UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

WORKSHOP

On Evaluation of Waste Streams Associated with LWR Fuel Cycle Options

Tuesday

June 7, 2011

Hilton Arlington Hotel
950 North Stafford Street
Arlington, Virginia, USA 22203

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I N D E X

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P R O C E E D I N G S

9:00 a.m.

ABKOWITZ: Between that and the coffee, hopefully that will get us going here a little bit faster. I want to welcome everyone back to Day 2 of our Workshop. We have a pretty busy agenda today, especially given some additions that we've made based on yesterday's conversations. So, we'll launch right into it right now.

On the formal program, the first session is on the Phase 4 analysis. We're going to put a couple of things in front of that. You may recall yesterday that there was discussion about other benchmarking exercises that have been performed recently by various organizations for various reasons. And, there are three that were brought forward: one, the IAEA; another by NEA; and one performed by MIT. And, both Steven and Eugene have been gracious enough to be willing to share their thoughts on those experiences, what was discovered and how it relates to what we're trying to do here.

So, I'm going to turn it over to Steven to start off with the IAEA and NEA discussion, and then Eugene on the MIT side of things.

PIET: I got a few slides from one of my colleagues, Brett Dixon, who has been involved with actually all three of the benchmarks that you mentioned, and so I'll do a few slides here that he sent me last night that we've talked about.

So, background that Brett put together, this was two years ago, system codes, like we've been talking about, are difficult to verify. No surprise. Benchmarking provides one of the means for doing data validation. If you can't do the experiment of going 50, 100 years into the future, how do you validate. You can go backwards, but I can always trittle a code to reproduce history.

VISION has been benchmarked in two separate activities, the NEA benchmark, the MIT benchmark, and I guess, Eugene, you'll talk more about this.

There was also an IAEA benchmark that we put a lot of time into, but Brett believes, and I agree with him, it will never get finished. It actually got too complicated, took too long, and the key person at the IAEA moved on to other activities. So, it's just going to dock. It's too bad. One of the things that was in that particular exercise was heavy water basis that hadn't been in some of the other ones.

The NEA benchmark--I'm not too good at this thing--had three cases, an open cycle, just once through, mono recycling, or a single recycle of plutonium and PWRs as MOX, very similar to what we'll be discussing later today, and then the same thing as this, followed by fast reactors. So, this is very similar to GNEP option space.

Benchmark specifications took several iterations. They grew, they became many, many pages long, specified all the reactor properties, the core properties, the fuel, input/output, compositions, the schedule for when separation plants would come online, and specified electricity production year by year.

What they looked at was natural uranium, SWUs, fuel fabrication and flows, inventories, various places in the system, how much fuel was separated, mass flows, and so forth.

What's not on this list, what is unique about the benchmark here is more focused on individual isotopes. So, no two benchmarks, just like no two codes, are exactly the same. Different people have set them up to look at different things. This was really focused on what's going on with the reactors more than anything else. Yeah, they talked about storage, but the real focus in the discussions and the iterations was why were you getting different numbers of reactors and a different amount of fuel.

So, the first case was an open cycle. For some strange reason, they don't care about US graph, which of course is something different about this benchmark. So, it was a very exciting scenario there, constant electricity for 120 years. VISION at the time only did 100 years, so that gave us some headaches. We had to change the model so it could further.

The second case was almost as exciting. There was a phase-in with MOX, and then 115 years with MOX and UOX. And, then a fast reactor scenario. I never understood why they did this. They had this specification of MOX coming in, phasing out, and then fast reactors coming in. I don’t have a clue why someone dreamed that up, which is my way of saying don’t ask me because I don’t know.

So, some of the conclusions to be drawn from this, benchmarking is not easy. It is simply not easy. Even a simple case ended up requiring many pages of input. There’s always differences of interpretation that require iteration of specifications. Once we got through all that, all the codes did demonstrate similar behavior, especially when we realized that the purpose of these codes is not am I going to get ten grams of this and twelve grams of that. That’s not what these codes are all about. These codes are looking at what is the behavior of the system, or possible system. Where are the choke points. Where do you get into trouble. Where do you--where do things break down. Where is it fragile. Not the exact numbers, none of these are really designed to say oh, twelve grams versus ten grams.

Basically, differences tended to be traced back to, gee, I got more time steps here, or less time steps there, and none of the benchmarks tend to deal with the advanced features of models. VISION, I don't know about the other models, VISION will--I can run it in two ways. I can tell it, for example, in introducing MOX or introducing fast reactors, I can tell it I want you to build exactly this profile of reactors. I can do that.

But, the real part of the code is when you let the model, using various algorithms, see how the system naturally should evolve over time, because then you learn more about the dynamic behavior of this option versus that option.

And, so, benchmarks, you generally throw all those advanced features off. You've done down the model in order to force a consistent behavior, the same sort of situation.

And, so, what we really ought to be doing, personal opinion, is understanding whether different models are telling us the same thing about fuel cycles. How fast can they be introduced? And, I'll leave you with an analogy that I've come up with. I used to fly a twin seat plane, single engine plane. Well, a fuel cycle is like I'm taking off, I'm flying somewhere, but I don't know where I'm going. And, I move the stick, or I change the throttle, and nothing happens for 20 years, and it's dark and it's raining outside, and oh, by the way, I'm not the only pilot. There's these guys from AREVA, and these guys from NRC, and everybody else and we're all trying to fight over the controls of this airplane, and we don’t even know where we’re going. That’s what a fuel cycle is. And, that’s what playing with these models over time tells you.

ABKOWITZ: Thank you, Steven, for such a rosy picture. I think we have a collective identity crisis now.

Let me ask a question, and then we’ve got Andy and some others. This is now your third, fourth, fifth benchmarking exercise, depending upon how you count, I guess. I think you’ve identified for us some of the things that are valuable and some of the things that we’ll never accomplish.

Do you have any general guidance going forward for a better way to do these kinds of things in the future? Because, I mean, at the other end of the spectrum are, you know, policymakers and technical analysts who are trying to come to terms with where the airplane should go.

PIET: Right. I don’t have a simple answer. At least I haven’t dreamed up one. Any of these models, any of these benchmarks, you need to first think what do I want from the model or models. Then, what sets of things can I do to convince myself that the models are telling me what I need to do?

Now, of course, none of the international benchmarks care a whiffle about US parameters. Okay? So, one of the things that was valuable for me in playing the models through these scenarios was I spent more time on US history than I have before.

One of the reasons I sort of kind of blew off the 32 and 39 historical benchmark--burnup, as part of the benchmark is I wanted to see how well the model could replicate the history. So, I gave it a histogram and played around with it. That gave me more confidence that I had a reasonable way of approaching the last 40, 50 years of the US. So, that gave me more confidence in certain things about our model.

So, what are you really looking for from the model? I submit if it’s ten grams versus twelve grams of isotope X, and 40 years, this isn’t the way to get there. So, what are you looking for? And, then, what sets of things do you need to do to get there? Now, VISION was put together to look at the range of parameters necessary to judge fuel cycles, with relatively less emphasis on what’s certain, as I said yesterday, so you have to decide what that emphasis is.

If you want to get into see how much in this fuel cycle, how much is going to produce low-level waste or high-level waste, or greater than Class C, these models can tell you that with the right input, but it really comes down to what is the right input, and these models can’t tell you what the right input parameters are. That’s another set of questions, and my other talks today will get into that. So, I don’t have a simple answer to the problem.

ABKOWITZ: Okay. Andy?

KADAK: Kadak, Board.

In terms of the second bullet and the models that were run, was there any, when you say significant difference in, say, if they're looking at numbers of reactors, that were meaningful in terms of this benchmark?

PIET: (Nods head no.)

KADAK: In other words, would one say, well, we needed 15 reactors when only ten were required? So, there's no statistically significant difference?

Now, if you can go back to the slide that talks about the last one with fast reactor introduction, I just want to speculate on--I'm going to reason why they phase out MOX. We had a conversation last evening about this. And, my sense is it's probably due to this availability of plutonium for feed stock for fast reactors, but perhaps AREVA can validate that, or others. Because the MIT study was criticized because we didn't go into a MOX cycle first. We proposed directly going to a high enriched uranium start-up core, with then recycling the bred fuel. Could that be a possible explanation for that?

PIET: I'm not in a position to speculate on that.

KADAK: Okay.

PIET: One of the issues that we try to look at in our model is that facilities, not just reactors, but all the facilities in a fuel cycle have a finite lifetime. And, when I look at this type of thing and say well, gee, that sort of implies I built a whole MOX infrastructure and am going to run it for 70 years, are we're going to run these plants for 35 years and replace it halfway through?

One of the things that you may, when you conjure up some of these fuel cycles, is if you're not careful, you end up specifying something where a given real facility, implied by that model, would have a ridiculously long and a ridiculously short lifetime. I'm not going to build a MOX fabrication and separation plant and only run it for 20 years. That would be kind of stupid. So, you need to, at some point, think through how you're going to do things from the standpoint of real facilities, and how am I going to stage them, how long are they going to last?

KADAK: And, these models didn't include any economics?

PIET: No.

KADAK: Just benchmarks, okay.

PIET: Some of the models can do that, although when you go into an international benchmark, then, you know, what currency are you messing with.

KADAK: All right.

ABKOWITZ: Any other Board member questions? I know Andy would like to speak. Changing microphones today, I see.

WORRALL: I think Steve has made a really important point, in that the industrial experience and expertise into these fuel cycle models is imperative. It's things like, for example, claiming crazy separation factors of the efficiency of a reprocessing plant. You've got to ask the guys from AREVA, because if you don't get that right, it can give you all sorts of crazy ideas and numbers, have bigger reprocessing plant, can really be-- can be 2000 tons a year or 20,000, you know, you see some of these scenarios, crazy things, that's not going to happen either. So, that's why you need the input of an AREVA or a reactor vendor, a fuel manufacturer.

But, flip that around a little bit, is that these models can go also, therefore, help inform the industry, and that's the other way around, I think. Sometimes it's the tail can wag the dog, but sometimes the dog has to wag the tail, because, for example, it's a bit like a safeguards by design approach. You could almost go through this kind of analysis, and certainly then says this suggests we need a fuel plant that's 2000 tons. Well, maybe that is possible. You know, it just kind of begins to make the industry think a little bit differently.

You know, you achieved this success, whatever this success may be, this is what the industry needs to look towards achieving, is that actually achievable, and it just makes things--it's just in--form, the industry a little bit, too. You know, looking at things like, you mentioned a MOX fabrication facility. Can it last for 40 years? Well, maybe and maybe not. Go and ask the guys who know, ask AREVA or anybody else. Maybe they could stretch to 50 years. And, if you could stretch to 50 years, then it will save you the cost of, you know, 4.6 billion, whatever the, you know, M triple F is running at the moment. You could say you've got a refit would be the obvious thing to do instead, so you can look at a refit, because it's only stretching it by ten years.

So, it does work both ways, but I think it's really important, though, Steve raised a really important point, these things must be real, fed into by the industry, and don't let some crazy decision be made by these modelers. You know, that's what could happen.

ABKOWITZ: Thank you. Given that unpaid commercial advertisement, Paul, do you want to comment on the willingness of AREVA to participate in the manner in which Andy would like?

MURRAY: Okay, Paul Murray from AREVA. Most people know me in this room.

Yeah, we're willing to participate, but, you know, I can answer the question there quite simply by the MOX--tail it off. If you were supplying MOX to light-water reactors, at some point, you've got to switch over to supplying the plutonium to fast reactors, so you've got to slowly tail off one customer and build up another customer. So, that’s probably why you tail off. Yes, we participate, but we’re industry, we know how to build things. So, as long as you stay based in reality, we’ll support you. But, when you start talking about fast reactors, very high temperature reactors, molten salt reactors, some future fuel cycle, we can’t help.

ABKOWITZ: I think one of the interesting ways you might be able to help is establishing what I guess I would refer to as boundary conditions.

MURRAY: Yes.

ABKOWITZ: Giving some sense as to where the exploratory thinking should stop, because it just gets into craziness.

MURRAY: I could give a really good example of that. Is in obvious models and various programs produced, and Steve, you’ve heard me many times talk about this, the transition scenario is going to drive everything. It’s one of the big problems we have. We’re currently in one fuel cycle today, and a lot of these models just instantaneously change over to a new fuel cycle, and all of a sudden, we’ve got 50 sodium reactors going, and all the light-water reactors have disappeared.

That’s not going to happen. We’re going to transition over to a new fuel cycle over hundreds of years, and we’re going to change all the time as we transition. We don’t have to commit to any one fuel cycle. And, that’s the big thing that’s missing from these models. The further you get, the more flights of fancy you get.

ABKOWITZ: Howard?

ARNOLD: As a long-time employee of another industrial company, I want to make sure that you understand the utilities don’t buy a plant until they have seen one like it operate.

ABKOWITZ: Ron?

LATANISION: Mark, it seems to me that what’s emerging from all these conversations is that we have at this table the participants, a group of people which has a very definite--each of which has a very definite sort of agenda and constituencies. I mean, you’re interest in--

ABKOWITZ: You’re saying that in a positive way?

LATANISION: In a positive way. Oh, absolutely. But, your interest is in recycling. Your focus may be on advanced fuel cycles. And, you know, we have the skills on that table to do almost anything that’s of interest. But, what’s missing is to frame the question in a way that’s tractable. What are we really trying to answer? What is the question we really want to get? I think that’s what you were saying, Steve.

I’m convinced that the skills to answer almost any question that’s of interest to us, probably are represented on that table. But, I think--

ABKOWITZ: And, if not, in the room altogether.

LATANISION: Well, yeah. But, I mean, I think the challenge for this workshop ought to be to frame a question that is of interest to everyone who is here, and then to decide perhaps not at this--at the conclusion of the workshop, but maybe in the next step. But, I think this may be the first step in the development of something that may be useful to the whole industry, to DOE and to the NRC. Let's frame the question in a way that makes sense.

ABKOWITZ: I think that's an excellent observation. I see Nigel scribbling fast here, because--

MOTE: It's chicken scratch.

ABKOWITZ: Okay. But, the purpose of the last session in this workshop, Where Do We Go From Here, I think that's a very legitimate issue to raise.

Thank you.

MURRAY: May I just make one comment?

ABKOWITZ: Sure. If you could come to the microphone?

MURRAY: The actual workshop you're doing in really, really important to industry. That's why we're here to support it, because as industry, GNEP, we all ran our codes and our analysis for the waste, and we all came up with different answers. And, even the Blue Ribbon Commission said, you know, as industry, why can't you give a consistent answer. So, the work you're doing here today is really, really important to industry.

ABKOWITZ: Thank you.

PIET: One thing I would add to what Paul said--two things. I'm a little more optimistic on advanced reactors than I think you are. But, we can debate that over a beer or wine. But, one of the ways we should, but don't, assess fuel cycles is how much a given choice along the way opens or closes doors, flexibility. So, at least we agree on that score.

There is the agility of the system. None of us know what's going to happen five years or ten, twenty years with regard to uranium. Now, I can talk to five different people that will tell you five different things on uranium. The waste management rules, we know what the rules are today, what are they going to be twenty years from now?

ABKOWITZ: Probably--well, never mind. Just look where they were twenty years ago.

PIET: Right. So, we can make choices that increase or decrease flexibility, agility. That's something we need to do more thinking about.

ABKOWITZ: Okay, thank you. Eugene, do you want to follow on this?

SHWAGERAUS: I want to preemptively apologize for not probably providing all the answers to questions that might follow because I wasn't directly involved with this benchmark.

ABKOWITZ: We also only gave you 18 hours.

SHWAGERAUS: So, a few years ago, I guess three, 2008, or so, there was another attempt to benchmark various codes. It was initiated by MIT. That was the first time that a CAFCA code was compared to other codes. There were four participants, COSI code from CEA, VISION, DANESSE from Argonne, and CAFCA. All these codes have, as you know by now, they all have different levels of complexity for their models and assumptions and things that they can do.

And, the benchmark compared only common capabilities of the codes. Obviously, there's one more thing that all codes could do, which is economics, but that wasn't part of that particular benchmark.

There were three scenarios with three different fuel cycle scenarios that involved light-water reactors, light-water reactors with MOX, and fast reactors with different conversion ratios, with different combinations to, you know, to light-water reactors, followed by fast reactor with conversion ratio one, which is a self-sustainable fuel cycle, that was one of them.

A two-tier scenario, something similar to that where you start with recycling PWR fuel in the form of MOX and then that followed by a fast reactor with different conversion ratios.

So, there were three of those, I don’t remember exactly how they were put together or formulated, which conversion ratio would work, two-tier or one-tier.

And, there were three prescribed energy growth scenarios: no growth, modest, and ambitious. The report, by the way, the benchmark was eventually summarized in the MIT report, which is available, and I can give you reference for those who are interested, or just send you an executive summary of that report.

And, the conclusions are very similar to what Steve has been describing. All codes, if you sufficiently tune the assumptions, will give you the same answer. So, if you prescribe a recipe of how you built things to the extreme level of details, all codes will give you exactly the same answer.

If you let codes decide based on their internal logic whether it’s hard wired or user specified, it’s prone to interpretations, also some internal assumptions that discrepancies can be large, and they were observed to be large.

But, if sufficient effort was put into sort of free iterating these assumptions, the agreement could be exceptionally good. So, that gave confidence that if we model the same thing, we’ll get the same answer. And, even if not, as Steve also pointed out, all codes gave the same trends, which is what you would, from the beginning, want from these types of tools. You're not looking for a specific number, you know, this many grams, that many grams. You want to know how the system behaves, whether it will go up and down, at least.

My view of how the ultimate dream code should look like and what type of things it should provide, and I don't have all the answers, or I don't have a clue how to get there, but everything that we put in has enormous uncertainty, which almost adheres to my answers, basically what does it mean if I have an answer, like number three, what does it mean. And, it could be plus or minus 100 percent, so what do I learn from this. So, some of the outcomes of this benchmark, one of the outcomes is that whether things go up and down, is already--that already has a value. It already tells you something.

So, how to incorporate these enormous uncertainties that basically every input parameter that you can put in, how does that affect what the behavior of the system, what time would be. I don't know how to get there, and formulating questions also was pointed out already today, is a crucial thing. What do I want to know? Because if we can specify fitness function to a complex system that can give you many outputs, and for this benchmark, it was again a list of these parameters, you know, how many kilograms of TRU in storage, how many separate work units you need of natural uranium, and how many reactors and reprocessing capacities. All those were included and given sufficient effort to put all the initial assumptions in line between participants, you will get good agreement.

So, formulating the answers and how to incorporate uncertainties in this analysis I think is important challenges that need to be addressed in the future, in future codes.

ABKOWITZ: Thank you. Ali, you had a comment or question, please?

MOSLEH: Yes, a question. This is Mosleh, Board.

On this benchmark you just described, was the convergence a result of specifying the input or did it also require changing the code to comply?

SHWAGERAUS: The models in all these codes have different structure. So, maintaining, for example, constant capacity for codes like COSI, which is not a constant--which follows batches, unlike other codes that can do continuous mass flow, were some of the things that were difficult but not impossible to overcome. And, that resulted in some oscillatory behavior because you’re approximating something constant or a smooth function with discrete batches. You know, some codes account--the simple way of accounting things on the 1st of January versus the 31st of December--

PIET: That was one of them.

SHWAGERAUS: --you know, things like that were discovered over and over again, and helped to understand where all these differences came from. Another important outcome, I would say, is that although notable differences were observed in some cases where not that many iterations were made to make them converge on the same answer, the source of these discrepancies was pretty well understood, I think. And, it all boiled down to these initial assumptions or the way how different codes approached modeling different things.

ABKOWITZ: My take-away from this conversation, which I think has been a really important conversation, is that the modeling community is--its capability is at a reasonably decent level, and it’s really more a matter, as Ron said, of framing the question and trying to focus on what the performance measures are, if you will, that address the question appropriately.

PIET: Yes.

ABKOWITZ: And, so, you’re basically sitting there on a toolbox looking for better guidance on where you should be applying your trade.

SHWAGERAUS: Yeah, tell us what you want.

ABKOWITZ: Yeah.

PIET: And, sometimes better data.

ABKOWITZ: Right. Well, that gets back to the issue of uncertainty. Although I will say that I think there's a danger in trying to develop models that are too sophisticated.

PIET: Yes.

ABKOWITZ: Because when you do that, you introduce that many more parameters that you don't have a lot of confidence in, so you create a perception that you're modeling things with more precision when, in fact, you're introducing opportunities for more errors that actually have a chance to multiply more aggressively.

SHWAGERAUS: Yes, absolutely.

ABKOWITZ: Any other comments or questions on the benchmark review?

(No response.)

ABKOWITZ: Thank you, both of you, for your willingness to do this. I'm going to turn the program over to Nigel Mote, who will be moderating the next session.

MOTE: We are going to pick up now from where we left off yesterday a little early, and see if we can't bring today in early as well.

And, yesterday, we changed the order of the presenters from the participants, and today, we're going to mix it up a little bit. So, we're going to start this one with Gene, and then run down the order that you have them on the--actually, the way they are on the Excel spreadsheet now, turned into a PDF on the full screen there.

So, Gene, is it best to run through all six first, or just--yeah, let's do all six for each of the participants in order.

ROWE: Okay, the first couple of slides are just going to be copies of what's on the screen on the right side, just the results. You will notice that I've got some of the boxes colored yellow. Those are the actual values that we requested from each of the companies.

I did one other set of scenarios, okay, which are the ones that don't have the yellow boxes. And, the reason for that will become more obvious on the next slide. This is showing the uranium savings. And, there's been a lot of discussion on the amount of uranium savings, and I can give you any number from 5 to 60 percent uranium savings, depending on what the assumptions are.

And, so, the reason that I added this second scenario down at the bottom is to show you the variation. They both use the 3000 metric ton capacity, but if you will notice, I have also added another column, the third column over, which is the actual fabrication mass. Okay? And, I did some analysis a while back and I came up with a new term, and that was what it was is the ratio of the reprocessing mass to the fabrication mass. Okay? So, that if those masses are equal, basically, and I don't like to use the word "steady state," but you're reprocessing everything you're discharging, and then you're refabricating the assemblies to compensate for those that you have discharged.

And, the curve was very interesting. It was a very straight line, and it showed that as the reprocessing capacity--as the ratio of reprocessing to fabrication goes above one, okay, i.e. you have higher reprocessing capacity than what your actual need is, i.e. you're reprocessing inventory not just what you're discharging this year, then the uranium savings goes up, and it's almost a linear function.

And, so, the reason I showed this is if you'll look at the second, this bar here, you can see that the amount of mass that was reprocessed is considerably larger than the amount of need of reprocessed mass. And, therefore, you'll get very high uranium reduction.

On the bottom three lines, you can see that as the actual reprocessing mass goes down, your fabrication mass is about the same, but your uranium savings goes down significantly. And, I mean, it's pretty obvious, I think, that that should be the case, but I think this illustrates that point quite well.

The table on the right is another table that I added, just to show you what the percentage of reprocessed PWR assemblies are. And, again, as the percentage of reprocessed assemblies goes up, obviously your percent uranium reduction goes up also. So, I think it's pretty obvious, but I think these numbers clarify it quite well.

I'm not going to spend a lot of time on these. Again, these are the numbers that show up on the spreadsheet on the right screen. Reasonable agreement with some of the other vendors, and we'll talk about that sheet later probably. Let's go to the next one.

Same thing. The numbers are just transposed over into the other spreadsheet. Next one? Okay, this shows, again, the process that's actually happening here. The red dotted line is the total metric tons discharged. The solid red line is the total metric tons in inventory. The green line is the number of metric tons reprocessed. And, I show the purple line also just because it happens to be part of this report, but it's an interesting one that shows how many dry storage casks you have in storage.

And, for the 1500 metric tons case, as we all know, we end up with less reprocessing capacity than the amount that we're discharging. So, we never run out. So, we saturate at 1500, and those can stay constant throughout the life of the analysis. Go to the next one.

This shows the overall mass flow of this particular scenario, and it shows several things. In this one, we have also added these little yellow barrels, the amount of low-level waste that's generated from each of the processes. And, I categorized it as to the various categories in the US, mixed greater than Class C, greater than Class C, low-level waste and mixed low-level waste. And, so, I do try to capture the amount of low-level waste that's being generated.

As I said yesterday, from this graph, you can go and you can draw a circle around any of these nodes, and you can do a mass balance and that mass balance comes out, but I think we all know what the actual material flows are. So, I won't go into anymore.

ABKOWITZ: Gene, can you go back to that slide for a minute? This question may come up later. You've got one very large number in the low-level waste category that comes out of reprocessing. Can you talk a little bit about how that's generated?

ROWE: Okay, the basis for the calculation is an analysis done by Savannah River. I think a lot of the people are probably familiar with that. Savannah River did some estimations of the various categories of low-level waste based on various reprocessing techniques.

And, the last slide that I had yesterday in the overview, I showed you one of those graphs that came out of that report. It was a curve that showed, as you increased the capacity or the mass per year, then the amount of low-level waste decreases per unit mass. And, I used those curves for this calculation.

One of the Board members had some questions on this, and these numbers appeared to be--this number--sorry, go back one--this number here was questioned because it was quite a bit higher than what AREVA had been reporting. And, I have some other slides that if we need to get into that level of detail, but this is an uncompacted number, and I requested from Paul some information on compaction ratios.

And based on the compaction ratio of six, this number differs from the AREVA number by 7 percent. And, that is, first of all, the low-level waste calculation is extremely difficult to do. There’s a whole bunch of variables in it. And, so, I figured two completely independent calculations that agree within 7 percent, I’m happy with that. I’ve very happy with that.

So, I think this number, it is large, but I think it is a reasonable approximation of what the amount of low-level waste generated is. And, like I said, I can go through that in more detail if you like, Andy.

KADAK: Well, maybe Marie-Anne, if we can plug your computer in, we can do a spot check.

ABKOWITZ: Let me just ask quickly. Is a compaction ratio of 6 within the boundary conditions of reality?

ROWE: (Nods head yes.)

ABKOWITZ: Okay.

BRUDIEU: Just to add on that, it depends on which waste are you talking about, not out of the low-level waste is going to be able to be compacted, you know, I mean whether it's based on what material you use, and also what the radioactivity level, sometimes compaction is just not an option. Otherwise, you know, you raise the concentration of radioisotopes too high. So, for the parts that can be compacted, yeah, the 5 to 7 compaction ratio is actually correct. That's what we have at the La Hague plant.

ROWE: Because of those issues, that's why I don't want to report compacted volumes, because there's just too many variables in there that I just don't want to try to address and justify.

ABKOWITZ: Well, let me ask one other question. Does that include the dry storage casks that would have to be cut up at some point--

ROWE: No.

ABKOWITZ: --if they can't be dealt with some other way?

ROWE: Let me make one point. I'll address it. For the repository, I also calculated--well, this one is zero because this particular scenario doesn't have a repository, so it's zero. But, in the calculation, the assumption that is used in the DOE report, the Savannah River report, is that the amount of low-level waste you generate is dependent on how the waste is received at the repository. If you receive the repository in TADS--and, Jeff, you'll be happy to hear this--if it's received in TADS, you generate a lot less low-level waste.

And, so, the calculation I do for the repository, there's a curve that is a function of the percentage of waste received in TADS, not DPCs, TADS. Okay? And, as the number increases, the amount of low-level waste decreases. None of the information in the Savannah River report includes the disposal of the DPCs, whether you ship that DPC to a repository or to a reprocessing plant. And, that is a considerable amount of low-level waste.

If you do the math, you know, DPC is six or eight feet in diameter, 14 feet high, times 10,000, you get literally millions of cubic feet uncompacted, millions of cubic feet of low-level waste that you have to deal with from the DPCs. Yes, sir?

KADAK: I think you're suggesting that I may have asked this question. It's hard to read that chart. But, if you take the uncompacted low-level waste, 10,040 cubic meters, what is the input stream of spent fuel to compare that to, cubic meters-wise?

ROWE: I don't have it in cubic meters. I'd have to--it's based on 1500 metric tons.

KADAK: And, what would that be in cubic meters? The reason I ask this is that the criticism of reprocessing, at least one of them is, that we're taking a finite volume of high-level nuclear waste, and making possibly an increasing volume of total waste to be disposed of. So, what problem have we just solved, and what's the goal here?

ROWE: Well, I think in the report, the AREVA report, there's I remember a .6, a reduction of fuel, one fuel assembly is about .6 cubic feet. I've got that on another slide. But, there is a reduction. There's no question.

KADAK: Okay.

MOTE: Quick calculation is 50,000 cubic feet. It's 1500 tons.

ROWE: 50,000 cubic feet?

MOTE: Yeah.

ROWE: Cubic feet or cubic meters.

MOTE: Cubic feet. So, you divide by ten. 5000 cubic meters.

KADAK: So, we're doubling the waste, plus, the high-level waste.

MOTE: Not ten. You divide by 30.

ABKOWITZ: Let's be careful here, because we're not getting into policy, but I do think it's important if we can stick to how the calculation needs to be done, so that what comes out of these models is representative.

WORRALL: That's a package volume. Remember, Nigel's is not a package volume. You take your spent fuel and you have to overpack containment, whatever containment is. So, just be careful with those comparisons.

ABKOWITZ: But, do you understand the point? The point is, I think, an important one. As a Waste Board, we need to think through what we're actually ending up as total waste that needs some--the solution. And, some of that low-level waste has no disposal pathway, which is also a question that we should address. I would suggest that one of the outcomes from this workshop might be an effort to try to come up with a low-level waste calculation methodology that we can all subscribe to in some way.

WILLIAMS: This is Jeff Williams with DOE.

I just wanted to say we have just posted a--provided a report to the BRC on that. You might want to look at their website and check it out. Okay?

ABKOWITZ: What was the report on?

WILLIAMS: The report was on low-level waste generation.

ROWE: Was this from the Savannah River?

WILLIAMS: Yes. That was the source document.

ROWE: Yes.

WILLIAMS: The data that--the basis for this was the report from Savannah River.

ROWE: What's the gentleman's name? I'm sorry, I can't remember. Joe Carter?

WILLIAMS: Well, no, it was Robert Jones.

ROWE: Yeah, Robert Jones. And, I talked to him, and it's a difficult calculation, but, I mean, it's pretty straightforward.

The other thing, if you're talking about low-level waste, or waste in general, the other thing you have to consider is the tails, and I know that AREVA hates this when I say this, but especially the tails from the recycled uranium is, right now, no one really knows what category those tails are going to be classified as. And, so, that's also a significant volume of waste that needs to be looked at.

ABKOWITZ: Let me just say, though, in fairness, there's a picture of tailings coming off of the natural uranium process that needs to have a calculation beside it just for total life cycle assessment purposes. And, I know we're working on that.

Paul, I'm sorry, you've been patient.

MURRAY: Just to say we really need to have a closer look at the low-level waste numbers, and compare apples and apples, because we looked at the Savannah River numbers, we looked at the GNEP PEIS, and we couldn't make head nor tail of them. So, we really need to have a separate exercise where we look at the specific low-level waste numbers before we start.

ROWE: Well, you know, in the Savannah River report, as you well know, there was a, for each of the curves, there was also an AREVA number in there. Okay? And, there was a series of curves for each of the waste forms, categories of waste. Okay? And, I took the lowest one.

MURRAY: What we need to do is go back and compare waste packages as well. How did Savannah River package waste?

ROWE: Again, this is not packaged. And, I don't want to get in--I don't want to. That doesn't mean that I won't be forced to. But, I don't want to get into that because it depends on the techniques. You know, to estimate the low-level waste depends on the design of the facility, depends on the operating philosophy of the facility, and there's just so many variables in there.

MURRAY: You're comparing waste packages of the high-level waste.

ROWE: I think that's an easier calculation. I think there's less unknowns.

MURRAY: One of the big things I want to point out is that this is a benchmarking exercise. We shouldn't be drawing firm, fixed conclusions from this benchmarking exercise. That should be the subject of the next workshop, not this workshop.

ABKOWITZ: I think we've identified a place here where--

MURRAY: Yes.

ABKOWITZ: --it’s an important calculation that we don’t have consensus on, and, therefore, there needs to be more work done in this area.

MURRAY: But, my worry is we’re throwing out huge numbers now, and it’s going to be the subject of public records, and as AREVA, we can’t validate the numbers that are being thrown out.

ABKOWITZ: Okay, I think we’ve stimulated an interest here. Go ahead, you’re next, and then Steven.

PHILLIPS: Chris Phillips from Energy Solutions.

I just really want to support what Paul was saying, that again, when we conducted the GNEP exercise, in the same way that AREVA did, we came up with a whole range of waste volumes and masses. They weren’t identical to AREVA’s, although they were similar, and the reasons for that were different assumptions. But, again, they differed markedly from the PEIS, which Paul refers to.

So, I would just like to support, there is a real need to get into the detail here, look at the assumptions, look at the packaging assumptions, and come up with some real details.

The only other thing I would mention, in relation to the point made about how reprocessing may end you up with a bigger volume of waste that you originally started with, you've also got to look at where the radioactivity goes. And, reprocessing allows you, and we know this from European reprocessing plants, to concentrate the radioactivity, over 99.5 percent of it, in a smaller volume of vitrified product. Sure, you've got a larger volume of low-level waste, but it's a tiny fraction of the total radioactivity that was in the original used nuclear fuel. And, we don't need to lose sight of that.

ROWE: I think everyone is aware of that. But, I think also on the other side of that coin is, in the United States, we have just as large a problem siting low-level waste as we do high-level waste.

VIENNA: Absolutely not. Absolutely not. You can't defend that. We don't have a high-level waste repository. We have four low-level waste.

ROWE: My point is that low-level waste is not an easy solution, and there have been, to the best of my knowledge, no new low-level waste sites.

VIENNA: Andrews, Texas.

KADAK: But, that's one for the country, and it's only permitted for, was it Texas, Vermont, and those are the only two states for which B and C waste can be shipped.

ABKOWITZ: Okay.

VIENNA: They're taking out compact waste now.

KADAK: They are?

VIENNA: Yes.

ABKOWITZ: Okay. Let’s reserve this for an off-line conversation, and I’m going to ask Steven if he would like to offer the next comment?

PIET: I have to echo what Paul and Chris said. But, let me go back to the idea that if you think of waste space as longevity and heat, high-level waste, high heat, high longevity, low-level waste, low heat, low longevity. To me, the unexploratory in terms of how much, what are the right strategies of dealing with it, are the other two boxes. High heat, low longevity, low heat, long longevity. Greater than Class C, if you want to use the current legal formulas, but it’s those two boxes, personal opinion, that are going to determine whether recycling improves things as much as some people believe, or not.

Low-level waste, we know how to site that. It’s difficult, but we have sites in the US. High-level waste, we’ve done zero. Okay? So, the number of high-level waste sites is zero. Well, zero is less than a finite number. But, it’s the greater than Class C situation that has not been explored enough.

ABKOWITZ: Okay. What we’ve identified here, I think, is a very important need to calculate the various families of waste, other than high-level and spent nuclear fuel, in the manner that everyone can understand and subscribe to, even if it ends up with several different types of results, depending upon the types of assumptions that you make.

I'm going to ask Gene to return to his presentation. And, I apologize because I started all this.

ROWE: Let's go to the next slide, quickly.

I just want to spend a second on this. This is the 300 metric ton case, and I think all of the people got similar results. You can see that we eventually ran out of waste to reprocess because we're reprocessing more than we're discharging, and it happens around, what, 2060, or something like that. And, then, it varies for the remainder of the time, depending on the amount of plants--the volume of waste being discharged. Again, I think that everyone, all the other companies got the same type of results.

I think the next one is the same thing, which is just the same flow chart, different numbers, because of the high volume of waste.

I think that's it. Thank you.

MOTE: Thanks, Gene. The next one up is Robby or Andy, whichever.

GREGG: Okay, to be honest, the results aren't that different to everyone else's. So, there's no particular point in laboring it.

Basically, the assumptions which are made are similar to what they were before. And, the total and new build fleet, which I assumed the size of it in this phase was 100.3 gigawatt a year, as it was for all the others. It wasn't defined in the benchmark. So, that's why I put it there.

And, all reprocessing throughputs are like they were before, are given as heavy metal mass rather than total fuel mass. So, some of the differences might be attributed to that. And, the numbers are quite similar to NWTRB, and I'm not surprised that the percent of the fleet and PWR MOX is quite similar in all six scenarios, which are essentially in the same model as us.

There is nothing really there of importance, I don't think. Okay?

ABKOWITZ: I just wanted to offer an observation. I'd ask whether the folks that did this work agree. It seems like the age of the reprocessed fuel really has little to no effect on the types of results that were seen. Is that a fair assessment?

ROWE: Yeah.

GREGG: No, not really. Well, the Plutonium 241 content would vary with age. But, the Americium 241 content might, because it's reprocessed and then used straight away.

ROWE: And, you can see that uranium savings goes from, you know, like in our case 18 percent down to 15 percent. So, there was some effect because of decay of Plutonium 241.

ABKOWITZ: Okay. I was using as my basis the ten versus twelve arguments that people were using earlier.

GREGG: I guess the scenario is slightly different, and one of the things which varied was the age of the separated plutonium, and that would have a bigger effect on the numbers, but that wasn't the case.

MOTE: Any more questions for Robby?

(No response.)

MOTE: Okay, Steve?

PIET: Well, I can see over here where the outline is that one thing that was different about our calculation is I did not have data in the right form to do calculations that involved re-enrichment of uranium. And, that could be some of that difference. It might be all of it, I don't know. So, let me talk a little bit about what we did do.

In our recipe of fuels library, we've got one for-- that uses recovered uranium and plutonium, so we're taking used light-water reactor fuel, in this particular recipe, the plutonium is about 11 percent of the metal in MOX.

Now, we know from independent physics calculations, that the lower end uranium in re-enrichment, that a one recycle of plutonium in the form of MOX saves 14 percent. That's if I've got it for a whole system at equilibrium.

Well, in this case, it's about two-thirds of the fuel, about two-thirds of the time period, so integrated over time, numbers work out to be about 6 percent. Now, I made a goof, I started in 2040 instead of 2030. I must have had DOE on my brain, because 2040 is what we say in the fuel cycle program now. So, I'll have to redo those calculations and get the numbers to you.

At 1500 tons a year, uranium savings go from 3.8 to 3.2 percent. Same number. But, at least you see what the trends are. 3000 here, these two numbers are the same. That always gives me a warm fuzzy. And, of course, per the specification, BWR fuel is not recycled.

Now, I've got a bunch of graphs that I'll go through quickly, because some of the trends are perhaps of interest. If you look at the uranium ore used over time, going back from 1960 on up, this is showing you that one recycle MOX just doesn't do a whole lot, it just plain doesn't.

In the questions we were asked is depleted uranium tails, again, you can see what these numbers are. It's just not a big effect. And, it takes a hell of a long time to see it.

We were asked about the recycling rate. These are the six cases. 1500, 3000, so you can see my color code here, the dotted lines are the higher recycling rate. Solid lines are the lower rate. What happens is in a model at a given--when you set a different age limit, what happens is you run out of backlog at a different time. So, for example, if I've got the requirement that fuel only ages five years, and I start a recycling plant at 3000, then it will go to 2080 before it runs out of backlog.

If, on the opposite side, I'm over here at the dotted green line, so I build a plant and turn it on at 3000 metric tons per year, and I require that fuel has to be 50 years old before it can go into the plant, well, it runs out of backlog in about ten years, and then it drops down because only a certain amount of fuel that's 50 years old. So, that's what the model is telling you.

So, the age doesn't change all the much what goes into the plant, but it changes how much you can send into the plant, what passes the rule.

I took the calculation out further, to 2160, and you get the same behavior. You start seeing the same behavior, but for the smaller recycling rate. Again, the first turnover is for the 50 year fuel specification. So, you can work off the backlog, but it takes longer.

One of the questions we were asked is the composition of used fuel, and this has real implications on designing a real facility. A real facility has got to deal with a constantly varying input stream. So, this is, in one of the particular cases, you can see that the composition changes over time. It changes depending on what your composition rule is, the 50 year or 5 or 25.

So, all these cases that are in the spreadsheet that I provided, which I have to redo now because I got the start date wrong, but recognize this as a log graph, so each one of these has to deal with quite a bit of difference in composition over time.

So, one of the things I plotted, this is just plutonium coming into the plant as a function of time. When you work off backlogs, then your numbers come down, and in general, if I’ve got the ability to have younger fuel, so five years or greater, then I’ve got more plutonium coming into the plant. If I require the fuel to be older, 50 years or more, then there’s somewhat less plutonium, and that’s the Pu 241 decay. This is just a little easier to see. But, it bounces around.

Americium only, here the trend is the opposite, because Pu 241 has turned into Americium 241. So, the Americium content goes up the longer I wait.

Now, I looked at the total heat in the separation plant. This is no longer a log scale. This is linear, it’s actually in gigawatts. We model the separation plant typically as having a quarter of a year stockpiled in any incident of time. And, so, the younger fuel case, I’ve got more heat. Older fuel, I’ve got less. But, it’s a factor of two or three. So, by waiting, I’ve reduced the heat that the separation plant has to contend with. But, I've lost some of the fuel value. Pu 241 is good stuff, it's good fuel, so the longer I wait, I have less heat in the separation plant to contend with, but I've lost some of the value.

This is the same thing, but instead of heat, it's gamma emission, and I honestly don't remember what these units are. But, think of it as a relative comparison. Again, you get maybe a factor of four instead of a factor of two, and it's because you've got the short lived isotopes are decaying off.

Neutron emissions, same sort of pattern. So, by waiting to have longer cooling before coming into the plant, you reduce heat down to neutron, but it's less valuable fuel, and you've had to build a whole bunch of storage facilities. So, that's a policy trade-off, not a model trade-off.

And, I think that's it. Questions?

MOTE: Steve, I'd like to make a comment. What I just saw there was fascinating, and following Paul's comment about let's keep our feet on the ground, that is really a way to see the implications of demanding 50 years cooled fuel. However, for benchmarking exercise, what we have seen with the Board and NNL is, as we said, an unlimited currently of 50 years cooled fuel. Unrealistic it may be.

PIET: Yes.

MOTE: But, in terms of benchmarking, what we wanted to do was look at how the curves compared. And, while it’s fascinating, that’s a later chapter in the book than the comparison that we were doing here.

Could I ask, I maybe missed this and you maybe said it, for your numbers of the uranium reduction, did you base those on these curves, or did you assume an unlimited quantity of 50 years cooled fuel?

PIET: I based them on these numbers.

MOTE: Okay. So, we’re not comparing apples with apples.

PIET: Right.

MOTE: Because your feed stream is very different from what we had specified.

PIET: Yeah, I don’t have a--I’d have to--

MOTE: I understand that. I know you said that this was all you could do in your model. I didn’t know whether you had found a way to manipulate the input that meant that there were in fact numbers that were compatible.

PIET: I could do that, but it would take--

MOTE: Okay. I just wanted to be sure that we knew the basis for the numbers then. Okay.

PIET: And, again, I didn’t do uranium re-enrichment here.

MOTE: I’m sorry. Say that again?

PIET: I did not do the uranium re-enrichment.

MOTE: Yes. Yes. Okay, so it’s a different number.

PIET: Yes.

MOTE: I just wanted to be sure that I was understanding that correct.

PIET: Absolutely.

MOTE: Okay. Questions, comments, discussion?

(No response.)

MOTE: Well, thanks, Steve.

WORRALL: I just have one quick one.

MOTE: I should have known.

WORRALL: It is an interesting observation about the, and Robby alluded to in his presentation, is the build-up can change of the plutonium 241 to the Americium, is that clearly one of the--and, again, this is kind of outside the benchmark, just bear in mind, is that if you give it time, and again, the French model is very good, the French approach is very good, minimizing the amount of separated plutonium having been stockpiled at any one time is a good objective for a safeguard to cure, et cetera, but, it’s also a way that you ensure that your Americium doesn’t build up.

Now, that’s because it sends you in energy output, of course, but also, it sends you in terms of fuel manufacturing because Americium is not a good thing from the fuel plant for the dose and operators, and so on, heat. And, in fact, so all of that is really important. That’s exactly the situation in the UK.

Now, we separated 100 tons of plutonium, not all of it is plutonium 241, fuel reprocessed plutonium, its plutonium composition has low 241, so the Americium is not such an issue, we can store it for a lot longer. But, all the other fuel, the AGR in particular, does have the opposite problem. We get lots of Americium in those.

So, it's important, and the reason I mention in the modeling context is it does beg the question in the next phase of this. Somehow the models, the tools are going to have to reflect this kind of dynamic position that the plutonium aging will have an impact on the fissile quality when you begin to look to recycle it. So, that dynamic situation has to have feedback, and the fact the total quality of plutonium has on how much fuel you can make, or it will come and bite you later. So, there is a factual application in the modeling, but also more or less reflects reality.

PIET: I should have pointed out in this graph, it's neutron emission, the drop is not Americium and plutonium. It's Curium 244, is the dotted--exchange.

SHWAGERAUS: Additional comment on the same subject. If you take high burn-up fuel, plutonium from high burn-up fuel, and let it decay for a long time, in order to produce MOX for MOX plant, or for MOX reactor, you would need high loading of plutonium. And, one of the things that may limit the loading is the reactivity coefficient. That puts an ultimate limit on how much plutonium you can have. And, that is not reflected in any of the models, and I actually don't know how to incorporate it. So, it's not just the fissile value, that you need a certain amount of kilograms to drive your fuel to certain burn-up, you might not be able to put this many kilograms because of the safety constraints on the reactor.

PIET: Yes, this case did 11 percent plutonium in the MOX, and that's probably too high. I believe the French, it's 10 percent is your limit.

BRUDIEU: The limit is 12.5 percent.

SHWAGERAUS: Yes.

ROWE: This is Gene Rowe.

The reason we specified 14 in the specification is because we knew that at 55 gigawatt days per ton, you were going to be less than 14, and even though--we didn't want to run into that limit. And, even though 14 may be not a practical number for this exercise, we didn't want to run into that upper limit.

SHWAGERAUS: Maybe for partial loads, and things like that. But, 14 percent for MOX--

ROWE: You can't. As Paul says, this is a benchmarking exercise, and that's why we didn't want to run into that limit. Okay? And, the numbers if you look at the--and, that’s why we wanted to report the Pu percentage and the quality, okay, and except for AREVA seems to be a little high, but NNL and we are in reasonable agreement on the Pu percentage.

MOTE: Thanks, Steve.

GREGG: Quality will be based on the ORIGEN calculations, which I’ve done to calculate what the composition of the spent fuel is. And, then, the percent plutonium depends on what model you use to calculate what is our content you need in your fuel, and for NNL and NWTRB, because we gave you the date, we calculate what percentage plutonium we need in the fuel. So, it’s not surprising that those numbers are the same.

MOTE: All right, anymore comments on the INL presentation?

(No response.)

MOTE: Okay, Eugene, are you presenting, or is it Stefano?

PASSERINI: So, those are the results from CAFCA for Phase 4. As Nigel was saying, we did assume the capacity to be fully saturated for two cases, for this scenario, but of course not for the following one. And, those were for the four metrics that we were required to calculate.

First of all, just a reminder. As I said yesterday, for our 100 gigawatt electric LWR fleet, we required about 20 hundred metric tons of fuel per year, and that from our CAFCA model corresponds to a natural uranium requirement of about 16,000 metric tons per year. And, that was used, of course, to calculate the uranium--the decrease in the uranium demand following the production of MOX elements and the recycled uranium, too.

And, here, we reported the vectors that we used for our calculations for the different aging of the fuel. And, as you can see, of course, the content of plutonium 241 goes down, as was said many times, and of course that affects again the amount of plutonium also that is available in the reprocessing and for the final decrease in the uranium demand.

So, for the first three scenarios, or the 1500 metric tons per year of reprocessing capacity for the three cases, as you can see, there is a reduction in the natural uranium demand, and between the three scenarios, of course, it decreases. And, other than that, I think all the other numbers are kind of consistent. I already e-mailed I think in the consolidated version of the Excel spreadsheet, you will find those. So, all the other numbers that I felt that were not directly calculated from these numbers, but I had them, so you will find a better comparison also of the other numbers here.

And, the same for the scenario 4, 5 and 6, so doubling the reprocessing capacity and steady state, assuming full operation of the reprocessing facility, doubles also the natural uranium reduction, and also the production of the recycled fuel and recycled--and the production of the MOX fuel elements compared to the previous cases. And, of course, also the tails decrease compared to the previous case. Of course, they have a different distribution, so we have more tails from the MOX facility and the recycled uranium, and less from the uranium--from the principal uranium enrichment facility.

MOTE: Okay. Any questions on the MIT results?

(No response.)

MOTE: Okay. All right, well, now we have the pleasure of results from AREVA. So, Marie-Anne, take it away.

BRUDIEU: Thank you. Okay, I'm just going to go back to the specifications that we didn't go through yesterday because we did not talk about Phase 1, 2, and 3. So, as a reminder, because I said there were, you know, questions, I want to go back to the whole discussions on what codes and benchmarking and everything. But, then again, this is the part of a code that would be the very end of, you know, the other codes that we talked about. And, it's really a calculation focused on the back end only.

Just to compare to what a more general fuel cycle code would be like, the COSAC, COSI code, COSAC and COSI are nearly the same rate. COSI is the CEA code. COSAC is the AREVA MP code. Others are here, but we use today for the NWTRB, really has a fixed input of fuel cooling time and burn-up. Then we use CESAR to look at the isotope compositions. And, then Excel micros, based on, you know, La Hague and MELOX data to see what's coming out of it. So, we have data based on existing recycling plants.

Now, on a more generic code like COSAC, what you're going to have is multiple inputs with reactor types, fuel cycles, scenario comparison, and then you get into different codes, that includes CESAR, but you also have the ORIGEN, you know, ICRP tables and equations. And, then, you have the overall integration that's going to give you proliferation index, isotopic, you know, heat optimizations. We felt that this is not responding to the needs today. We didn't want to have something too complex, and we wanted to choose the right toolbox. Now, then again, you know, if we decide and we frame the right question, as was mentioned earlier, we do have other toolboxes that we could use. This is just not the one we use today.

Just to mention the COSAC code was benchmarked twice, once with COSI and OECD scenarios, and there was the NFSS--I'm not sure how that's called--which is the IAEA code. So, that was just a--for the recycling models, the Phase 4 that we're talking about here today, the type of fuel has initial enrichment of 4.4 and a burn-up of 55 gigawatt days. And, we talked about how the results are going to be affected by the cooling time, I would just like to mention that based on my experience of what's going on in the recycling plant, the burn-up is also very important. When you have low burn-up, you know, you don't need to cool the fuel as much, and when you have higher burn-up, you need to cool it a lot longer.

So, here, 55 gigawatt is pretty high, and if we look at the reality of what would be the overall fuel in the US, I'm guessing, and I don't know that much about that fuel, it's probably much lower burn-up and, therefore, you would have different impacts.

The annual discharged was calculated to be 1880 metric tons per year. And, as mentioned, we used the CESAR code for all the isotopes, and we had different scenarios, so we also calculated for the isotopes, the actual fuel that would be recycled in case of Legacy fuel, not just the output of the year.

Now, the recycling capacity in the model, we include also the 800 metric tons per year. And, why did we do that? It's because in the past, we've been communicating a lot about the recycling plants that would be 800 metric tons. So, people can make the data on that.

Also, you did ask for six scenarios, 1, 2, 3, 4, 5, 6, and we found that 4, 5, and 6 were really .23 times 2, the difference, so in order to have some more added value, we modified 4 and 5 into 4 prime and 5 prime scenarios where we completed the 3000 metric tons capacity by Legacy fuel.

Now, the output, and we also talked about it, especially for plutonium, can be adjusted between 9 percent and 14 percent. Now, to respond to the specification, we calculated the number of MOX assemblies based on the 14 percent plutonium content. That doesn't mean that, you know, what it needs to be to have the equivalence in terms of NRG, and, I can give you those numbers. They're actually more like between 9 and 11 percent.

The quantity of uranium that can be saved by having recycling was based on the real plutonium content, not the 14 percent. I just wanted to specify that point.

That's what I just talked about. So, the results are here. As a quick scenario for the actual scenarios, we took into account, 1, 2, 3, 1500 metric tons per year in terms of capacity, and then we go to 3000, which means 1880 of the actual fuel that comes out, and then some Legacy fuel.

I'm not going to go into the details of the fission products and actinides that were separated. Just in terms of looking at the comparison, the extension over there, for Scenarios 4, 5, 6, I think some numbers, I'm not sure how you added them up, and we can look at that together, but that doesn't seem right to me, compared to what we have here. It says--

ROWE: Could you scroll the spreadsheet on the right screen?

BRUDIEU: 1500, in terms of the mass, I think of PWR separated, when maybe it should be just more or less the double of what you asked for, Scenarios 1, 2, 3. So, maybe there was--we just need to talk about it, but I'm not sure that number is representing the calculations we did.

ROWE: I could have done it wrong.

BRUDIEU: That's fine. We can talk about it.

The reduction in natural uranium demand is also fairly consistent with what the other participants had, as well as the uranium tails. So, I'm not going to talk too much about that.

But, we have the numbers of assemblies fabricated, and here, I saw that the MOX assemblies that we have fabricating is a bit lower than what the other participants had, but then again, that's because we chose to use 14 percent plutonium factor. The actual percentage of plutonium, the real one that was calculated, would be for Scenario 1, 9.2 percent. Scenario 2, 11.9 percent. Scenario 3, 11.7 percent. Scenario 4, 10.19 percent. Scenario 5, 11.34 percent. And, Scenario 6, 11.7 percent, which is a lot more consistent with the other numbers.

Also, in terms of--we had discussions of what's the impact on cooling time, et cetera, but what I want to mention is we can look at the Americium that we have, the plutonium, practicality speaking, the vitrification is usually what you have as an issue. There is only so much heat load that you can put, you know, in your vitrified waste, and that's something that is not taken into account in these scenarios, that has to be benchmarked, that's something that shouldn't be forgotten, you know, if it's just too hot, you won't be able to do anything with it, and you'll have to wait, no matter was. And, have your fission products in some kind of waste tanks waiting there.

Now, I'm just going to talk a little bit, as was asked yesterday, about waste streams. And, this is really based on the waste that we see being produced at La Hague and MELOX plants. I took a couple slides that were presented here in the US in February. The numbers that we show today are not entirely consolidated, and you shouldn't take this, you know, as real numbers. They are really dependent on what type of forms you're going to have and are going to choose to compact your waste. Are you going to choose to put them in major concrete or grout tanks or just more, you know, metal canisters.

And, that's really something I think should be taken into account. The primary volume of waste is data, but that’s not going to help you make your decision in the end, because depending on how you’re going to treat this waste and put it in the waste tanks is going to have a major impact on the cost of your recycling activities.

Altogether, otherwise, we have what we call the processed waste, and that’s the one that you’re going to have no matter what, so that’s the one that’s in this--the fission products, that’s going to become vitrified waste, and then the compacted hulls and end pieces of the assemblies waste, and this is high-level waste, it’s going to go in the repository.

The interest of having this waste in this form is that it diminishes the volume of it. That’s one point. It does concentrate the toxicity and the major activity, but also it’s in a much more safer form. You know, when you have the glass, basically, you can never go out and take out the fission products out of vitrified waste.

Now, what we call the techno waste is everything else that’s been produced by the recycling plant, and that’s why people say how come I’m--you just put all your contamination everywhere. That’s going to be low-level waste, and we’ve been diminishing that over the last ten years drastically. That’s going to be greater than Class C waste and TRU waste, that’s mostly for the MOX fabrication plant. And, then, low-level waste, and that’s everything that's, you know, the tubes that you're going to use on your recycling plants.

Just a couple of numbers that have been mentioned earlier today. Basically, we're going to have in terms of geological disposal 0.6 cubic meters per assembly of high-level waste based on one special assembly that's this PWR assembly, and, you've going to have 1.4 cubic meters if you don't do anything. And, these numbers were presented in February at the PA meeting, when that was.

Just to mention that depending on, you know, you said, and I don't have all the history on that, that the waste prediction sometimes can be based on the Savannah River site, and I don't know the history of the Savannah River site, that will--or Sellafield, for instance, looking at when is the basic data taken from is very important. We all know that the country has made huge progress in terms of dealing with the waste over the last 20 years. And, we've seen that at La Hague and every year basically, we try to cut down the amount of waste we produce.

So, this is the type of waste I presented yesterday. I just wanted to remind you of that, the low-level waste streams that are calculated from the level we brought here today.

And, so, the results that you have here is waste--that does not include tritiated water, because tritiated water, if you're going to grab it, it just doubles the volume. If you put it back in the ocean, it just disappears. If you concentrate it, you know, concentrated, it's going to be much smaller volumes. So, depending on what's the policy and what's the regulations, it can have a pretty big impact on the amount of waste you're going to have. I have fairly, you know, generic numbers in mind that's about 2000, 3000 cubic meters of tritiated water produced every year.

At the La Hague plant, for instance, that's why La Hague was where it is, you know, it just goes straight into the ocean and goes back up the coast. There are very strong currents there.

In terms of vitrified waste and compacted waste, and when I say compacted waste here is hulls and end pieces. That's very much proportional to the amount of spent fuel you're going to recycle.

Now, the technological waste, the rest of it, is not proportional to the amount of spent fuel you're going to recycle. It's really directly linked to the size of your plant. So, if you're going to have three lines of vitrification, vitrification has lots of equipment that are kind of very fragile, so that's why we produce most of your technological waste. If you have three lines, you have that much waste, and then if you have six lines of vitrification, then you've doubled it. But, if you have a more efficient vitrification line, then it won't produce, you know, more waste because you have the same number of equipment. And, that's something that's very important to keep in mind. It's not related directly to the amount of spent fuel you reprocess, but to the size of the plant and the number of equipments you're going to have.

The numbers I put there are primary volumes. Gene, that part does not include tritiated water, so we can compare them. As I mentioned earlier, some of the primary volumes in the surface waste, and I did not want to go into the details, categories of the US regulatory because they're very different from the French ones, and really in terms of impact, I think the big difference is is it surface or is it deep. And, then, we have the TRU waste, as was mentioned. That's also one of the big ones that we need to take into account.

Some of this waste can be incinerated, and then the volume is divided by 10 to 15. Some of the waste can be compacted, and then the volume can be divided between 5 and 7, and then some of it just has to be put in casks, and then the volume is multiplied because it's going to take this little piece of equipment and put it in this huge concrete cask.

KADAK: Quick question. The units, is that 2100 canisters per year?

BRUDIEU: Yes.

KADAK: That's per year, okay.

MURRAY: Paul Murray. Just a point of clarification, these aren't the same canisters as DWPR with WTP? They're universal canisters based on about so tall and that wide?

BRUDIEU: They're 200 meters canisters. If you put them in water, are going to displace 200 meters.

MURRAY: So, that's a really, really important fact that people involved in the mix, that, you know, the U.S. has a vision of a canister being 12 or 15 feet tall. These are universal canisters?

BRUDIEU: These are the baby canisters. We all have one in the office in Paris, if you come see them. And when you see them, you can put quite a few of them in a transport cask.

ROWE: Gene Rowe. I have a question. On the third line, surface waste, about 1500 cubic meters. Is that your low-level waste?

BRUDIEU: Yes.

ROWE: Per year?

BRUDIEU: Yes.

THE COURT: So, 1500 times 27 is bigger than--

BRUDIEU: But, this is not compacted. You asked me for primary waste.

ROWE: Yeah, that's what I wondered, is primary waste, thank you.

BRUDIEU: But, that does include everything. And, then, we have the TRU waste, which is basically, as I mentioned, the plutonium waste. And, that's coming out of the MOX plant. As surprisingly as it seems, a plant like La Hague doesn't produce much TRU waste. There is fairly plutonium contamination on the equipment. It's mostly MELOX, and, that's mostly also due to the history of the plant, and we expect to see much, much better numbers in new plants.

I think that's it.

MOTE: Thank you. I was going to say are there anymore questions? I think Dr. Abkowitz--

ABKOWITZ: No, you're not good yet. You've been really good about this. You had a slide early on that made reference to a benchmarking using an OECD scenario. Can you give us anymore details on what that exercise was involved in?

BRUDIEU: No, I can't. But, I can send you information on that very soon.

PIET: It may be NEA.

ABKOWITZ: Okay.

PIET: Or OECD.

ABKOWITZ: Okay.

BRUDIEU: That would make sense.

ABKOWITZ: So, they're one in the same then?

PIET: I think they are.

ABKOWITZ: Okay, thank you.

BRUDIEU: I don’t know if that benchmarking was done, you know, really NEA benchmarking, or if after, as we said, you know, CEA is a big partner, so we might have said, you know, hey, look, can you do that benchmarking for NEA? Let’s take the same scenario and benchmark COSAC and COSI, which is probably what was done.

KADAK: What is the typical practice at La Hague relative to aging of spent fuel prior to reprocessing, especially if it’s going to go into a MOX plant?

BRUDIEU: We don’t choose which should be recycled. The customer chooses to do so. So, it’s EDF choice, and we can only provide advice. We need to have minimum cooling time before we recycle the fuel, and that’s because of the heat. You know, we can have too much heat in the plant, but that’s a pretty short time.

KADAK: How long, roughly, is it? Five years, ten years?

BRUDIEU: It’s between five and ten years.

KADAK: Five and ten years. And, from a fuel utilization point that Eugene made, and that is what is the most optimum time for putting this fuel back into a reactor in terms of age?

BRUDIEU: Well, you don’t want to wait too long for plutonium. Once the plutonium comes out of La Hague, you want to stop fabricating the MOX and send it back to the customer as quickly as possible because otherwise, you start beading up Americium, and then if you have too much Americium that beads up, then you just need to take your plutonium and put it through the recycling cycle at La Hague again to take the Americium out. So, really, waiting is not a good thing once you've been separating, you know, your plutonium from the other materials.

Now, if you want to wait, you just wait and you just put your assembly in the spent fuel pool, and depending on whether that's a good idea or not depends on what you want to do later on. Do you want to do multi-recycling of your MOX? Where do you want to put your MOX? Do you want to have a call that is 100 percent MOX or not? Do you want to keep some kind of plutonium on the side for, you know, fast reactors? And, then, we go into the overall fuel cycle strategies and codes that we were talking about earlier today.

KADAK: But, you don't do multiple recycling right now?

BRUDIEU: We don't do multiple recycling right now. We have recycled some MOX spent fuel assemblies that has been proven to be doable at La Hague, have done a couple of them. Today, EDF, which is our main customer on that, chooses to keep their MOX for future use, especially probably for fast reactors.

KADAK: Okay, thank you.

MOTE: Paul? You and Allen are running neck and neck.

MURRAY: Just two points of clarification. The recycling UOX fuel, you have to try and do it for 14 years, up to 25 years, because of that period in the middle, you don’t want to do it, you can just go and look at the isotopics for making the MOX.

KADAK: The 14 to 25; is that what you said?

MURRAY: 14 to 25, you don’t want to try and recycle the UOX.

KADAK: That’s the period of not recycling?

MURRAY: You don’t want to recycle. And, that’s not the ages, it’s dependent on a lot of other things. This is the danger of where we are. This is a benchmarking exercise, I know, but in the US, we can do multiple recycling of MOX. I’m actually doing a study with Oak Ridge right now to look at that, and we should publish that later this year. We’re in a unique position in the US where we can do multiple recycling of MOX.

KADAK: What makes US different than France?

MURRAY: We have this huge stockpile of used nuclear fuel, which allows us to blend it in with the used MOX so we can get good isotopics on fresh MOX that’s produced. So, we can do multiple recycles of MOX. And, this is one of the dangers in what we’re doing, Andy, is we have this huge inventory of used fuel, which gives us loads of options, which other countries don’t have. We also have specific regulations, like 40 CFR 190, which would drive us down seven paths to the cycle--it will dictate to us what is the age of the fuel that we can recycle, recycle in the US.

BRUDIEU: The key of multi-recycling the MOX is really to start doing so with the oldest spent fuel, UOX spent fuel you can have, the older it is, the more, you know, the easier it’s going to be to have multi-recycling of MOX and using--because recycling is find a number--you’re assuming to have the utilities willing to use it in their core, and wants to manage their core that way.

KADAK: The one thing that I was surprised to see is the natural uranium savings. I’m not sure whether it was Steven or MIT’s, but 30 percent, and I interpreted that to be simply plutonium.

PIET: I’m still not sure how in the world you get 30 percent.

KADAK: Pretty high.

ROWE: I think the numbers are in reasonable agreement. About half of the uranium savings is due to MOX, and about half of it is due to RepU assemblies, about half.

ARNOLD: Aren’t you using--that aren’t counting as fresh uranium? I mean, they’ve got a billion pounds of tails sitting around in the US.

ROWE: Well, the fresh tails are used in the MOX assemblies.

ARNOLD: Yes. So, I'm saying that the use of tails does not involve fresh uranium.

ROWE: No.

BRUDIEU: No, but the tails are used in MOX refabrication, so you don't have to use natural, you know, new uranium for that. In our model where we have numbers that are quite consistent with Gene's, the radiation in terms of natural uranium is basically based on the MOX fuel, you know, if you have MOX fuel, you don't need to use UOX fuel, and then the equivalent fuel of enriched processed uranium, and, that gives you these numbers.

KADAK: So, you agree with the 30 percent?

BRUDIEU: Yes. If you look at the next slide--

PIET: I'm completely baffled because it takes 6, 7, 8, 9 assemblies of UOX to recover the plutonium necessary to make one assembly of MOX.

ROWE: Well, that was the point that I was trying to make.

PIET: I'm baffled.

MOTE: What Gene did was to reprocess more per year than the discharges.

ROWE: Yes.

MOTE: So, we’re reprocessing 3000 tons a year and recycling all the products, when the discharges are 2000 tons a year. This is borrowing from a bank account, getting ahead of yourself, it’s not a year by year equilibrium. It is if you have a lot of spent fuel and you can reprocess the backlog, it gives you more than pro rata uranium to recycle and plutonium to recycle. So, for some years, you can catch up with the spent fuel that you have in inventory. But, you can’t keep going like that, because eventually, as your slides show, you run out of the backlog.

So, if you have a 3000 ton a year reprocessing plant, and you run out to infinity, you cannot keep it fully loaded because you only have 2000 tons a year discharges. If you’re reprocessing 3000 tons a year and recycling into a 2000 tons a year demand, then your displacement as a percentage goes up.

ROWE: Yeah, if you look at the right columns over there, the percent of recycled assemblies, you notice that for the 30 percentage uranium savings, you’re getting half of your assemblies from recycled mass. And, the reason you’re getting half of your assemblies from recycled mass is because you’re reprocessing more assemblies than you need, or more mass than you need. Does that make sense?

PIET: I’ll have to, now that I understand what you’re talking about, I can do that calculation off-line. But, I don't want anyone to leave the meeting thinking that one recycled MOX as a routine matter of business in a real fuel cycle is going to give you 30 percent savings on uranium. That's flat out not going to happen.

PASSERINI: And, I think we will see that also in the next scenario, we will see that it's not a sustainable practice over time.

PIET: Right. I'd hate to have a wrong impression there.

BRUDIEU: This is a benchmarking--and we're so used to Legacy fuel to come to the 3000 capacity of the plants, not only is that we work until 2100, you know, in 2100 we might have fast reactors at that point, and might have transmutation, I don't know what we will have. But, okay, that situation cannot go on for infinity. I'm not sure we want to find a solution, you know, for infinity here. Up to 2100 would be a good point.

MOTE: All right, on the agenda, we should have finished at 10:15, but that's fine. We would have taken a 15 minute break, so let's still take a 15 minute break. I have a feeling that we're going to catch up on the next set of results presentation.

(Whereupon, a brief recess was taken.)

ABKOWITZ: Okay, we're entering our session where we're going to be talking about the final phase of the benchmark exercises. This is where we bring reprocessing together with recycling. And, because Robby gave such a lengthy and prolific presentation on Phase 4, since his thunder had already been stolen, I thought it would be appropriate to ask him to go first.

GREGG: I might say also that my results are very different from everyone else's, so it might take me a bit of time to explain it. Thanks.

So, this is my ORION model, Phase 5. And, actually, all the fuel which is generated before 2011 is basically injected into the scenario. And, PWR stuff is disposed of, and in a repository, the PWR stuff is sent to a reprocessing plant where plutonium goes up that stream, uranium goes up that stream, and fission products and minor actinides go up that stream, not to be seen again. Plutonium goes into MOX fabrication, which goes into the PWR fleets. The separated uranium goes into enriched reprocessed uranium fabrication plant, which also goes into the PWR fleets.

With the PWR fleets, they will preferentially load MOX fuel, and then they will preferentially load ERU fuel, and for anything else, it will choose to use just standard uranium fuel. Fuel then is cooled in ponds for ten years, and this material, so this is a standard UA2 fuel from the new build fleet, goes back into reprocessing facility, and it goes around again. Everything else goes into the disposal facility.

As I stated before, the problem with ORION is limitation really, but these processing facilities here can’t preferentially process either the newest or the oldest fuel first. It can either process material from a particular stream, or the others, but it can’t process the newest material in here, for example, over the oldest because it’s basically just a lump of material, essentially, in there, it’s everything from the 1960s to 2010, is just lumped together, so it’s an average composition. So, there’s no way I can process the newest or the oldest material, because that information is just not there anymore. So, that’s what I was talking about there.

As for the results, there are quite a few differences, so I’ve made some notes here. The biggest difference is if we look at the second table, you can see that my numbers are out by three orders of magnitude. The reason why is basically I’m just--I thought the benchmark was asking for results in 2100 rather than the cumulative masses up to 2100. So, that explains that. I basically just need to redo the benchmark and give you updated results.

The reason why these results here are different is because I can’t preferentially process either the newest or the oldest fuel first. So, the total is the same, roughly, 91,000 tons. But, the ratio of PWR to BWR fuel is different because of that reason.

When I did this scenario, and I've got a choice of how many nuclides I track, and in the other four scenarios, I chose to track all 2500 nuclides, but for this one, I thought there was a need to use the NPR function in ORION, which is basically the end of the--the radiation method used to calculate the spent fuel inventory is based on cross-sections rather than--and, obviously, the other is a lot more, so for that reason, I had to reduce the number of nuclides which I tracked from 2500 down to 100, and even with 100 nuclides, the scenario takes about four hours to complete--or is it two hours--it's a long time. But, if I tracked 2500 nuclides, it would be a lot longer. I'd probably still be going.

So, for that reason, I'm not tracking all the fission product mass, so that explains why the differences, and 4000 tons, and if I did it again, and I probably will, and I'd probably include like to catch all nuclides, so all the--for example, and only the nuclides which I track, the products which I track will all be accounted for in that figure. And, if I'd like to catch all material, and to account for the other nuclides, then that figure would be very similar to what--to the NWTRB value.

And, as for the plutonium quality, that figure there is the figure in 2100, and I'm guessing the figure which NWTRB has there, and 61 percent is like an average, an historic average, so, that explains that difference.

And, the average enrichments here, I think this is simply just a rounding error because the results I gave in my Excel spreadsheet, for the--well, to one decimal place, and I think if you just use it to complete to ten decimal places, well, two decimal places probably you get 4.40 exactly.

And, that's about it, really. All the same reasons for the differences, will be the same in Scenario 2 as well. So, in a nutshell, I need to redo it.

ABKOWITZ: Thank you, Robby. Are there any questions or comments related to what he has shared with us?

(No response.)

ABKOWITZ: Very good.

MOTE: I was wondering why you gave him first place if he was going to be just as quick?

ABKOWITZ: But, there was more eloquence in his voice, knowing that he was excited to be, you know, in the lead-off position.

Steven, do you want to go next?

PIET: All right, the specification dealt with a single recycled MOX. The numbers I used were the same as for the Phase 4 calculation, so it's an 11 percent MOX, because that's the recipe we had in our library, and used MOX goes to repository.

I did an extra case with enriched uranium transuranic MOX. This is a set of calculations done by Gilles Uanue in San Bayes a year and a half ago now. It keeps the percent of transuranic in MOX to 8 percent because of the void coefficient concern. And, then, you look cycle by cycle how close you are from achieving the appropriate reactivity, and then throw in enriched uranium to give yourself the right burn-up, and what not.

In this case, the MOX never goes into the repository. It is repeatedly recycled. Because I read the spec wrong, I did this at 2030 instead of 2040. The repository capacity is not particularly important. Two separation cases, a minimum aging before separating used fuels five years. Per the specification, BWR fuel is not recycled, and as isotopic data I think in the spreadsheet. So, I can redo this from 2030 to 2040.

Now, this is the physics calculations. It's not VISION, but I wanted to talk about a bit for what happens when you recycle MOX, physics calculation. So, this is once through, what we call recycle zero, on up to equilibrium. If I recycle only plutonium in a thermal reactor, I do the best. As I recycle other transuranics, my use of original uranium ore is lower than if I recycle only plutonium. So, a thermal spectrum, the general trend we find is recycling minor actinides decreases uranium utilization.

In a fast spectrum, it's the opposite. Now, of course, in either case, if I recycle minor actinides, it burns up some of the stuff that would otherwise be waste. It increases separation and fabrication cost. It may, depending on who you listen to, increase proliferation resistance. That last point, I can get four proliferation experts in the room, and get at least five different answers, particularly if you let me pick them.

So, we've done the physics. We know what happens here. And, so, one of the cases I did was multi-recycle with all the transuranics.

So, this is uranium ore utilization as a function of time starting at the beginning of the US fleet. And, separation cases are here, separating all the transuranics, and doing it as a multi-recycle situation improves uranium utilization. I'm going to have to study why the numbers are a bit different than what I see over there. Although, again, I did not do uranium re-enrichment in these calculations, and that's at least some of the difference.

I always like to try to put things into context. So, this is a graph that a colleague in San Bayes came up with. This is the rate that we consume heavy metal ore, and what fraction of that ore we utilize to generate, in this case, heat, which gets turned into electricity. Well, theoretically, the best you can do is 100 percent. That's up here. That's the fission Q-value of about 950 gigawatt day energy per ton of ore, per ton of heavy metal.

Well, all the cases we're talking about are way down here. Once through is about .7 percent ore utilization. One recycle, whether it's MOX or TRU--PU. TRU is slightly different. Multi-recycle goes up a bit more. Sustained recycle, fast reactor, if it's a burner, is down in here. And, of course, a breeder can go up there if you're recycling all the transuranics. If you don't recycle all the transuranics, this number drops a bit, because you're throwing away some of the energy content each time around.

So, depending on what the charter of the Board is, we've been talking for a day and a half all down in here. Whether you want to look at the rest of option space is a different question.

We were asked the waste mass, dispose 2030--this should have been 2040--to 2100. So, no recycle, one pass, continuous recycle with transuranics. Of course, the fission product mass is a changing, fission products are fission products. You dispose of less uranium. This is the PWR only because that's the case where you're recycling. This throws in the BWR, but the BWR is not changing any. So, this tells you better what's going on.

If I do one recycle of MOX, I'm getting rid of some of the plutonium. If I continuously recycle on this scale, I'm not throwing away any plutonium. It would only be process losses.

And, again, to put things into context, a report that we put out last year, this is more to stimulate thinking for the afternoon, down here, this particular graph, I didn't put numbers on because I can get slightly different numbers depending on what cases you want to look at, but go back to this idea of a two by two box, high heat, high longevity. That's the type of waste no one has disposed of anywhere.

So, this scale, this axis is how much of that mass do you have. This scale is long-term radiotoxicity. We typically plotted out a thousand years, since it's been used in the fission community for decades as a metric. The trans aren't particularly sensitive to whether I pick a thousand years of ten thousand years, same basic trends.

This takes a minute to walk through, but it really poses the question to the Board as to what you care about and what part of option space you care about. If I do nothing, I'm out here, because the mass that has to get disposed of is not just the heavy metal, but everything that goes with it.

In a light-water reactor, 20, 30 percent of the mass comes out in the fuel assembly, isn't the heavy metal, it's the steels, the zirc, all that sort of stuff, and if I don't do anything to it, it's got to go to the repository along with everything else. If it's an HTGR, that's a factor of 100, and at a hundred times more mass, in terms of all the carbon, the silica and so forth, goes with the used fuel to the repository if I don't do something about it.

So, I start off here. I can reduce that mass, again the high heat, high longevity mass, if I start doing things like punching the compacts for HTGR or taking fuel assemblies apart, then I can reduce the amount of mass--I'm not doing all that much on radiotoxicity. I'm doing a little bit in terms of reducing mass. I can continue that trend by going to higher burn-up. I'm still once through fuel cycle.

If I recycle once, I can keep moving a bit more, still reducing mass, slight reduction in radiotoxicity. If I recycle once, then the lower the conversion ratio, the further that way I go. For example, instead of MOX, I can move further that way by inert matrix fuel. I hit a limit, and that is the mass of fission products, because if I haven't done anything clever with the fission products, I can't go any further this way. I can come down in radiotoxicity as I repeatedly recycle. Thermal system, fast system, I can drive down my residual radiotoxicity. I have to go from Pu to TRU because the minor actinides are a big part of the story.

I can come down here. I can eventually move that way again by now separating fission products. Remember the graph I showed--or, table I showed yesterday, where I've got cesium, strontium. I can take the high heat waste, which has pretty low longevity waste, do one thing with that. Take the lanthanides, which are probably Class C, take the transition metals, which are relatively low heat, and more in terms of longevity. If I segregate the fission products into different bins, then I can again reduce the amount of heat, high heat, high longevity waste.

So, one of the reasons we put this graph together is people have asked me in the past, well, how much does burn-up matter, or how much does conversion ratio matter. Well, I can't answer that unless I know where you are in strategy space. Because if I am talking up in here, burn-up matters a lot. If I'm down here, burn-up doesn't really do much for me. So, this tries to put the whole thing in a perspective, and where the Board wants to go, of course, is up to your charter.

Last slide. Benchmarks and comparisons are tricky. We have talked a lot the last day and a half on how important timing is. And, as you get more into these sorts of scenarios, more of these sorts of cases, timing is important. And, if you want to see the US or any country's waste story to change, it takes a long time to get there.

Uranium, waste management, I'll let you read that. So, it's been an interesting exercise. I'll have to redo some of the calculations, some of the things I botched, get you some of the numbers that you couldn't get from my cryptic spreadsheets, and it’s hopefully been useful.

ABKOWITZ: Thank you. Any questions or comments on Steven’s analysis, results and philosophy?

(No response.)

ABKOWITZ: All right. Stefano, do you want to go next?

PASSERINI: Thank you. So, as I said yesterday, for Scenario 3, 4, and 5, at the moment, I have the results for a calculation that we made in which we are not considering the spent fuel Legacy as a part of the fuel discharged. So, we are only considering the new fuel that is produced after 2010, and that’s why, for example, you see that in this case, we do not saturate the repository capacity, because we are not recycling or disposing of the spent fuel. That’s one of the reasons I redid the calculation, and I’m sure this number will definitely match better.

And, the fact that we are not considering the spent fuel Legacy is also the main reason, and I’ll show that why. There are no major differences in my results between the two reprocessing capacity scenarios. So, in both cases, the reprocessing capacity turns out to be under-utilized in my scenario. So, those are the results for the PWR spent fuel disposed.

Those are for the BWR. Well, in this case, the same amount should be expected, because we are not doing anything with the BWR, and that’s one of the approximations that I made, is that we distinguish simply the mass flows through the system, through a fixed constant after the scenario was run, and that that brings some, of course, some of the mass that I think I don't have complete control of, but I track back and forth a few times, and that's the results. They are slightly different, but that's because I'm not able to distinguish the single units. I'm just separating by a fixed proportion the mass flows into the system. That's why the two numbers are not exactly the same.

So, the Measure 3 is the fission products and minor actinides disposed in the repository. And, again, we didn't observe a major difference in this case, and again, that's because of the, if it turns out in my simulations that the reprocessing capacity is under-utilized, then I'll show a graph to say what that means.

When we look at the--that's the total mass of PWR spent fuel reprocessed, and that's the percent reduction in total natural uranium demand. Also, in this case, you will see basically the same results for the two. The green line is the Scenario 2, so the nominal case basically, and the other two lines, show the reduction in the total natural uranium demand following the reprocessing of the spent PWR fuel in MOX and also the recycling of the residual uranium.

And, that's the mass metrics, so the total mass of the fuel assemblies fabricated in terms of the new PWR, new

BWR, recycled PWR UOX fuel, and the MOX.

So, the recycled UOX PWR assemblies assumes to have the same enrichment as the other ones. We do have, in CAFCA, actually the option of increasing the enrichment following the presence of Uranium 236. I didn’t use it, but I will definitely do it for the rerun, including the other changes. And, for the MOX fuel, we assumed 8.73 percent of plutonium enriched, and the rest is like the tails. And, loading in the PWR cores of about 30 percent is MOX, and the rest is the fresh fuel, fresh Uranium 235 fuel, as was specified.

And, the plutonium quality was assumed to be the one presented before, with a five year old spent fuel, which is the time that we have to wait on the temporary storage, or temporary cooling before sending the fuel to the reprocessing facility.

And, I want to show you why my results are basically the same for the two, by going back to the first picture that I showed yesterday. So, basically, that’s the results that I have. So, not having the spent fuel Legacy and reprocessing only the PWR fuel, I am not able to saturate the entire reprocessing capacity for the first case, and definitely not for the second case, in which I can run the full capacity only for ten years before going down to a lower steady state value.

The reason why the steady state value is lower is because by reprocessing more fuel earlier in time, I deplete the PWR fleet that I can actually then go and reprocess again, because we said that we only reprocess the fresh PWR fuel. So, when I introduce MOX earlier, and like in larger quantities, I am depleting the feed for future reprocessing in my system. And, that’s why the steady state value here is lower than the other one. And, for my case, it turns out that basically the area under those two curves that gives you the total amount of mass reprocessed, turns out to be the same.

I will rerun the calculation, including the spent fuel Legacy, and I expect to see some differences. But that’s one of the interesting things I think of the dynamics, that according to the assumptions you have in your system, and the way one fleet is feeding another fleet, for example, or one fuel comes out of another fuel. It’s not only the case where having a larger reprocessing capacity turns out to give you like large ability of the other fuel, because it turns out like one year in time of doing that, really affects the feeding of your system later in time. So, that’s one of the outcomes of my simulation.

Again, I will redo everything, and other than that, I think the numbers are pretty consistent in terms of the uranium saving and other metrics.

MOTE: Stefano, could you go back to your Output Measure

5 slide? Okay, down at the table at the bottom, you have 3000 metric tons a year disposing 10.93 percent.

PASSERINI: Yes.

MOTE: And, a smaller capacity disposing of a larger percentage.

PASSERINI: Yes. So, the difference is really small, but it also, I think, if you look at the numbers that you have, as you see, it’s what I was talking about, so the fact of having a larger capacity turns out to have an integral of the simulation, a smaller amount of fuel turns out to be reprocessed, because I’m reprocessing more material right away in time when I can start my facility, but since I’m depleting earlier in time, the PWR fleet that can then give me materials and fuel to be reprocessed, the integral over time turns out to be slightly smaller for this scenario than for this one. But, I think the difference comes out to the fact that I’m not saturating the reprocessing capacity, so that’s the point.

MOTE: I can see why on an individual year that might be the case. But, that presumes is integrated over the period, is it?

PASSERINI: Yes.

MOTE: It seems counter-intuitive to me because anything you do with a 1500 tons a year plant, you can do with a 3000 tons a year plant. And, if your total demand is the same--

PASSERINI: No, but remember that, for example, I'm always under--on the steady state, I'm under-utilizing my reprocessing capacity because I only reprocess the PWR fuel. So, let's say I can reprocess max, 1000 metric tons per year of PWR fuel, which is two-thirds of the capacity that I have here, let's say.

MOTE: Yes.

PASSERINI: So, if I am introducing a lot of MOX earlier in time, the number goes down because I did not reprocess the spent MOX fuel. I have to dispose of that. So, it's not available for--

MOTE: Oh, I see what you mean.

PASSERINI: That's the point.

MOTE: Okay. The same with the UOX.

ROWE: This is Gene Rowe.

The enrichment for RepU, UOX assemblies, did you take into account the build-up of U236?

PASSERINO: No, I didn't, but CAFCA can do that. I just forgot today the selection. I remembered about it yesterday when you showed like your function.

ROWE: Okay, no problem.

PASSERINI: But, actually, I just started doing it yesterday, and the enrichment that we get by taking into account that with our fixed specters, is 5 percent.

ROWE: Yes, that's exactly what we get.

PASSERINI: And, I actually checked. I think we have implemented the same simplified equation that you have in your system. So, it gets 5 percent for us.

ROWE: That’s good. Thank you.

KADAK: The difference between the 30 percent and your 10 or 11 percent--

PASSERINI: Yes.

KADAK: --is really that you didn’t fully utilize the capacity?

PASSERINI: Yes.

KADAK: Do you think that would make it up to 30 percent if you did?

PASSERINI: No, but that’s the point. So, the previous benchmark case assumed that you are fully utilizing your reprocessing facility. But, the capacity of that facility turns out to be larger than the fuel that you are on steady state discharging from your fleet. Since I should have assumed that, I don’t think anybody would ever build, because it doesn’t make any sense to have that facility and under-utilizing it to that point. That actually is a totally different exercise.

KADAK: Right.

PASSERINI: As you see here, when you take into account the actual amount of fuel that you can reprocess over time, so not considering that you always saturate your facility, the numbers turn out to be different. But, they are two different benchmark cases, I would say.

KADAK: Now, MIT also ran a case for the fuel cycle study on the conversion ratio of one.

PASSERINI: Yes.

KADAK: That seemed to be saving equivalently, or demanding less equivalent natural uranium enrichment as were plutonium start-up. Are you familiar with that analysis?

PASSERINI: Yes, I've really done it--yes.

KADAK: Could you just sort of summarize that, just as a general point of information?

PASSERINI: Well, what the outcome of the MIT study is in general that by introducing fast reactors with different conversion ratios, the reduction in uranium demand is much larger basically because of the total different account you use. And, in particular, I would say the main conclusion of the MIT report, when comparing the fast reactor, was that the conversion ratios greater than one do not perform much better than conversion ratio one. That was, I think, the main conclusion that the MIT study had on that point of view.

So, that we observed kind of a saturation effect as the reduction in the uranium demand--with increasing conversion ratio over the time frame that we analyzed.

KADAK: And, that was the 2100. Now, what was the basic reason for a breeder not doing as well as the conversion ratio one reactor?

PASSERINI: Pardon?

KADAK: What was the basic reason why, given there’s a finite time that you ended the study at 2100, the breeders didn’t save as much uranium as a conversion ratio of one?

PASSERINI: Well, they did relatively better, but in a very small amount. The main reason is that when we include our recipe of the reactors, so the most affecting parameters for development of fast reactor fleet is the amount of transuranic you need to load into your core, because that determines how quickly you can build your reactors, given the amount of transuranic that you can separate from your reprocessing facilities.

KADAK: Right.

PASSERINI: It turns out that in the design that we include into our system, basically, the prism design, which is the design we took for the example of breeding reactors, requires a very large amount of transuranic loading into the core. And, that slows down a lot the start-up of the fleet. So, over that limited period of time, smaller reactors, in terms of requirement of transuranic material into the core for the same electric energy, like conversion ratio equals one, can develop much faster and, therefore, it can only integral of the simulation performed basically equally good as the breeder reactor. So, it’s a matter of the difference into the design of the core.

KADAK: And, then, the key point there being using--I'm sorry--using enriched uranium as the seed, in other words, for the core?

PASSERINI: No. We're still talking about plutonium--

KADAK: For conversion ratio one?

PASSERINI: Yes. We are analyzing the process of having the--we are in 235 initiated fast reactors right not, but it's not in the MIT study.

KADAK: Oh, it's not in the study? I see.

SHWAGERAUS: So, how do you sustain it between two different cases? The reason you don't see dramatic improvement in uranium utilization as you move from LWRs to conversion ratio one, or higher, is the rate at which you can introduce these fast reactors, which is limited by the ability of transuranics. So you're depleting your Legacy transuranics very fast as you start to deploy them, and then you are limited by the production of transuranics from the existing reactors, LWRs, and newly build fast reactors.

So, the base at which you're deploying fast reactors with a high conversion ratio, it determines the rate at which you save natural uranium, which is not dramatically different from, at least for the period of simulation. So, that problem could be overcome by starting fast reactors with enriched uranium.

And, in this case, you can build many more fast reactors which have much higher uranium utilization, obviously, because they're self-sustaining or better. And, in that case, even if you eliminate this step of reprocessing light-water reactor fuel, don't build reprocessing plant for reprocessing light-water reactor fuel, build only fast reactor reprocessing plant, which presumes it should be cheaper, and just simply looking at the through-put of materials, you need a lot more mass of spent fuel to process from light-water reactor to feed fast reactors. Whereas, in fast reactors, it's a one to one ratio or higher. So, that's basically the basic--

ABKOWITZ: Howard?

ARNOLD: First, an obvious comment. Arnold, Board.

An obvious comment. You could have recycled the BWR and put it into MOX and PWRs, but that's trivial. What I'm curious about is how you're in fact treating the depleted uranium. There isn't in existence right now, semi-infinite reservoir of depleted uranium, and if you use it, plus the plutonium from reprocessing, you're basically not using any newly mined uranium for a very long time. So, I don't understand these numbers as they relate to that.

Basically, when you're using depleted uranium, you shouldn't call it something I had to mine, because the mine exists at Portsmouth and places like that.

PASSERINI: Yeah, sure. That’s part of the simulation. But, as long as you don’t have enough PWR spent fuel to be able to produce the amount of plutonium that you need, then even if--

ARNOLD: Yeah, I understand.

PASSERINI: In the benchmark case, we are limited to reprocess only the fresh PWR fuel so, it will reach an equilibrium. It’s not possible to move everything to MOX because otherwise, we wouldn’t have anything to get the plutonium from.

ARNOLD: Yes. Way back on the Clinch River project when it was in the process of being cancelled, we did a bunch of studies of burner configurations, which were basically what you’re talking about, loaded up with uranium and burner, and it makes a pretty good reactor.

MOTE: I think there’s another case where the real world collides with the benchmark models, and that’s an interesting study to go into to. But, what we wanted was to look at what ifs that were limited, so that we compare the codes against each other and the outputs based on the same input scenarios. So, it’s all real, but that’s the next stage.

ABKOWITZ: Okay, Stefano, thank you. Gene, you have the final presentation. And, I would ask you while you’re up there, if there are any other issues you want to raise that are in the comparison tables, this would be your opportunity to do so.

ROWE: Again, I'm not going to go over this particular slide. The numbers are the numbers that show up on the right. Let's go to the next one.

I do want to talk a little bit about this. In relationship to comparing to some of the other results, is you will notice that our plutonium quality is lower than the other vendors. I think the reason for that is the way that NUWASTE works, it actually looks at the year that the assemblies are reprocessed, and calculates the individual isotopic content based on the age of that fuel when it's reprocessed.

And, the way that the calculation works is actually due to two decays of the plutonium 241. I do a decay from the time it's discharged from the reactor, until it is reprocessed. The Americium disappears, it goes along with the minor actinides and fission products. And, then, I decay it again for two more years, and the Americium stays with the assembly and is included in the reactivity calculation.

And, so, because I start with five year old fuel and I work backwards, I think that is the reason why my plutonium quality is less than the other calculations.

And, I think that to address how its comment is--you will notice in this scenario, that we're only generating a few over the 40 years, or whatever, we're only generating a few MOX assemblies in comparison to the total number. So, we still need a huge amount of natural uranium to make up for the number of natural uranium assemblies that are being fabricated. So, I think that's why that number isn't quite as big as you might think.

The tails, again, the numbers are reasonably consistent. I think that as we indicated in my last stumbling up here, is that the reason that I wanted these reported is to get an idea of, first of all, to make sure that the enrichment calculations were reasonably consistent between calculations. Also, to emphasize the fact that this is a stream that we need to deal with, and it's something that hasn't been dealt with yet, and it needs to be. And, I think that's part of what we as a Board should be looking at.

Let's skip this one and go to the next one. Okay, this just shows the individual processes as a function of time. Again, the dotted line is the total MTU discharge. The red line is the amount that is in inventory. You can see since we've got 4500 metric tons of overall capacity, that this starts decreasing quite quickly, and that our number of dry storage casks also decreases quite quickly.

Same situation as the MIT and the NNL calculation. The green line is the reprocessing capacity, and we eventually run out of assemblies to reprocess. That's why this drops down so much. It's just there was a delay between when an assembly is discharged and when you can reprocess it. There's this lull here, if you will, before we can start getting new discharged assemblies to actually reprocess. So, that's why the shape is like that.

Same mass balance chart that shows basically what the flow of mass in material is throughout the whole process. And, I think that's really all I've got to say.

ABKOWITZ: I have a question for Eugene. If we can go back to Slide 7? I know this was not a metric that we asked for in the exercise, but I think it's an interesting question in terms of the utilization of these facilities over an operating lifetime. And, you have the ability, I think, in this slide to kind of comment on that. And, the point of the matter, I guess, is the larger the reprocessing capacity, the more we can anticipate that it won't be totally utilized over its lifetime.

ROWE: Yeah, that's--

ABKOWITZ: Paul is shaking his head. Good. I'm glad we're bringing this up then. Gene, do you want to talk first, and then--

ROWE: I'll go on the defensive. Go ahead.

MURRAY: Murray, AREVA.

This is a benchmarking exercise, and so these numbers are nice. They show what would happen in a particular scenario. But, this scenario isn't real. It's made up. The purpose of this is to benchmark. This isn't how we bring capacity online in the US. This is just a benchmark, everybody's codes. So, we can't draw conclusions from this.

ROWE: And, as we have said at the very, very beginning, that was not what the purpose of this was. It was strictly to benchmark. But, it's interesting, though, one of the-- and, as I mentioned yesterday, we have several parameters that we can evaluate and compare to various scenarios. One of those parameters is facility utilization. And, it's really interesting as we can also compare various parameters over various scenarios, and if you start looking at facility utilization for various rates, the benefit from the higher capacity of the reprocessing facility really diminishes relatively quickly. And, this shows it, if you will, qualitatively that that's what occurs, but when we're looking at multiple scenarios and we're looking at multiple variables, it really kind of jumps out and hopefully, we'll do some of that in the future.

ABKOWITZ: Yeah, and I didn't mean to stir up the pot that much, other than I think it's an interesting performance metric that you may want to add to the mix, just because at some point, questions are going to be asked from an economic analysis standpoint. If we're investing "X" amount of money in something and it's only being used "Y" amount of the time, you know, you know the rest of the storyline.

Anything? Yes.

KADAK: Just recognizing what Paul just said, that this being a benchmarking exercise. I don't know how many of you had a chance to look at the report that was produced by the Board. That is not a benchmarking exercise. That's an application of the tool. So, I would be very interested in your feedback on the results presented therein, because people are reading this and making judgments. And, that's what we need to understand, whether we're on a strong footing about those, because the curves are not too different from some of the curves you've seen here. And, we want to be sure we've got them right.

MURRAY: We'll read it and get comments back.

ROWE: I'd just like to emphasize that the scenarios that are in that report are not good scenarios. They're not recommendations. They're an example of what NUWASTE is capable of doing. And, that's very, very important to understand. Anything else? Lunchtime.

ABKOWITZ: We're very close to being back on schedule. Does anyone else have a comment to offer before we break?

(No response.)

ABKOWITZ: Seeing none, we will reconvene at 1:15. Thank you.

(Whereupon, the lunch recess was taken.)

AFTERNOON SESSION

MOTE: Well, good afternoon. We'd like to resume.

This afternoon, we're starting off with something a little different. I should have said that differently. I made it sound like Monty Python. Maybe a laugh-in, which this is not.

Anyway, having talked about fuel cycle, and now we're going to look at how some of the waste streams are dealt with on DOE sites, and DOE EM, Environmental Management, has a model which is focused on the management of waste at the DOE sites. Terry Tyborowski is here from EM, with some support from MITRE Corporation. So, Terry, let me hand it over to you for 15, 20 minutes.

TYBOROWSKI: Okay, great.

MOTE: And, Terry would be prepared to accept and would encourage questions during her presentation rather than wait until the end, and then have to scroll back through overheads.

TYBOROWSKI: Thank you, Nigel.

First off, I would like to introduce our MITRE colleagues who have worked on the model. Dr. Tim Hoffman right here, and then Greg Love in the back is the principal director of the project.

I currently work in the Environmental Management program at DOE, and I've been there for two years most recently. But, I know folks in the room from previous lives. I worked on the House Appropriations Committee for five years dolling out money for the Department of Energy, and then I spent 13 years at the Department prior to that, seven years in Nuclear Non-proliferation dealing with international fuel cycles, conversion of MOX program, and the Material Protection Control Program, and then prior to that, I worked about seven years in the Department Management Program when it first got started in 1990 and 1991. So, I've been around for a while touching on these issues, not always spent fuel, but jumping in and out of it.

So, when I came back to EM, my management was interested in looking at systems dynamic modeling, and we thought that our site at Savannah River would be the best candidate to look at systems dynamic modeling. And, could you go to the next slide, please?

So, just some background. I don't know how many of you are familiar with the Savannah River Site. It is a former nuclear weapons material production site, so it's different from your commercial nuclear facilities. It no longer produces fissile material for weapons, and, however, we are currently constructing a mixed oxide fuel fabrication plant. The majority of the work at the site is on cleaning up the Legacy of the cold war.

And, if you look at this chart right here, I'll step you through each of the boxes. But, everything in blue, belongs to the Environmental Management Program. And, we have down here the mixed oxide fuel fab, and associated waste solidification building, and pit conversion. Those belong to the Nuclear NNSA Program.

So, within the confines of the blue, the annual operations for all these facilities is approximately $1.3 billion a year, annually. And, just stepping through the processes, we have a spent fuel storage pool right here. Now, the fuel in storage here is basically highly enriched uranium clad fuel, and comes from our farm research reactor return program, and comes from our Oak Ridge test reactors program, and also the universities in the country send their used nuclear fuel here as well. So, our input is a little bit different than what we've been talking about today.

Then, we have a reprocessing facility here. It's plutonium/uranium mix reaction technology, which you know is 40 years plus old, and we have an HB line here, which is a facility on top of the reprocessing facility that's essentially a line of boxes that deals with plutonium, and it works off the plutonium storage facility over here. We have to test the veracity of the plutonium in the cans, and so we will do a destructive assay up in the HB line.

And, then, continuing along the way, we have our tank farm. We currently have about 52 tanks, one which has been closed to date. A few items about the management of these facilities. We are self-regulating here under the Atomic Energy Act for the reprocessing facility and the spent fuel pool. However, when it comes to our waste manage side activities, we're regulated by the state and the fed EPA. We currently have a Federal Facilities Compliance Agreement which says that we have to be out of our tanks I believe by 2025, which is not a lot of time left, considering we're only out of one so far.

And, then, from there, it leads over into our vitrification facility, which has one melter, and then in preparing the feed for the vit plant, we have to take out the cesium and strontium, and then the remaining waste goes to saltstone, while the cesium and strontium is re-introduced back into the vit plant. And, then, for our saltstone process, which is basically the grouting of this material, we have on-site disposal, and that is at the, not pleasure, but at the consent of the state.

And, one thing about the Environmental Management Program where we have multiple sites in multiple states, is that particularly when it comes to regulation of waste, it's highly dependent upon the generosity or not of the regulator. And, so, in Savannah River, we have a very cooperative regulator that lets us do things like dispose of things on-site. But that's not true of other places as well, in particular the State of Washington is a little tougher.

One comment on our Purex Separation Process right here. While we currently have plenty of fuel in storage, we have a policy right now that we will not reprocess the material. And, that is because we're waiting the outcome of the Blue Ribbon Commission. I think there was a lady here today from the BRC. There she is. So, that's basically a policy we have at the Department right now. We want to hear what the BRC says about spent fuel in general before any decision is made to go ahead and reprocess that material.

KADAK: Can I ask a question? Is your separation plant in operation now, or not?

TYBOROWSKI: It has been down blending highly enriched uranium for about a decade, but it has not been reprocessing spent fuel.

KADAK: Okay. It's been down blending but not reprocessing?

TYBOROWSKI: Uh-huh. It's not been taking spent fuel for reprocessing.

KADAK: Any spent fuel?

TYBOROWSKI: Correct.

KADAK: Okay.

TYBOROWSKI: Any other questions about this slide, or operations?

KADAK: Explain the down blending process as opposed to separation. Do you have to make it into a chemical, liquid again for down blending?

TYBOROWSKI: And, I have to say right now I don't know. I don't know the distinction. I'm not a chemical/technical person.

KADAK: Okay.

TYBOROWSKI: Do you want to add anything, Ken?

No, he says no, he doesn't. How about you, Greg?

LOVE: This is Greg Love.

There is some dissolution that's being done of some of the enriched uranium, and that is subsequently blended down to commercial grade fuel. So, it is not a whole Purex recovery process, but there is some dissolution that's being done.

KADAK: But, you're doing it at this facility, the H Canyon?

LOVE: That's right.

TYBOROWSKI: Okay? Okay, so why this model? I've indicated my background is highly financial, and a lot of the decisions made within the EM program of $6 billion, and given our current outlook of the budget, which isn't too great, we need to look at a tool that can help us make decisions on where we put our investments.

Now, clearly, we have drivers on the tanks, which means we have to get out of business pretty soon there, but we don't really have any drivers on the spent fuel. It's in a pool. It's safe. And, so, we've developed this high-level policy model to help us look at different policy options. And, in no way is it a decision-based model where we will go and implement them immediately once we come up with items, but it's a starting point.

I will also say, too, that we have three different contractors working at this site. Essentially, everything dealing with the nuclear materials, the Purex in the storage facility over here, and the nuclear materials over here is one contractor, which is FLUOR. For the Waste Management side over here, we have URS manages the waste streams. And, then, we have a third contractor over here dealing with the actinide removal on the salt waste processing facility. And, so, there's lots of integration that needs to occur, particularly in the transfer of effluence between the actinide removal, back to the good plant, and from the tank farms, and then what feed are we going to get from Purex going into the tank farms.

And, this integration model really helps with that, because when we think that all contractors would work well together, it's nice to have a verification process that looks at it from a macro perspective as well. And, as we go through the presentation, we'll tell you where this model has actually helped out in that regard.

And, so, I would like to have, Greg, do you want to go ahead and take it from this point?

LOVE: I will. I will try to move through some of these slides a little quickly, just so we can get a view of the model. I'd like to share that with you so you'll get a perspective of how we've approached the solution here.

So, unfortunately, I have to move back here behind my table to navigate.

The objective here is to really look at scenario analysis through 2035, explore alternative strategies, and calculate mass and volumetric balances of the surplus used nuclear materials, and the by-products, and calculate life cycle costs. So, that's really what we're designing the model to do.

Now, some of the analysis that's done is directly to support some of the policy options that are being considered in EM. It's also used to analyze plans, future campaign plans, for instance, address any kind of management challenges, especially between the M&O contractors, and develop any kind of mitigation strategies to improve the outcomes, so that you really have a robust plan for moving forward.

So, how does this really work? This model is actually a hybrid model of--a lot of it is discrete and process, deterministic type modeling. It also has some system dynamics in it, which we will improve over time. But, it simulates behavior over the horizon, looks at system sizing and performance, so we can identify bottlenecks. We want to be able to validate operational schedules. This is not an operational model, but it is one that we can look at high-level plans, so we can begin to look at the timeline that it takes to close the facility and to empty the tanks at Savannah River.

And, the big thing with the life cycle cost is we can make investment decisions to the operational plans. We can look at the improvement in the operational side, as well as the payoff for making investment to shorten the life cycle. And, also, it obviously helps us with the challenges of dealing with a level funding profile.

And, we talked a little bit, Terry talked about the managing the interface between the M&O contractors on site to make sure that at those interfaces, the transfer of materials is done well.

I'm going to jump into the model very shortly. But, before I do, I'm just going to give you an example of just a process flow sheet. This is the dissolvers in H Canyon. They have three dissolvers there. Two are currently active. And, the idea here, of course, is to model the streams going in and out, and at this point, the model, and I will show it to you in a second, is a discrete process model.

We’re actually loading it with assemblies and dissolving those into a liquid solution for the Purex processing downstream.

Now, the material balances that we are setting up to track in the model, I know this is very hard to read, but we’re looking at some of the isotopes, obviously, but as equally important is the downstream processing in the tank farm, because the liquid waste streams are very complicated in their own right, and there’s glassmaker chemistry that creates certain challenges in the vitrification plant, as well as the removal of the cesium and strontium from the--to decontaminate the salt solution. So, we have to make sure that we track those from the front end through the back end of the complex at Savannah River.

So, what I’d like to do here is take us back, take us out for a minute, and--

TYBOROWSKI: One of the things I’d like to highlight while this is coming up is that, you know, an important aspect of this model, which I haven’t seen any analyses yet, but look forward to it, is the cost aspect of all these operations. And, as you look at different scenarios, you can actually trade off and look at the different cost variabilities.

LOVE: So, I’m going to go ahead and just start the model with a standard configuration, and walk through the flow sheet here, starting with the pool and L-Basin, and here you see some of the discrete model components. Basically, the material moves from left to right on the screen, and you have right, you have certain storage for different types of fuels that are being received, and they're stored in this rectangular box, which is really our inventory of the used nuclear fuel, as it's called down there.

We have the ability to set up schedules for these receipts according to the plans and agreements that are in place, and then as a campaign starts, material will be pulled out of storage and be transferred to a rail car, cask car for movement into H Canyon. And, so, that is being simulated.

And, in H Canyon itself, you can see where the fuel comes in, comes in in the upper left-hand corner, and the cask is unloaded, and then, of course, it's loaded into the dissolvers where there are restrictions as to how many assemblies can be charged to the dissolver at any one time. Now, remember, the geometry of these assemblies change, depending on the reactor type, so there's no one size fits all. There's inserts that have to be put into these dissolvers that really control how much, and also the safety concerns, how much can be dissolved at any one time.

And, the characteristics of the fuel assemblies does vary depending on the origin. And, for that reason, we are really starting this model with an assay, a typical assay of the used nuclear fuel that's going to be charged during a campaign. So, it isn't tied back to the reactor technology, it's just simply an assay of what a typical assembly would look like. It's dissolved, and at that point, it goes through the first and second cycle of the Purex process.

Let me take you just to a quick view of liquid waste. We have an overview of the liquid waste dashboard, and just right here instantaneously, you saw that the project started up, the salt waste processing facility, it just turned on. Previous to the start of that facility that's currently planned in the middle of 2014, there's some other smaller, more experimental units that are being operated to remove some of the cesium and strontium, the large scale plant will start up. And, the advantage of having the systems model is there's some recycle streams between the salt waste processing facility and the defense waste processing facility. That's our vit plant.

And, it's very important to understand that balance because the liquid recycle is one of the most challenging material balances to deal with in this operation. And, any bottleneck in the flows here could shut both plants down, because they're so closely--they will be interconnected, so closely interconnected at these higher rates, that you have very little time to react if there's something that interferes with the normal flow.

TYBOROWSKI: If I could just jump in here? The other value of this, too, is that that SCIX component in the middle there is actually a new technology to take the sodium out of the tank, and it has not been introduced yet, but this model allows us to make some assumptions on how it will accelerate the program and how much it will cost. We're going to have cost savings in the out years.

LOVE: That's right. Then, down here at the very bottom left, you will see the saltstone facility, where the decontaminated salt solution that's recovered from the salt waste processing facility and SCIX and the other salt removal facilities, is then mixed with the grout for on-site disposal in the vaults.

Now, we have a view of the individual tanks. We're working on getting the data into this model to actually track at a high level basically four different levels in each of these tanks, what we call the supernate, the salt solution sludge, and any interstitial material.

TYBOROWSKI: And, they're not empty yet.

LOVE: They are not empty yet, no. And, so, we're still in the--we're in the late stages of our development, but we're working on developing the algorithms to actually develop some rules for how to efficiently move the materials from the tanks to blend them so that they can eventually be processed downstream.

TYBOROWSKI: One of the things we discovered as we went through each of the facilities and talked to the folks that actually operate them is that they have different levels of modeling themselves. You know, the tank farm has a very detailed model that looks at the transfer between the tanks, and it takes a long time to run a scenario, up to six months, I think, to get an actual nuclear waste plant going. And, then, the nuclear material side is very elementary, good operational model, but not a high level kind of policy analysis model. So, I think MITRE has done a really great job to kind of levelize what currently exists into, you know, one approach to looking at these functions.

LOVE: I know in the interest of time, let me just show you, we have interactive graphics here for the vitrification plant that shows you the different feed tanks and the staging of those feed tanks that’s necessary in order to provide the material in the melter for the production of the glass canisters. We have a few dashboards throughout the model that allow us to monitor the utility utilization rate, and where the bottlenecks may be over time with the different feed tanks that are supplying the material to the melter.

I think I’d like to spend just the last few minutes here taking a look at some of the costs here, because this really is one thing that sets us apart from the model. I’m going to go to an overview here, where you look at the cost by area. So, we're breaking down the operating costs over time, according to the government fiscal year, for each of the processing areas down at Savannah River.

And, as the model is unfolding, the costs are captured. Essentially, there's baseline cost information that we've captured at the site that then is projected out using the prescribed escalation rate into the future years. And, so, it's directly related to the contractor costs down there on site.

TYBOROWSKI: So, some of the policy analyses we can run on this is the assumption of what fuel goes through the Canyon, when, what timing of that is, what impact it has on the reprocessing program, introduction of new technologies, we talked about SCIX, what cost savings we can have as a result, what happens if you introduce another melter into DWPF. So, different policy scenarios we can run through here and see what the impact is on costs and schedule.

LOVE: For those of you who may be curious, SCIX stands for Small Column Ion Exchange. That's the technology that's being introduced in the tank.

In terms of costs, we also have investment costs, so certain investments, for instance, with the--this is the tail end of the construction period for the salt waste process facility, and we show the construction costs, and then at the time the construction is completed, it becomes an operating asset, and there’s an operating cost profile that takes it out to future years. So, this builds into those scenarios where you have to invest in order to create an operational capability to get you to the--achieve your goal of closure by a certain time, within a certain time frame.

That’s pretty much the information I have to share with you. We’ll be glad to entertain any questions.

TYBOROWSKI: John?

VIENNA: John Vienna. This is John Vienna. Do you plan to extend this to the other sites?

TYBOROWSKI: Well, I think Hanford is the logical, you know, next site to go. This is really kind of revolutionary in EM, as you can appreciate the fact that we’re introducing this type of modeling, and from a systems dynamic standpoint as well, to avoid that stovepiping. But, you know, it was easier to start with Savannah River because they were operational, and of course Hanford is not quite ready yet with their facility. So, I think Hanford would be the next one.

ABKOWITZ: Abkowitz, Board.

I wanted to learn a little more about your costing approach. It looks like you have both capital and operating costs involved. Have you run sensitivity analysis on things like discount rates and useful life, and some of those things, to see just how those types of assumptions may impact the financial benefit costs?

TYBOROWSKI: Have we done it yet? No, but this model has the ability to do that, certainly when you're looking at different long-term scenarios, in particular, investment scenarios, which one looks best. But, to be quite frank with you, thanks for putting that up, the activities in dark blue are pretty much solid right now, we're not going to do much more work on it. But, you can see there's some light blue activities there that we haven't really straightened out yet. So, to do a full analysis on the whole life cycle, we need to fill in some of those light blue boxes, including costs.

One of the large costs down here, believe it or not, is our pensions liability. And, that swings the cost around every year in terms of what we have to put in, depending how the economy is doing. But, it's a tremendous load of burden that we have to take into account, add on, after we have figured out what the facility costs are.

KADAK: Kadak, Board.

I'm just trying to understand what happens in 2025 to this chart?

TYBOROWSKI: The tanks should be closed.

KADAK: That's the goal?

TYBOROWSKI: That's the goal.

KADAK: And, what about the storage and separation and the pit conversion.

TYBOROWSKI: Well, certainly the pit conversion will stay there because it supports the mixed oxide fuel fabrication facility. There's an agreement in Russia to basically get rid of 34 metric tons of weapons material. So, 34 metric tons of weapons material will be coming through Savannah River and be made into MOX fuel for disposition in reactors. So, that all stays alive. So, you see it's kind of two different time, you know, historical moments here where we have the down side of weapons production and kind of, you know, the emergence of getting rid of plutonium, weapons grade plutonium.

KADAK: Is there a plan to build a commercial reprocessing capability with Purex separation plant?

TYBOROWSKI: No, there's no plans to do that at all. Right now, while we are not reprocessing, some of the ideas being proposed by the Department is actually to use it as an R&D facility for advanced separation technologies.

KADAK: Okay. In your economic modeling, could that facility be used for commercial reprocessing?

TYBOROWSKI: I can't answer that because I don't know.

MURRAY: I've look at it. I'm Paul Murray from AREVA. It's got no head ends, there's no capability to share fuel. You would have to retrofit that onto the front end. It's also connected to the tank farm, and I guess DOE ultimately wants to disconnect it from the tank farm. So, you would have to put basically a back end on it as well to vitrify the waste.

KADAK: I guess that's where I'm confused. If the tank farm goes away--

MURRAY: Yes.

KADAK: --and the Purex separation process continues, and you still have high-level--I'm sorry--spent fuel from I guess research reactors in storage, plus other orphan waste, how does that all fit?

TYBOROWSKI: Well, right now, there's sufficient capacity to take the spent fuel, I think, through 2025.

LOVE: That sounds about right.

TYBOROWSKI: Yes. And, that our mission to close the tanks should happen around the same time. Right now, the whole issue of the spent fuel disposition is on hold, pending the Blue Ribbon Commission's decision on spent fuel in general. The Department didn't want to move ahead and start reprocessing fuel unilaterally without the advice of the Blue Ribbon Commission. So, right now, it's on hold.

KADAK: Is the Blue Ribbon Commission specifically looking at your facility here?

TYBOROWSKI: I think they're looking at spent fuel in general, and we're going to take a time out and take a lead to see where they're headed on it before we start.

KADAK: Correct me if I'm wrong, Paul, you maybe know this, but I don't think the Blue Ribbon Commission is looking at defense wastes, like this is, and all that research reactor stuff. So, I'm just trying to understand why the decision to wait if you have spent fuel in storage, high enriched, that you need to separate and your tank farm will go away.

TYBOROWSKI: No, the tank farm is not going away for another 25--

KADAK: Well, 2025, that's like 14 years.

TYBOROWSKI: 14 years, yes.

LOVE: Can I interject something here? And, that is that the value of taking a systems perspective and view of this model is to align the time scales of these campaigns that might occur for spent fuel in H Canyon, with the expected life cycle and the tank farm and the downstream units to decontaminate the salt solution. So, the purpose of this model is to look at those timings and those interdependencies very closely so that we can prepare, DOE EM can prepare, better plan for the closure of the tank farm.

TYBOROWSKI: The Blue Ribbon Commission draft report I think is out in July; right? Is that correct? So, I think shortly, we will know.

KADAK: Thank you.

WILLIAMS: This is Jeff Williams. Wasn't that spent fuel that was there part of the 2600 tons that was planned to go to Yucca Mountain as co-disposal packages previously?

TYBOROWSKI: I think that the preferred alternative in the aluminum clad spent fuel EIS was in fact melt and dilute, was the disposition path forward on that. Although what you're talking about was another option, but it wasn't the preferred option. And, then, during the Bush administration, they didn't fund melt and dilute technology, so we're kind of at a point where we haven't pursued the technology that was preferred alternative, and we need to have an amended Record of Decision in order to reprocess the fuel if that's what the Department chooses to do.

MURRAY: Isn't it fair to say that the enriched uranium that comes out of H Canyon has historically gone to the Blue projects, been down blended, and then the uranium fuel goes to TVA?

TYBOROWSKI: Yes, it does.

MURRAY: So, by stopping H Canyon, you stop the Blue project as well?

TYBOROWSKI: I don't know what the Blue project is. I know that under the uranium blend down agreement, which I noted earlier, that we fulfilled our commitment under it and that any additional uranium would be another agreement with TVA.

MURRAY: Okay.

MOTE: I'll stand up here so I can see behind where I was sitting with Andy. No questions? Okay, any other questions?

(No response.)

MOTE: Terry and Greg, thanks a lot.

LOVE: Thank you.

MOTE: All right, now we come to the last of the presentations with overheads. I apologize. I don’t think many of you will know that there are overheads printed for this. That’s because we kept them back until today to see if the overheads that we had drafted in advance reflected where we are right now. And, in fact, they do, so we don’t need to change that, but as of this afternoon, those overheads are now out on the table.

So, what I would like to do now is to run through the next level of thinking, which is we are where we are. Where do we need to be and how do we get there. So, the presentation is coming up any second now. Mark just volunteered to tell us a story.

ABKOWITZ: I volunteered Nigel to tell us the story.

MOTE: As we catch up with the overheads, and I can walk you through the first couple, so we came here with some objectives. We were looking at a number of models and benchmarking them against each other, which we can check off because we have done. We talked about the input assumptions and clarified where there were differences, and where we found differences, we've resolved a number of those. We've compared results and we have, to a large extent, reached consensus on where there's areas of agreement and where there are still some differences.

And, in many cases, I think maybe all cases, the participants who had produced results and tabulated them, and we found that by comparing numbers on the tables, where there were differences, we've resolved those. We know where they come from and the participants who said they would revise the numbers they need to, provide them to us, and we will produce revised copies of the Excel spreadsheet with the final numbers in so everybody can see how well they align. And, we would expect there to be small differences, and where there are differences, we know where they come from and we're happy with it.

Next slide, if you will, Bill, and the next one? Thanks.

So, we talk about what remains to be done. We need to focus on the particular issues and problems that we have found, and identify which of those we need to work on. Find the best path forward and see what activities there are that we need to do to be of use to the community.

So, the first step of that is to identify. There's a list of things here which is not meant to be--it's meant to be as complete as we could see in advance, but there are surely other things as well.

So, I just went through quickly the items that remain from the workshop objectives, that is, to align the results and to end up with Excel spreadsheets with revised numbers in some cases, and we understand where the differences are.

So, the issues to be resolved. Now, I don't have any here in that category. The low-level waste issue, I'd rather bring back in the fifth one down because it's identified there.

All the issues to be resolved from the work that we have done so far in the workshop, I do not have a list of those in my record of the meeting. Any bids for issues to be resolved?

(No response.)

MOTE: Okay, additional models/tools/codes with similar capabilities? We have talked about the IAEA, the codes that they have, and we've talked about the OECD, NEA, and they have a code. We have talked about benchmarking from that. I said at the beginning in the opening that in parallel with this meeting, with this workshop, the technical working group, the IAEA's section called NEFW, Nuclear Energy Fuel Cycle and Waste, that they have a technical working group meeting going on now, and they would like to know what comes out of this meeting, and would like to take the output from this as an input to one of their meetings, potentially the next one in three months time.

They are also going to discuss in their working group meeting this week, the extent to which the members of that group know about the codes that we can bring into the community here for comparison, to the extent that might be necessary, and if it’s not, it will certainly let the operators of those codes know what we have done, and they can take the results and do whatever they want to with those to broaden the discussion within the community.

Is there any other action that we need to do, that we need to take with respect to identifying other codes, models, looking at results, comparing and advising other people of what we have done here?

MURRAY: Can I make a general comment?

MOTE: Absolutely.

MURRAY: This exercise has been a real success. We have enjoyed it. I think everybody has participated here. But, one of the most important things that’s going to come out of this was this was a benchmarking exercise, and we can’t have any firm, fixed conclusions about future US policy based on this exercise today.

MOTE: I think we’re all agreed on that.

MURRAY: I know, but I think we need to clearly state that somewhere.

MOTE: Okay. Well, we will produce a note from the meeting, and that will be sent to State.

MURRAY: Excellent. But, one of the other things that clearly came out today was we've all got to go back and run our codes again. Instead of looking at hypothetical fuel cycles, why don't we all agree that we're pretty much all in the same ballpark on our codes, why don't we look at a real scenario of the US based on conditions that are relevant to the US.

MOTE: You mean this one down here?

MURRAY: Well, yes, but you need fast reactors. So, these are all question marks. They're question marks after all.

MOTE: It's not meant to be a sheet of these things we need to talk about. If we decide not to do them, we'll do them left handed instead of right handed, or anything, that's fine. This was merely a set of discussion points.

MURRAY: Yes. I don't believe we finished what we're trying to do here first, before we start broadening--

MOTE: Well, let's go back up to the first two there. What else is there from the workshop that we still have to do here that we need to do?

MURRAY: We really need to look, that the US has unique regulatory requirements, totally different from the rest of the world. We're also unique from the rest of the world that we have this huge stockpile of used nuclear fuel. Nobody in their right mind is going to go ahead and build a 1500 ton a year plant or a 3000 ton a year plant, for the very reasons we saw. We'd run out of material to process through it. So, as industry, and I'm talking to Chris here as well, and hope Chris doesn't mind, but maybe we could set the parameters, we could write down the parameters to say okay, we start recycling in the US as industry, this will be the size plant, we'd operate that, these are the regulations we'd have to operate under and why, and move forward that way.

MOTE: Well, will you move to the next slide, please? Thanks.

I think what we're moving into is--and certainly I have no problem bouncing between the slides because it's meant to be if not iterative, then as flexible as we need to be. I think we're talking about other technical panel working groups, which would be some representation from the people here in defining some of the steps and where we go next. Now, who we is is another point of discussion. And, the Board at lunchtime had a discussion about exactly what we should be doing because we're at risk of getting outside our mandate. So, at this point, we need to be very clear on that we set up this meeting, we're not clear what further involvement we need to have, and that's a discussion that's still continuing.

So, without saying we, meaning the Board, we as a community need to define how we go forward in these areas. If AREVA wants to be part of that, with Energy Solutions, maybe DOE needs to be part of it, maybe it’s all of the players who have activities in the area or related, that’s fine, but if we at the end of this discussion get to--we’ve got three or four different action items, and we’ve got players identified who want to be involved, and there’s a time scale anyway, that’s great. I mean, that’s exactly where we obviously need to go.

MURRAY: Because, at the end of the day, well, it’s two options at the end of the day, the government pays for this, or industry pays for this. So, if the government is going to pay for it, go at it and design fast reactors, you know, whatever you want to. But, if industry is paying, then maybe industry should talk about what scenarios we see could be deployed, and then look at it and say, you know, we’re open to suggestions and comments and things we haven’t thought about before.

ABKOWITZ: Abkowitz, Board.

I like that. I think Paul has set the table quite nicely. It seems to me that--you made a comment earlier during the workshop about realistic scenarios and boundary conditions, and I think everyone would be better served if we can pick a date, 2100 or some other date, and then basically say within the time space between now and then, what are the family of realistic scenarios that we can agree represent what this world might look like in this respect.

Or, if that’s too difficult because some people have much more optimistic views of new technology than others, maybe we just say well, let’s stay within the light-water reactor world until such time as--until some date, and talk about what we can do within that scope.

But, I do think we have to anchor it in something that’s, you know, time dependent and starts with where we are today.

MURRAY: It comes back to my argument as well. I’m sorry for talking--but it comes back to my argument as well, is we don’t have to commit 100 percent to anything at this stage, and we never do have to. The scope of the problem is so big in front of us that we have options. But, what can we start with to move forward?

ABKOWITZ: Ali?

MOSLEH: I think that relates back to the discussion this morning about the scope, for instance, if we want to look at realistic scenarios, the question is what sort of questions would be issues we want to try. Because otherwise, the scope, as I see it from a sample of problems and capabilities that you have introduced so far, that a wide range of things that different models can address and tackle.

So, as a community, maybe identification of a set of core issues or questions, based on which scenarios to develop to be the first action.

MURRAY: I think one other thing is missing, is the ultimate repository of the high-level waste, which would dictate the unloading of the high-level waste that industry would strive for. You know, you get us a repository, we can go to higher heat load, and that encourages us to produce phosphate based glasses to get higher loadings.

MOTE: I'm not sure how we handle that here.

MURRAY: That's going to be a big driver for the ultimate waste volume.

MOTE: Well, maybe that's something we need to define in the scenarios.

MURRAY: Uh-huh.

MOTE: Andy?

KADAK: Just an observation. In looking at some of the MIT benchmarking study, we also have agreed we're kind of in the same trend. We've got the same general idea. But, if you look at the details of the results, they're quite different in terms of scenarios and number of plants that are being deployed. I just took a look at the MIT benchmarking, and yes, grossly, we're kind of on the up-curves. But, if you look at the details, they're quite different.

So, even though--and, you're also are pretty comfortable with your models. They are different. And, maybe based on assumptions--but, that needs to be understood better, because we can't look at the model, individual models and say well, Model A predicts this, and, therefore scenario for future fuel cycles should be that, when Model B predicts a dramatic drop. So, there's no what I would call coherence in the modeling to be able to reach any kind of decision making.

Our interest, I think, as a Board is really on the waste forms. We talked about this earlier. In other words, if we go to a UREX A, whatever you call the numbers, A1, B1, C1--

MURRAY: DOE doesn't use that anymore.

KADAK: Whatever you use today, I don't know how all that was reflected here, the whole non-proliferation discussion, but you can have separated plutonium. It's crucial to this conversation. And, the chemistry, as Steve points out, way different. You can't assume 99.9 percent separation. You've still got stuff. And, that level of detail is where I think we would like to have a better comfort zone about what are we going to do with this waste, whether it be vitrified waste, whether it be A, B, C, D, and the volume.

So, if we could come to some--and, this is from the Waste Board's perspective, at least from mine--understanding of how to fine-grain it a little bit better on that side, given the chemistries, I think that would be important to do. But, the only model I saw that's capable of doing that was perhaps AREVA's, because they do it.

PIET: Can I--

KADAK: Sure.

PIET: First off, I can't speak about all the other models, but VISION can do a lot of what you're talking about. We've got a different model, and maybe other people do, too, called FIT, which is really chemistry and waste forms, and so forth. Now, VISION and FIT do some things that are overlapping because they have different related purposes. But, if, for example, the Board wanted to get into how--let me start over.

There are trade-offs. When I choose a separation strategy, or for that matter, a fabrication strategy, it's not just the number of nines, but it's the order of events, sequence of events, so I can shift the equilibrium so that I have relatively dirty waste, or relatively dirty fuel products. Dirty in this sense means something that I didn't want to have there.

So, one of the things we're struggling with in the fuel cycle program is I can have less transuranics in my waste, which has advantages, and so forth, with regard to waste classification, if I were willing to accept more fission products in the recycled material that I'm going to make--do fuel out of. It's a chemical equilibrium shift. And, how those things trade off against each other is not well understood.

KADAK: And, I think that's very important, because as Paul said, the repository is affected by what you produce as junk.

PIET: Absolutely.

KADAK: And, if you have bad stuff the repository can't hold or requires, you know, "X" number more million cubic feet, that's a problem. So, there's much more integration to do here, and we're struggling to figure out what is our proper role because we're not policy makers, but we're sort of commenters on directions. And, maybe DOE has something to add here on this. Where's Jeff? Is he here? He just left, okay.

MURRAY: One of the other things, a salt repository is the panacea for everything. Everything can go into a salt repository. If that's true, we don't need fast reactors. We don't need advanced separations. We send everything to the salt repository and just use LWR MOX.

KADAK: We haven't looked nearly as deeply as we need to on that.

MURRAY: You know, maybe the Board could set a current set of guidelines for each type of repository that would help us determine which is the best.

MOTE: Mark?

ABKOWITZ: Abkowitz, Board.

I wanted to follow up on this conversation, and introduce another one that's somewhat related. It would seem to me that in addition to talking about realistic scenarios, we should also work together to come up with an agreed-upon set of waste management criteria, or some type of indicators so that we know what we're trying to measure and we can discuss, you know, in useful terms what the trade-offs are from these various scenarios.

What I also wanted to mention, this is--Steve was talking about flying with other pilots going into the darkness. This is actually my second experience in less than a week. I, along with George Hornberger, who is a colleague of mine, and on the Board of Vanderbilt, we co-hosted a climate change risk analysis last Thursday and Friday, and we heard from the climate scientists and, you know, there's at least as much uncertainty in their models as there are in these.

But, one of the things that struck me in terms of the summit that we had was an agreement that there needs to be better communication and interaction between the modelers and the policy analysts and decision makers.

And, so, one of the areas that I think would be fruitful is to not only work on how we can best communicate the kind of information that we're producing, but the other thing is to try to prioritize where the uncertainties are likely to offer the greatest confusion. And, if we can maybe come to terms with the fact that if we don't agree on certain uncertainties, but it doesn't really change the robustness of the results, you know, that's not where you want to put your energy. Maybe there's a way we can try to identify what the key uncertainties are that are going to drive the waste management implications, and that would then be the target to try to work better at modeling those relationships.

MURRAY: I believe DOE, through any UP program, is going to come up with a fuel cycle simulator, which might go some way to answer your policy questions.

MOTE: John? Do you know who's working on that fuel cycle simulator?

MURRAY: Jeff can answer the question?

ABKOWITZ: Actually, Steven is the best one to answer that question.

PIET: Well, in general, it sounds like you need, some or all of the Board needs to sit down with the leadership of the fuel cycle technology program that John and I are part of, because more and more I'm hearing topics that you guys are discussing just now that are things that are going on either in Systems Analysis, where I sit, Separations and

Waste Forms, where John sits, the Used Fuel Disposition, you talk about scenarios, we'll have to create new ones, we can give you some of the things we've analyzed.

But, one of the reasons this is an intractable problem is that it is a mixture of the hard engineering and a soft sciences, and we have to remember that that mixture is out there. And, the problem is that each one of these entities that I mentioned, the Board here, we all have our charters and there's no macro charter that involves policy.

The Blue Ribbon Commission, I guess, has that to some degree, but they're not going to get down in the details. That's just not what they're constructed to do. So, you guys can't do policy. John and I can't do policy. OMB is going to do policy? I don't know. But, that's the part of this that I don't think is very clear.

KADAK: But, don't you think DOE should do policy? In the real world, they're the responsible agent for disposal.

PIET: As long as the microphones are on, I'm not going to answer that question.

MOTE: And, would we implement policy? Okay? When people are commenting, they go to the mike and introduce themselves. Thanks.

GIDDEN: Okay, Matthew Gidden, University of Wisconsin.

Quickly on the NEUP fuel cycle simulator question. I was in the recent call for proposals by the NEUP, but they have not yet made a decision about who is funded and what the project is going to be. So, that would be the near future, I want to say probably the beginning of fall, end of summer, I’m not 100 percent sure on when that comes out. But, it’s there. It hasn’t been decided on who’s getting the funding.

PIET: I would not make huge assumptions on how much money is going to go into those. Realism isn’t important there, too.

BRAD WILLIAMS: Brad Williams, DOE NE, and I can answer some of these questions. I’m actually in charge of that program.

MOTE: Welcome. We welcome your input.

BRAD WILLIAMS: Thanks. I do have to be a little vague because we haven’t made announcements, but the fuel cycle simulator is something that we have been discussing about over the last year or so. We’re trying to get it started. The idea is that it would be a tool, a full simulator from mining to disposal, open source, module based, with a heavy focus on the user interface visualization as a communication tool so that we could work with policy makers to come to decisions on specific fuel cycles.

The other part of the picture is within the fuel cycle program, we are implementing a systems engineering approach. We just recently evaluated over 800 options. Theoretically, every potential fuel cycle that you could imagine was included in that. In February, we finished a demonstration of that screening process, and in the coming years, in 2013, we'll try to conduct a formal screening to consider all of these different options and set of metrics that would be important, and different weighting, depending on policy considerations.

So, we do have a very active program within NE, looking at many of the things that you guys have been discussing the past two days. This fuel cycle simulator theoretically would do exactly what we have been talking about yesterday afternoon and today. We're trying to get it started, part through the NEUP and also through our program with the National Labs and with industry.

We held an initial workshop a few months ago. I believe someone from the Board participated.

MOTE: Gene and I were there. Paul was there as well.

BRAD WILLIAMS: Right. And, we'll have another one coming up in the next couple months, later this summer, and I'll make sure that you guys are included in that. But, I think conceptually, it would address almost all, if not all, the questions that have come up.

KADAK: I guess I'm confused again. We have VISION, we have ORION, we have CAFCA, those are arguably fuel cycle simulators. So, we're doing yet another one?

BRAD WILLIAMS: No. And, that's a key that we don't want to reinvent the wheel. We're looking at everything that's been done. We want to come up with something, much like what you're doing, come up with something that everyone can agree to. Maybe it's using one of the existing models.

But, the key I think is making it a tool that both researchers can use to identify where more research needs to be done on certain technologies, but also as a policy or communication tool, both here in Washington or with the general public, so that we--right now, VISION, for example, our number one tool, we generate a 500 page report that, you know, people can't even get through the Executive Summary, let alone the whole report.

We want something that is quick and easy for less technical people. So, it's essentially developing a user interface and making sure it's consistent with all of the existing models and making changes or connections and links where needed. But, it's more to enhance the current capabilities so that they can be as useful as possible.

KADAK: I think you should put the Board on distribution for your workshops, and also for any reports that you might have on what you have so far.

BRAD WILLIAMS: Okay.

KADAK: Thank you.

ARNOLD: Do I conclude from listening to you that you really haven't decided how to proceed? You're looking at the various input pieces.

BRAD WILLIAMS: We're still in early development, and with budget uncertainties and program priorities and shifting focuses, it bounces around a little bit, but we're coming to more of a focus, most likely with a major emphasis on getting university teams to do a majority of the work, with our National Lab led campaign doing the oversight. But, we're still getting started with it, and it has--the method has shifted a little bit as we've been going forward, and until we know how much funding we can put towards it in the next couple of years, it's still a little bit unclear.

ARNOLD: Okay, another question. These scenarios are input to a policy making effort. Is DOE facing up to making those policy decisions?

BRAD WILLIAMS: We are evaluating all of the options from a technical standpoint of looking for gaps, where we can focus R&D so that they would apply to the widest set of options, so that we can have the information available to those who do make the policy decisions, and we can inform them.

ARNOLD: Who are they?

JEFF WILLIAMS: It depends what the question is. Okay? I mean, if it's a repository somewhere, obviously it's not DOE.

Jeff Williams from DOE. All I was saying was it depends on what you call a policy decision and what level that policy decision is. And, in many cases, we are, as I said, we are the policy implementer rather than the policy maker. The Nuclear Waste Policy Act was Congress, the President, and our job was to implement it until they changed it to the Nuclear Waste Policy Amendments Act. So, now, there's other decisions that are made that some people may call policy, that DOE can make.

MOSLEH: Your timeline horizon for developing this integrated path, what is that timeline?

BRAD WILLIAMS: We would like to have at least a demonstration of the capability by the end of 2012, early '13, but again, it depends on the funding that we're able to apply to it. But, in the next couple of years with a fully operating line, say five years from now. But, again, it depends on budgets and funding levels and priorities.

MOSLEH: Do you agree with my characterization of it being an integrated existing capabilities, to the extent that you can actually get access to them.

BRAD WILLIAMS: Yes, initially that is the approach we're taking.

PIET: Can I add one thing. John Greeves yesterday made a good point about the need for waste to communicate. Brad and I and others use the word visualization. I threw some things into particularly my last talk that were not requested in the benchmark, I think you called it philosophy. Well, it’s a “P” word, so, you know, policy, philosophy, maybe they’re close. But, I think all of us need to search and concentrate new ideas on how to get some of these concepts across to people that are less technical than the folks in this room. I don’t think we’ve got the answer. I think we need more explanation of possibilities, because yes, we want to communicate, but we’ve got to do some testing and exploration on just what does communicate. Of course, we can’t decide that here. We can dream up things. But, we’ve got to do some testing there.

WORRALL: In fear of being slightly controversial, we just heard the DOE statement that by 2012, ’13, they’re looking to demonstrate capability. But, only two or three hours ago, we heard from Andy, who said--I think it was Andy, said in this room, we have demonstrated and shown the capability to deliver on fuel cycle modeling and assessment. So, somebody is wrong. I believe I’m on that gentleman’s side there, who said--and, also, this is back to the fuel cycle meeting we just referred to, I think it was the Advanced Fuels Campaign that was in Atlanta--I’m sorry, Jeff, in Atlanta? The Atlanta meeting, where at the end of it, the industry partners and AREVA were there and Westinghouse, and I just mentioned others, and Ed LaHood from Westinghouse said, “In terms of these tools, you don’t need to develop anything else.” There are two already in place, and with our fear of--ORION is one of those two--and we didn’t pay Westinghouse a single cent for them to say that. But, the other one was the code I mentioned, the AREVA code yesterday, is COSI or COSAC the equivalent for the AREVA side?

So, if these things already do exist, it’s just understanding here, based in the current climate, with lack of funding, lack of resource, lack of time, I think utilizing, which is I think is about the same, is actually taking what we already have and looking for the best way forward. I think we are 90 percent--let’s not reinvent the wheel because it will only just add time and delay onto these things. We have the capability in place today, and the expertise, to make those assessments.

VIENNA: I’d like to make a comment, too. This is John Vienna from PNNL. You had asked a little while ago what you could do with this tool? How you could develop it and where it could be applied? And, one idea I have that would be very timely is to use it to study the different disposition options for low-level waste, and in particular, the NRC is relooking at Part 61, which has the potential to change the infrastructure for how we classify and dispose of low-level waste. And, right now, there’s dis-incentive to reducing volume of low-level waste, as we’ve all heard. And, from reprocessing over 70 percent of the low-level waste is amenable to readily available proven technologies that could volume reduce it.

We don’t use those in the US because of the way Part 61 is written right now. So, right now, we have the Blue Ribbon Commission and others saying that all waste is the same, and if you reprocess, you’re going to increase the amount of waste that you have to dispose of, and they don’t understand the difference between low-level waste and high-level waste. And, we have NRC relooking at the Part 61, and that may change dramatically how we dispose of low-level waste.

So, I think if you could tailor your tool to look at those options that give guidance to the policy makers for low-level waste, it would be very timely.

MOTE: What I’m hearing, I think, is that there are two parts to this discussion, which I think can be treated separately. One is do we have codes that can do what we want now, and do we have enough redundancy that we don’t need to do anything else? And, that’s a discussion I think that we have heard both sides of. So, getting to an agreement--a consensus on that I think would be the target.

The second one is what else can we use the codes for that we have now? And low-level waste is one that’s come back time and time again. And, by low-level waste, I’m hearing everything that’s not high-level waste, and that it’s

Class A, B, C, and greater than Class C in the US, and what other countries might consider intermediate or low. And from earlier in the workshop, a history that Gene put up, which is there is indecision as far as we know in how you would deal with reprocessed uranium as a waste stream. I know in Europe, it's treated very much as a low-level waste, and it's not--does not seem to be a significant problem, maybe with some delayed storage. But, in this country, there's no determination of how recycled uranium tails would be disposed of.

So, if I package low-level waste to include things that may not be strictly low-level, but that they could well be and they need to be considered as other waste streams that's not vitrified high-level waste, and there are two actions that I see from that discussion. Is that a fair statement? Is there any clarification, dissent, counter-suggestions? Steve?

PIET: Well, let me at least throw out, there's one other activity going on that you may or may not be aware of, and that is in addition to the Blue Ribbon Commission, in addition to 10 CFR 61, et cetera, et cetera, et cetera, there's also a DOE EIS procedure that's going on with regard to greater than Class C waste disposal options. They have a draft EIS. Public hearings have started. I attended one as a private citizen in Idaho two weeks ago. So, they're looking at above-ground vault, enhanced, near surface burial, and an intermediate depth borehole.

And, if you go with the two by two matrix that I mentioned, none of this is high heat generating waste, so it's long lived, but low heat. And, so, how that plays in with all these other acronyms, I will confess to be confused. But, all these different things are going on. Whether it adds up to a consistent strategy on behalf of the US, if it does, my guess is it's going to be more because of accident than because of any coordination.

MOTE: If I look at the bullets we have up here, I can see a working group on codes and a technical panel on low-level waste types, including taking account of the DOE EIS consideration, including boreholes, and some of these things become cyclic, because boreholes have other characteristics, other potential applications as well. But, that would be boreholes in the context of an EIS, looking at some part of the low-level waste disposal issue. Is there a comment on that that may fit into a technical panel or working group?

MURRAY: Bring it back full circle again. We've loved today and yesterday because fundamentally as industry, we cannot agree on the waste volumes we would generate from recycling. That's it. No matter what codes we've got, anything else, we cannot agree how much waste we produce.

So, the first step we do before we start looking at fast reactors, repositories, is to go back and find out why we don't agree. And, I think we take it to the context of the scenario, a realistic scenario for a small plan in the US, look at the outputs, all in the same scenario, come up with the same waste volumes, that's the next logical step to do before we start doing anything else. It doesn't matter what anybody else is doing. Figuring out what the waste volumes are from recycling, nobody can agree.

MOTE: Mark?

ABKOWITZ: I just wanted to get clarification on that. Your proposal, Paul, would be that we define some realistic scenarios.

MURRAY: Yes.

ABKOWITZ: And, waste indicators?

MURRAY: Just one realistic scenario.

ABKOWITZ: And, then, the modeling community comes back at that.

MURRAY: Yes.

ABKOWITZ: Now that we've done the benchmarking, and we see where we land in our predictions, and discuss why they're different, if they are in fact different.

MURRAY: Yes.

ABKOWITZ: When you say just one scenario, why just one?

MURRAY: Let's just pick one.

ABKOWITZ: Well, I was going to say if we're going to go through the effort, we may want two or three that are--

MURRAY: I think the point is make is realistic.

ABKOWITZ: Yes, I absolutely understand.

MURRAY: Make it realistic and agree on one.

ABKOWITZ: Right.

MURRAY: And, what we do after that, we can all go our own separate ways. If they're all benchmarked, we all know we're saying the same thing at one point in time, and then we can go on.

ABKOWITZ: Okay, thank you.

KADAK: I'd like to share Steve's frustration with the greater than Class C waste. To account a little story when I was president of the Yankee Atomic, and we had greater than Class C core baffle. We said, "What are we going to do with this?" And, the answer was, "We need to show DOE the way." So, we cut up this core baffle, and we put it in what we called a spent fuel shape, if GTCC is supposed to be in a geological repository, or something equivalent. So, we figured maybe we can make it look like a spent fuel assembly, put the slice of metal in a spent fuel-like assembly, like a BWR, put it in a cask, seal it like a spent fuel can, that maybe DOE will understand that maybe it could go into a repository. No.

The problem is not the EIS. The problem is the law. Somebody, when they talked about greater than Class C waste, called it low-level, when it’s really high-activity waste. Worse than spent fuel over the duration. So, it’s not--I mean, the EIS, shallow burial--do this, and do that. It’s geological. Okay? And, I think the problem I think Paul raised, it’s the regulation, the classification that needs to be fixed first. Then, we know how to dispose of waste based on its risk level, why won’t some refinate from some reprocessing plant that was conceived in 1952.

PIET: Andy, there was a Catch 22.

KADAK: Yes.

PIET: If you go back and read, without falling asleep, the technical reports that led to 10 CFR 61, and I’ve gone through parts of it, but they’re very sleep-inducing, the regulator takes, if you will, the opposite position, at least the NRC did at the time, which is they looked at all the possible waste streams that they saw at that time, and then said oh, well, these, these and these, we don’t have to worry about those yet because nobody is doing them yet.

So, they wrote the regulation on the basis of the waste forms they knew they had to regulate. So, they left this whole zone between high-level waste and A,B,C amorphous, and it was a deliberate decision on the part of the NRC, because nobody was pressuring them to set regulations.

So, you can’t do anything without knowing the regulations. The regulations aren’t going to appear without someone wanting to do something.

MOTE: Can we bring this back in? It’s a great discussion, but we need to focus on where we’re going.

So, I was hearing earlier there were two things that were of interest to the group to take another look at with a smaller group in the near future. I’m not sure, Paul, that I was hearing you saying we don’t need to do that until we’ve done another scenario. But, to some extent, how you would deal with low-level waste is not conditioned on how much there will be.

MURRAY: Well, I beg to differ. In the US, we have so many options, you know, waste isn’t classified until it actually gets ready to leave your plant. It’s what you do with it before that time is up to you. So, in Europe, we try and segregate the waste, minimize waste volumes. In the US, it’s totally opposite, and sometimes, it’s better to blend your waste and create a bigger volume before you start shipping out the door.

So, I think it’s important that we agree what the minimum waste volumes are from a set scenario, and then look at the options for each of those waste streams, for its ultimate disposal. Does that make sense?

MOTE: Well, it does if the consequence of selecting the scenario, or the consequence of the scenario you select is going to determine whether or not you have waste in certain categories, then yes, except for as Mark said. You know, if we pick one scenario, it might be a realistic scenario. It may not be the scenario that ends up being--

MURRAY: Here's a scenario. If I separate my short lived low-level waste, and I never ship off my site, it's not waste. I store it on site and it decays to nothing. It's not waste. Under the regulations, it's not waste. I'm not shipping off site to dispose of it. I'm keeping it on site.

KADAK: It's a fine point, but I think NRC is now looking at regulations, and help me if I'm way off base, but they're looking at the amount of low-level waste now being accumulated at reactor sites, and establishing perhaps more stringent criteria for watching it as it, whatever it's called.

MURRAY: Some say license it as a storage facility, I can keep it on site.

KADAK: They may end up doing that. Okay, is a consensus that--Eugene?

SHWAGERAUS: Yes, it's not exactly on the same subject. But, it's related to path forward where should--what should the next step be. We're discussing what is expected from this fuel cycle simulation code, and it seems like the focus is drifting towards we have to get more precise modeling of reality, or you have to get more realistic with respect to this scenario, but getting back to the uncertainty, it may be a time to recognize that uncertainty on everything, assumptions, you know, data, is so large that it’s impossible to make a prediction or pick a realistic scenario.

So, instead of focusing on making the precision of the codes better, maybe the focus should be to have a tool that will help create a system, a fuel cycle system, you know, with all the components of this fuel cycle that will be robust and prone to the potential changes in policy, and assumptions, there’s so many things that can happen, you know, nuclear accidents, God forbid, right, they could stir things 180 degrees from one thing to another. And, if you base your policy decision on this specific scenario, thinking that it’s realistic, then you commit a large amount of resources to that, that, you know, post factum, could be considered as a mistake.

So, maybe the focus, at least some effort should be devoted to thinking that these tools should be a help to create these versatile and robust systems that are adaptive, basically, to these changes. So, recognize the fact that uncertainty is inherent and it’s so large, and there’s nothing you can do about it.

MOTE: Isn’t that different from Paul’s position, though? I mean, Paul’s position is we can determine where we’re going, not by making a decision, but by saying if it’s going in this direction, it may preclude needing to deal with some of the low-level waste streams. If we want to do what Eugene is saying, it means keep all your options open. And, those two seem to be at opposite ends of the scale.

SHWAGERAUS: They're not contradicting.

MURRAY: They're two options. It comes down to, again, who's going to pay for it. If DOE is going to pay for it, then all the options should be on the table, and maybe that should be one scenario we look at. If the government is paying for it, we can have any scenario we want. But, if industry is paying for it, what's the scenario industry would deploy to start the cycling in the US? There's two scenarios.

MOTE: Is it any more realistic to expect that industry, I mean, it's easy to say industry as an indication of a single body--

MURRAY: Well, let me and Chris Phillips get together. We'll come back and we'll say this is the potential scenario that industry agrees. If it is on the table to pay for this, this is what we would go and try and build.

MOTE: Is industry broader than that?

MURRAY: Well, they can come forward if they want to. You know, you get GE, we're going to go to sodium fast reactors, and stuff like that.

MOTE: Where is Rod? Would you want to be part

MURRAY: Absolutely.

MC CULLUM: Industry is broader than that. I mean, industry is the electric utilities. Right now, our future fuel cycle policy is driven by extending the operation of 104 plants, bringing 105th on at Watts Bar, building Vogtle 3, Vogtle 3 and 4, perhaps plants, Bellefonte, and then as those demonstrate their success, more light-water reactors. Economically driven fuel cycle policy right now points us to light-water reactors.

I look at the mission of this Board, which is to review DOE’s program. DOE has said today that their program is to wait for the Blue Ribbon Commission to tell them what to do, and that will also require Congress to enact something, because as Jeff has said, you know, Congress makes policies, DOE implements policy.

So, in terms of what there is on the table for this group to do here, it has to be focused on light-water reactors, and our continuing to move--is there something that supports the continuing to move off the broader industry, in the direction of light-water reactors. And, there’s some novel things like small reactors, on the table. Until DOE is either directed by Congress or by the President to put in place some other program, there’s really not much else that needs to be considered right here. I mean, that’s--

MURRAY: When industry went before the Blue Ribbon Commission, we couldn’t agree on the waste volumes from recycling. So, as if you--builds recycling plants, and Energy Solutions who have access to the UK technology, and also design recycling plants, we can put a realistic scenario down--if anybody else designs recycling plants, they can potentially join in as well, but, you know, what would industry build in the US if we had to start?

MC CULLUM: You, really, as a review Board, have to look at what's out there. And, I should say, in respect to GE, there is a fast reactor design in the marketplace. But, you know, it's a broad industry, but absent some other program, it's hard to get too far out in front of this. There's a move to extend the life of and build additional light-water reactors. There is one potential fast reactor player in the marketplace at this point. And, we're waiting for DOE to have a program to fulfill its statutory obligation, the same statute that creates this Board's mandate, to manage the waste from those reactors. That's what this has to fit into.

MURRAY: But, don't you think the entire industry would be literally interested to know how much waste was produced by this cycling? Instead of one company saying A, somebody else saying B, somebody else saying C, somebody else saying D, if it's agreed, we could agree on a realistic scenario, look at the waste that was produced, and all agree on that waste volume, and not make a recommendation, just agree on the waste volumes that would be produced by a particular scenario, everybody moves forward.

MC CULLUM: I think it would be useful if there was a program to address that waste. I mean, that’s not going to affect decisions to build new reactors at this point.

MURRAY: No. But, then, once you know the waste volumes, then you can look at the next step, which is in waste, where should it go, stuff like that. But, until we know what those waste volumes are--

MC CULLUM: That’s valuable. Again, I’m waiting for some leadership from DOE on a program now.

MOTE: I think maybe for the record, we should say that the Board may not be involved in some of this work, because if it gets into policy issues and areas outside the Board’s mandate, we would not be part of that.

MURRAY: But, the Board’s position is to look after the waste, isn’t it, the high-level waste?

MOTE: It’s to review and comment on what DOE does.

MURRAY: Okay.

MOTE: So, we’ve got to be careful not to be out in front of that. But, in the interest of facilitating that there is a need to do that, this meeting is obviously pointing in that direction, but we would want to be very careful about that.

ARNOLD: Just maybe somebody could argue with me on this point, but the Blue Ribbon Commission is itself a DOE entity.

It was not a separate entity. It was established by DOE. People may have other opinions, but that's a fact. And, our charge, our mandate is to review technical activities within DOE. So, we're involved in parsing between those parts of the Blue Ribbon Commission, those that deal with technical issues and those which deal with policy.

MOTE: What I'm hearing is that Energy Solutions, although Chris I think is out of the room, but I think--

PHILLIPS: We had already spoken about it, so--

MOTE: Okay. Energy Solutions and AREVA, two are prepared to work together. Do we need to have a third or a fourth body working with them to agree realistic scenarios, or one realistic scenario, so that we can look at the--

MURRAY: If we can just get one scenario on the table that we can all look at, then we can open it up afterwards. It's really just one realistic scenario, the benchmark models.

MOTE: All right. I feel like an auctioneer here. Is that okay? Are we solved on that one?

ABKOWITZ: I was just going to say that we have to agree on what the metrics are, the performance metrics are as well.

MURRAY: We'll take the US speculations, the EPA regulations, groundwater regulations, everything.

ABKOWITZ: Okay. And, that has to be part of the scenario, what the output measures are.

MURRAY: Most definitely.

MOTE: Okay, jumping through to are we going to have responsibilities, and the schedule actually is on there, if that's AREVA and Energy Solutions working together, what is the sort of time scale for you coming up with a joint scenario, that is, a jointly agreed single scenario?

MURRAY: Can we talk about it and get back to you?

MOTE: Sure. Coming back to the low-level waste issue, are we saying that then we do not need to address potential volumes of low-level waste of different categories until that scenario has been defined, because there is something of a cycle to be broken, and we need to start with the scenario first? Because a theme that I heard through the workshop with a number of people saying it, was we need to understand better what the potential options are for disposing of low-level waste, and what the volumes are.

Now, if from this scenario, presuming one of the outputs which we did not ask for here as an output, would need to be the low-level waste issue if that's going to be dealt with, now, the Board's mandate doesn't cover low-level waste but to the extent it impacts on things like displacement of high-level waste volume, there may be a secondary route by which we need to be interested in that. But, is that scenario going to be looking also at generation of low-level waste?

MURRAY: I'd say yes, because the requirements in place in the US will drive us to recycling older fuel, and one of the biggest low-level waste streams in the US will be grouted tritium waste. Old fuel, the tritium is gone. It's all leaked away or decayed away, pretty much.

KADAK: The other thing, I'm not sure our mandate is so narrow as only high-level waste, because once you get into the reprocessing side of it, it becomes part of that cycle. So, I think generally speaking, low-level waste from nuclear power plants is not in our domain. But, once you get into the question of reprocessed outputs, I think it falls into our domain.

MURRAY: The current regulations, everything that comes up, first cycle refinate, is always--

ABKOWITZ: Gene?

ROWE: Just need some clarification. Are you talking about waste streams or waste forms, low-level waste streams or low-level waste forms?

KADAK: My deal would be stream and then form.

ROWE: Both, yes.

MURRAY: I think it's a duly useful exercise.

MOTE: Yes. Okay, what other actions are there that we need to take following this workshop? And, the ones that we just talked about are the ones that I had down as issues that I saw have been the focus of discussion that we were not already covering here. Mark?

ABKOWITZ: Well, Abkowitz, Board.

A couple of things. You know, one is that if there's any other related documents that people want to share with this audience and with the public, make sure that you follow up by getting that information to the Board, so we can put it on our website.

The other thing is that there will be a follow-up report of some form coming out from the Board that summarizes the results of this workshop. And, before we get too far along in that, we need to get some sense of what the commitment is for updating the benchmark results.

MOTE: The time scale?

ABKOWITZ: Yes.

MOTE: Yes. Well, all of the participants have said that where they acknowledged that there was a difference of input, or there was an error in setting up the model, then they would revise that. But, let's agree on a time scale for that. Is it reasonable to get that out in the next two weeks? I mean, all results in to the Board within two weeks from now?

ROWE: I'm a little concerned about Steve, because he's taking a week off. His son is graduating from college I guess next week. So, he's not going to be around for a week. So, two weeks may be a little--

MOTE: Okay, well, let’s check that with Steve, and then--has Steve gone finally?

ROWE: I think he left already.

MOTE: Okay. Then, we’ll check with Steve and put the date in the record. So, two weeks from now will be okay for the participants who are still here? Okay.

ABKOWITZ: Abkowitz, Board.

I guess I have another question, which is if we are going down this scenario and benchmarking path to Phase 2, or whatever we want to call this, then I think we also need to think about the medium or forum for which those results will be discussed, and who will take the lead in coordinating that activity?

MOTE: Maybe you can combine that with a follow-on workshop.

ABKOWITZ: That’s what I’m saying, is this a--will the Board take that on, and are we looking at early fall, or what?

MOTE: I don’t know. I think my view is that the Board could be the catalyst in putting that together, subject to depending on the results and depending on what happens in the other actions. It may be that we put that together, but with a view that we hand off some of the responsibilities if we find that it’s getting outside our area. But, that’s my view. I’m looking for comment on that.

KADAK: Kadak, Board.

If the focus is on truly waste streams and waste forms, I think we certainly could do that.

MURRAY: Yes.

MOTE: Okay. Time scale? Three months from now, four months from now? October?

ROWE: We have a Board meeting in September.

MOTE: We do? So, maybe October? And, how far can we get now? Is it reasonable to say same place, or is there an idea that maybe Arlington is not the right place for the next one, somebody will like it somewhere else? The agency in Vienna has said that at some point, they would be happy to host a sequel. If we're talking about a follow-on from this, which is essentially US based, that would not, I think, be the right time for that. That could be the one after the next one. Is Arlington sometime in October a target that everybody here can agree with at least in principle? Okay, sold.

SPEAKER: When you said Vienna, I thought you meant--

MOTE: No, no, the other Vienna, the one where they have no kangaroos. Are there any other--well, we have the assignment. One off. The responsibilities really are combined with that. But, if Energy Solutions and AREVA come through with a single scenario, well, I guess we need a time scale for that. And, you said you will advise us. That's got to be time enough that all of the participants, and any others who come along, can run the scenario in time to have results for an October meeting.

MURRAY: I think so. I think we can do it.

MOTE: Okay.

MURRAY: Say within a month.

MOTE: Within a month? Okay, all right.

ABKOWITZ: This is Abkowitz, Board.

Just for those of you that are still here, and actually a goodly number, if you haven't already communicated when you registered, your e-mail address, please make sure that you make that available to Linda Coultry or to one of us so that we can keep everyone that's been at this workshop apprised of the developments for the next one.

MOTE: All right. Are there other actions that we need to follow-up on? We have one working group, a small one. And, the one that I saw on low-level waste, we have put on ice until we see what's happening with the scenario.

As Mark said, if there are any presentations that have changed, apart from the new stuff, AREVA, Marie-Anne, you changed some of the overheads, if you would let us have the revised version, we will put them out on the webside.

BRUDIEU: He has them.

MOTE: Oh, you have it already. Okay. Well, of course, because we presented it. Yes, okay, I'm sorry.

Well, are we at the end of that discussion? I think we probably are.

HARRISON: I'm Bill Harrison from the Board Staff. I'm the IT guy. The one thing that came up that I'm not sure if we've gotten resolved or not is Steve talked about the two by two matrix of hot long lived, short lived, and he was having difficulty mapping that to be registering the mandate world, and there was some confusion about how everybody here interpreted outputs. Is that another thing that needs to be clarified, or did I hear that wrong, or was there need for clarification about those outputs.

MOTE: I heard confusion about where they would go, rather than there are other forms. But, that was part of the discussion, any place we were just going through with Paul.

Did anybody else hear an outstanding issue in that area?

(No response.)

MOTE: No. Thanks, Bill.

Just before Mark starts to close out, I would like to recognize four people. And, we've all sat here with things running smoothly, and that has been very easy. I've been in meetings where it has not run smoothly. I have been astounded at the number of changes that we've had in overheads, the number of people who have been speaking, the loud voices and quiet voices. And, these three guys back here have done a stellar job.

Scott Ford is our established reporter, who will be producing the transcript. Bill Harrison is the IT guy on the Staff who has put the presentations together here. He and Linda Coultry, who is not here, but you've seen Linda around. They were, I know, because I saw them, they were working Saturday, they were in the office on Sunday, they were here on Sunday. They've put the last week into this completely. And, Julian Johnson, the sound guy, has done another outstanding job.

I'm difficult to go on a mike, I know, and I've seen people like it. I'll put Gene out just because he's on the Staff and I'm not going to embarrass another organization. Gene gets enthusiastic, as we all do, and then forgets that he's focused on the mike. It's so easy to do, everybody does it, so you three guys, thanks very much, and Linda as well.

I'd like a round of applause for those guys.

(Applause.)

ABKOWITZ: Thank you, Nigel, and I certainly echo those sentiments.

We do have on the program a public comment period, and unlike yesterday, we have no one who is confused as to whether they're signing the attendee list or the public comment list. We've pretty much allowed this whole workshop to be a public comment period, but if there is any other comment that anybody would like to offer, this would be the time to do that. Is there any additional participation?

(No response.)

ABKOWITZ: Okay, I'm supposed to be giving closing remarks, and we're supposed to adjourn at 3:00. So, I think we're going to do just fine.

MOTE: Two minutes.

ABKOWITZ: Two minutes, I can do two minutes.

MOTE: If you try hard, Mark, you can run over.

ABKOWITZ: Probably. Duquette is not here to bug me about it.

In any event, there is another group that I would like to recognize who have put in endless hours trying to get their arms around how to develop this exercise, and have had a lot of interaction with the people that have actually performed the analyses. And, that's Gene Rowe and Bruce Kirstein and Nigel Mote.

So, if you would join me in a round of applause for them?

(Applause.)

ABKOWITZ: The culmination of a 36 hour event really starts in the planning stages, months, if not years, ahead. And, I can attest to the amount of energy that's gone into getting us to where we are today.

I also would like to thank my fellow Board members who elected to participate in this. As you know, we have our public Board meetings, which are coincident with our Board business meetings, and there’s an expectation that you will attend those as a Board member almost at all cost. But, when we get into workshops, there is a lot of latitude in terms of Board member participation, and it’s generally a function of whether or not that intersects with your sphere of influence and interest.

It is not typical to have the majority of Board members attend an individual workshop. So, I would like to commend my colleagues, as well as indicate to the rest of you the level of interest that this particular area and initiative has.

I would also very much like to thank our participants. We kind of threw something at you that may have been somewhat unorthodox, given that your tools are all designed for whatever purposes they are, and we asked you to conform to something that was more narrowly defined, and probably a little more planted towards things that we knew we could do with our own tools.

So, I think it’s very important that you agreed to participate, and I appreciate the time that you put in, and I know that some of you came long distances, either within the US, or across the pond. And, for that, we are also very appreciative.

And, finally, I would like to thank everyone that has come. This was a workshop, a public workshop. Without the interest and input from most everyone here, I think the vast majority of the people that are not sitting at the tables here, have interacted in one way or another, if not in front of the microphone, then certainly out in the hallway, and during the breaks. And, I think it's a testament to this group that the level of interest has been sustained over the last couple days.

We didn't anticipate the numbers to be this large when we planned it, and I certainly would not have expected you all to stay this long as you have. So, a thank you to all of you.

And, with that, I declare this workshop adjourned. Thank you.

(Whereupon, at 3:00 p.m., the workshop 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 Workshop On Evaluation Of Waste Streams Associated With LWR Fuel Cycle Options, held on June 7, 2011 in Arlington, VA, taken from the electronic recording of proceedings in the above-entitled matter.

July 14, 2011

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