuck with the spent fuel, I think they will not so quickly participate in an expansion of nuclear power plants until that problem is solved in their states.

And, so, we have to do things--well, and, then, a geologic repository. There are lots of different geologies, there are lots of possibilities. The geologies can be matched to some of the different waste streams. Shallow burial, deep burial, different time periods, but it's not too early to reactivate our efforts for geologic repositories, particularly thinking about, just as you do with your reprocessing waste streams, thinking about different repository types for different waste streams. We should be matching waste forms to different waste streams.

And, so, I think in my view, if I were developing a strategy, at this moment, I would say that nuclear is a bridging technology, because it exists, it's ready to go. It can expand. It can help, and it can bridge to a time when either more advanced nuclear technologies come on line, or alternative energy resources.

And, so, what I take away from this morning's discussion, which maybe is not fair because you had a particular subject, is we seem to be jumping over the obvious problems in front of us, and dreaming of longer-term solutions that may not come to pass.

So, that's without slides. Questions?

GARRICK: Okay. Bill?

MURPHY: Thank you, Rod. That was eloquent as usual, and I appreciate your insights and, in particular, I'd like you to elaborate on a point that you rose just now, the matching of waste forms to geological environments. And, you have a lot of experience in waste forms and in geologic environments, and if we look around the world, I don't see matching of spent fuel with geologic environments very often. It certainly doesn't match at Yucca Mountain, and if you look at the Swedish program, or the Finnish program, which are advanced, it's really more a matching of the proper container with the geologic environment. And, in the French program, perhaps there's more of a reliability on the waste form. But could you just speak generally about the matching of spent nuclear fuel with geologic environments?

EWING: Sure, if we take spent fuel, UO2, the last place that a geochemist would put it would be under oxidizing conditions. The uranium four plus phases in nature, there may be fewer than ten, but basically, there are two, UO2 and Coffinite, uranium silicate. So, in the reduced form, it’s not very complicated. But, if you oxidize it to uranium six plus, there are 200, 300 different uranium six plus phases.

So, as a mineralogist, I’m please as I can be to study those 200 phases, but as someone disposing of waste, I’d rather stick with one or two that are prominent for uranium four plus state. Now, it’s not quite so simple, because you have alpha radiolysis over time in the repositories, but just as a first iteration, the redox conditions matter a lot for UO2.

MURPHY: That’s correct as a first iteration. But, I’m more interested in a more specific matching. Are you--can you conceive or if we’re in a position now where maybe we can, as you suggest, think about matching waste forms to geologic environments, and we have an open field for looking for geologic environments, can you think of geologic environments that might match well?

EWING: So, two examples, pretty simple. One is borosilicate glass. If you look at people, and I argue about the corrosion mechanism, but one think all corrosion mechanisms have in common is that pretty much, the corrosion rate scale is to the flow rate. So, if you want to preserve glass for a long time, static conditions would be better than non-static conditions.

Another more advanced example would be disposal of actinides, which are alpha emitters, and, so, as alpha emitters, radiation damage is an important consideration. I won't here propose to dispose of plutonium, because I know we try to keep it and use it, but say for the minor actinides, you don't have to burn them in a fast reactor. You could dispose of them directly. The volumes aren't so great. And, there are materials for which now we know enough about the temperature or thermally induced annealing of the radiation damage that we can model, over geologic periods, the damage accumulation and the change in leach rate for actinides which are alpha emitters.

And, knowing what the thermal conditions are, let's say you had deep borehole disposal for the minor actinides, the volumes are small, then you would pick a depth that would leave you, thanks to the geotherm, above the temperature required to anneal the alpha decay damage. So, this type of thinking back and forth between material science and repository environment I think can be done and should be done.

MURPHY: Thank you.

GARRICK: Rod, I agree with you that when we have a waste form that we're trying to decide what to do with, that you'd like to know the exact composition and you'd like to know the isotopic content. But, doesn't that present a real conflict to the planners who are wanting to consider multiple alternatives, where for each of the alternatives, you're just not going to have that level of quantification of either the isotopic content or the composition? Or, is that what you meant?

EWING: Well, what I'm hoping is that with the documentation that goes behind these flow diagrams, I could look up at each stage what the inventory is for a metric ton of reprocessed spent fuel, and I can follow it through, it doesn't have to be so precise, but it's very important to know what the mixture of elements will be, because that will affect the materials that I consider as a waste form.

Also, and I would tell you the reprocessing strategy, which generates waste streams in its most advanced form, should be trying to match the composition of those waste streams, radionuclides and what's called inert elements, non-radioactive, to the material. So, if you have iron or silicon in your waste stream, or chlorine, that it's also part of the building blocks of your material. Once you have that material, then the next matching has to do with what type of geologic repository would be appropriate.

GARRICK: And, you need to get into the details of the environmental.

EWING: Right.

GARRICK: So, it’s really composition, isotopic concentration and distribution, and the environment.

EWING: Right.

GARRICK: And, this has been a problem we’ve been having in the past with the Yucca Mountain source term, is really having the feeling that the source term is representative of what’s going to happen.

EWING: Right.

GARRICK: Because of the absence of some of the detail that you’re talking about.

EWING: Right. But, I think the reprocessing, I’m hoping to know the details. That has to be part of the effort. And, the reason isotopic composition matters is because it’s the half-life that tells you, you know, whether you’re disposing of something for a thousand years or a million years. It provides real guidance about the durability of the materials that you would like to be part of the solution.

GARRICK: Okay. Any other questions from the Board? Because I know we’re--okay, Andy?

EWING: I’m okay.

GARRICK: Oh, okay.

KADAK: A couple of comments, and then a question. Sorry, Kadak, Board.

The comment is on the Cesium/Strontium issue at Hanford. As I understand it, that it’s legal limbo that’s stuck in, not anything technical in the sense of it becomes a high-level waste when it in fact doesn’t need to be. But, you can correct me if I’m wrong on that.

But, I’m addressing the “timing is everything” comment. And, if you take a look at today’s realities, if Yucca Mountain is indeed cancelled, and if, let’s just say, a solution, quote unquote, whatever that definition means, to the nuclear waste problem is the impediment to building more nuclear plants, haven’t we sealed the fate of nuclear in the sense of making a difference from the standpoint of getting these plants built, as Moniz has said, and as you have just repeated. And how will that affect your thinking about whether or not Yucca Mountain licensing should at least proceed to the point where we find out whether it’s good, bad, or forget about it?

EWING: There are several parts, actually. So, on the timing, actually, the time is about up.

KADAK: Okay.

EWING: Time is about up. So, it’s all right to talk about the distant future, but the rest of the world is on a shorter time frame, and you just should, I would suggest, think about that.

On Yucca Mountain, I have never been a great fan of Yucca Mountain. I've been in criticisms of the strategy. But, also, I have never said that it's safe or not, because I can't tell. We need to go through the process. I think the tragedy with Yucca Mountain is not the loss of Yucca Mountain, but the kind of last step in a process in which we have had no process. We have now demonstrated that there is no transparent straightforward process by which these decisions will be made. And, I think that's the difficulty.

So, if we start over and we start looking for new repository sites, unless we straighten out the process, and I think this Board is in a position to, better than probably anyone else, to comment on what's needed in the process, unless we straighten out this process, I don't see why the same fate won't befall the next repository.

So, for me, the timing is bad, almost couldn't be worse. You have a little gap where you might get started and actually succeed, but that gap will collapse around us all unless we settle on a transparent workable process that moves efficiently forward. Did I answer your question?

KADAK: You're getting there.

EWING: Okay.

KADAK: Let me just make it more blunt. Do you think the licensing process should proceed to a point where we know whether it is an option or not, technically?

EWING: It seems to me inappropriate to proceed with the licensing process when the decision has already been made, because then at the end of that licensing process, I don't know whether the decision was made in a technical or political basis. So, I really question the wisdom, as I may, but--of proceeding with the licensing application and telling the world that we're not going to do this. Take me as an example. I'm very critical of Yucca Mountain. But, if it's not going to be a repository, I'm not going to spend my time giving comments and working on the subject. And, so, a licensing process that goes forward without the full attention of the community, because of this political decision, I think is a licensing process that's compromised. And, that's not a criticism of the Nuclear Regulatory Commission. It's just my personal view of the situation we're in.

KADAK: About waste forms. You sounded like you were critical of the borosilicate glass solution, which apparently at least two of the three vendors are proposing. What is the basis of that criticism?

EWING: Well, the basis is that there's no details. I mean, when people tell me that the volume is reduced by a factor of four, or factor of five, I need to know the waste loading. I need to know what's in the glass. So, the effect of radiation, if you put all the Cesium and Strontium at high concentrations into a glass, I want to look carefully at the radiation response of that glass.

KADAK: Well, let's take the stuff that they're already making now.

EWING: At Savannah River?

KADAK: At LaHague.

EWING: That's interesting. It's fine, it passes the seven day consistency test. But, the waste loading has been changing gradually over time, and we don't go back and check those glasses. So, I don't know. Now, this is a full-scale industrial process, and one in which you don't actually check your product.

KADAK: Okay, thank you.

GARRICK: Okay, any other questions? I think we'd probably better move along, and we thank you very much, Rod.

Adam?

LEVIN: Thank you, John.

I'm Adam Levin. I'm the Director of Spent Fuel and Decommissioning for Exelon Nuclear. And, as part of my responsibilities, I have governance and oversight of all things associated with dry cask storage, or spent fuel pools, special nuclear material, as well as decommissioning of all of our decommissioning planning and decommissioning operations at our nuclear sites.

I was asked to take a few minutes to talk about the implications for managing MOX used fuel at our sites, and I'd also like to spend a couple of additional minutes talking about the implications of operating with MOX fuel and how it actually impacts our current fleet of reactors.

The Exelon fleet consists of ten operating sites and one retired site, and we currently have five operating dry cask storage facilities, with three more that are in construction right now. We have over 100 dry cask systems placed on the pads and over 1000 metric tons of fuel in them. Once we do get up the balance of the sites, the other three sites in operation, we'll be placing something on the order of 30 casks a year into dry storage, about 300 to 400 metric tons of fuel every year into dry storage. So, it's more than a cottage industry for us at this point in time. It's become a significant part of our operation.

We do have a couple of mixed oxide fuels back from the days, for those of you that were around, and those have actually been placed already into dry cask storage, as they were very old. They were quite cold thermally.

One other thing I did want to mention is that as we get the balance of the sites in operation across the fleet, we're running close to about 10 percent of our operating cost is going to be associated with dry cask storage. So, it's become a significant operation at this point for us.

Moving over to the impacts of using MOX fuel, I'd like to address a couple of the items technically that actually impact the cost considerations that go above and beyond just the cost of purchasing MOX fuel and the cost that, you know, you've probably seen so far to date, the estimated costs of anywhere from two to four or five times or more, the costs associated with purchasing uranium fuel.

The first piece is that, and again, I'm discussing just our current fleet. We'd have to go in and amend the operating licenses to address all of our safety margin issues, fuel performance issues, plant design basis. We also have to work on assuring that we've got sufficient reactivity--I'm sorry--margin to criticality to address the increased reactivity of MOX fuel. We're going to have to address plant physical changes to address security, radiation and shielding because of the MOX fuel's higher level of radiation.

And, from the dry storage side, the thing that I have to focus on, or the folks that I work with have to focus on, is the heat load issues, as well as the site boundary dose conditions. I think the heat load issues are one thing we probably have to go back to the vendors and talk with them about how to manage the increased heat load from the casks. But, the other piece is there's only so much shielding you can put into 125 ton casks, and I have to somehow figure out how to ensure that I’m not going to increase my off-site doses of a significant nature, and I have only 25 millirem in that bucket of off-site doses that I have to deal with. Some of them are already taken up by plant operations, some of them by existing dry storage already. So, obviously with higher radioactivity of fuel, I have to concern myself now with what that means to my off-site dose limits.

Continuing on with impact on reactor operations. Refueling outages, the critical path for refueling outage is partially driven by our ability to move fuel from the reactor to the spent fuel pool after shut-down. Now, typically, in the range of 100 to 150 hours is about the time limit, and that’s again tested by our ability to cool the fuel once it gets over to the spent fuel pool.

So, in dealing with MOX, one of the things that I have to do, or two things I have to do is address the issue of time to boil in the reactor once I’ve gotten the vessel head off, as well as once I get into the spent fuel pool, the ability of the systems to be able to cool the fuel adequately. So, there may be either a modification to the systems that are required and/or we’d have to wait additional time before we could actually remove fuel from the vessel and put it into the spent fuel pool, delaying our refueling outage. So, obviously, there’s some economic impacts associated with that.

One of the things that has been mentioned is that the reprocessing, recycling and reprocessing nuclear economy potentially results in fuel remaining at the reactor sites for some extended period of time. And, co-locating used fuel at the operating reactor sites really isn't appropriate as part of a long-term management strategy in my view. Reactor sites near water, near population centers, exactly for the purpose of efficiency and delivery of electricity, and it doesn't, from an ecomanagement standpoint, ecomanagement practices, good practices, it makes a heck of a lot more sense to be able to move hazardous waste away from the reactors and population zones when it's practicable to do so.

So, in my view, centralized storage makes much better sense, and this is true for either a once through a recycling and reprocessing nuclear economy.

Finally, I think one of the things that I feel the studies that are out there can add a little bit more to and address is impacting the--identify and discuss and address the issues that impact local stakeholders. And, talking about it from addressing the current fleet of reactors that we have, and using MOX fuel in those, obviously Exelon's costs of generating electricity would go up, at least based upon the economic analyses that we've seen today.

There would be fuel and plant modifications as well to address. And, again, I think the business cases for recycling economies need to take a look also at the costs associated with, at least for the current fleet of reactors, making the necessary modifications in order to operate with with MOX fuel.

Of course, the local stakeholders have yet provided any impact on the proposed methodologies, which includes potentially leaving fuel on sites longer than we have told them that fuel would remain on site. So, all in all, as to the bottom line, Exelon has had some serious reservations about proceeding with new plant construction, which is why our program has been somewhat held back at this point in time, until used fuel management issue can be resolved. And, part of that is going to include looking all the way through the process to the back end, which says there has to be a geologic repository at some point in time in order to be able to get rid of these final waste streams.

So, that’s all I had. Thank you.

GARRICK: Our next speaker is Dan Stout.

STOUT: Good afternoon. As was just said, I’m Dan Stout. I work for the Tennessee Valley Authority. I’ve been there a little less than six months. I work in the New Generation Development and Construction Organization. In case you’re not aware, TVA has the only reactor under construction in the United States, Watts Barr, Unit Number 2. We have about 2000 people down there working as we speak.

Prior to TVA, I worked at the Department of Energy. I was Director of Nuclear Fuel Recycling. And, prior to that, I worked in the uranium enrichment industry.

I'm going to briefly cover six topics over the next ten minutes. First topic is really a listing of the key documents of interest in regulatory space. Then, I'm going to address the NEI white paper, it's about a 150 page document that was submitted to the NRC in December. Then, I'll talk to my understanding of NRC's approach to licensing nuclear fuel recycling facilities. I'll address safeguards, security, and transportation. They are interrelated. Then, I'll talk about the interface with light water reactors, and close with EPA regulations.

I think it's important to point out that what we're talking about here is NRC regulations, not DOE regulations, although I suppose it's feasible that DOE could build recycling facilities on a DOE site, and could make a case to regulate them if Congress didn't order otherwise. But, practically speaking, we're talking about managing the country's used fuel. We're talking about a commercial enterprise. We're talking about NRC regulations.

So, I'm not going to go through all of these. Again, this is more of a ready reference. But, as an overview, I'm going to point out that the original NRC activities in the 2007 time frame were focusing on a DOE led program. That approach shifted over time to being more responsive to industry, particularly driven by correspondence directly from the three industry teams. In that correspondence, there were some statements, you know, statements of intent to submit license applications for nuclear fuel recycling facilities in the 2012 time frame.

An industry task force forced in September 2008 and prepared this white paper as a guide, and it was submitted to the NRC in December, and the NRC was able to use it as part of completing their GAP analysis, which they completed in the spring of 2009.

With regards to licensing nuclear fuel recycling facilities, the NEI task force proposed that the NRC create a new 10 CFR, Part 70X. The task force looked at current Part 50 regulations, and that's where reprocessing is currently mentioned, but Part 50 has evolved and is much more focused on light water reactor design and technology. So, it doesn't contain a design basis for a reprocessing plant. It doesn't address the chemical hazards that would be present in a reprocessing plant. It isn't risk informed or performance based.

Current Part 70 isn't a clean fit either. Therefore, the NEI task force that included members of the folks that spoke this morning, and the utilities, concluded that a new Part 70X would offer the best of all worlds.

You're able to capture the elements of Part 50, Part 52, Part 70 that would be most applicable, and in addition, create some flexibility.

The fuel recycling facility includes the entirety of the newly licensed facilities on the site. Now, there could be a co-located reactor, but that would not be part of Part 70X.

Now, as you can see from the chart, it offers flexibility. You could envision a scenario where a licensee would get a license for interim storage and start up interim storage operations under Part 72 prior to receiving the Part 70X, which would enable reprocessing.

Now, another example, associated operations, this includes things like vitrified waste production. You know, clearly, that would fall under a more rigorous regulation and would likely fall under a Part 70X like structure. So, again, this approach would allow the opportunity to apply more regulatory rigor where the hazards are greater, and less regulatory rigor where the operations are consistent with the types of operations at existing nuclear facilities.

So, based on public documents and statements made by the NRC, it seems clear that they are supportive of developing a regulatory framework for recycling, and the question that remains is a matter of the relative priority and the urgency. To that end, you know, they have stated that they are proceeding at a pace that's consistent with industry progress and commitments.

Now, they stated in SECI in 2008 that they're initially focused on developing a framework, considering those technologies that are most industrially mature. In other words, aqueous reprocessing. So, they have not begun regulatory framework for fast reactors, as the industry teams and DOE have indicated, that the next fast reactor is going to be government funded, a government project.

So, the NRC approach to regulatory framework development was the focus of a meeting that took place last week, September 18th, and they laid out their approach. And, they're in a phase right now called technical basis or regulatory basis phase. They're targeting to complete this phase at the end of 2010. The next phase would be development of a draft rule. They estimate that that would take approximately one year, and that would be followed by the development of a final rule, which also would take approximately one year.

They laid out the resources that they would need to get this work done. This regulatory basis phase, they estimated at 5 FTEs and $1.1 million. It's about halfway complete. I believe they're estimating FY 2010, roughly two and a half full-time equivalents.

Regarding safeguards and security, I'm going to point out three different documents, regulations, activities. First, the graded safeguards table. Now, this is a way of categorizing the attractiveness of materials, and, then 10 CFR, Part 73, which is the physical protection of plants and materials, and 10 CFR, Part 74, material control and accounting of special nuclear materials.

Now, post-911, some of the factors that determine the attractiveness of materials has changed. You know, for example, if a terrace is willing to die, then dose of the material is less important then the purity or the enrichment level of that material. So, those equations have started to be adjusted.

The Department of Energy is in the process of updating those tables, and there have been a number of national laboratory reports that have been published on that topic. The NRC is aware of and understands the technical basis behind those activities, and they are evaluating whether or not to take a graded approach to categorization as well. And, if they do, they're on a path where they could have regulations in place in the 2011, 2012 time frame. And, those changes, if implemented, will affect the definitions of Category 1, Category 2, which will, in turn, affect the design and the transportation regulations.

So, regarding transportation, now, there are systems in place for international transportation of MOX fuel and other materials. The United States did put MOX into one of Duke's reactors, CATABA. They used DOE and NSA's Office of Secure Transport to do that, but they're in the process of looking at more economical solutions.

The bottom line is the dominos need to fall. First, the rules need to become clear on attractiveness. The regulations need to be made clear. And, then, the next step would be for the transportation industry to develop the casks and packages and the conveyances for safe and secure transportation.

With regard to interface with the light water reactors, it wouldn't do much good to build a reprocessing plant if you don't have a market for the output of it. So, there have been a number of activities where utilities have been engaged with the vendors that spoke this morning. Utilities are getting educated on the technical issues, on the business case, not there yet, but that progress is proceeding. So, we have activities that are taking place evaluating recycled reactor MOX, as well as weapons drive MOX from DOE's Savannah River MOX Project. In any case, from a regulatory standpoint, those manifest themselves in a license amendment from the utility to the NRC for each individual utility to start to load MOX into the reactor.

Last, there's an EPA regulation that covers the radioactive releases from fuel cycle facilities. And, it's a well thought out regulation in the 1970’s. At that time, you know, we had shag carpet and olive green countertops and appliances. And, just like that, this regulation needs to be updated. A lot of the basis behind it was a world of the 1970’s looking forward and predicting, for example, that there would be 80,000 metric tons of reprocessing capacity in place in the year 2020. That isn’t going to happen.

Likewise, there had been a lot of advances in the ICRP’s, and it would be prudent to take advantage of the progress that’s been made over the last three decades. You know, the industry teams talked about this. This is one of the greater uncertainties in how, if these regulations are updated, it will impact plant designs. If they are not updated, it will be a challenge for industry to be in compliance.

In closing, I’m encouraged by the presentations shown here today and by the Board’s interest in this topic. I think that spent nuclear fuel can be stored safety where it is today for a long, long time. However, I think it’s better to be actively managing the waste.

You know, as Adam suggested, moving the waste away from population centers and water supplies just makes good sense. One thing that Dr. Moniz said this morning that I totally agree with and want to highlight is that options have value. Right now, in terms of waste management, there aren’t many options, and with all due respect, panels and board and national labs generating paper documents doesn’t get us to active management.

We would like to see real progress on interim storage, on the steps necessary to enable recycling, like the regulatory framework development. It’s important from the utilities’ perspective to manage the risk that lack of a clear policy on back end creates, and it is worth the economics of solving this problem to go forward with a number of pathways that generate options.

Thank you.

GARRICK: Thank you. Okay, the panel of three is now ready to accept questions from the Board members. Howard, we’ll start with you.

ARNOLD: Arnold, Board.

I don’t know whether--maybe this is addressed to Adam, but anybody can comment. My understanding of what comes out when you try and make a MOX assembly is that from a given reactor run, you only get about a quarter back of what’s needed to run a reactor. So, in an economy where you’re just recycling MOX, I guess you don’t need every reactor to be able to use MOX. You can pick a fairly small number, and then you can figure out where they’re optimally located. I’m not addressing the economics at all. I’m just asking have people thought about the logistics of that?

LEVIN: The use of MOX in current reactor designs, and again, I'm addressing our fleet, would require that we limit the number of MOX assemblies that would go into any given reactor, probably in the 20 to 30 percent range. Beyond that, would require some extremely major modifications, I doubt we would even consider embarking upon, such as, you know, for a PWR, if you pushed 40 or 50 percent, or higher, MOX assemblies, you would end up having to replace the vessel head so that you could have more control rod drives. So, there's some practical issues, which limit you to the number of assemblies you can use in the current light water designs.

GARRICK: Okay, Bill and then Ron and Mark, Andy?

MURPHY: This is Bill Murphy of the Board.

My first question--I have two questions. The first one is for Mark. You made subtle and somewhat enticing comment that seemed to me to suggest that there were activities within the Department of Energy oriented toward site selection processes. Is that true? And, even if they're unofficial, I'd be interested in your comments.

PETERS: I was being intentionally enticing, but I didn't mean site selection. DOE NE has started an effort, in addition to the existing waste form R&D work that's going on that's been part of the AFCI program, they're starting an effort to look at the disposal alternatives aspects of the problem as well, and that's what I've been asked to step in and start to lead. So, that will start officially in fiscal year ’10. So, we’re thinking about how to build the predictive tool to think about some of the questions, so, yes. That’s something as a technical person, it’s above my pay rate, but as a technical person, that’s something that I think this Board could provide tremendous insight into as we try to think about how to develop that program.

MURPHY: Thank you. My second question is for Dan Stout, and you gave a rather comprehensive list of the relevant regulations that govern the issues associated with using MOX, and so forth. There’s also a regulatory rule that’s called a rule, the waste confidence rule, but it’s not a strict regulation, but at this moment, it has a rather profound effect on the licensing process for new reactors. And, I’m curious what your view is of the NRC’s waste confidence rule?

STOUT: That sounds like a good question to defer to NEI.

MURPHY: Well, I’d like in particular to hear from a reactor developer.

STOUT: Well, I don’t have an opinion on, you know, NRC’s approach to waste confidence. But, from a utility perspective, it’s very important for us to have the ability to be able to build new builds. And, that was directly relevant to my comment that I’d like to see us making real progress on generating options to manage the spent fuel. And, to that end, that builds waste confidence.

MURPHY: Thank you.

GARRICK: Okay, Mark? Or, Ron, I'm sorry.

LATANISION: Latanision, Board.

Adam, you mentioned, and I wrote down part of the comment, I wanted to first get a clarification. From Exelon's point of view, the corporation had reservations about building new capacity. At a time when, and this is the question, at a time when a solution for handling our waste was either in place or at least had been decided, or which of those options is it? How long are you willing to wait? I mean, let me go a little bit further. Even if we were to have the division at Yucca Mountain will be completed, it would still be ten years, or thereabouts, before it would receive waste. And, if not Yucca Mountain, we're probably talking about 30 years. So, I'm just curious which of those is it?

LEVIN: We're not looking for something to be operational necessarily. What we're focused on is a good solid definitive plan to get us there that we can present to the stakeholders and say here's what we're going to do, and here's how we're going to manage used fuel. Right now, we don't have that, and that's what's limiting us.

LATANISION: Well, just a follow-on question. I think in this current economy, with the melt-down in our industrial base, and in consumer demand, and I suspect that the demand for electricity is down and, therefore, there is a certain period of time in which you might be able to take that position, but as recovery occurs, and as the demand once again grows, are you going to be left behind if you don't have a--or, how would you manage that? Would you turn to fissile, or would you look to other alternatives? Or, how would a utility look forward, given the attitude that without having something reasonably clear in terms of waste handling, we're not going to build new electric generating--nuclear electric generating capacity? How would you deal with that?

LEVIN: Well, from the standpoint of developing a new nuclear unit, again, I think I have to stick to the comment that unless we have something that gives us a good black and white sense of where we're headed with managing used fuel, it would be difficult for us to turn to nuclear generation as our source of increased generation.

LATANISION: Okay. Well, that sounds like a partial answer. One last question for both Adam and Dan. Dan, you said that you were concerned that the options were not clear and you thought it would be a good idea to have options on the table. What would the utilities be prepared to do to stimulate the evolution of those options? I mean, we're in a limbo right now in terms of this whole question. In terms of this nation's needs, what are utilities prepared to do to move this forward?

STOUT: I think there are a number of activities. There are some task forces that have formed under NEI's leadership and under the Nuclear Infrastructure Council's leadership that are engaged in the public dialogue. I think opportunities to talk to you, and when the Blue Ribbon Commission is formed, talk to them, and drive this process. But, you know, there needs to be real progress on the development of these options, be it interim storage, be it reprocessing, recycling, and geologic disposal.

LATANISION: Okay, thank you.

GARRICK: Mark?

ABKOWITZ: Abkowitz, Board.

I'd like to follow along with what my distinguished colleague from Massachusetts has introduced here. I was trying to overlay the comments from the panel and we heard from Rod Ewing and he said basically, the climate change window of opportunity for nuclear is closing. I've heard the utilities say that there's not a strong enough business case for using recycled fuel at the moment. I've heard vendors are getting very enthusiastic over new technologies, but, oh, by the way, we need a risk free investment to do the R&D necessary to bring this to market. So, it seems to me that we have a pretty strong Gordian knot tied. And, my question to all three of you is that if there is a path forward, I'd like to hear from each of you what the first couple of things are that you think are compelling in order to launch us in the proper direction? If you were king, what are the first couple things that you would do to try to solve this problem?

PETERS: So, I guess I'm supposed to take that bait. The lab guy takes the bait, okay.

If I was king, okay, first deal with interim storage in a real way. I don't know what the correct solution is, centralized, distributed, whatever we do, deal with it now. And, then, this is going to probably cause snickers, but I would pretty quickly start to reopen the dialogue on revamping the Nuclear Waste Policy Act and get us going on the right path. If I was king, I would like to see that reopened in the near future. Those are two things that I would like to see.

STOUT: So, he answered the policy one. I'll take the R&D one. You know, we should be building facilities. We should be building research reactors at universities. We should be building demonstration reactors at national labs. We should be demonstrating advanced separations processes. You heard from the industry teams. You know, we need to demonstrate the best available techniques to capture radioactive gases. We need to demonstrate the best material control and accountability techniques, and industry will incorporate them if facilities get built. Those are the things that need to be worked on.

LEVIN: Frankly, I don’t have anything to add onto those two comments, with the exception that I still feel strongly about the fact that we need to, at some point, put together an integrated business approach between the utilities and vendors in this case. Otherwise, without a consistent business plan development, you’re never going to get excitement that you see by the vendors generated by the utilities across the board in terms of using recycled fuel, recycled and reprocessed fuel.

ABKOWITZ: Thank you.

GARRICK: Andy?

KADAK: This is for Adam. I’m puzzled by why Exelon has decided to use MOX given the things that you’ve said. And, let me see if I got those things correctly. The cost of a MOX fuel assembly is two to five times higher than a basic fresh fuel assembly. The operational difficulties and costs associated with dealing with MOX would lengthen your outages. And, the hassle associated with storing of MOX, higher heat loads, maybe storing it longer at the sites. Why is it then that Exelon is looking at MOX? Because I know you’re very financially conscious here.

LEVIN: Well, we don’t have a program at this juncture where we have identified and decided upon design of MOX fuel that we're going to load into our reactors. The fact of the matter is that it could be part of our future in terms of new build, and, so, it's something that we just feel we need to stay abreast of. We don't have any vested interest in MOX at this juncture.

KADAK: Okay. So, you're basically saying in order to show perhaps a solution, you would take on the additional cost burden of a MOX, short-term cost burden of a MOX fuel cycle to show that something is moving along, ala the Dan route, just build something and get it moving to some other place, like a centralized interim storage facility, which I gather from the industry's perspective is viewed as a step in the right direction towards a solution.

LEVIN: We are not ready to take that financial step and go through the whole licensing process, and everything else. That's not a decision that's been made at Exelon. I still feel that we need to focus on the centralized storage from the standpoint of the issues that I mentioned when I spoke earlier. But, we don't have a financial interest at this point in MOX.

KADAK: How about Dan, what is your view?

STOUT: Again, we're not interested in paying more for MOX, and it is in that context, because we have high confidence we're going to be able to obtain the MOX at a discount, the fresh fuel, that we're evaluating that as an option.

KADAK: As I understood the Duke deal, it was revenue neutral, whatever additional costs were associated with using of MOX from the weapons program, would be paid by the government as a no-cost burden, if you will. Is that correct? Is that your understanding?

STOUT: It’s my understanding that there is a discount to fresh fuel, and that’s needed for the utility to take on the additional risks and the one-of-a-kind challenges.

KADAK: In the Rod Ewing comment of the process being fought, namely, there’s no assurance that even if we find yet another place to dispose of waste, or maybe co-locate a reprocessing plant and a nuclear waste site, there is no assurance that the process could be compromised in the way the Yucca Mountain process has been compromised. Do you guys have any reaction to that as a basis for making future investments?

STOUT: Again, in the context of if we are moving forward with a recycling option, that doesn’t mean that you are not also moving forward with a geologic disposal option and an interim storage option. So, you know, if one of those falls through and others happen, that’s better than not doing anything. So, it’s in that context, we’d like to see progress on viable solutions for waste management.

KADAK: Mark?

PETERS: Even though I don't have a financial investment in this, I think Dan captured it, yeah, I guess I'm more glass half full than Rod on this one, maybe on a lot of things. But, I think we need to proceed ahead on all fronts, and part of my message is is don't forget that part of this is informed by longer range R&D. But, I think it's a long range path. I get concerned that we have not been able to establish a long range path and stick to it as well, but that's kind of why I think we need to reopen the policy now and lay that out, and hopefully do it, we made a lot of mistakes, I don't know if we can do it better, but I'd like to think that we can document what we did and what went wrong, some of which is in our control and some of which is is not, and try to do it right the next time. But, I think if we wait five years to reopen all this, I think we're--I'm not convinced we're not too late already, but we're getting there pretty quick. So, we need to move now.

GARRICK: Okay. It's David and then Howard and then Carl, and that's--your question has been covered? Okay. Then it's David and Howard.

DUQUETTE: Duquette, Board.

I know this has already been more or less covered by some of the questions, but we heard this morning that we seem to be on the threshold of being able to put a spade in the ground, as someone put it, for reprocessing plants.

We've heard from Exelon, who is a major player in the field, that they're not interested in proceeding with new construction until something is done about long-term disposal and/or interim storage, and we heard this morning that reprocessing wouldn't go forward unless someone wanted to build new plants. It seems to me we're at a Catch 22 where everything is stalling, and if Exelon or someone else isn't willing to bite the bullet and go ahead with new plants, just based on either interim storage or long-term disposal, then all these reprocessing schemes that we heard about this morning will basically die on the vine, meaning another process technology is going to be delayed by a very long time.

Do any of you have any comments on my very immature observations on what's happening here?

GARRICK: On his half empty observations?

LEVIN: I am, I guess, you know, again this is more of a personal opinion, but I think there's opportunity here. I really do. I think, as Mark has pointed out, going back and revisiting the Nuclear Waste Policy Act, taking a very hard look at pushing these programs in parallel can get something moving. But, I think, again, at least, and I'm looking at this from a very business point of view, something has to be done to demonstrate that there's a business case for going down certain paths, reprocessing paths, or whatever it is, and there has to be demonstration of the political willingness to support this kind of effort. Because, without that, I think industry is looking at this as another poor path towards repository development, and I don't think we want to repeat that. I think we want to be out in front and be able to have the kind of support that we need all the way through to see this happen. It can be done.

GARRICK: Okay.

LEVIN: It's just a matter of willingness.

GARRICK: Mark, do you have a comment?

PETERS: David, this is a little off topic of waste manager, but the labs in general, maybe I should just speak for myself, but the lab directors wrote a letter, and they made it pretty clear that there is not a lot of support necessarily for going and developing a reprocessing plant with the technology that is within your reach now. It could be that the better path is to do R&D development and then commercialize. The perspective this morning was much more it's nearly there, let's go do that. I just wanted to bring that up. It could be that we don't develop today's technology, we wait.

GARRICK: Okay. Howard, and then Ray, do you have any comments or questions after Howard?

WYMER: This is not exactly in my field.

GARRICK: Okay. Howard?

ARNOLD: Okay. We're kind of at the end of this part of the agenda, and I wanted to restate a few things that--maybe I'm just restating the obvious. In a scenario in which you have only light water reactors to deal with, to me, reprocessing and MOX fuel and recycling are definitely not at--there's no economic case for it. So, the recycling case or reprocessing case has got to be made on reduction of waste volume by itself. And, I don't think that case is proven. I've still got to see where the uranium goes out of all this.

So, the entire scenario drives towards an advanced reactor program, which then provides the rationale for proceeding with recycling. And, that has a very large financial threshold to overcome. The United States has been through these decisions in the past and reached these same conclusions. So, I'm not saying anything new.

GARRICK: Okay, it's time for a recess, or a break, and let's make it 15 minutes. So, that will be just about 3:15.

(Whereupon, a brief recess was taken.)

GARRICK: Our attention now turns to the international arena, and we're going to first hear, as it's appropriate, from somebody that covers a lot of ground when we speak about international, and that's Claudio Pescatore. And, the Board has interacted with Claudio for many years. He has been an important link to many of the activities and many of the visits we have made, as a matter of fact, abroad. So, we are delighted to get him here in our backyard, and we are looking forward to his remarks. Claudio?

PESCATORE: Thank you, John.

I am totally impressed by the way you are running this meeting, always some time. So, the first thing I need is to cut my overheads in half. So, I will not speak to my 55 overheads, and that is the part given to the secretary here, but about half of them. And, overnight, I also got a little wiser, so I fixed some of those overheads, so there is a little more information for you, and perhaps also more up to date.

I'm Claudio Pescatore. I've been working in this field for like 30 years. My Ph.D. thesis at the University of Illinois in fact was on glass leaching. I've learned since then that glass leaching is perhaps not so important as people think, because in the end, these source terms, at least in most of the repository projects, you know, the source term, the glass source term is not so important, and you can be off by several factors and still have a safe repository. And, which again means that perhaps you have to build a safety case more than a performance case. You're not interested in performance in the absolute, but in what gives you confidence that everything would be safe.

So, I think I've worked several years. First, it was at Nuclear National Lab for ten years, where I worked on the material sciences side. I did work on the then important programs, the WIPP, the TOUGH program and the SALT programs, and then I worked as a consultant to the EPRI, and then as a professor at the University of Stoneybrook. And, then, as a manager here in Paris at the OECD, and I'm in charge of all the programs, waste and decommissioning. In this capacity, by the way, I also organized many international peer reviews. One was of the Yucca Mountain TSPA.

So, I'll just speak just briefly about the OECD just to give you a sense, perhaps working, but more of my talk will be about review of developments, expectations, as expressed to us, and covering this period 2008, 2009. So, I will not talk about the long-term plans, because they can change, as we know, but I will just show you which are perhaps the worries or the concerns that countries have at this moment in this specific period of time. I will not talk very much about the Nordic countries. I think this will be covered very much I think by our Swedish friends. And, then, some final observations.

And, I notice that many of the things I will say sort of tie in with what we have heard around here, and perhaps I will try to make those things.

The OECD basically is about economic development. It's a collaborative of nations, and this is basically what this is about, is about economic growth, human capital, social cohesion, shaping globalization, governance, non-member economies. And, the sustainable economic growth is within the mandate of the OECD since 1948 when it was funded as basically the NTD. It was managing the national plan for Europe.

These are the countries of the OECD is basically the most advanced democracies in the world. You see Russia is not a member, but it’s now an observer state, and, so, perhaps I can say something also from Russia. And, we have special contacts with the emerging economies, China, India, Brazil. Overall, we have 28 countries, and we do very much look at the scientific, technological basis that are applied for the use of nuclear energy.

In the waste business, especially, the governance aspect has become very, very important, the stakeholder aspects. I was very glad that the colleague from--was mentioned. They are very, very important, and I also was impressed on one of my visits here in the United States where the Board allowed me to be part of their contacts with the stakeholders in Nevada. It was very, very interesting.

Also, we do, besides the technical work we do, we write things like these two-page leaflets, which are called Moving Forward With Geological Disposal. This is two pages for the lazier of us, or there’s a 50 page book so they can download from the web.

In the OECD/NEA countries, basically 24 percent of the energy share is produced by nuclear in our countries, and France is the most advanced in terms of nuclear. In the area of waste management, which is my area, and decommissioning, basically we look at decommissioning all types of waste, but in particular, our long-lived waste.

I just would like to give you some of the results of a recent workshop that we had in Tokyo. It was last January. Basically, we still see that there are some fundamental issues, like some of these terms, what is the basis of policy, like, you know, who can define what is undue burden with the safety. It’s not so clear from international guidance. And, the countries interpret it in various ways.

Perhaps also there is a convergent on objectives. But, perhaps not on the criteria. The criteria can be different from country to country. And, also, on the way the case is built, and about how to protect people in the far future at the same safety level as is present, and still on-going, in fact, is it possible. Is it possible at all. One of the questions is is it in fact needed that we have a definite boundary in time. Like, here in the U.S., you have a one million year time. Some countries do not have this boundary in time, we go forever.

So, more time is needed, for in fact we find to discuss cutoff, compliance, we weigh the short-term protection with long-term protection. In this country, going back to the criteria, there is a position by the American Health--Society that basically says--in fact, says that a dose is only a concept that you can use for a few generations. So, you cannot project over many, many years. And, this is one of the bases by which they say spent fuel should not be disposed of, in fact, should be maintained.

And, the ICP are saying not exactly the same, but they are also saying a dose is not a measure beyond a couple generations. So, these are important statements that should be taken into account when writing regulations, or when thinking a policy. So, we look at a very large consensus that if you use this concept, they are just indicators. They are not measures of protection. They are just indicators for protection.

As I mentioned, I will not give you an organized, as they say, presentation, but just let me show you what people have told us in March, last meeting, calling basically what they did in 2008, and what we are expecting in 2009.

So, for instance, in Korea, which we had a specific presentation in Korea, you can see that finally, they have now a nuclear waste managed agency, and they have started in earnest a very important plan to discuss spent fuel management in their country. There is a whole series of committed goals that go all the way to the president of the country, and they've given themselves 20 years to basically flesh out their plan for spent fuel.

They have learned the hard way from difficulties in the low-level waste areas. Now, they have a way forward in the low-level waste, and they foresee a disposal center in 2010. They are going to build a dry storage facility for the CANDU and, in fact, we heard before that there is an interest in the CANDU family to increase the enrichment, and, in fact, they are working on it.

Many countries are expanding or re-licensing the old waste disposal facilities, like in the Czech Republic, Hungary, Spain, also the U.S. In Norway, they licensed recently a NORM facility. Regulatory bodies have also been reorganized in several countries, Italy, Sweden, Switzerland, in different ways. Sweden, for instance, there are two regulators that have been put together. In Switzerland, they have a new statute completely, and also in Italy.

They have been taking first steps for siting process of repository in Switzerland and U.K. U.K. is in red because people should realize that U.K. is now basically two or three countries. So, this is really England. The Scottish government is totally, in fact, not in favor of disposal, and they go for near-site at a disposal, short storage or near-site, but a shallow level disposal.

In Switzerland, also six siting regions have been announced, and the first is at the first step to be completed in 2011. Updated regulatory policy for spent fuel in Finland, and a new plan. In Finland, the interesting thing was that the earlier provision, request for retrievability in the regulation has been removed. Then, of course, in 2008, there was the final safety regulation, the license application for Yucca Mountain.

In the UK recently, they received also three special interests for discussions regarding the repository. This is really just the beginning of interest. There has been a special interest in low-level waste disposal facility in France. This is graphite waste, long-lived waste. The government decision was expected in June 2009. That has been given. I will explain to you.

There's been a license application in Slovak Republic, and new laws and new regulation in Spain to make it more in tune with the ARAS (phonetic) convention. Perhaps you're not aware of the--I'm not sure the United States are part of the ARAS convention, but it's basically an international convention for the right of stakeholders to--basically people have a process that allows them to express their views, a way to be effective and in charge in court. In Europe, it's become very important. The U.K. government was challenged and lost in fact, based on the ARAS convention, on their first white paper on nuclear energy, because they did not give enough information to the people, and they were taken to the court and lost. And, in France, a decommission program was delayed for over a year, until certain things were not done by the government.

So, what's expected in 2009. As you can see in green, what has already happened in fact, and in black, what--I'm not sure this happened. In fact, I don't think it has yet. For instance, in Sweden, there's been a selection of the geological repository site.

Then, in Germany, we are waiting for final regulation. This will be a different regulation from what you have seen up to now. There has been, in fact, an exclusion zone. You can think of a nuclear facility having a perimeter. Well, you can see a repository as having basically a volume, which will be a continuing volume. So, the regulation actually functions, which are contained--are the numbers.

Basic proposal released in Canada for starting the process of implementation of spent fuel repository in Canada. This is a 20 year process this year, I mean, this is just the beginning.

They are going to restart a process in the Czech Republic. There is an important event in the Czech Republic in November where both the national level politicians and the local level politicians and stakeholders and international guys, perhaps I myself will go.

There is the start of national dialogue for a high-level waste repository in Belgium. As I mentioned regarding the low-level waste site, there were the designation of three sites by the government, but the communities were very quick in retreating from their initial offer to participate in the process, which jeopardizes the process. Even if there are additional communities that have indicated their interest, initially there were 14 communities chosen. 40 were in favor, 14, basically whittled down to 14. Three were chosen, but the three said no again, which is basically a serious setback.

In the high-level waste area, a workshop in April of this year, and we are waiting for the designation of so-called zone of interest on a high-level waste repository in France. Basically, there is now an area which is 250 square kilometers, and they want to reduce it to a 30 square kilometer area. And, interestingly, they are doing this in fact with the mayors, with the mayors of the region. The police is the local information and follow-up committee. They made them of mostly mayors.

And, you can see this is the area, 250 square kilometers, and they are starting different, they say, ways to define the area. And, the access pass, and so on, basically infrastructure and this is also an interesting picture because it shows the current plan for the repository. The entry to the repository and to the repository itself is basically almost--so, you will enter in one commune and one part of the region, but the repository will be underneath in another part of the region because this is a 5 kilometers incline. And, of course, this also gives them a certain radius of access so they can change, depending on what the mayors want, or they can change from which part of the region they can access the area. What is important to me is that basically, it has not been done in isolation. They are doing this with the people.

Also, in 2009, we are waiting for the announcement of the site selection process for a centralized spent fuel storage facility in Spain. The strategy for all types of radioactive waste in Poland. The continuation, of course, for the U.K. repository progress. We also have in the past, but some information in the U.S. program.

I’m not sure these have happened already, but we are waiting for the application for renewal of the license of the WIPP in this country. In Belgium, they are also working on the license application for a repository of low-level waste. And, in May of this year, there was the third meeting of the joint convention on the spent fuel, on the safety of spent fuel, and radioactive waste management, of which the United States is signatory.

Some general trends. There is some expansion of nuclear power and new build. There are countries that are now looking at the global nuclear waste management plans. There is a trend also to clarify the regulatory framework.

There is a conceptualization and implementation of the so-called volunteer siting strategies. And, there is also clearly effort, an important effort through public participation and dialogue involving municipalities and regions.

There is at the same time expansion of the interim storage facilities, both on-site and at nuclear power plants. There is reviewing of the funding schemes to ensure sufficient for eventual disposal.

This too has in fact--had in mind only a couple countries, but waste condition treatment seems to be a higher priority. Well, what I had in mind is discussion right here in this context in the United States on, for instance, a new policy perhaps. In Russia, there is also some new repository facilities.

Challenges are political decisions, which are pending. There is an organizational evolution or transition, especially among the regulators, but also in Japan, the implement has been given not only the job to work on high-level waste now, but also to work on TRU waste. And, in France, with the new mandate, the implement has basically switched from a phase of research to a phase of industrialization.

Certainly, there is a continued need for storage. There are waste disposal capacity limitations. One example, of course, is the low-level waste in France, where does it go. Not many countries have this low-level waste, and especially, to me, the low-level waste repository going. And, back to the problem, also these countries have, some of them have legacy sites and historic waste, and they need to in fact have places where they can put their waste.

Now, especially in this climate of also nuclear lessons, in the nuclear waste management business, we find that many people are missing, they are very--it is really difficult to retain qualified personnel. At the same time, this is a long-term process. It is a specific set of issues, and the integration of information and knowledge management is very important. And, as I said, societal dialogue and public dialogue is very, very important. And, major programs are really restructuring themselves around this. I see the program in France, I see the program in the UK, they are totally different in the way they were just a few years ago.

Now, the geological disposal, I want to have five more minutes. We have produced collective statements, as I mentioned earlier. In these collective statements, we are saying that basically storage is being implemented successfully, of course, but this is no substitute for waste disposal. There are no miracle solutions that would eliminate the need for disposal, and I think everybody was agreed this morning as well.

But, geological disposal is technically feasible and affords unparalleled protection. And, one thing I'm missing here it's also flexible, because it has been shown to be adaptable to many, many geologies, to many, many types of wastes. And, we heard this morning, all the types of waste streams that people would be willing to produce in the future cycles, recycling, you know, evidently they must rely on this technology which is geological disposal being very flexible.

We have learned also how to do the safety case for disposal. We have a large amount of experience from research and demonstration of our programs.

We do have an international framework. It is important to define a national energy policy, in fact, that basically addresses the role of nuclear, in which the waste arisings are recognized. It seems to us to be a very fundamental requirement when writing a policy. Then, under this policy, the plan with a vision for the final management of which wastes goes where.

And, of course, the decisions need to be prepared in our societies in a democratic manner, which means nowadays with more and more stakeholder involvement, public involvement, taking time to take decisions, basically. And, these longer implementation times are, of course, very challenging because you must continue to maintain momentum, interest, and so on. But, also the opportunity to adopt the program, an opportunity to learn.

We find that retrievability and reversibility are two concepts that are very important nowadays, and they shape programs, in fact. There are two principles. One is that basically, the repository has to be safe, but another principle is also we have to leave future generations as much as possible the freedom of choice. And, of course, if you want to give the future generations the same freedom of choice as today, then you don't close, you don't do anything. Basically, you store. So, there is a tension between the safety principle and this freedom of choice principle, and which causes, in fact, very different philosophies in the way these repositories are designed.

The philosophy of the waste repository in Sweden is very different, I find at least, from the philosophy of the waste repository in Switzerland, which is still different from the waste repository in France. So, what works in one country may not be as effective in another. We must recognize this. And, certainly, there are lots of different parts, but perhaps all these parts are parts to the same common objective, safety objective.

Overall, if I can end this presentation, I would like to say that radioactive waste management and also decommissioning, decommissioning in a way is a configuration in fact of waste management, is really best looking into decommissioning. Many things can go wrong in decommissioning, or went wrong in decommissioning, they realized themselves, in waste management. This cannot be considered as being solely a technical issue to be resolved solely by technical specialists. And, failure to recognize this has led to significant delays in the waste management programs, and in some decommissioning programs.

Geological disposal we see is moving forward, but the progress needs to be consolidated. We had the Nordic countries program, Sweden and Finland, and the French program is following. Now, unfortunately, we have this uncertainty on the U.S. program.

We find that the “wait and see” strategy is contrary to safety and ethics, in a way, because to keep these facilities under watch, and storage facilities, basically is an increasing burden for the future. We also heard that it perhaps is not so safe to keep some of these materials near water bodies and high population areas. And, ethics, because we have to start now getting a solution. If we don’t start now, why should others start later.

We think also that making decisions should be taken seriously, so we have to have a plan where we can come together and decide whether a disposal plan is going forward or not. And, of course, we have to take into account the regional levels, even more the regional levels are nowadays as important as the national levels, and they really need to be taken into account.

Thank you, John.

GARRICK: Thank you. Okay, questions from the Board? Andy?

KADAK: Yes. Based on your experience and observation of the countries who are siting, attempting to site nuclear geological repositories, have you done any common success criteria for site selection that allows the repository plan to continue? Do you have any information about what works and what doesn’t work?

PESCATORE: We have a lot of experience, a few years ago, we have come up in fact with two reports which have a lot of this information on work they have done with what works and did not work. And, we took into account both the input of the technical folks and of the human sciences folks, and we came up with and suggested eight action items, we call them, and this information is available on the web. There is a leaflet like this that you can read. In fact, we can send it to you. We have this, yes.

KADAK: What would you say are the top three things that allow it to work? And, let me just be a little bit more specific. I mean, does the form of government matter? Does the political--is it driven by the political will on a governmental level, state level to do this? Or, is it a local decision that has to be, obviously, first arrived at, but when you look at the local community, then you have the community that surrounds local communities. You have the state, then you have the federal, then you have the whole process.

PESCATORE: Well, I don't think it is necessarily top-down, but in the sense that we say some of the action can be taken in--but, certainly, there should be a national policy that recommends the--President Obama is talking about using CO2, and if nuclear is important in this mix, you should recognize, I mean, this is--and is the country going that way? In fact, probably the parliament would have been talking about this and deciding about this. So, it was something that the country wants to do, and it recognizes also this waste.

And, then, if possible, regarding this waste, which waste goes where. And, only then you can really start to--well, you can start to have more meaningful negotiations with states or local communities explaining, you know, this is what we have, and explaining the roles of everyone, explaining perhaps also that there are regulations. And, perhaps the only implementer alone to fight by itself. Besides some of the things we say, and we have also said that basically there are three principles, three principles in democracy that really need to be looked at. One of the needs is for people really to be able to learn together. So, you have to give time for these processes, too, to mature so people can understand which are their interests. And, they have to put together as many possible world views. The Canadians do this very much in their country, and the UK is now.

GARRICK: Claudio, has the action that has been taken on Yucca Mountain had any impact on any of the activities in the members?

PESCATORE: Not yet. But, in the strongest programs, probably you can turn the question to our Nordic friends, perhaps it will not make much difference, but in the less strong programs, it may make some difference. I’m not sure what, you know, especially the Poland and France, I’m not sure whether this will play, and play well.

GARRICK: How would you characterize the current mood relative to the management of nuclear waste versus what it was a few years ago? Is it on the upswing or downswing, or is it very much nation-dependent?

PESCATORE: I’m not sure of the question?

GARRICK: Well, is the mood increasing? Is the mood more against dealing with some of the nuclear issues, or is it more cooperative than it has been in the past? And, I know it’s country-dependent.

PESCATORE: That I believe is country-dependent. But, you’ve seen from this overview that perhaps if we are focusing now only on high-level waste, there is in fact more upswing, in the sense that you see that the Canadian program is now better, they’re already operating. The UK also, their program. The Belgium program, for instance. So, there is more life into this.

But, the important thing is you see I participate sometimes in national committees, and in updating documents from the past, sometimes there’s corrected documents that deal with regulations, for instance, and there are very heated debates amongst the, especially the technical folks, because right now, there is more of a sense that you have to talk to people, you have really to explain to people, to be honest with people, and some concepts have changed. For instance, there is no longer a feeling which was true I would say 15 years ago that basically you build a facility and then you go, and you leave. There is no longer this feeling. And, some of the technical folks are not willing to accept that. So, there’s more need to talk how you end the operational phase and what you do afterwards. This is, for instance, a very difficult question that some of the technical folks have difficulty listening to or discussing. Whereas, the public, they want to know this. Who has responsibility.

GARRICK: Yes. Yes, Ali?

MOSLEH: Mosleh, Board.

Two questions. One quickly, I'm not sure if you showed anything about the current level of activity in the Netherlands, and then Italy. Did you say something about that?

PESCATORE: Okay. Well, in the Netherlands, they have a policy of basically continuing to store the waste for 100 years. The interesting thing about this is that not only spent fuel or nuclear waste, it's also chemical waste, in fact. So, they have this facility. They do say that for them disposal is an option, but perhaps better can be done, or will be done. And, they continue to work, they continue to have a very small effort on disposal, because from the ethical point of view, they still see this as imperative to continue to work, to continue to lead through the generation of choice. But, also, they are looking at a solution whether, since they're a small country, whether it's possible to work with other countries to share a repository in the future. So, for them, the storage is sort of a buffer storage while strategies are developed and while not forgetting research.

For Italy, it’s very different. There is no official policy in Italy about waste, so there is no real person who is in charge of it except a military person. And, it’s not clear what--there are no strong signals that the waste management situation is going to change in Italy any time soon. Well, I cannot say much more on this.

MOSLEH: My second question is what is the level of discussion, dialogue regarding the influence of site selection in one country and another country, because, you know, there are a lot of small countries neighboring, you know, Belgium and Holland and, you know, a number of other ones. Are these part of the equation and discussion that were the site selected?

PASCATORE: The first example I have in mind to respond to your question is Germany and Switzerland. The Germans are very interested and also concerned, if you like, for what goes on in Switzerland, because the repository regions, they border with Germany. And, they worked out, the two countries, a protocol, the Swiss and the Germans, the Germans said--in fact, they even have the German Ministry of Environment. They also have a team that basically does--sort of performs assessments of the Swiss case, but at the same time, the people from the neighboring regions, they participate in the Swiss meetings, for instance, it takes place all the time. And, also it takes place all the time, people from Austria, they also go to the meetings in Switzerland. And, the Swiss are not so happy, the local ones, because they find that the Germans are too vocal. There is a different culture.

In a lot of the countries, they apply the ISPO convention, and in Finland, they wrote the environmental assessment in five languages, including Estonia, the Nordic country languages, the languages from the Baltic Sea, and invited, in fact, the governments to collect the views of their people and to give the views to them. They cannot invite the people from Estonia, but they invited the authorities. So, where there are border situations, this is how they are handled.

MOSLEH: It’s on a case by case basis?

PASCATORE: Of course, yes, because this ISPO convention only applies to them, and they use it, yes.

MOSLEH: Okay, thank you.

GARRICK: Howard?

ARNOLD: Arnold, Board.

Occasionally, periodically, the question comes up whether any country would be willing to take any other country’s nuclear waste, and obviously, the answer has always been no. But, do you see any possibility of that in the future?

PASCATORE: No, I don’t see any possibility.

GARRICK: Any questions from the Staff?

(No response.)

GARRICK: Ray, anything?

WYMER: No.

GARRICK: Okay. Well, thanks very much, Claudio.

PASCATORE: Thank you. Thank you, John.

GARRICK: We're now going to hear from Professor Hilding-Rydevik and Eva Simic. And, I will ask them to tell us a little bit about what they do and who they are, et cetera.

HILDING-RYDEVIK: Well, good afternoon, Ladies and Gentlemen. Thank you very much for giving us the opportunity from Sweden to come and give this presentation. It has been a very useful day for us, and we are bringing back a number of issues to discuss in the Swedish Nuclear Council for Nuclear Waste. We'll be performing a duet and a solo piece. Eva Simic a PhD in hydrology, and a director of the Swedish Council for Nuclear Waste, and I, being an Associate Professor in the Royal Institute of Technology and a research leader at the University of Agricultural Sciences in Oskarshamn, and also a member of the Swedish Council for six years. We will talk on the headline, Reflections on the Swedish Site Selection Process. And, then, Professor Willis Forsling will do the solo piece on the copper corrosion work.

So, the present situation in Sweden then, as also

Claudio has pointed out, is that in June this year, SKB being the implementer, the Swedish Nuclear Fuel and Waste Management Company took a position on where to put the spent nuclear fuel repository in Sweden. And, that was in the municipality Oshammar and in the Forsmark position.

So, SKB says that there's a clear advantage of the Forsmark in terms of long-term safety. And, as you see, it's about, of course, the safety issue that this place has been chosen due to its good rock conditions, its crystal and rock.

I should also say if I say something stupid about the technical issues, that I'm a social scientist, and I'm also supposed to be that on this council.

The next phase then is that SKB, by the end of 2010, will deliver the application, license application, according to the Nuclear Activities Act, and then there will be roughly about four years of review from the government authorities, from the council, et cetera. And, we think by 2017, there will be a decision from the government if everything goes well, as it has done quite a lot so far.

But, there has been a history of difficulties, and Eva will give you a few highlights from this history when it comes to the site selection process in Sweden.

SIMIC: Yes, I will talk about the basis for the Swedish program and the site selection that we covered, a period from early 1970 until the site selection started in early 2000.

I will start with a governmental study on the high-level waste from the Swedish nuclear power plants, which took place ’73 to ’76. This study proposed a number of things. To start with, it focused on reprocessing. So, it is suggested that we should have an intermediate storage for the spent nuclear fuel while waiting for the construction of reprocessing plants.

It also kept open for a direct disposal concept, and it suggested that the suitability of the rock should be investigated near the nuclear power plants in Osthammar and Oskarshamm, as well as alternative sites. And, this could be interesting since we ended up with Oskarshamm and Osthammar a few years later.

This study also proposed that the government should be engaged in the nuclear waste management in Sweden. So, we had a governmental organization formed. It was funded both by the industry and the government, or states, and it primarily was focused on geological investigations.

So, the first of these investigations started in 1977, and it was more like a research program, and the aim was to characterize the whole of the Swedish bedrock. And, I think it looked at about ten sites in Sweden.

And, in parallel with this investigation, there was also a discussion in the government, and we had a new government which decided that the states should not be involved in the nuclear waste management at all. So, in 1981, the governmental committee was dissolved, and the investigation was taken over by SKB.

There was no dialogue with local stakeholders during those investigations, and this led to an increasing opposition. So, in 1985, SKB had to stop the program. It was impossible to continue.

So, a new start was required. SKB needed to find another way, and they did. So, in 1992, they presented a new siting process based on the voluntariness and dialogue with local stakeholders. And, they sent out a letter to all municipalities in Sweden. They got positive responses from eight, distributed all over Sweden. It resulted in--well, these studies indicated that there was potentially suitable rock in all but one municipality. So, we had seven left. There were two north communities as well involved in the feasibility studies. But, they said no, we don’t want to continue. And, Osthammar and Nynashamm was part of those feasibility studies as well.

SKB also published a number of other siting studies during this period, and in the year of 2000, they proposed to conduct site investigations in three municipalities, Tierp, Osthammar and Oskarshamm. The authorities and the government had no objections to this, so they started the site investigations, but not in Tierp, since the municipality, the council declined to continue. And, that was the background.

And, what actually is the character of this process, is that it seems to be a lot of trust between all the different actors. Here, you see the mayor of Oskarshamn, who says that it was the long-term safety that determined the site, and that he has confidence both in the implementer, and in the regulator. It could have ever been said that there might be too much trust in this process. We are actually investigating that in one of our research projects, especially between the regulator and the implementer. That’s another issue.

And, when it comes to the government then, in 2008, we had a hearing on the site selection findings. You can also find the report from this hearing in English on our website, if you are interested. And, there, you heard the environmental minister say a number of things. For example, that the government wants to build this repository now, and not postpone it, and that it has to do with responsibility for future generations.

However, if you look at what the minister has said, it is a bit unclear as to what this means in relation to being able to retrieve the fuel after it has been disposed. So, this is being discussed at the moment.

He also declared that the nuclear industry has the formal responsibility, the polluter pays principle here, but that it’s also a societal issue, since we are all using the electricity that comes from the nuclear power.

So, more findings from this hearing was that all participants agreed that the safety issues of course remain the basis for the site selection. But, there were also conflicts even on how active the politicians and the government should be. As I said, the nuclear waste issue is not only a technical issue, as also Claudio said, it’s very much a political issue, and a part of the societal development. And, therefore, for example, in our council we have the social science perspective as an important one to being able to give the government advice in both technical and societal issues.

But, the question is what does the responsibility for future generations mean? Does it mean to postpone the decision and the repository, or to take it today? The difference is an opinion when it comes to that.

So, some reflections then on the very short overview we have given from the site selection process. For example, the introduction of voluntarism when it comes to municipalities, and the open dialogue that we had to introduce, or the SKB had to introduce, opened up for going ahead with the process that stopped.

And, as I said there appears to be trust among most of the stakeholders to both the implementer and the regulator. There has been some doubt, though, that the regulator actually has enough power and finances to do a proper review. But, that's also an issue that can be discussed.

NGO's had had a very important role in this process, making it democratic, raising their voices, and their participation is also today financed from the Nuclear Waste Fund.

And, the legislation, there's been changes in the legislation during these 30 years this process has been going on. For example, the introduction of the Impact Assessment demands came in 1998. That's bringing in more broad knowledge production concerning environmental and ecological issues into the process.

But, there are also unclarities in the three pieces of legislation that is to be implemented in the licensing process and decision-making process. To what extent it is the best site or sufficiently good site or the best available site that is to be reached in this process, and that will be very interesting to see how the environmental court, the authorities, and the government will interpret these three different concepts.

It's also so that the methods for the two site investigations are not exactly comparable. So, it will be difficult to actually compare these two different sites they have been drilling in.

Also, the safety analysis in the licensing application, we've only begun for the site selected, and that will be interesting to see if that's okay according to the Impact Assessment legislation.

So, a few reflections, and in many ways, this has been a successful process, but there are quite many uncertainties still to be solved.

So, maybe we will talk about that in the evening. Please, the solo piece, Willis?

FORSLING: Okay, my topic is you can say very specific, and limited in a way. But, it's still a very, very important, the concept of KBS-3, they call it, because the copper canister is actually is a key barrier in this concept, together with bentonite. And, copper actually is chosen due to its physical and chemical properties.

And, we can say that the copper canister is, we can say, an industrial product, with a far most long operational lifetime. I mean, more than 100,000 years. You have no comparison to that to date. So, it's very, very important, and that's--yes, it's chosen, as I said, because of its physical and chemical properties. It's a rather noble metal, as you know.

So, now, I will talk a little about new mechanism of copper corrosion, and I put a question mark after it.

And, I can introduce myself. I'm Willis Forsling. I'm a Professor of Inorganic Chemistry at LULU University of Technology, very far north of Sweden. And, I have been on this council for eleven years now. And, I started, I mean, my responsibility actually is, of course, chemical things and bentonite, especially bentonite, and the properties and behavior of bentonite in this repository.

There are, of course, known copper corrosion mechanisms. Copper corrodes under certain circumstances. There are, for example, sulfides, if you have a sulfide in the environment, if you have chlorides in the environment, if you have carbonates, it can corrode in neutral aerobic aqueous solutions. That is well known. Copper is a very much used material. So, it's very well known. And, also, it can be introduced by stress, granular imperfections, and pitting. And, I only give some pictures about this, and it's well known. This is the mechanism that cooper is oxidized through copper sulfide and you get hydrogen evolution, if you have--you can even have anaerobic conditions with sulfides. That may happen.

And, if you have carbonate, I mean, you have a lot of carbonate, there are cooper roofs in Sweden, you can see the color of malachite due to reactions with carbon dioxide and forming this product. So, it corrodes. But, there is aerobic condition.

And, of course, as I said, you can have pitting, intergranular corrosion, stress corrosion, cracking. I will not go into detail. But, it is well known.

But, may copper corrode in pure water under anaerobic conditions? Actually, the first time this was pointed out was 1986, it's more than 20 years ago, by an associate professor at the Royal Institute of Technology, Gunnar Hultquist. He presented an experimental study on hydrogen with a solid electrolyte probe in solution. This publication, this work was very much criticized by people from SKB, of course, and also the other people involved in this concept of KBS-3. And, I haven't the reference to these criticisms, but it's easily found in the literature.

And, then, you'll notice the comment on this, in another paper, and he complimented this hydrogen probe by spectroscopic studies, found that something happens at the surface, it is really corroding, as they say. Then, it was very silent about these things. That was before my time in the council.

But, now, recently, 2007, a paper by Peter Szakalos, Gunnar Hultquist, and Gilmer Wikmark was published in the Electrochemical and Solid-State Letters, as you can see there, where they claim that copper is corroding, and forming hydrogen, and they actually say that a new product is formed, and they call it $H_xCu(1)O_y$, but they cannot say how--

I mean, I had a lot of discussions with them, but they cannot tell exactly how it's really, how it looks like, or something like that, but they say it is there.

And, then, furthermore, they participated in a conference in 2008, I think it was, in Las Vegas, where they presented new results about these things. They have, I will not go into detail, but they found that if you keep the cooper, a small piece of cooper in an aqueous solution for a very long time, it may corrode. I think it was 15 years. It's a difference if you allow the hydrogen gas to escape, then you will have corrosion, but if you keep the hydrogen there, it will not corrode.

And, they also say that the mechanical properties of copper are reduced due to hydrogen coming into the cooper to make it more brittle. And, they show some experimental studies, and I have given some ideas of what they have--I mean, the methods, ion pump experiments, pressure gauge experiments, and spectroscopic analyses of copper surfaces, and so on, and so on.

And, what did we do then at the council? You have to react, because no only this--it was also published in the Swedish newspapers, big Swedish newspapers. I mean, they took up this and said this concept is not good. The cooper canister will corrode, and you will have big problems. I think it was, in the worst case, it was in 50 years, or 100 years, or a very short period of time.

Then, we have to, I think, as a council, we have to react on this in some way or another, not to defend SKB, that is not our main purpose, but we have to make an end of discussion, I mean, make it more open and more, let me say, avoid the biggest examinations in this. So, we commented on this article, and we replied on the thermodynamic arguments, and it shouldn’t happen, and we had a lot of discussions with these people. And, also, actually, we also sent to the newspaper and telling them we are not happy with this, we criticized it, in a way.

Then, we had, from that point, you have a lot of meetings and discussions with the researchers from KTH, the industry. We are meeting with the industry, the authorities, and also environmentalists. And, we met them and discussed with them. But, actually, we had to be careful, I mean, it’s not--as scientists and also, we are not--we don’t want to defend SKB, in a way, they must defend themselves. But, we actually want to be a capitalist for these discussions, so to say. As I told some of you, I mean, if they ask me, you can say you have to be open minded, but that doesn’t mean you have to have a hole in your head.

And, then, we are generating now an independent review, a relevant publication and report on copper corrosion. We are doing that in the council. I do it together with Professor Arno Hendenen (phonetic). He’s an expert in the council. And, now, we will also arrange an international workshop on the mechanism of copper corrosion, together with all the parties concerned. I mean, the researchers, and so on.

And, this scientific workshop will take place in Stockholm. It is the 16th of November, this year. And, we have panel members, and these panel members actually are chosen by the different parties in this. Khuan Chuah, she is chosen by people from KTH. Ron Latanision, he’s chosen by us. Digby McDonald I think by the authorities. And, Dave Shoesmith from SKB. So, we have to limit the panel members. Each of us had to select one. And, the moderator will be Rune Lagneborg, the Royal Institute of Technology. He’s a professor emeritus.

So, that is what we are doing, and how we are reflecting this new thing. I think it’s our duty to do something in this area.

Okay, thank you.

GARRICK: All right. Questions from the Board? Yes, Bill Murphy?

MURPHY: This is Bill Murphy of the Board.

One of the features of copper that lends itself to consideration as container material is its persistence in a native form in nature over geologic times. And, I’m wondering if you're aware of the occurrence of this corrosion mechanism in nature?

FORSLING: Yes, we have--actually, we have published a few things. I think you can find this report, Final Disposal of Nuclear Waste. You'll find some examples from the nature in here. And, also, we have published Final Disposal of Nuclear Waste, actually, we started the R&D program of SKB. So, in both those, you will find some of our real thinking about this, and also some questions to SKB in asking for more research, in a way. So, you're right, we have found it and we have discussed this as well.

MURPHY: Thank you.

GARRICK: Mark, Andy, and George.

ABKOWITZ: Abkowitz, Board.

I had a question about the Swedish site selection process. On your last slide, you mentioned that only now is there a formal safety analysis being conducted at the selected site. I was curious, I'm trying to understand was there not any safety analysis performed in selecting the final site, or are there different levels of detail associated with the safety analysis? Could you clarify that, please?

SIMIC: SKB will only do a full safety analysis or comprehensive safety analysis for the selected site. They will look at some important safety factors, and compare with both sites. So, that's what our site selection is based on. But, there will not be two equally extensive safety analysis for both sites in the application.

ABKOWITZ: Okay. So, if I could try to understand? Issues that have to do with the operational safety of the repository surface facilities and the actual safety analysis of putting materials into the repository and managing it over time, that's what is being done now for the selected site? Is that the comprehensive nature of it?

SIMIC: Yes, and also the long-term safety analysis is only done for the selected site.

FORSLING: Actually, I can add that we have criticized that from the council through the years. We actually wanted SKB to do a real investigation of both sites. But, I mean, some are chosen due to the property of the rock. It's very tight and very little water there compared to Oskarshamn. But, on the other hand, we have maybe a bigger stress there.

HILDING-RYDEVIK: I just want to add that we've criticized it also due to, I mean, the decision, the basis for decisions. I mean, how is it possible for a politician to take a good decision if you don't have anything to choose between. And, that's also what the politicians have asked for. They're expecting that there will be a decision basis that gives them possibility to choose between something. But, SKB and their lawyers have made another interpretation of, for example, impact assessment legislation. So, they're only handing in one site. So, it's going to be interesting to see if the environmental court will judge this as efficient.

GARRICK: Okay, Andy?

KADAK: Kadak, Board.

I'm trying to follow up the lessons learned again from my previous question. Why was it that the government decided that they should not be involved in the siting of a repository, and gave it back to private industry?

SIMIC: I don't know really, but I think it was part of the early legislation to start the nuclear power plants in Sweden, and it was a way for the government to--well, I'm not sure if I gave you the right answer now. But, they wanted to have a clear distinction of roles, so they think that industry and the principal, that they should really take full responsibility for developing a method for the final repository. And, then, the government and the authorities would do the legislation and review.

KADAK: And, the private company gets the money to study or do whatever it needs to do from the utilities. It doesn't pass through the government hands for the funds to do the studies and development; is that correct?

SIMIC: We have a waste fund, and it is the authority that determines the fee that should be paid per kilowatt hour for energy produced.

KADAK: But, again, I'm trying to distinguish between what we do in our country and what apparently works in your country. It doesn't work in our country. And, that is the government collects the waste fee from the utilities in your country, and it is only that which is needed to conduct next year or the next couple of year's work, as opposed to collecting the waste fee, using it to balance the federal budget, or your budget, and then giving only a little bit to the developer. I mean, can you explain that a little bit?

SIMIC: It's not the government that collects the money. It's a separate fund, and it's controlled by a separate institution.

KADAK: Yes. Yes. And, one final question, if I may, Mr. Chairman? When we were in Sweden, we were trying to understand what the standard was that the repository had to meet in terms of is it a risk based standard, is it a dose based standard, is it an isotope standard, and the duration. And, it wasn't very clear, at least my recollection was it was a rolling standard. Let's do what we think we know how to do, and then defend that before we make a commitment to, say, to some absolute number. Can you explain the standard process?

SIMIC: It is a risk based.

KADAK: It is a risk based standard?

SIMIC: Yes.

KADAK: For how long? Timeline?

PESCATORE: It is risk based, but at least for the first 1000 years, 1000 years is tied to risk, which in fact comes to less than 10 micros per year if you do the conversion. But, then, I think it is not as strong, and you have to use what is called optimization arguments. Optimization arguments based on a quantitative analysis, and this goes up to I don’t recall now, it’s like 100,000 years. And, then, afterwards, you have to do qualitative analysis in terms of what are called the best available technology. So, we have only to show that you did the best you could. And, that is seen as part of the radiological protection. So, they have three, in fact, it’s evolving standards with respect to what you can really say you’ll be doing.

KADAK: Thank you.

GARRICK: Okay, George?

HORNBERGER: Sweden has been, throughout the history, has been very open with international collaboration, and of course the international community has gained a lot. I was wondering if you could say a few words as to how, if and how the international collaboration has been important for Sweden, and perhaps for the other countries as well in Europe?

FORSLING: It’s always important to have collaboration.

That is for sure. And, I think this--actually, we have, we can say, a laboratory on the ground at Dorotea, maybe some of you have been there. You know that it’s a lot of international experiments going on there. And, of course--not we, but SKB will gain from this in their research as well. So, I think we can say that we have gained a lot also from other countries.

HORNBERGER: Is there any gain in terms of public perception of having international collaboration, more from the social science side, I mean, I understand the hard science, the papers get written, but I was just wondering, you outlined the acceptance ideas. Do the international collaboration or reviews play into that at all?

HILDING-RYDEVIK: Well, my impression is that the international collaboration is important for the NGO’s and their knowledge basis, because they’re quite aware of what’s happening internationally. But, I mean, for the local citizens, I don’t think that makes a difference. So, it’s mainly for the NGO’s, and especially now when they have quite good funding for their participation.

GARRICK: Carl DiBella?

DI BELLA: Carl DiBella, Board Staff.

This is a question for Willis on the copper corrosion issue. The copper corrosion claim has been out there for over 20 years, as you pointed out. It would seem to me in that period of time, there would have been some attempts to replicate the experiments. And, I'm wondering have there been such attempts, and what do they show?

FORSLING: I think you are right. We have been asking the same question, of course. But, I know that SKB, they have done some experiments. They have done some with--I don't know how you translate that, but it's independent of SKB. They have also done some experiments, and they couldn't repeat that. Of course, that's a problem for these researchers, but still, I want to be, as I said, open to this, and I want to--I mean, it may be some catalytic reaction. I mean, the copper itself, maybe it's not reacting thermodynamically, but you may have some surface property.

HILDING-RYDEVIK: Can I just add from a knowledge production perspective, we've put forward a critique to SKB and the Swedish government that there's actually being too little research, both on the technical and natural science and social science side, that could parallel SKB's research. So, it means that SKB is actually the only one doing research and making the knowledge input in this field, basically. This copper corrosion piece is one example of where we have had other kinds of research. But, the government hasn't listened to this critique yet.

GARRICK: Yes, Andy?

KADAK: We spent all morning talking about reprocessing, and you as a country decided you’re not going to do that. Are you thinking about revisiting that question, or not?

FORSLING: It’s not a big issue just now, but of course you can retrieve this maybe in the future, I mean, this spent nuclear fuel. But, it’s not the big thing. For us in the council, it has been more important to solve this problem in this generation. We don’t want to leave it to the next generation to solve it for us. We have used this energy. We want to solve it.

KADAK: And, as I understand it, the Swedish government, I just read something that says that they need nuclear, and they will not be shutting down more plants. But, are they building, or thinking about building new plants?

FORSLING: I don’t really think so. But, we can say that the government we have today, they are open for continuing. I mean, at least repairing or something, doing something with the plants we already have, not end up with new nuclear power in Sweden, as before. So, it has been opened up, maybe, in the very long run for new plants. But, just now, it’s not discussed. I think it’s not a good thing to discuss it just now.

GARRICK: Okay. Any other questions? Yes?

PESCATORE: I believe it’s--

GARRICK: You’re supposed to provide the answers.

PESCATORE: Yes, I’m sorry. One part of the answer is also that in Sweden, in fact, they had this decision to phase out nuclear, and this decision was recognized a few years ago in a workshop also by SKB, is one that helps in the problem going forward, that is, people feel that they have used the energy, okay, no more power, but, you know, the waste is to be taken care of. So, there is a sense of responsibility. Somehow this closing of, or phasing out the nuclear, does play a role in the conscience of people. So, if they open now nuclear, perhaps it also changes the equation in terms of going forward.

HILDING-RYDEVIK: Just to add, but it’s this phasing out that has been changed now by the new government.

PESCATORE: But, not going forward. They’re only basically saying okay, we increase the power, and the lengths of the operating lifetime is longer. So, you increased the amount of nuclear they have in the country, but it’s not new nuclear. In fact, they shut down one plant because of the old decision.

GARRICK: Okay. Oh, Eva, go ahead.

SIMIC: I just want to clarify that the government has actually opened up to build new reactors of the same kind as we already have. But, since we cannot prolong the reactors we have for how long, well, they have opened up for new reactors, but not new technology.

GARRICK: Okay. Well, we want to thank you very much.

It was a refreshing addition to our agenda. You've come a long ways. You haven't adjusted to the time change yet, and now you can go back and adjust again. We appreciate it very much, and we're looking forward to spending some more time with you.

Now, we come to the part of our program that is the public comment period, and we have two people that have signed up, and the first one is Brian O'Connell.

O'CONNELL: Thank you very much. My name is Brian O'Connell. I'm here on behalf of Leon Niehouse (phonetic). Leon contacted me shortly after the announcement of the termination of the Yucca Mountain program, and he was very concerned about what the country was going to do, and I said, "Well, there will be a Blue Ribbon Commission. You can present your ideas to that Commission."

Well, since that Commission hasn't formed and you are in existence, I thought I would suggest to him that he pass on his ideas to the Board. And, I will just introduce him. He's with the Durajo Energy Institute of Maine. He has a degree in physics, an MBA, served seven years in the U.S. Navy's Nuclear Submarine Program, worked seven years in the commercial nuclear power, has been employed for over 30 years in the shipbuilding industry, and has started the Durajo Energy Institute, whose present project is to investigate using distance as a failsafe barrier to protect the health and safety of the general public from the affects of unexpected or improbable events associated with commercial spent nuclear fuel.

The project is described in this proposal, which I will give to the Board, entitled Mooring Fields for the Interim Storage, or I should say Managed Storage of Commercial Spent Nuclear Fuel. Three copies will be left with the Board.

This may be an old idea that has been looked at before, but it's coming from a fresh look, and it's certainly worthy of consideration by the Board, and he would appreciate anything that you can provide to him.

Thank you.

GARRICK: Thank you. Our second member here is an old friend of the Board, and, in fact, a former member of the Board, Dick Parizek.

PARIZEK: I appreciate the chance to comment briefly. I want to congratulate the Chairman of the Board and the Staff for the development of the priority goals. It lays a path forward of activities that really are relevant to this whole operation.

I had a question for Dorothy Davidson with regard to the Carbon-14 releases. The implication was it would go up the stack, but there would be some possibility of mixing with the CO2, and maybe not having much CO2 go up the stack.

But, how much CO2 goes up the stack? We often have to defend or discuss nuclear energy advantage about having CO2 releases appear at the coal-fired plants and gas-fired plants. Do we have a number for that? I mean, I don't know whether it's a small number or not. It's a tiny number, but it's not zero; right?

The other observation was the statement by Dr. Moniz about there's no urgency to have a repository. The implication was at the end of his comment that we really shouldn't leave the wastes where they are, but he didn't say where they should go. Maybe that was going to be interim storage somewhere. But, on the other hand, it seems to me it weakens the argument that there's a need for a repository, because a policy comes out and says well, we don't have to do anything, maybe postpone this thing indefinitely, and we have heard today good reasons why a repository ought to progress, and progress ought to be made in that direct.

So, I was just following on Rod Ewing's statement, he said, you know, I'm not going to spend much time betting on a dead horse, or spending much time evaluating a horse that's not going to come out of the barn.

But, isn't really the recycling, reprocessing a horse that's in the barn, for the moment, I mean, it was the present, they said we're not doing that; right? But, we're discussing it today, we would do this.

So, it seems to me if that's worth discussing, it's surely worth discussing keeping a repository program alive. A lot of money has been spent on it, and clearly, to have it cancelled because maybe there's no technical support for it, no ground support for it, would be basically a bad use of our time and our money as a nation.

We've got all this investment. We've got a lot of science. NRC ought to go through its process and some sort of decision ought to be made at the end. And, even if we don't use the repository for a period, perhaps like the German program, you resurrect it at some day in the future. So, it seems to me those are the kind of comments that I would like to share with the group.

GARRICK: Thank you very much, Dick.

Is there anybody else? Ray, do you have any comment that you would like to make at this point?

WYMER: No, mine would be closely related to specific technical input on reprocessing. But, this is not the appropriate time.

GARRICK: Right. Okay, any other questions from anybody?

(No response.)

GARRICK: Then, I think we have had a very good day. I want to thank all of the presenters, the questioners. I think this was an excellent example of how we can change our course a little bit, and have a very productive exchange. We appreciate it very much.

Then, the meeting is adjourned.

(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 Winter Board Meeting held on September 23, 2009 in National Harbor, Maryland taken from the electronic recording of proceedings in the above-entitled matter.

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