

NUCLEAR REGULATORY COMMISSION

**ORIGINAL**

REPLACEMENT FOR

ML 011840025

ML011840034

Title: Advisory Committee on Reactor Safeguards  
Subcommittee on Advanced Reactors

PROCESS USING ADAMS  
TEMPLATE: ACRS/ACNW-005

Docket Number: (not applicable)

Location: Rockville, Maryland

Date: Tuesday, June 5, 2001

Work Order No.: NRC-244

Pages 341-705

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TR04

1 UNITED STATES OF AMERICA  
2 NUCLEAR REGULATORY COMMISSION  
3 + + + + +  
4 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
5 (ACRS)

6 + + + + +  
7 SUBCOMMITTEE ON ADVANCED REACTORS

8 + + + + +  
9 TUESDAY,  
10 JUNE 5, 2001

11 + + + + +  
12 ROCKVILLE, MARYLAND

13 + + + + +  
14 The Subcommittee met at the Auditorium,  
15 Nuclear Regulatory Commission, Two White Flint North,  
16 11545 Rockville Pike, Rockville, Maryland, at 8:30  
17 a.m., Thomas S. Kress, Chairman, presiding.

18 COMMITTEE MEMBERS PRESENT:

19 THOMAS S. KRESS, Subcommittee Chairman  
20 GEORGE APOSTOLAKIS, ACRS Chairman  
21 MARIO V. BONACA, ACRS Member  
22 F. PETER FORD, ACRS Member  
23 GRAHAM M. LEITCH, ACRS Member  
24 DANA A. POWERS, ACRS Member  
25 WILLIAM J. SHACK, ACRS Member

## 1 COMMITTEE MEMBERS PRESENT (Continued):

2 JOHN D. SIEBER, ACRS Member

3 ROBERT E. UHRIG, ACRS Member

4 GRAHAM B. WALLIS, ACRS Member

5 B. JOHN GARRICK, ACNW Chairman

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P-R-O-C-E-E-D-I-N-G-S

(8:31 a.m.)

CHAIRMAN KRESS: Will the meeting please  
come to order?

I have to read this mandatory statement.  
This is the second day of the meeting of the ACRS  
Subcommittee on Advanced Reactors.

I'm Thomas Kress, Chairman of the  
Subcommittee.

Subcommittee members in attendance are  
ACRS Chairman George Apostolakis. That's him right  
there.

DR. APOSTOLAKIS: On time, as usual.

CHAIRMAN KRESS: On time and under budget.

Mario Bonaca. I almost missed that one.

Peter Ford.

Graham Leitch.

Dana Powers.

William Shack.

Jack Sieber.

Robert Uhrig.

And Graham Wallis.

Also attending is the Honorable ACNW  
Chairman John Garrick.

The purpose of this meeting is to continue

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1 our discussions of the regulatory challenges for  
2 future nuclear power plants. The Subcommittee will  
3 gather information, analyze relevant issues and facts,  
4 and formulate proposed positions and actions as  
5 appropriate for deliberation by the full committee.

6 Michael T. Markley is the cognizant ACRS  
7 Staff Engineer for this meeting.

8 The rules for participation in today's  
9 meeting have been announced as part of the notice of  
10 this meeting previously published in the Federal  
11 Register on May 10th, 2001.

12 A transcript of the meeting is being kept  
13 and will be made available as stated in the Federal  
14 Register notice.

15 It is requested that speakers first  
16 identify themselves and speak with sufficient clarity  
17 and volume so they can be heard. If the people from  
18 the audience wish to make comments, ask questions, and  
19 so forth, please use these microphones on either side  
20 and also identify yourself and speak with sufficient  
21 clarity.

22 We have received on written comments or  
23 request for time to make oral statements from members  
24 of the public regarding today's meeting.

25 The morning session up until lunchtime

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1 will be here in this auditorium. The afternoon  
2 session, we lose this auditorium, and we have to move.  
3 The afternoon session will be in the ACRS Conference  
4 Room, T2B-3 on the second floor. I think everybody  
5 knows where that is.

6 I don't have any additional comments. Do  
7 any of the members, co-chair have any comments?

8 (No response.)

9 CHAIRMAN KRESS: Seeing none, we will now  
10 proceed with the meeting and call on Ron Simard of NEI  
11 to start us off this morning.

12 MR. SIMARD: Thank you.

13 Dr. Kress and I were just reminiscing.  
14 When we first met each other 30 years ago, he was  
15 working on Generation IV concepts down at Oak Ridge.

16 This is probably not the most interesting  
17 title for this talk. Sometimes I've taken to giving  
18 this talk and calling it "The Future Isn't What It  
19 Used to Be," because -- Jenny, would you go to the  
20 first?

21 Just a reminder as to what's changed, and  
22 today let's try to understand why it's changed and  
23 changing so rapidly, and then I'll try to tie that  
24 back to what it means in terms of challenges to the  
25 NRC in being able to respond to those changes.

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1 But just to summarize what's different  
2 about our view of the future now is it's clear that  
3 we'll need more electricity. This has been coming for  
4 a while as demand has grown, as we've eaten into our  
5 reserve margins. We've seen it in the annual  
6 projections by DOE, the Energy Information  
7 Administration, and now we have the National Energy  
8 Policy out, which makes it pretty clear.

9 And the problem we have with that is that  
10 we are looking at -- even at the lower end of DOE's  
11 estimates, we're looking at increasing our generating  
12 capacity by almost 50 percent. Fifty percent of a big  
13 number is a very big number, and it's not going to be  
14 possible to meet it entirely with fossil fuels,  
15 whether it's natural gas or coal.

16 It's becoming increasingly clear that  
17 there are long-term concerns about the price of the  
18 fuel, as well as the physical inability to add that  
19 many more megawatts solely of fossil fired generation  
20 without violating clean air constraints.

21 And, on the other hand, we're seeing an  
22 increased prospects for nuclear energy partly because  
23 their economics are being perceived as potentially  
24 better in the future and partly because with  
25 restructuring in the industry and consolidation, we're

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1 moving toward a situation where a number of large  
2 generating companies, a small number, are increasingly  
3 moving towards operating the majority of our plants.

4 Now, I think that this is partly  
5 contributing to the increase we're seeing in the  
6 performance of the plants, this consolidation of  
7 expertise, but it also means looking forward that  
8 these folks have the capital to consider adding more  
9 nuclear plants to the fleet.

10 We're also seeing a significant change in  
11 public support and certainly political support. I  
12 think Thursday of this week, for example, you'll see  
13 Senator Bingaman's bill introduced, which will help  
14 expand the nuclear work force not only for the  
15 industry, but for the NRC, the full range of the work  
16 force, and the public support has completely reversed  
17 itself even in California where now 60 percent of  
18 Californians tell the field poll -- this is not an NEI  
19 sponsored survey. This is an independent poll --  
20 that more nuclear energy is going to needed.

21 And finally, and this is what we're here  
22 to talk about today, that last bullet, the potential  
23 is there for increased certainty in the licensing  
24 process, and this is important because it's a new  
25 business environment, and we have to be able to have

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1 certainty with respect to what it's going to take to  
2 bring these new plants to market now in a restructured  
3 environment.

4 Remember that 60 percent of our nuclear  
5 plants today, 60 out of 103 units, are operating in  
6 states where electricity restructuring has occurred.  
7 So there is a fair amount of effort underway, which  
8 I'll try to summarize for you, to prepare for what we  
9 know are near term business decisions.

10 We know that several companies are  
11 beginning today to make their business plans and their  
12 decisions about whether to add more nuclear to their  
13 fleet, and, Jenny, let's go to the next slide. I  
14 think the next slide might be even better to show you  
15 the scope of activities underway.

16 You have a copy of this in your handouts,  
17 and what it does is it tries to tie together the  
18 activities I just showed you on that previous slide  
19 and show you how they all come together in an  
20 integrated way.

21 Up at the top of the slide there, we need  
22 to change the very top of that slide. The very top  
23 box refers to a seminal document that we've been  
24 working from for the last few years. It's a document  
25 that sets the direction for nuclear energy going

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1 forward. There's a new document. As of last month we  
2 have something called "Vision 2020," which I'll talk  
3 about a little bit toward the end here, but what I'd  
4 like to show you here on this slide is that from that  
5 "Vision 2020," or from that statement, which by the  
6 way has been bought into by the NEI board of  
7 directors, that means the chief executives of all the  
8 generating companies and a fair mix of the other  
9 companies across the industry that belong to NEI.

10 At that level of industry leadership they  
11 have bought into this, and in fact, what you'll see is  
12 that the NEI business plan, our whole plan for next  
13 year and our budget, will, in fact, mirror this  
14 "Vision 2020." It will conform with the objectives  
15 that we're going to be talking about today.

16 And under that we have a plan, and this  
17 plan assigns work in four areas, and the intent of  
18 this work is to take on as many of the open issues as  
19 we can in the next couple of years roughly and provide  
20 that certainty that the executives are going to need  
21 in their business decisions.

22 I might just point out on the extreme  
23 right-hand side, I think one of the most challenging  
24 things for us is the infrastructure, and I'm talking  
25 here about not only the people, but also the

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1 manufacturing capabilities, the equipment suppliers,  
2 the engineering services.

3 We had a kickoff meeting of a task force.  
4 It's the second one in from the right, the work force  
5 issues task force, at NEI yesterday, which has  
6 representatives from the generating companies, the  
7 labor unions, the contractors who supply contract  
8 personnel to our plants, NRC and DOE, and the purpose  
9 of that is to identify the manpower needs for the  
10 entire industry, all aspects of running this operation  
11 in the future, and then to identify where the gaps  
12 are, and finally to lay out actions, how we're going  
13 to fill those gaps.

14 Now, going back to the licensing area,  
15 that box in the middle, you're going to hear about  
16 that later today, the new plant regulatory framework.  
17 That's the subject of a separate presentation this  
18 afternoon.

19 Let's focus on the other boxes over there.  
20 Jenny, would you please? Let's go to the next slide.

21 And let's talk about licensing, and in  
22 three areas in particular. We're talking about the  
23 licensing needs in the very near term with respect to  
24 working out the Part 52 implementation details. Also,  
25 with respect to not only assuring the safety, but how

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1 other types of NRC regulations will apply to these new  
2 types of designs, the kind of designs you heard about  
3 yesterday afternoon.

4 And finally, reflecting the fact that the  
5 next group of plants that's going to be brought to  
6 market may not be brought to market by regulated  
7 utilities in a cost and service environment. Rather,  
8 they will be merchant nuclear power plants competing  
9 on their own merits. They're going to sell all or  
10 part of their electricity to the market, and they're  
11 going to be run by some new approach to the ownership  
12 and risk sharing in these projects.

13 So let's talk about those three areas.  
14 With respect to Part 52, let's go to the next slide,  
15 Jenny. Maybe it's even better to look at this in a  
16 picture.

17 Compare the top and bottom here. What we  
18 have on the bottom is an efficient new approach to  
19 licensing future plants, and what's relevant to our  
20 theme today, talking about the uncertainties in cost  
21 and schedule, is the fact that this framework holds  
22 the promise for being able to bring these plants to  
23 market with a certainty we've never had before.

24 On the lower left-hand side, with design  
25 certification, which the NRC has now certified three

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1 advanced designs; with design certification, we also  
2 have this concept of ITAAC, inspections, tests and  
3 analyses, that you can perform and then acceptance  
4 criteria that show that, in fact, you've built the  
5 design that was certified.

6 That's key because at the end, the bottom  
7 right-hand side here, the focus in post construction  
8 hearings is on whether or not those acceptance  
9 criteria have been met.

10 So with design certification and the fact  
11 that it's been applied now three times, I think we've  
12 made tremendous progress. What still has to be tested  
13 though are the other two key pieces of Part 52.

14 On the bottom left, early site permitting.  
15 So one of the things that we currently have underway  
16 are interactions among the industry and between the  
17 industry and NRC and public meetings to work out  
18 exactly how early site permitting will apply.

19 For example, if we're going to add  
20 additional reactors to sites that already have  
21 reactors up and running, sites that have already been  
22 reviewed by the NRC, the environmental characteristics  
23 are known, for example.

24 But then the other key and the other  
25 challenge to the NRC now is working out the rest of

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1 that line along the bottom. Once the construction  
2 permit and operating license has been granted and once  
3 the licensee has this extremely effective construction  
4 schedule now, which is capable of bringing these  
5 plants to fuel loading in three years or less, how can  
6 the NRC superimpose its inspection process, and  
7 especially how will they, beginning for the first  
8 time, use this -- verify that, in fact, the ITAAC had  
9 been met?

10 So I think one of the larger challenges  
11 that we're working on today is construction inspection  
12 and ITAAC verification, and that's key. It's key not  
13 only to being able to meet the licensee's construction  
14 schedule, but, again, it's key to that arrow on the  
15 bottom right, to being able to demonstrate to all of  
16 the stakeholders here, the licensee, the NRC, the  
17 public, all of the stakeholders, the key to being able  
18 to demonstrate clearly and unambiguously that the  
19 acceptance criteria have been met.

20 This is the second area we talked about.  
21 Not only are these designs likely not going to be  
22 brought to market by regulated utilities who are going  
23 to put them in a rate base, get a guaranteed rate of  
24 return, but we're now, as you saw yesterday, talking  
25 about different designs. They are not necessarily

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1 light water reactors anymore.

2 Some are. We have three advanced light  
3 water reactors that are certified. They're on the  
4 shelf. They're ready to go, but other designs, like  
5 the ones you heard yesterday are modular, for example,  
6 and there's a list of four questions you need to ask.

7 If it's not a single reactor unit anymore  
8 but a series of modules, well, then how do some of  
9 these NRC regulations apply? For example, you need to  
10 bring clarity to whether or not you can issue one  
11 license for five, six, seven, ten modules at the site.

12 You also have to clarify the requirements  
13 under Part 140 or Price Anderson.

14 That third bullet is key. What about the  
15 annual fees, which is on a per reactor basis?

16 And then finally, the NRC regulations are  
17 quit specific as to the number and qualifications of  
18 people in the control room.

19 Similarly, in the second bullet, if there  
20 are gas cooled designs, the regulations, for example  
21 5075, currently give estimates for how much money  
22 you'll need to set aside over time to decommission a  
23 PWR or BWR. What about a gas cooled reactor? What  
24 about the generic environmental impacts which are in  
25 Part 51, those two tables that you see there?

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1           And finally, what about the fact that  
2           you're going to have to redefine what are the  
3           appropriate actions to take as part of your emergency  
4           plan?

5           On the next slide, here's the third  
6           example now. Here's yet a third example of a number  
7           of issues that need clarification by NRC, given the  
8           fact that, again, these are not necessarily regulated  
9           utilities applying for a license.

10          So if it's a merchant plant, for example,  
11          some of the issues that you see currently being  
12          discussed and need near term resolution are the  
13          previous requirements for an anti-trust review, the  
14          requirements for NRC to determine the financial  
15          qualifications, and finally what mechanisms are  
16          appropriate in terms of setting aside that money we  
17          talked about a minute ago for decommissioning of the  
18          plant.

19          So those give you examples, I hope, of the  
20          types of challenges that are before us. Now, let's  
21          just remind ourselves of the urgency. If you believe  
22          DOE projections, and, by the way, you shouldn't  
23          because they've been consistently low. For the past  
24          ten years, their annual projections have been on the  
25          low side, but let's take them at face value.

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1           At their low end of their projections, we  
2           would need to add 400,000 megawatts of new capacity to  
3           the grid by 2020. Now, today 30 percent of our  
4           generating capacity is non-emitting. It's nuclear;  
5           it's hydro and some renewables.

6           Now, if all you wanted to do was maintain  
7           that 30 percent contribution to avoid getting into  
8           even more problems with clean air, you'd actually have  
9           to add 60,000 megawatts of new nuclear, 60,000  
10          assuming you can get maybe another 10,000 megawatts  
11          out of up rates, 50,000 new.

12          That's the basis for "Vision 2020."  
13          That's what the industry announced last month at the  
14          Nuclear Energy Assembly. That's what's going to drive  
15          us to the future.

16          Could you raise it a little bit, Jenny?  
17          Are you able to?

18          DR. POWERS: There seems to be a body of  
19          opinion that takes issue with this though. I can't  
20          reproduce their arguments, but they seem to think that  
21          maybe we don't need that much electrical energy, and  
22          that we, in fact, can achieve the necessary energy  
23          supplied by conservation.

24          MR. SIMARD: No question that conservation  
25          and efficiency are important, but it's folly to think

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1 that you're going to conserve your way out of having  
2 to add almost a 50 percent increase.

3 I mean the gains that we have made in  
4 conservation have been impressive, you know, at times,  
5 and efficiency has really helped quite a bit, but  
6 there's no way that you're going to conserve your way  
7 out of the low end of this projection without  
8 disruptive impacts on the economy.

9 So, you know, take issue. You don't  
10 believe we need 400,000 megawatts? Okay, fine. Cut  
11 it in half. Let's suppose that we're able to bring  
12 the sort of passion to this that we brought to the  
13 Manhattan Project, and we're able to achieve  
14 unprecedented levels of conservation and efficiency  
15 and shave that in half.

16 DR. POWERS: You don't look like you're  
17 intimately familiar with the passion of the Manhattan  
18 Project.

19 MR. SIMARD: Well, seriously, I think that  
20 what you find now across -- yes, it's true. There are  
21 still some people who will question that, the need to  
22 have that much electricity and they might even go so  
23 far as to say that we can keep our current demand  
24 steady. I don't know.

25 But you don't find them having prominent

1 roles in policy making anymore. What you find among  
2 the policy makers, whether you read the  
3 administration's national energy policy or whether you  
4 look at the Nuclear Caucus in the Senate or the House  
5 Nuclear Issues Working Group, when you look at the  
6 bills that are currently out there from Senator  
7 Dominici, Bingaman, Murkowski, Mr. Gramm, you see a  
8 growing consensus, I think, among the policy makers  
9 that this sort of aggressive action is going to be  
10 needed.

11 I mean this is what we could do. To  
12 maintain that 30 percent, as you work your way up the  
13 bottom here, there's a small yellow band, which  
14 actually it's small on the scale, but 10,000 megawatts  
15 from power upgrades is actually pretty substantial.

16 And then you see what would have to be  
17 added, some 50,000 megawatts, and again, that's just  
18 to maintain the brackets there. That's just to  
19 maintain the current contribution and to avoid getting  
20 into even more trouble with clean air.

21 So let me just summarize then over the  
22 next couple of slides. The future isn't what it used  
23 to be because I think the consensus is here now that  
24 the demand will grow, and we used to talk about the  
25 nuclear option. It's not an option anymore. It's an

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1 imperative.

2 The business case for new plants is pretty  
3 clear, but we have to have cost and schedules known to  
4 a greater degree of certainty than we ever had before,  
5 which leads us into the challenge for the NRC because,  
6 as you saw a minute ago, the ability to bring this  
7 plant to make depends upon being able to work out  
8 these Part 52 implementation issues in a timely  
9 manner, and having in place efficient and,  
10 Commissioner Diaz's word, "scrutable" processes for  
11 early siting and licensing and construction  
12 inspection.

13 And I think what's emerging here from this  
14 day and a half is the challenge for NRC to be able to  
15 respond to this with a whole new focus and discipline  
16 and efficiency.

17 Thank you.

18 DR. POWERS: One of the persistent  
19 problems that we encounter when new things are brought  
20 to this particular body is the documentation is  
21 incomplete, documentation is not rigorous. Those  
22 kinds of things slow the process substantially.

23 Is the industry doing anything to try to  
24 address those kinds of questions?

25 MR. SIMARD: I think the challenge on our

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1 side is to bring in an unprecedented quality of  
2 application. On our side, we need to bring the NRC  
3 the highest quality information and application.

4 And I think what you're seeing both with  
5 the Westinghouse and PBMR North America International  
6 with NRC now is an effort early on to really clearly  
7 identify exactly what the staff needs are going to be  
8 to be able to do their review.

9 So I think that's encouraging, but you're  
10 right.

11 DR. POWERS: For heaven's sake, solve the  
12 momentum equation properly.

13 MR. SIMARD: You're right. We need to do  
14 better, too, on our side.

15 CHAIRMAN KRESS: Ron, one of your slides  
16 pointed out some of the regulatory challenges  
17 associated with multiple modules on a given site, how  
18 you deal with that with respect to site permitting and  
19 certain financial issues associated with that. It  
20 seems obvious to me that what you should do is get a  
21 site permit for the maximum number of modules you  
22 expect to put on that and call it one facility.

23 Is that something your guys are proposing  
24 or is that --

25 MR. SIMARD: Yeah, and maybe -- in that

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1 area maybe "challenge" is too wrong a word here.  
2 Maybe we're getting carried away by the theme of the  
3 workshop here. Some of these things ought to be  
4 fairly straight.

5 CHAIRMAN KRESS: Yeah, that one looks  
6 pretty clear to me.

7 MR. SIMARD: But the point is they do  
8 though require either a clarification or a change to  
9 the current NRC implementation requirements. So, no,  
10 I think that's a good point.

11 Some of these shouldn't be challenges.  
12 They're pretty straightforward.

13 DR. APOSTOLAKIS: In one of your earlier  
14 slides on new licensing process significantly reduces  
15 project risk where you have the chart, maybe we can go  
16 back to it. They're not numbered, but, the heading is  
17 "new licensing process significantly reduces project  
18 risk."

19 MR. SIMARD: Yeah, it reduces the  
20 perceived business risk on the part of the licensee,  
21 and it certainly provides for earlier and more meaning  
22 parts of --

23 DR. APOSTOLAKIS: It's the fifth or sixth  
24 from --

25 MR. SIMARD: Yeah, she's got it now.

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1 DR. APOSTOLAKIS: Oh, yeah, that is the  
2 one.

3 When you say at the bottom here  
4 "acceptance criteria met," I guess the acceptance  
5 criteria, do we have those now or --

6 MR. SIMARD: Yes, in the three designs  
7 that have been certified, a key feature and a high  
8 level of detail in those certifications are the ITAAC.  
9 So they're clearly specified. In the ABWR, for  
10 example, the high pressure core flooders system, I  
11 understand there were 31 separate ITAAC that clearly  
12 focus on the performance of a pump, for example.

13 What inspections or tests will be done on  
14 that pump and what acceptance criteria will be  
15 necessary to show that, in fact, that pump is going to  
16 deliver the amount of water you need at the time you  
17 need it?

18 So in the design certification, a key  
19 feature of them has been these ITAAC. We need to add  
20 a few more that are site specific when the licensee  
21 brings you the application, but --

22 DR. APOSTOLAKIS: So in terms of Part 52,  
23 which you cited as one of the major challenges, the  
24 implementation of Part 52, and if I look at this  
25 particular chart, where does the implementation of

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1 Part 52 come into the picture? Just the whole  
2 sequence?

3 MR. SIMARD: Well, there are actually  
4 three pieces to Part 52. The bottom left there,  
5 there's one that outlines design certification. Then  
6 there's one that outlines early site permitting, and  
7 then in the middle there on the bottom, there's one  
8 that talks about the conditions on granting a  
9 construction permit and operating license.

10 And then finally it also covers at the end  
11 of construction and prior to start-up the basis for  
12 the NRC determination that the plant is ready to go.

13 DR. APOSTOLAKIS: Well, yesterday there  
14 was a lot of discussion of using risk information in  
15 all of this. So if I were to choose one of the  
16 designs that have not been certified yet, then the  
17 potential for using risk information is on the left  
18 where it says "design certification"?

19 MR. SIMARD: Oh, no, certainly. But what  
20 about all the way across?

21 DR. APOSTOLAKIS: All the way.

22 MR. SIMARD: Yeah, when the NRC has to  
23 dust off its construction inspection and program and  
24 apply it now to these new designs, this new  
25 environment, but with the knowledge that we've gained

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1 over, you know, the past 30 or 40 years, it certainly  
2 would make sense to focus on the aspects of  
3 construction and the completion of SSCs that are most  
4 important to safety, and I think in our interactions  
5 with interactions with NRC on this subject, which are  
6 about to begin this month, we'll certainly be looking  
7 at it from our point of view.

8 DR. APOSTOLAKIS: So we'll hear more about  
9 this this afternoon, I understand, right?

10 MR. SIMARD: I don't know that you will.  
11 You know, from Adrian Heymer you're certainly hear  
12 about the proposal that we have in mind for the  
13 overall regulatory framework, but in terms of the  
14 specifics of how NRC might modify the inspection  
15 manual --

16 DR. APOSTOLAKIS: No, no, no, no.

17 MR. SIMARD: No, that's still something  
18 that needs to be worked out.

19 DR. APOSTOLAKIS: Sure.

20 CHAIRMAN KRESS: Any other questions from  
21 the audience or other members?

22 DR. APOSTOLAKIS: There is one here.

23 CHAIRMAN KRESS: Ah, good.

24 MR. ALLEY: Neil Alley.

25 In your projections for energy demands

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1 looking forward, what assumptions did you make about  
2 plan life extension?

3 MR. SIMARD: You know, i'm not sure. If  
4 you're asking specifically about "Vision 2020" and how  
5 we're going to meet the need for 60,000 new megawatts,  
6 I think that we assumed almost all the plants are  
7 going to go in for license renewal. I can't tell you  
8 for sure though whether it was 100 percent or, you  
9 know, maybe we drop back a bit, but certainly the  
10 feeling in the industry is that all or almost all of  
11 the plants are candidates for renewal rate.

12 But also remember -- I'm sorry. The real  
13 answer to your question is this is 2020. All right?  
14 So you wouldn't see a significant number of today's  
15 plants reaching the end of their life anyway before  
16 2020.

17 DR. POWERS: Yeah, there are a bunch of  
18 them. Without license renewal, there are a bunch of  
19 them that are out by 2014, some by 2007. Yeah,  
20 license renewal is very important.

21 MR. SIMARD: But anyway, the answer is at  
22 this point it looks like all, if not -- it looks like  
23 all or almost all of the plants are candidates.

24 DR. POWERS: About 80 percent.

25 MR. QUINN: Dr. Kress, it's Ted Quinn.

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1 Ron, good morning. The reason for success  
2 in the license renewal process to a large extent was  
3 the project management role that was put in place with  
4 a lot of work by NEI with a lot of work by the NRC,  
5 and a suite of documents that became part of the  
6 process, the GALL report, the NEI guideline.

7 Have you considered working with NRC on a  
8 similar type of suite of documents to help us make  
9 this a more stable framework?

10 MR. SIMARD: Yeah, I think you're right,  
11 Ted. That's been a good model in the past. By  
12 bringing to bear the range of industry resources and  
13 expertise on an area and combining that with the NRC,  
14 I think we've wound up with a better quality product  
15 in the end and improved the efficiency of the process.

16 So building on our success with license  
17 renewal, maintenance rule or other things like that,  
18 yeah, it's our intent to put a lot of thought from our  
19 side into how -- for example, the format of an early  
20 site permit application, and that's something we  
21 actually have underway, or with respect to  
22 construction inspection at ITAAC verification, it's  
23 our intent to bring together the folks who still have  
24 construction experience in the industry, if we can  
25 find them, and again, drawing upon their expertise and

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1 our knowledge of how Part 52 -- the basic principles  
2 of Part 52.

3 Again, it would be our intent in cases  
4 like that to bring in a document and ask the NRC for,  
5 you know, its review and reactions and use that as the  
6 framework for these productive discussions.

7 CHAIRMAN KRESS: Well, thank you very  
8 much, Ron, for this very informative and interesting  
9 talk.

10 Then we will turn to the next item, safety  
11 goals for future nuclear power plants, and I'm  
12 certainly looking forward to hearing this one.

13 By the way, Neil, I know that you don't  
14 need any introduction, but the fact is I don't have  
15 any introductory material so you have to introduce  
16 yourself at this particular meeting.

17 DR. POWERS: I'm dying to know what a  
18 KEPCO is.

19 DR. TODREAS: KEPCO in the title speaks  
20 basically to the success of the Asian countries in  
21 developing nuclear power and up till now the lack of  
22 success in the U.S. So the Korea Electric Power  
23 Company gave a chair to MIT in nuclear engineering,  
24 which I hold, and the Tokyo Electric Power Company  
25 gave a chair to nuclear engineering that Mughid

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1 Khazzami (phonetic) holds, and we're still waiting  
2 perhaps nationally for one of the U.S. utilities to  
3 step in.

4 (Laughter.)

5 DR. TODREAS: Okay. What I'm going to do  
6 is stand here. My intention is to address you guys  
7 relative to this question of future nuclear plants and  
8 also bring the audience up to speed in terms of our  
9 activities.

10 Yesterday, the DOE folks were here, and  
11 they talked about the program, and it's called really  
12 a Generation IV reactor development program, and it  
13 covers the near term, which is zero to ten years;  
14 deployment, in that period; and then from 2010 to 2030  
15 the development of what's called Generation IV plants.

16 So the word "future" here means a lot to  
17 different people. What Ron just spoke about in terms  
18 of my focus was the near term deployment, mainly zero  
19 to ten years. So you have to switch horses now in  
20 terms of the safety goals that I'm talking about  
21 relative to future plants are aimed at the 2010 to  
22 2030 developments.

23 You can take these goals, focus them back  
24 and ask what about the near term deployment plants,  
25 but in a sense that isn't fair because you know some

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1 of them are already certified. If they're not  
2 certified like the ESBWR, they've been under  
3 development for years, and so they've been aimed  
4 differently.

5 There are also nuclear power plants in  
6 terms of near term deployment, and you'll see that  
7 although I was given this title, our goals are on  
8 nuclear energy systems, the difference. Nuclear  
9 energy systems brings in the whole fuel cycle. In  
10 terms of our activities, we put the whole fuel cycle  
11 on the spectrum.

12 So with those introductory remarks, I just  
13 want to conclude by saying John Garrick is on the  
14 group with Saul and I, Saul Levy and I leading it, and  
15 we have five, six rather, other people on the review  
16 committee overseeing the DOE activity and offering  
17 comments, and John is a valued member of that  
18 activity.

19 So if I could start, having talked to the  
20 people in front of me before at times, I thought I'd  
21 start off and tell you how not to construe this talk  
22 or how to misconstrue it to try to get you on the  
23 right approach.

24 So first, it's the talk and then the  
25 goals, and then we'll get into it.

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1           So the way you follow this slide is four  
2 points here, is really what I'm talking about down  
3 below. So I'm not talking about the NRC safety goals.  
4 That's the first thing that probably jumps to your  
5 mind when I say safety goals.

6           We're generating what we call technology  
7 goals. These are goals to drive new reactor systems  
8 development.

9           DR. WALLIS: Are you going to mention the  
10 word "risk"?

11           DR. TODREAS: Risk? Maybe at the very  
12 end, but actually Graham, that is one of the themes.  
13 What I want to do or what we want to promote through  
14 this program is technological innovation and  
15 development, and we want to structure things so that  
16 we can promote that and not clamp down too early.

17           Of course, risk has to be mentioned from  
18 the beginning.

19           We are not suggesting regulatory  
20 requirements for future plants. These goals are  
21 formulated to stimulate innovation, as I've already  
22 said, and the goals, of course, as you're going to  
23 see, are general, and there's a group that's following  
24 up to put specific metrics on each of the goals so  
25 that we can use those.

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1           We also use those to sort out concepts  
2           from among -- we've gotten effectively almost 100  
3           concepts or pieces of concepts submitted into the  
4           program, and these have to be sorted out, selected,  
5           and areas of R&D picked out either generic along a --  
6           if a set of concepts come together in a technological  
7           direction, will pick out the R&D that's relevant to  
8           this set, and push ahead.

9           And so we're going to need to make some  
10          selection, and the selection will be based on metrics  
11          which are derived from the goals which are now being  
12          worked on. That's what the word "metric" means here.

13          I mention the point we're not talking  
14          solely about power reactors. We're talking about fuel  
15          cycles, and the power reactor is part of this. We  
16          started this before the national energy policy was  
17          announced. It's interesting that there's some  
18          consistency there, but it wasn't a grand plot.

19          And then finally, I'm not talking about  
20          goals for near term deployment plants. I mention that  
21          point. We're talking in the range 2011, 2030 or 2010,  
22          2030.

23                 We go to the next slide.

24                 I've got a few points to mention on how  
25          not to misconstrue the goals. One way to misconstrue

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1       them is to assume that future plants must meet every  
2       goal or must even exceed every goal, and what you're  
3       going to see is these goals are fairly encompassing.  
4       Just immediately, to put some meat on those bones,  
5       we've got issues of fuel utilization,  
6       nonproliferation, and waste, and through the fuel  
7       cycle there's obviously got to be a tradeoff among  
8       those areas, and the tradeoff -- there's multiple  
9       tradeoff solutions available and some of them will  
10      favor one of those factors. Some of them will favor  
11      another factor.

12               I'm almost convinced that you won't be  
13      able to come up with some scheme that will uniformly  
14      meet and exceed all of these goals. So --

15               DR. POWERS: I'm glad that you mentioned  
16      the word "tradeoff." One of the questions that comes  
17      to mind, especially after the previous speaker  
18      portrayed something of a crisis appearing, I wonder if  
19      in looking at these goals and looking at new systems  
20      that you compare the more modern or the existing  
21      plants against him to see if we really need all new  
22      concepts, and the 94 new concepts that were portrayed  
23      to us yesterday or, in fact, how well do the existing  
24      plants meet these various goals that you've laid out?

25               DR. TODREAS: The answer to that is on the

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1 metrics that we're going to develop to assess these  
2 new concepts. We've picked a standard, and the  
3 evaluation process will measure these new concepts  
4 against the standard. Is it better, much better, et  
5 cetera, worse, much worse, and the standard we picked  
6 is the advanced LWR with once through fuel cycle.

7 The rest of your question asked me what's  
8 the answer going to be, and I don't know that yet.

9 DR. POWERS: I find that a peculiar  
10 standard to pick because we don't have a whole lot of  
11 experience with advanced LWR, or if we do with  
12 existing machines, we have a lot of experience, and  
13 that experience, at least my friends at NEI certainly  
14 provide metrics that suggest that experience is  
15 outstanding right now.

16 DR. TODREAS: And is the implication that  
17 the advanced LWRs will be less --

18 DR. POWERS: I have no idea what they are.

19 DR. TODREAS: -- performers than --

20 DR. POWERS: I have no idea how they'll  
21 do. I certainly have opinions on a couple of them,  
22 but I have no proof. Whereas with some of the  
23 existing machines, I know exactly what they're doing.  
24 I've got data I can point to.

25 DR. TODREAS: I can see thinking about

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1 that, but if we're going to develop advanced systems,  
2 I would say from the vendor community and the  
3 development community, we've got ABWR experience to an  
4 extent, and we have some degree of real respect for  
5 what the designs have accomplished in the ALWR.

6 And I would say as a minimum you'd include  
7 both, but I certainly wouldn't go back just to the  
8 operating reactors as the standard for the future. I  
9 wouldn't ignore the 15 years of ALWR development.

10 CHAIRMAN KRESS: Well, you probably have  
11 three criteria. You want them to be safe, and you  
12 want them to be economic, and you want them to be  
13 acceptable to the public and other people.

14 I would say the current place is certainly  
15 safe enough if you compare them to certain safety  
16 standards, but I would guess economics might be a big  
17 driver, especially the capital cost. I'm not sure.

18 DR. POWERS: The numbers I see suggest  
19 that they're producing power as cheaply as anybody.

20 CHAIRMAN KRESS: I know. That's because  
21 they've already gotten rid of their capital costs, and  
22 they're just talking about operating costs, but I  
23 would suspect these new designs are much cheaper to  
24 build.

25 DR. POWERS: Well, I wonder how much it

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1 would cost to build a plant today, a current plant  
2 today?

3 CHAIRMAN KRESS: Well, that's a good  
4 question, and I'm not sure I know the answer to that.

5 DR. POWERS: I don't know the answer  
6 either.

7 CHAIRMAN KRESS: My guess would be the new  
8 designs would be cheaper to build, but then there's  
9 that third attribute, and that's acceptability, and I  
10 suspect newer, safer, inherently -- plant that has  
11 these attributes that we're looking at might be more  
12 acceptable from the standpoint of the public.

13 DR. POWERS: Yeah, I don't know.

14 CHAIRMAN KRESS: I don't know.

15 DR. POWERS: You're giving up 3,000  
16 reactor years of operational experience when you make  
17 those statements, and --

18 CHAIRMAN KRESS: Well, maybe.

19 DR. POWERS: -- I don't think we've begun  
20 to discover all of the ways that you can run afoul on  
21 some of these modern control systems.

22 CHAIRMAN KRESS: Yeah, you have a good  
23 point there.

24 DR. TODREAS: Okay. Well, I think you  
25 guys will have plenty of time to focus on that one

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1 actually when you get your next certification  
2 application as well, but let's say that point's on the  
3 board. We can chew it further later if we desire.

4 I'll carry on on these goals down at this  
5 point. The desirable outcome from this program and  
6 effectively the goals which are going to drive this  
7 program I believe is a spectrum of designs, each of  
8 which best meet possible future market conditions.

9 For example, we don't know, although we  
10 think uranium will be cheap in the future, in fact, as  
11 cheap as it's been in the past, but we don't know that  
12 for sure. So it would be nice to have advanced  
13 designs on the table as the output which could respond  
14 in either direction.

15 If you want to have designs which would  
16 respond in either direction, then these alternate  
17 designs effectively would be aimed at optimizing and  
18 exceeding certain goals in one direction and then  
19 meeting, but exceeding other goals in the other  
20 direction.

21 So you want a spectrum of results, and  
22 therefore, different goals will drive you in these  
23 different directions.

24 the next point is some of the goals, in  
25 fact, one presently appears unattainable.

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1 CHAIRMAN KRESS: That one really surprises  
2 me.

3 DR. TODREAS: Well, why don't we wait for  
4 the full discussion when I get there?

5 CHAIRMAN KRESS: Okay.

6 DR. TODREAS: But the point I want to make  
7 is don't jump on it now. We want a goal that will  
8 drive design and innovation. We can't meet it no, but  
9 does that mean we shouldn't write it in?

10 That's the question. I know you've read  
11 ahead. We'll get to it where we cover S&R3, Safety  
12 and Reliability 3.

13 And then finally, as I mentioned, the  
14 goals in terms of their specificity purposely have a  
15 little generality to them because we are talking about  
16 reactor systems that we want to bring on in this time  
17 frame, 2010 to 2030, which gives us an opportunity to  
18 innovate. So we don't want to squeeze down too early  
19 on that.

20 DR. WALLIS: And, Neil, we're still not on  
21 the subject of misconstruing goals, are we?

22 DR. TODREAS: Yeah, I am.

23 DR. WALLIS: You are? Okay.

24 DR. TODREAS: Yeah. The point of  
25 misconstruing there is why are they general. They're

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1 general to open the door.

2 Next point.

3 The next point is that one can misconstrue  
4 these goals by assuming that all the safety  
5 considerations are under the title of the grouping  
6 "safety and reliability goals."

7 To go ahead, we have sustainability goals,  
8 three of those; safety and reliability goals, three of  
9 those; and economic goals, two of those. So a quick  
10 reading would say, hey, let's just look at the safety  
11 and reliability goals for safety implications.

12 Now, we should be all smarter than that to  
13 realize that future designs are going to involve new  
14 cycles and a broader range of energy products. So  
15 we're going to get into new fuel materials, higher  
16 burn-ups, longer operating cycles, higher temperature  
17 operation, and all those design directions bring in  
18 safety considerations as part of it. They have all  
19 been reduced specifically to risk criteria, but  
20 there's tremendous safety opportunities and safety  
21 factors that one must consider as part of the  
22 sustainability and, in fact, the direction that the  
23 economic goals will drive us to. That's the point of  
24 this figure.

25 Now, with that, we can go to the next one

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1 and start on the goals. the logic in framing these  
2 goals cycled many times because obviously there was a  
3 large community involved in deriving these goals.

4 What we finally felt was it would be  
5 desirable to group them and then have these  
6 subcategories, and the first grouping that we picked  
7 was sustainability with the idea that if nuclear power  
8 was going to stand head and shoulders strong relative  
9 to alternate energy generation approaches into the  
10 future. we had to address and label part of the goals  
11 through the sustainability label and really place or  
12 position nuclear power and the product that came out  
13 of this product as a sustainable product.

14 You can get into arguments on this in the  
15 sense that sustainability if you go through the formal  
16 definition kind of projects it out without any time  
17 bound, and yet nuclear power in terms of fuel that  
18 we're going to use has a long time horizon, but it's  
19 finite.

20 There we didn't basically accept that  
21 point and, therefore, say nuclear power will no be  
22 sustainable, but we really took the bit and through  
23 the first goal effectively positioned nuclear power  
24 product as a sustainable product.

25 This, I've given you the words, but the

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1 words in red are the words that we got into the most  
2 discussion about because this went through the NERAC  
3 process, and NERAC is -- let me call it a balanced  
4 committee. So there's viewpoints on all sides of the  
5 drivability and the effectiveness of nuclear power.

6 If you've been in the business a longer  
7 time and you're a nuclear engineer, when you think of  
8 fuel utilization, the word "high fuel utilization"  
9 jumps to your mind. This word that's here, which is  
10 "effective," is a long, negotiated word. It doesn't  
11 say we've got to go toward high fuel utilization  
12 because if you say you've got to go toward high fuel  
13 utilization, you immediately prejudice the outcome, so  
14 it is viewed, and with some justification. You  
15 prejudice it toward the fact that you definitely need  
16 a breeder, and also that fuel economics are going to  
17 come and constrain you in this 20-year time frame.

18 And that definitely is a view that  
19 definitely is not held throughout the review  
20 structure. So the word "effective" here means that  
21 you balance fuel cycle economics with environmental  
22 considerations and with nonproliferation  
23 considerations.

24 So effective fuel utilization implies that  
25 a tradeoff is going to be made between those factors

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1 because when I said fuel cycle economics, if, in fact,  
2 we have uranium constraints, that will drive up the  
3 price, and that will be reflected in fuel cycle  
4 economics.

5 In terms of Sustainability 2, that issue  
6 comes down to saying something about nuclear waste.  
7 We have got two key words here, minimize and manager.  
8 Manager is not controversial, but the word "minimize  
9 nuclear waste" was very controversial, and it was  
10 controversial in the sense that the other viewpoint  
11 was that minimization isn't really what you're after.  
12 What you're after is even beyond toxicity. It's  
13 ultimately burden to public health and safety, and  
14 there's a lot of different factors and a lot of  
15 different streams that finally get you down to that.

16 We effectively pick that up through  
17 reduced long-term stewardship burden, but we -- and  
18 now I'm talking about our review committee and the DOE  
19 whole project -- we still felt that there's great  
20 advantage going into the future with systems that  
21 minimized the waste generation because if you minimize  
22 the waste generation, you at least tend to reduce  
23 pressure which comes from the pile-up of large amounts  
24 of waste, and the question of what do you do after  
25 Yucca Mountain.

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1 And I was going to say hopefully. What do  
2 you do hopefully after Yucca Mountain, with the  
3 "hopefully" being hoping Yucca Mountain gets moving?

4 On the third one on Sustainability 3, this  
5 has to do with nonproliferation, and there was a  
6 special group that was run by John Taylor called TOPS  
7 on nonproliferation where that issue was debated, and  
8 they effectively came up with these words: very  
9 unattractive and least desirable group.

10 And that comes from the view that we're  
11 going to have intrinsic and extrinsic barriers to  
12 proliferation. Hopefully they're mutually supportive  
13 in that you can do something intrinsically that may  
14 have a positive effect on external barriers and vice  
15 versa, but the view is that there's no silver bullet  
16 here. We're not going to come up with a fuel cycle  
17 that from an intrinsic point of view puts the  
18 nonproliferation issue to bed.

19 And therefore, we're going to come up with  
20 schemes that are very unattractive and are the least  
21 desirable group. That's how those words came about  
22 and why they're important.

23 We go to the next slide. Here we have the  
24 safety and reliability slides. They're set up in the  
25 logic of maintaining excellence in safety and

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1 reliability. Here we're really focusing on accident  
2 initiators, reliability of operation of plant.

3 Actually it stimulates a point relative to  
4 what Dana Powers mentioned. We do want to capture all  
5 the lessons, all of the positive lessons from  
6 operating plants and put those into these Generation  
7 4 systems relative to their ability to operate with  
8 safety and reliability.

9 This goal, when you're working on advanced  
10 plants, you really at least in the conceptual stage,  
11 you really always focus down on the second two goals,  
12 and what we wanted to do was actually put something  
13 right up front that reminded all of the designers, all  
14 of the conceptual innovators that fundamentally the  
15 plant operating through steady state and through  
16 transience had to capture this base.

17 Now, when we come to the second goal, then  
18 we get into the traditional language, dialogue that  
19 we're all used to about low likelihood and degree of  
20 core damage. So we, of course, want to emphasize  
21 that.

22 DR. POWERS: One of the ways of assuring  
23 that you have minimal --

24 DR. TODREAS: What was the verb you used?  
25 One of the ways of?

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1 DR. POWERS: Assuring --

2 DR. TODREAS: Assuring.

3 DR. POWERS: -- that you have minimal core  
4 damage would be to release all of the fission products  
5 so that you have no decay heat. Release them as  
6 they're generated. That would meet this goal.

7 DR. TODREAS: You would have to release  
8 them and sequester them because we're talking about  
9 systems, but along the line you're talking about, we  
10 get them out of reactor core system where we might  
11 have less control into a system that wasn't operating.  
12 Not a bad --

13 DR. POWERS: My point really is that I  
14 think this goal is perplexing in the context of the  
15 kinds of designs that people are coming up with where  
16 classical core damage doesn't really occur, but you  
17 still worry about fission product releases.

18 And why not cast the goal in terms of  
19 release of radioactivity?

20 DR. TODREAS: Oh. It's -- maybe, maybe.  
21 That effectively leads to number three, where we're  
22 talking about the need for off-site emergency  
23 response, various ways to do that and fission  
24 products.

25 Fission products actually could be the

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1 whole story down here, and you might think about  
2 writing it that way. I'm not sure, Dana, whether just  
3 off the top, whether writing it that way would capture  
4 the end product or not, but it's simulating --

5 DR. WALLIS: I think that while you're  
6 being innovative, you should not use -- you seem to be  
7 here really talking about core damage frequency, and  
8 that just may get you in a box, and I think to be  
9 innovative, to follow up with Dana, you really ought  
10 to get away from these terms of the past and be more  
11 general.

12 CHAIRMAN KRESS: And after all, I think it  
13 is fission products we're worried about.

14 DR. TODREAS: I think that's a reasonable  
15 point. If I've got you guys or if you've got me  
16 saying that we ought to get away from terms of the  
17 past which will lock us into certain design directions  
18 and means of dialogue, that is really my whole  
19 message, too.

20 And if you're offering me a suggestion  
21 that says, hey, what you wrote doesn't go that way;  
22 you should go a different way, then I'd perfectly  
23 accept it.

24 DR. GARRICK: I think we have to be a  
25 little careful to unduly focus on fission products

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1 because for many of the most important scenarios it is  
2 not the fission products that's driving the long-term  
3 performance of Yucca Mountain. It's mainly -- well,  
4 technetium and Iodine 129 certainly are in there, but  
5 depending on the scenario and depending on how you  
6 look at it, Neptunium 237 is the principal driver.

7 And also, in most low level waste  
8 situations, you find that much to our surprise most of  
9 the low level waste is uranium contaminated. So,  
10 again, the fission products are not driving the long-  
11 term stewardship or management of a lot of the low  
12 level waste, but rather it's actinides.

13 The same thing is true in WIP for  
14 transuranic waste. Again, it's not fission products,  
15 but it's plutonium. So --

16 DR. POWERS: The distinction between  
17 captured products and fission products I'm not sure I  
18 would draw.

19 DR. GARRICK: Well, it sounded like you  
20 were drawing that. It sounded like you were drawing  
21 that.

22 DR. POWERS: I wouldn't do that. I would  
23 call them radionuclides maybe.

24 CHAIRMAN KRESS: We put quotes around the  
25 words "fission products" at ACRS. When we say that,

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1 we mean all of those things that you talked about.

2 DR. GARRICK: Well, then I think we need  
3 to be more precise.

4 CHAIRMAN KRESS: Yeah, precision would  
5 have helped there.

6 DR. TODREAS: But that also refers back to  
7 the sustainability goal. It really doesn't obviate  
8 the suggestion relative to S&R 2 here relative to core  
9 damage. I say that because what Garrick's comment  
10 really impacts on is the waste issue, not effectively  
11 the immediate release through core damage. Okay.

12 CHAIRMAN KRESS: I'm intrigued by that  
13 third bullet. Are you going to talk about it some  
14 more?

15 DR. TODREAS: Yeah.

16 CHAIRMAN KRESS: In particular, do you  
17 have some sort of criteria on what it would take to  
18 eliminate this need?

19 And if so, does that criteria encompass  
20 some sort of measure of defense in depth also?

21 DR. POWERS: I would go even farther and  
22 say that what more tangible proof of the concern over  
23 the public do you have than an emergency preparedness  
24 zone, and what are you going to replace that tangible  
25 proof with?

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1 CHAIRMAN KRESS: That's another way to  
2 view it, yeah.

3 DR. TODREAS: Yeah, but that's how you  
4 guys ought to look at it.

5 Will you skip to S&R 3? It's the third  
6 viewgraph after this.

7 CHAIRMAN KRESS: Number nine.

8 DR. POWERS: Number nine.

9 DR. TODREAS: Yeah, page number 9.

10 From the point of view of a regulator or  
11 a group advising a regulator, and we got into this  
12 discussion immediately, the immediate question comes  
13 to mind. Okay. It's find that you guys got this  
14 goal, but what are we going to do about it?

15 And this goal doesn't say at all that in  
16 the first instance you people need to back off about  
17 planning for emergency response. This is about the  
18 misconstruing right at the beginning.

19 These are technology goals. These are  
20 goals we want to drive the designers into thinking  
21 about.

22 CHAIRMAN KRESS: How would you know if you  
23 met that goal? That was my question. What is the  
24 measure that you're going to use to say, "Okay. The  
25 technology we have here meets that goal." Whether or

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1 not it actually comes about or not is another thing.

2 DR. TODREAS: The measure has got to be  
3 release of I'd say fission products or radioactivity  
4 of a certain amount past the boundary.

5 DR. POWERS: I can always find a way to  
6 get that many fission products out. There's no  
7 conceivable design; I can't imagine a scenario that  
8 will result in release of excessive amounts of fission  
9 products.

10 DR. TODREAS: That would prevent it or  
11 that would --

12 DR. POWERS: Any design you come up with  
13 I can find a mechanism to get the fission products  
14 out; the point that it violates some emergency  
15 planning guide.

16 CHAIRMAN KRESS: Yeah, there has to be a  
17 frequency involved there is what he's saying partly,  
18 and my question is: is that value of fission products  
19 a value that you would meet, for example, the early  
20 fatality safety goal without evacuation? That's one  
21 possibility.

22 DR. TODREAS: That's one possibility.  
23 What I did here is, well, we have written a discussion  
24 under each goal. I worked hard on Paragraph 1.

25 The debate was effectively you write down

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1 something now that you don't have a way in your own  
2 mind of achieving or do you come short of that and,  
3 you know, put some numerical or put something that  
4 kind of reflects current technology?

5 So in the interest of intellectual  
6 honesty, we wrote in its demonstration may prove to be  
7 unachievable, and this is what Dana Powers basically  
8 just said. He's saying as he sits on this group, and  
9 I presume and I hope he'll sit on it for a number of  
10 years, all of these designs which come through which  
11 claim that they can meet it, he's going to shoot the  
12 hole in them. Quite possible.

13 But --

14 DR. APOSTOLAKIS: Dana would never do  
15 that.

16 (Laughter.)

17 DR. TODREAS: But that is a reason to  
18 write this goal down, because if you're really talking  
19 about future systems and vulnerabilities of future  
20 systems, it's this whole -- and ultimately public  
21 acceptance, it's this whole idea of off-site response  
22 that's a very, very significant issue.

23 DR. WALLIS: Now, this includes you  
24 started your talk saying you were looking at the whole  
25 fuel cycle. So presumably this includes fuel

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1 fabrication, transportation, any kind of reprocessing.

2 DR. TODREAS: Yes.

3 DR. WALLIS: You seem to have focused,  
4 again, on the reactor in this discussion, and --

5 DR. TODREAS: In the discussion below, not  
6 in the goal above. I'm just scanning it.

7 DR. WALLIS: Off site radiation then means  
8 in the fuel fabrication facility as well, for  
9 instance?

10 DR. TODREAS: What was the word you --

11 DR. WALLIS: Well, you're looking at the  
12 whole fuel cycle you said in the beginning of your  
13 talk.

14 DR. TODREAS: yeah.

15 DR. WALLIS: And now I got the impression  
16 in talking about these goals you were focusing once  
17 again on the reactor itself.

18 DR. TODREAS: Yeah. It may be true that  
19 in the oral persona that I'm putting across my years  
20 as a reactor designer come through, and I should be  
21 pulling back, being consistent with nuclear systems,  
22 and as I read this discussion here, there's nothing  
23 here that's focused on the reactor. It's general to  
24 all of the facility.

25 So it's --

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1 DR. WALLIS: Well, it talks about off  
2 site. I mean off site presumably in transportation  
3 includes off the truck or something.

4 DR. TODREAS: Yeah, okay. Off site, of  
5 course, carries with it, yeah, we have to -- we have  
6 to go through and scrub it. I agree.

7 CHAIRMAN KRESS: But I would love for  
8 someone to tell me exactly what it takes to meet this  
9 goal. I personally think I know, and I'd like to have  
10 some corroboration of that some time.

11 DR. TODREAS: Okay.

12 DR. POWERS: And I'd like to know why  
13 you'd want to.

14 CHAIRMAN KRESS: Well, that's another  
15 issue, yeah.

16 DR. APOSTOLAKIS: I'd like to come back to  
17 the safety and reliability, goal number two.

18 DR. TODREAS: Could you flip back the  
19 slide?

20 DR. APOSTOLAKIS: Page 6.

21 DR. TODREAS: Go to page 8. It gives you  
22 more.

23 DR. APOSTOLAKIS: Yeah. In fact, I was  
24 looking at page 8.

25 It seems to me that when the discussion a

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1 few minutes earlier brought up the issue of fission  
2 product releases and as a possible candidate for  
3 replacing this, it focused too much on the safety, and  
4 here it says safety and reliability, and if you go to  
5 page 8, it says this goal is vital to achieve  
6 investment protection.

7 So it seems to me that I can have serious  
8 damage even with the new designs to my investment, and  
9 still I don't release anything. So the words "reactor  
10 core damage," I think, were a little bit provocative  
11 here because yesterday we heard speaker after speaker  
12 saying this is something of the past, and you know,  
13 this core cannot be damaged.

14 But I'm sure that one can define what we  
15 call plan damage states in PRAs, where you are not  
16 really releasing anything outside anyway, but your  
17 investment has been, you know, severely hurt, and the  
18 NRC is up in arms.

19 So the challenge will be to define those  
20 states, but I think by taking the words out, "reactor  
21 core damage," and finding some other words, not going  
22 all the way to fission product release, this goal will  
23 serve safety and reliability. You may need a fourth  
24 goal regarding fission product release. I don't know,  
25 but that, again, as you say, these are technology

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1 goals. They are not regulatory goals.

2 We will definitely have to look at fission  
3 product release. I mean there's no question about it.

4 (Laughter.)

5 DR. POWERS: You think?

6 DR. TODREAS: Yeah, let me pick up on  
7 that. This is on page 8, if you back into that.

8 We very much had investment protection on  
9 our mind as well, and in fact, that's why on the  
10 second line I've got that highlighted. Originally, or  
11 through a large part of this dialogue, in that goal we  
12 had the additional statement about preserving the  
13 plant's ability actually to return to power I won't  
14 say promptly, but to return to power over a period of,  
15 let's say, months, with the idea that we wanted to  
16 preserve the investment by having a design that  
17 actually could come back.

18 So that's what was in the second line.  
19 That one in the discussion, the comments actually came  
20 back as in the third one as to how would you ever do  
21 it. If you got core damage, it's just so much based  
22 on our experience that core damage, even to a minor  
23 degree, is going to really impact negatively the  
24 ability of the plant to return to power.

25 DR. WALLIS: Well, supposed you have a

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1 core which is fluid. You just flush out the back part  
2 and start again.

3 DR. TODREAS: Yeah. Well, see, that's the  
4 point. If you get locked back into solid fuel pins,  
5 et cetera, you can't conceive --

6 DR. WALLIS: But you're being creative.

7 DR. TODREAS: What?

8 DR. WALLIS: You're being creative.  
9 You're looking at all kinds of things. There may be  
10 things where you can just flush out the damage and  
11 keep --

12 DR. TODREAS: Well --

13 DR. APOSTOLAKIS: How about if you  
14 replace, say, generation for nuclear energy systems  
15 will have a very low likelihood and degree of plan  
16 damage, period? To be determined later. At this  
17 point you're high level.

18 DR. TODREAS: Well, in relation to  
19 Graham's point, we kept the idea here by actually  
20 putting it in the second sentence. The --

21 DR. WALLIS: The second sentence is  
22 terrible. The possibility is either zero or one, and  
23 you reduce the possibility. I mean, that's crazy.  
24 You're just trying to avoid the word "probability."

25 How did you ever let anybody use the word

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1 "possibility" in here? That zero or one, isn't it?

2 DR. TODREAS: Where is "possibility"? Oh,  
3 okay.

4 DR. WALLIS: On three.

5 DR. TODREAS: The second -- yeah, the  
6 third line, "reduce the possibility."

7 DR. WALLIS: Well, we shouldn't pick on  
8 words, but I mean, I think --

9 DR. TODREAS: No, that is fair because  
10 these words in this paragraph get reduced to more  
11 specific items subsequently. So the guidance in this  
12 paragraph is aimed at developing more specific  
13 metrics, and to the degree if that occurs that these  
14 words cloud the ability of the subsequent group to  
15 develop the metrics, it's fair game. So you've made  
16 the point.

17 Follow up. You're shaking your head.

18 DR. WALLIS: Well, the word "possibility"  
19 is inappropriate.

20 DR. TODREAS: Oh, that's what I said.  
21 You've made your point.

22 DR. WALLIS: All right. Okay. So you  
23 agree.

24 DR. TODREAS: The other point that I  
25 wanted to make down here was there was a lot of

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1 discussion about passive safety features, and this is  
2 written basically to say evaluate them, but there is  
3 a community and a viewpoint that passive safety  
4 features compared to active safety features should be  
5 strongly encouraged.

6 It seemed to those of us putting these  
7 things together that that was a design tradeoff. It's  
8 not necessarily obvious that the passive safety  
9 features throughout to be preferred, to be preferred  
10 and to push out active features.

11 That's more of a detail, a trade-off, and  
12 while we wanted to have passive features examined, we  
13 didn't want to push them unduly. That's the  
14 significance of these words at the end.

15 I haven't followed all of your  
16 deliberations and views on that, but I would presume  
17 it's consistent. If not, I presume I'll hear about  
18 it.

19 DR. APOSTOLAKIS: I have a comment in the  
20 middle of the paragraph.

21 DR. TODREAS: Yeah.

22 DR. APOSTOLAKIS: This is a factor of  
23 about ten lower in frequency by comparison to the  
24 previous generation of LWRs. That's not quite  
25 accurate. In fact, it is inaccurate.

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1           It is a factor of ten lower than the  
2       regulatory goal of ten to the minus four. There are  
3       many LWRs right now that have core damage frequency  
4       ten to the minus five or less. So it's less than the  
5       goal.

6           DR. POWERS: There is a body of opinion  
7       over here that thinks that that may be true for  
8       operational events, but not for the total core damage  
9       frequency.

10          DR. APOSTOLAKIS: That's right, but I  
11       don't think that's what they meant here.

12          DR. POWERS: Well, I think he should be  
13       looking at all of those things.

14          DR. APOSTOLAKIS: This is a factor of  
15       about ten lower in frequency by comparison to the  
16       previous. I don't think you have any basis for saying  
17       that it's a factor of ten lower than the current  
18       generation.

19                There are plants that are low even now.

20          DR. POWERS: Plants that certainly claim  
21       to be low. That's right.

22          DR. APOSTOLAKIS: That's right.

23          DR. GARRICK: But you do have to remember,  
24       George, that the PRAs still are limited in scope with  
25       respect to such subtle issues as modeling uncertainty.

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1 DR. APOSTOLAKIS: Sure.

2 DR. GARRICK: And a real genuine treatment  
3 of uncertainty, which is still lacking in a lot of the  
4 contemporary PRAs.

5 DR. APOSTOLAKIS: What I'm saying is that  
6 it should not be the intent of a document like this to  
7 pass judgment on the current generator of reactors.  
8 The factual statement is that this is a factor of ten  
9 lower than the goal. Now, whether it's reality is a  
10 different story.

11 DR. TODREAS: Yeah, the objective of this  
12 was to report reality, not to pass judgment. I mean,  
13 certainly your statement and your point is clear and  
14 noncontroversial. If this goes over the step, then --

15 DR. APOSTOLAKIS: Well, then it seems to  
16 me that somewhere else you should say that these  
17 probabilistic risk -- I mean that these goals that are  
18 being stated here should be from all modes of  
19 operation, from all -- you know, to make sure that --

20 DR. TODREAS: That's the second sentence,  
21 an additional sentence that we could put after that.

22 DR. GARRICK: But the real thrust of this  
23 was the recoverability issue. If you're going to have  
24 a goal and improve on it, you'd like to, if you have  
25 another Three Mile Island, to be able to recover the

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1 plant, and that's why there was --

2 DR. APOSTOLAKIS: So plant damage we're  
3 talking about.

4 DR. GARRICK: Yeah.

5 DR. APOSTOLAKIS: Not core damage.

6 DR. GARRICK: And so the other thing  
7 that's important, too, with respect to words like  
8 "possibility" is that we were trying to be extremely  
9 sacred with respect to what's in the box. The rest of  
10 this is discussion and explanation, but it's what's in  
11 the box that we were hopeful --

12 DR. APOSTOLAKIS: "In the box," what do  
13 you mean by "in the box"? Which box?

14 DR. TODREAS: Well, in the box at the top.

15 DR. APOSTOLAKIS: Oh, oh, oh.

16 DR. TODREAS: But nevertheless, John, as  
17 I said, the follow-up does take the write-up and  
18 transfer it to metric, but what's in the box, do you  
19 see what's in the box now, George? Is the specific  
20 goal statement.

21 DR. APOSTOLAKIS: Yeah.

22 DR. TODREAS: So there you can go after  
23 core damage versus broader. That would affect the  
24 very specific goal.

25 DR. APOSTOLAKIS: And also I'm not sure

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1 that you need both the likelihood and degree. A very  
2 low likelihood of plan damage, period. At this high  
3 level I think that would do it because plan damage can  
4 be anything, and then you can define plan damage as  
5 something I can recover from very easy.

6 DR. TODREAS: No, but see, degree is in  
7 there because degree leads to the ability to recover.

8 DR. APOSTOLAKIS: Yeah, but that's  
9 inherent there. I mean it's understood.

10 DR. TODREAS: No, I mean, you could have  
11 plant damage extent across a spectrum, and we wanted  
12 to cut that spectrum back. that's why the word  
13 "degree" --

14 DR. APOSTOLAKIS: I think very low  
15 likelihood and degree -- that doesn't sound good to  
16 me, but --

17 DR. TODREAS: Okay.

18 DR. APOSTOLAKIS: -- because the  
19 likelihood refers to the degree, right? It doesn't?

20 PARTICIPANTS: No.

21 DR. TODREAS: No, I don't see it that way,  
22 but --

23 CHAIRMAN KRESS: I think the two go  
24 together. I'm with George on this one. You have a  
25 likelihood of something. That something is a degree

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1 of core damage, and there's a spectrum, but the  
2 likelihood goes with --

3 DR. APOSTOLAKIS: I want to have very low  
4 probability and the non-damage states. What does that  
5 mean?

6 DR. TODREAS: You say likelihood of  
7 significant plant damage, but I think you have to  
8 qualify it or add something to it some way.

9 DR. APOSTOLAKIS: but you have to say  
10 something as to which noun the word "likelihood"  
11 refers to. Likelihood of what?

12 CHAIRMAN KRESS: Core damage. It's the  
13 likelihood of core damage of such a degree that it is  
14 recoverable from.

15 DR. APOSTOLAKIS: That's the correct --  
16 yeah, that's the complete statement.

17 DR. TODREAS: Okay. Except we are not  
18 going to go in in the box statement of the  
19 recoverability from that explicitly. We just got all  
20 tied up on that.

21 DR. WALLIS: Now, to be general, your core  
22 damage also includes what happens to it when it is  
23 taken out of the reactor.

24 DR. TODREAS: Yes.

25 DR. WALLIS: And put in a pool, for

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1 instance.

2 DR. TODREAS: The whole --

3 DR. WALLIS: The whole smear.

4 DR. TODREAS: Okay.

5 CHAIRMAN KRESS: Do you feel like we're  
6 picking on you, Neil?

7 DR. TODREAS: No, because what I was going  
8 to do, I was going to request from the Chairman that  
9 we get a letter with some suggested comments and --

10 PARTICIPANTS: No.

11 DR. TODREAS: -- and I did.

12 DR. POWERS: The only one that can request  
13 letters from us is the staff and the Commission.

14 CHAIRMAN KRESS: We only write letters to  
15 the Commissioner.

16 DR. POWERS: We only write reports.

17 DR. APOSTOLAKIS: -- write to the  
18 Commission commenting on the goal.

19 DR. TODREAS: We'll take your comments and  
20 suggestions and views any way we can get them, but  
21 they would be helpful.

22 DR. APOSTOLAKIS: By the way, in two or  
23 three days there will be a transcript available.

24 CHAIRMAN KRESS: Yeah, transcription.

25 DR. TODREAS: That's fine.

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1           Let me go to number ten, which is the  
2 economic goal. Two points here.1 In the discussion  
3 of economics, the word "clear" is here with  
4 considerable debate. Again, there's several  
5 viewpoints.

6           The pragmatic and certainly the majority  
7 viewpoint was that if nuclear power of these nuclear  
8 energy systems are going to have a future, they're  
9 going to have to penetrate a market, and the only way  
10 you penetrate a market, particularly given the history  
11 of nuclear power costs, is for the new product to have  
12 a clear advantage.

13          The other viewpoint is that nuclear power  
14 is going to be needed in the future. There will be  
15 environmental imperatives that will promote it and  
16 draw it in, and it's unfair to require that it have a  
17 clear advantage. All it needs to do is be  
18 competitive, available, and await the demand from the  
19 evolving market, which will emphasize new  
20 environmental points of view.

21          DR. WALLIS: Well, presumably all you have  
22 to do is put the environmental cost into the cost and  
23 add up all of the costs and then your statement is  
24 valid.

25          DR. TODREAS: Yeah, well --

1 DR. SHACK: What as a technology goal, I  
2 don't think clear -- certainly as a goal you'd want to  
3 have a clear advantage. Now, whether you need that to  
4 be economically competitive is another question

5 DR. TODREAS: Going back to Graham's  
6 point, what I interpret you're saying is take all of  
7 the energy systems take all of their costs and make  
8 them internal to them.

9 Interestingly on the NERAC Committee where  
10 we've debated this one extensively, the non-nuclear  
11 members, and particularly the non-nuclear economic  
12 people basically say that will never happen. Don't  
13 hold that as a pipe dream. Proceed and compete on the  
14 situation as it presently exists, and effectively  
15 don't wait for the non-nuclear energy systems to  
16 actually have their extrinsic costs picked up.

17 So while it sounds great, we all agree  
18 it's logical.

19 DR. WALLIS: It's like Safety and  
20 Reliability 3. Maybe even if it seems unattainable  
21 you should try.

22 DR. TODREAS: But we basically didn't want  
23 to -- well, let me actually back up and ask you again.  
24 Your point I got was an observation that if other  
25 energy systems made their external costs intrinsic,

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1 then this would fall out.

2 DR. WALLIS: No, I think it comes out  
3 politically, too, and if the coal plants in the Middle  
4 West that claim the fish in the New England lakes,  
5 then that is a cost to somebody, and it's not a  
6 negligible thing. It figures out in the political  
7 decision somehow.

8 DR. TODREAS: It's a huge cost.

9 DR. WALLIS: Right, right.

10 DR. TODREAS: Well, we agree. The  
11 question will then come when you make this judgment  
12 have you brought in into the alternatives their full  
13 life cycle cost.

14 DR. WALLIS: Right.

15 DR. TODREAS: We're together on that.

16 And the only point I was making, the  
17 advice we got is don't hold your breath till  
18 officially those are subsumed, and in fact, those  
19 people are not pushing that these other alternative  
20 energy sources should subsume and have them made  
21 visible, which is what I think the real deficiency is.

22 Okay. And then finally on Economics 2,  
23 the question came up and came up fairly strongly: why  
24 have it? If you've got Economics 1, you've got the  
25 financial risk reflected already in the life cycle

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1 cost, and so Economics 1 effectively is a complete  
2 statement.

3 The response to that was to get nuclear  
4 energy systems going, somebody is going to have to put  
5 up the capital to start with, which is a risk capital,  
6 and although all might be balanced out, ultimately in  
7 the life cycle cost analysis, you still have to come  
8 up initially with this capital, and that is going to  
9 need to be bounded, and therefore, it needs to be  
10 focused on.

11 DR. WALLIS: Well, I'm not quite sure  
12 here. It seems to me that one and two go together.  
13 If the nuclear energy systems have a tremendous cost  
14 advantage and they're very profitable, people will be  
15 willing to take more risks to invest in them. So  
16 they're not independent, as you know.

17 DR. TODREAS: Yeah. That's what I just  
18 got finished saying. I agree with you, but at the  
19 beginning of the project, you still have to put up an  
20 investment, and it's still a risk, and if that amount  
21 is focused on minimized or comparable, then getting  
22 the ball rolling is easier.

23 And so Economics 2 was put in there in  
24 reflection of that view.

25 Okay. So then the last figure is just a

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1 summary as to where I've been, but an important  
2 summary. So let's go to that.

3 I've done it in three bullets. The first  
4 bullet is to reemphasize to you that future reactors  
5 fall in three categories or more, but at least three:  
6 those that are certified or derivatives of certified  
7 designs, those designed to a reasonable extent and  
8 based on available technology, and then those in  
9 conceptual form only, with the potential to more fully  
10 satisfy the Gen. IV goals, and it's this third group  
11 that these goals are directed at.

12 There's a lot of activity in the second  
13 one. You'll hear about the gas reactor, IRIS, et  
14 cetera, but these goals are directed at Gen. IV plants  
15 in the 2010 to 2030.

16 DR. WALLIS: Well, this is true. I'm  
17 sorry, but it seems to me that a case could be made  
18 that present plants satisfy almost all of your goals,  
19 except for this off-site emergency response one; that  
20 they're becoming more economical; they're profitable;  
21 that they're safe. They have a low probability of  
22 core damage.

23 I mean it's all done already.

24 DR. TODREAS: Yeah. With some respect to  
25 you, Graham, if you go back to Sustainability 1, you

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1 will get into one hell of an argument that present  
2 plants or advanced ALWRs or anything on the once  
3 through fuel cycle is responsive to the sustainability  
4 goals, one, two and three, to enough of a degree.

5 That's where the argument is focused.

6 DR. POWERS: I mean, it seems to me then  
7 you're complaint, your argument is with Congress over  
8 the reprocessing issue.

9 DR. TODREAS: Or recycling, but there's no  
10 argument. What we want to do and what we've got  
11 imbedded in this program is an ability to reexamine  
12 the fuel cycle, and so my point is this.

13 DR. POWERS: I mean that seems like a big  
14 enough challenge that I would leave the plant alone  
15 and go reexamine the fuel cycle.

16 DR. TODREAS: The plant is a piece of that  
17 fuel cycle, but when you say that plants in the --  
18 either operating plants or the first two out of the  
19 three bullets meet these goals, they don't -- the  
20 sustainability goals is a spectrum, of course, on  
21 there, and there are views that with regard to  
22 nonproliferation, with regard to waste those plants on  
23 the once through fuel cycle are good enough.

24 But if we're going out 30 years, we get an  
25 opportunity to do something better in that, and even

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1 if you're debating the whole spectrum of people who  
2 impinge on nuclear power decisions, they won't accept  
3 that the operating plants are good enough on those  
4 sustainability goals.

5 That's where it's focused.

6 CHAIRMAN KRESS: Actually our assumption  
7 at this meeting in general is that NRC will be faced  
8 with licensing some sort of new reactor or Gen. IV  
9 reactor or Gen. III reactor. Therefore, the question  
10 is a bit moot, I guess. What we're interested in is  
11 what are the challenges that are going to be faced  
12 through the regulatory process when and if such a  
13 design comes forth.

14 We know how to license the present  
15 reactors. So, you know, I think it's a different  
16 subject as to whether the present reactor ought to be  
17 the next iteration or whether or not we should focus  
18 on the advanced reactors.

19 This is an Advanced Reactors Subcommittee.  
20 So I'm making the assumption that there will be some  
21 sort of advanced reactor that we have to deal with in  
22 the regulatory process.

23 DR. TODREAS: Okay.

24 CHAIRMAN KRESS: That's just to put things  
25 into perspective.

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1 DR. TODREAS: Yeah, I would just say a  
2 follow-up to this along the lines you're talking about  
3 is what I was prepared to discuss later in the  
4 afternoon, the challenges, but my challenges are going  
5 to be technological challenges coming out of the fuel  
6 cycle. That's the bottom line.

7 CHAIRMAN KRESS: Okay.

8 DR. TODREAS: Okay. Then the second  
9 bullet says we're looking for a range of design  
10 options that respond to various marketing demands, and  
11 I've got those in the four subpoints, and then the  
12 final bullet down here is I think what we started off  
13 agreeing on earlier in the discussion, that the  
14 dialogue, at least my point is the dialogue between  
15 the regulators and the designers relative to advanced  
16 plants, and I'm talking there about these Gen. IV  
17 plants has got to be framed to promote and encourage  
18 fundamental design evolution, revolution directions.

19 And in that sense, the interactions that  
20 come out of this I think require -- here I'll mention  
21 the word "risk" now -- require the development of a  
22 regulatory framework which is based on risk based  
23 principles.

24 And I think we need to move to that kind  
25 of structure and certainly that kind of dialogue as

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1 you interact and as the staff interacts with the  
2 conceptual and the development of these advanced  
3 systems.

4 That's the bottom line message.

5 CHAIRMAN KRESS: Questions or additional  
6 comments?

7 MR. LYMAN: Ed Lyman from Nuclear Control  
8 Institute.

9 I think that there are a few goals that  
10 are really missing from this whole formulation. First  
11 of all, under sustainability you refer to one that  
12 minimizes, that a goal is minimizing and managing  
13 nuclear waste, but at the same time, you really should  
14 impose a requirement that the routine emissions from  
15 the entire fuel cycle, as well as, let's say,  
16 occupational exposures are also minimized because one  
17 of the concerns with fuel cycles that involve  
18 reprocessing are these additional routine emissions,  
19 and you have to balance whether the reduced risk in a  
20 repository is justified by increased short-term  
21 emission.

22 So that's really something you have to  
23 keep to minimize at the same time or it doesn't make  
24 sense.

25 Second of all, under the financial goals

1 issue, you didn't really dwell on the one that  
2 requires or suggests that the financial risks should  
3 be comparable to other energy projects, and I was  
4 wondering if in that context you would also have a  
5 requirement then that Price Anderson protection not be  
6 extended to Generation IV plants because other energy  
7 projects don't require that kind of protection.

8 DR. TODREAS: Yeah, on the first point you  
9 brought up, the specifics of that have been recognized  
10 and will come up in Safety and Reliability 1 because  
11 there we are talking about across the whole fuel  
12 cycle, and those routine emissions are picked up  
13 there. They could be picked up either place, but  
14 that's where they come up.

15 And on Price Anderson, we didn't get into  
16 the specific item within the structure of the goal  
17 that can be picked up and debated. It's been debated  
18 to some extent, but we didn't pin it down and resolve  
19 it specifically.

20 I know that's coming up legislatively.

21 MR. BARRETT: I'm Richard Barrett. I'm  
22 with the NRC staff.

23 And my question relates to the methods  
24 that we use for estimating the likelihood of core  
25 damage and the likelihood of release of radioactivity.

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1           If NEI is correct and we have 50,000 new  
2 megawatts of capacity out there, and those are modular  
3 reactors -- that's 500 cores, and in an environment  
4 like that you find yourself striving for lower and  
5 lower core damage frequencies, and as you do that, you  
6 begin to put more and more stress on the current  
7 methods of estimating core damage frequency, and you  
8 begin to get to the point where many people think  
9 you're beyond the capability and the limitations of  
10 the method and the ability to have a complete model.

11           And in addition, as you move to different  
12 types of reactors, you find that you're depending less  
13 and less on highly reliable, redundant, and diverse  
14 systems and more and more on the intrinsic capability  
15 of the core itself to withstand these accidents, and  
16 to withstand them either indefinitely or for long  
17 periods of time.

18           And, again, the methods that we have today  
19 really don't deal very well with this kind of  
20 intrinsic, passive capability.

21           So my question to you is the stated  
22 purpose of your effort is to stimulate innovation in  
23 the design of the reactors, and my question is: could  
24 you also complement that with trying to stimulate  
25 innovation in the methods that we use for analyzing

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1 the risk associated with these reactors?

2 DR. TODREAS: Yeah, I would answer that  
3 two ways. First, it's a good suggestion and a fair  
4 suggestion. There's nothing implicit in -- what's  
5 going to come out of this fundamentally is a spectrum  
6 of concepts to focus on, but much more than that, an  
7 R&D road map of activities to flesh up those concepts  
8 and the methods associated with those concept  
9 development is certainly part and parcel of that. So  
10 we could do that.

11 The other thing though that I'd say  
12 implicit in a response is, you know, if the future  
13 were to evolve the way it is and even if we were to  
14 develop the methods, and we're going to have to reduce  
15 core damage frequencies further to get a desired  
16 output. So that really leads you to say that if you  
17 go with concepts now that are clones or like -- I'm  
18 talking about 20, 30 years down the road -- that are  
19 like these, you're going to reach a point where the  
20 methods can only go so far based on the existing  
21 approaches, and so that's a clarion call to change  
22 those approaches and go toward -- well, first, you go  
23 toward situations that avoid core melt, but that's  
24 very limited in a sense that what you really want to  
25 do is do what Dana Powers was talking about.

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1           It's not core melt. It's the fission  
2 products, and it's the radioactivity in the dose from  
3 that, and that's what you've got to get after.

4           So I would say we certainly would accept  
5 and develop methods, but what we are trying to do is  
6 stimulate. I'm talking about real innovation, beyond  
7 that, to try to open up approaches that really change  
8 the playing field.

9           Larry?

10          MR. HOCKRITTER: Larry Hockritter, Penn  
11 State.

12          It's not clear to me why in your  
13 conclusions you have to have small versus large power  
14 ratings. It seems like you're biasing yourself  
15 already towards a particular class of designs.

16          DR. TODREAS: Yeah. Yesterday I presumed  
17 the whole layout of this program was announced or was  
18 explained as an international program with eight to  
19 nine countries now, and one of the goals of the  
20 program in all the specific directions is to come up  
21 with design solutions or concepts that meet markets  
22 internationally, and there are some international  
23 markets, and also if you listen in the United States,  
24 too, depending on the grid size, there are some  
25 markets that have a priority toward low rated systems.

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1           And so you have some of those, and then  
2           you also have the traditional, if you talk about Asia,  
3           Japan, Korea, Taiwan, large systems.

4           So inherent in the whole program, since  
5           it's looking at worldwide markets, we're going to have  
6           this dichotomy, these two parts, and not one reactor  
7           thrust or direction is going to meet them. So you're  
8           going to have to come up with systems in both  
9           directions.

10           Now, your point may be fine, but they're  
11           not going to be sellable in the United States or the  
12           industrialized world. That's fine, but we'll have a  
13           product for that. We just may not use the other  
14           product.

15           MR. KHADAMI: My name is Presar Khadami.  
16           I'm with the NRC staff.

17           If I understand the rules by which the  
18           South Africans are trying to license their plant, one  
19           of their goals is that in the long term the concepts  
20           employed should be amenable for society to make a  
21           decision that higher levels of safety need to be  
22           obtained from these energy systems.

23           And therefore, one of their goals, as I  
24           read it, and if I should be corrected, I'd like  
25           somebody to point this out; one of their goals is the

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1 design should be amenable for society to demand higher  
2 levels of safety at some future time if we take, you  
3 know, these systems as operating for many decades.

4 Where does such a concept fit into the  
5 kinds of goals that you have articulated?

6 DR. TODREAS: Okay. On this let me give  
7 you a brief answer and ask for some help because I am  
8 not knowledgeable about a specific or the specific  
9 South African drive that you're talking about. I just  
10 haven't interacted with them specifically.

11 I would say that even though these are  
12 general, we are going to have some kind of constraint  
13 because we're going to come up with a set of specific  
14 metrics that go with each of these goals. They're  
15 going to be as we go on a year or two -- there's going  
16 to be some numbers and some specificity here . So.  
17 There's going to be a little bit of a lock-in, and  
18 that sounds to me like it's inconsistent.

19 The way I interpret what you're saying is  
20 you come up with a design. Society decides they want  
21 more safety, and so this design has somehow got to be  
22 expandable or have margin or a way to capture more  
23 safety. That's how I understand it.

24 So I don't know the answer. These goals  
25 have been pushed in through a discussion with the so-

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1 called GIF countries, of which South Africa is a part  
2 of, and we didn't get any effective comment back from  
3 them that's relevant to what you said.

4 But if Andy or somebody else can speak  
5 specifically to that, that would help me.

6 DR. SLABBER: Mr. Chairman, the South  
7 African concept, the baseline was to use existing  
8 technology as far as possible, existing technology  
9 that has been qualified and tested and proven to be  
10 acceptable for use in the PBMR&S, and with a basis  
11 that the fuel is the central point of focus.

12 And within that framework, we do the  
13 system design, that it fulfills the requirements that  
14 imbedded in the design without reliance on operator  
15 actions is imbedded a term, and I again say, in  
16 inverted commas, inherent safety and small units, and  
17 usable for not only producing nuclear power, but also  
18 some other usable byproducts specific for South  
19 Africa.

20 DR. TODREAS: Can I build on that maybe in  
21 answer to his question? You stay there because I'll  
22 need you.

23 I would say with that focus and the  
24 ability, as you went to successive improvements in  
25 fuel fabrication and fuel reliability, you could

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1 actually enhance your safety profile if the key focus  
2 is fuel, and that would be an answer back to how you  
3 reflect the future, the fuel.

4 DR. SLABBER: Yes, and I think the  
5 objective of any new innovator system should be to  
6 improve, but there is a limit because it's also  
7 costly. So improvement, the improvement for public  
8 acceptance, improvement of safety, that the boundary  
9 made improvements so that you do not have to shelter  
10 and evacuate, but these are all factored in to provide  
11 a facility which is still affordable and reliable.

12 CHAIRMAN KRESS: Thank you very much,  
13 Neil.

14 At this time I'm going to declare a 15-  
15 minute break. Be back at 20 till.

16 (Whereupon, the foregoing matter went off  
17 the record at 10:26 a.m. and went back on  
18 the record at 10:45 a.m.)

19 CHAIRMAN KRESS: Before we move on to the  
20 next speaker, I want to reiterate my announcement I  
21 made this morning, that we are changing rooms for this  
22 afternoon's session, and the room we're changing to is  
23 the usual ACRS meeting room, which is on the second  
24 floor of White Flint 2. There may have been some  
25 confusion in people's mind.

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1           And if you're signed in this morning, we  
2 will have a -- you have to have a badge to get up  
3 there, and there will be a temporary badge available  
4 for those people who have signed in at the security  
5 desk in White Flint 2 lobby, and that will be  
6 available after lunch.

7           But if you haven't signed in at all or are  
8 not currently badged, you will need to go through that  
9 and get a temporary badge before going up to the  
10 second floor.

11           So with that little aggravation, we'll  
12 move on to the next talk, which should prove to be  
13 very interesting, and as I mentioned earlier, I have  
14 no introductory comments. So you have to introduce  
15 yourself, Andy.

16           DR. KADAK: Thank you.

17           CHAIRMAN KRESS: And then I'll turn it  
18 over to you.

19           DR. KADAK: My name is Andy Kadak. I'm  
20 professor of the Practice at MIT. You can ask me  
21 later what that means exactly.

22           I was formerly a president and CEO of  
23 Yankee Atomic Electric Company. So I've been able to  
24 see directly and experience the strengths and  
25 weaknesses of the NRC regulatory process, and I'll

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1 just leave it at that.

2 (Laughter.)

3 DR. KADAK: When I first came to MIT --

4 DR. POWERS: Because if you went through  
5 all of the strengths, it would take too long.

6 DR. KADAK: Absolutely.

7 DR. POWERS: I understand.

8 (Laughter.)

9 DR. KADAK: When I went to MIT in 1997 as  
10 a visiting lecturer, Professor Ballenger and I engaged  
11 about 11 students under an American Nuclear Society  
12 program called the Economic and Environmental  
13 Imperative, and it was aimed at stimulating student  
14 interest in looking at innovative, new reactor  
15 technologies, and to see how we could make nuclear  
16 plants competitive, safe, and politically acceptable.

17 In 1996, the students chose a pebble bed  
18 reactor as the technology to develop since it appeared  
19 to best meet our attribute.

20 We then convinced the Idaho National  
21 Engineering and Environmental Laboratory that, of this  
22 particular fact, and they supported much of our  
23 research for the last three years.

24 Overall our objective is to develop a  
25 conceptual design of a complete power plant based on

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1 the concepts and ideas that we formulated in 1998.

2 We're now working in the following areas,  
3 just to give you a sense of the scope of our effort.  
4 We're doing and developing a fuel performance model,  
5 which includes and will include the manufacturing  
6 aspect of it.

7 We're doing some experimental work on  
8 silver and palladium, effect on silicon carbide.  
9 We've got a core neutronics capability, and ultimately  
10 hope to verify and validate using MCNP, a lot of the  
11 core neutronics.

12 We're developing a balance of plant design  
13 and a simulation capability to assess normal operating  
14 transient.

15 We're also working in the area of safety,  
16 loss of coolant and air ingress analysis. We've done  
17 some work on nonproliferation, waste disposal, and  
18 we're also now engaged in what I call true modularity,  
19 namely -- and this is the innovation -- true factory  
20 manufacture of essentially the balance of plant for  
21 site assembly.

22 We are also working with the University of  
23 Cincinnati on developing of a burn-up monitor for  
24 these pebbles.

25 If we get additional funding, there will

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1 be work on advanced INC with Ohio State. We're  
2 looking at management issues and a PRA.

3 So ultimately, if our work is successful  
4 and we continue developing this concept, our plan is  
5 to build a combination research and demonstration  
6 facility to test the technology, help validate the  
7 technology and operation, and essentially use it as a  
8 continuous test bed for the life of the plants should  
9 they be built in the future.

10 This is sort of an introduction to what  
11 I'm going to talk about today, which is this license  
12 by test, which I've been thinking about for many  
13 years. I've talked to many of the NRC staff about the  
14 idea.

15 Now, this presentation that I'm going to  
16 make today does not claim to have all the answers  
17 about how such a process might work, but it is meant  
18 to address some of the high level issues and the  
19 approach that we might consider.

20 And to determine whether this concept is  
21 workable, it is recommended, and that's my bottom line  
22 recommendation, that the NRC, we and other interested  
23 parties work to see if such a process can work rather  
24 than jumping on all of the reasons that it can't.

25 So with that, let me just begin. Here are

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1 the challenges as I see them. The regulations, as you  
2 all know, are focused very much on water. The  
3 knowledge of the technology, particularly in new  
4 technologies -- forget the pebble bed for the moment.  
5 This is generic -- knowledge of these new  
6 technologies is generally lacking, and the  
7 infrastructure to support some of these new  
8 technologies is also lacking.

9 We've heard plenty of that yesterday,  
10 regardless of whether it's gas, liquid metal, lead  
11 bismuth, whatever the technologies are.

12 And changes in the system, what I call the  
13 system is the regulatory system, take a very, long  
14 time.

15 So how do you introduce a new technology  
16 in less than a lifetime? And yesterday I heard hints  
17 of lifetime project.

18 We need to go back to the basic safety  
19 fundamentals. We need to work within the existing  
20 regulatory high level objective, use -- and here we go  
21 -- very early in the game, risk informed, which I  
22 define as risk based with deterministic analysis,  
23 approaches to determining safety; assess our gaps in  
24 the knowledge, especially if it's new technology to  
25 see what we understand and what we don't understand

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1 very objectively; prioritize namely what are the  
2 significant risks associated with what we don't know  
3 and what we do know; and then try to license this  
4 thing by test.

5 Well, here we got. Relative to  
6 establishing the safety goal, we would use a public  
7 health and safety goal, not a core damage frequency,  
8 and I think you were sort of getting at that yesterday  
9 in terms of releases.

10 You look at this public health and safety  
11 goal, and then you start to define your plant risks,  
12 whether they be normal operating risks, events,  
13 transience, accident scenarios, and then identify the  
14 safety margins as best as you can using deterministic  
15 analysis. Then begin or attempt to quantify the risks  
16 as you know them using a PRA, and then show defense in  
17 depth, and what I will describe later about defense in  
18 depth is how many barriers are there to prevent a  
19 release.

20 CHAIRMAN KRESS: Is that what you mean by  
21 defense in depth?

22 DR. KADAK: That's what I mean by that.

23 And I'm not defining the barrier, and how  
24 do I deal with the uncertainties that recognizably  
25 exist in this technology.

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1 Next slide, please.

2 The risk informed approach then really  
3 attempts starting with the safety goal, and it's a  
4 public health and safety goal, by applying what we  
5 know and using the probabilistic techniques that we do  
6 know in a scoping kind of a sense. We will obviously  
7 not know the performance of helium high temperature,  
8 high temperature helium turbines or compressors  
9 because the size that we're talking about hasn't been  
10 built, but we can estimate it based on other  
11 experience.

12 Are these health and safety goals  
13 something different than the quantitative health  
14 objectives that we currently have?

15 DR. KADAK: they would be based on  
16 fatalities, ten to the minus -- pick a number -- ten  
17 to the minus six. Start at that level.

18 CHAIRMAN KRESS: Yeah, but do you think  
19 that those we now have are sufficient or do we need  
20 something else?

21 DR. KADAK: I would say at that level it's  
22 sufficient.

23 DR. POWERS: Why do you focus on  
24 fatalities?

25 DR. KADAK: It's an easy measure. You

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1 could talk about injuries, if you like as a separate  
2 measure.

3 DR. POWERS: I mean if we're going to  
4 learn something out of accidents that have occurred,  
5 the most transparent consequence of Chernoble has been  
6 radiation injuries rather than fatalities.

7 Line contamination could arguably be the  
8 other thing that we've learned. Why not change the  
9 measures in response to things we've learned?

10 DR. KADAK: We could do that. I'm not  
11 limiting it. I'm just saying establish something that  
12 everybody is comfortable with, and I mean societally  
13 comfortable with. And if it talks to land, if it  
14 talks to injuries or if it talks to fatalities,  
15 fatalities is the one that we now have.

16 CHAIRMAN KRESS: Well, you know, part of  
17 the purpose of this meeting is to identify regulatory  
18 challenges, and my question was aimed at saying do we  
19 have appropriate let's call them safety goals now or  
20 should the Commission be thinking about something  
21 different for safety goals for the advanced reactor,  
22 and that --

23 DR. KADAK: My sense right now is we have  
24 already essentially established the policy that  
25 says -- we established the public health and safety

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1 goal. Let's start there. If there's more that needs  
2 to be done, add it, but I don't see that as a priority  
3 issue right now.

4 From what I understand of the British  
5 system, they're trying to harmonize safety goals  
6 across all technology, and perhaps we can learn  
7 something from that to be able to judge whether  
8 nuclears are in the right ballpark.

9 CHAIRMAN KRESS: Okay.

10 DR. KADAK: So we would then apply these  
11 deterministic and probabilistic techniques as best we  
12 can to see if the goal is met, and then using the  
13 risk-based techniques, identify dominant accident  
14 scenarios and what critical systems and components  
15 need to be tested as a functional system.

16 And in this case I'm trying to avoid the  
17 use of design basis access. I'm trying to see what  
18 really matters for safety and use the risk approaches  
19 to identify those.

20 The next slide gives an approach that I  
21 think has been used in the past where you go through,  
22 you know, the risk informed approach, namely,  
23 identifying on a very high level basis the issues of  
24 protection of the public, evaluate risks against the  
25 safety goals, use the PRA to quantify obviously larger

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1       uncertainties, limit core damage, mitigate releases,  
2       and then mitigate consequence.

3               Now, this is sort of a standard kind of  
4       approach. What I would suggest is that's where you  
5       start, and the master logic diagrams would be more or  
6       less technology specific relative to the kinds of  
7       vulnerabilities of the particular technology might  
8       have.

9               The next slide gets into a description of  
10      a master logic diagram, but that's for water reactors.  
11      One of our students at MIT is now attempting to try to  
12      define this better for, say, the pebble bed reactor,  
13      and we're going to start with a basically different  
14      approach at least from my perspective, and that is,  
15      you know, starting with the plant and how do I protect  
16      the public working backwards, and what events can  
17      cause release.

18              We're going to try to do a different  
19      master logic diagram on that basis.

20              Next slide, please.

21              This chart here, which you can't see very  
22      well, but it's in your handout, is a summary of what  
23      the South African national nuclear regulator is using  
24      for their assessment. They've got a very similar  
25      system to what I'm proposing, at least at a higher

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1 level, and they developed some requirements that  
2 starts from the public health and safety goal and  
3 establishes various safety criteria in a range of  
4 events which I think we heard about yesterday.

5 It's in the handout, and hopefully you can  
6 read it better, but I bring that up only to allow one  
7 to see that there is a logical frame of reference from  
8 which to proceed to establish such a process of using  
9 risk informed to establish and correlate that with the  
10 public health and safety goal.

11 The next slide, please.

12 We do have an existing regulatory  
13 structure, and I'm still trying to do this in less  
14 than a lifetime. So what we're going to try to do if  
15 we get a chance to is -- and it's already been  
16 discussed, I think, by Exelon -- and that is review  
17 the existing regulatory structure for the gaps that  
18 exist relative to that particular technology. For  
19 example, as far as I know, there's no error ingress  
20 safety criteria. We might need to have such a thing  
21 developed, but identify those kinds of issues as you  
22 look at the existing regulatory guidance.

23 And, in fact, look at the general design  
24 criteria and say how do we and how can we implement  
25 those, given what we think are the high level safety

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1 objectives that we've established in the previous  
2 step.

3 Where it gets confusing and where it will  
4 get difficult is trying to meet the general design  
5 criteria for non-standard or non-order technology, and  
6 it's in the details that you really get hung up, and  
7 that's where the whole process of show me that it  
8 doesn't require this criteria happens.

9 So we're trying to say by reviewing the  
10 existing structure, applying it to say the pebble bed  
11 reactor, and then being able to say on a risk based,  
12 you know, foundation what does and does not require it  
13 in terms of the fundamental design for the regulation  
14 that would apply to that.

15 Next slide.

16 So, and I use the word "design basis  
17 accidents" using risk based techniques. I really  
18 wanted to keep to the word design the dominant  
19 accident sequences using risk based technique, which  
20 you would then analyze to try to assess how much  
21 defense exists in those accident sequences.

22 DR. WALLIS: Can I ask you something here?

23 DR. KADAK: Surely.

24 DR. WALLIS: I mean, you seem to be  
25 applying what we do today to what we might do

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1 tomorrow, and did you question whether we really need  
2 design basis accidents in their present form?

3 DR. KADAK: My approach would say --

4 DR. WALLIS: Or would it be replaced by  
5 something else which might be less plant specific and  
6 be more effective?

7 DR. KADAK: The process that I would  
8 recommend is developing dominant accident sequences as  
9 part of the regulatory process, and don't call them  
10 design basis accident.

11 DR. WALLIS: But you just did.

12 DR. KADAK: Well, I made a mistake.

13 (Laughter.)

14 DR. KADAK: I was revising my slides, and  
15 I was looking for design basis accidents, hopefully  
16 not to include it, but I made a mistake. It should be  
17 establish dominant accident sequences. Okay?

18 CHAIRMAN KRESS: If you go back two slides  
19 to the one we couldn't read --

20 DR. KADAK: Yes, the big -- yes.

21 CHAIRMAN KRESS: It seemed to me like  
22 that's at least three points on it, a frequency  
23 consequence curve.

24 DR. KADAK: Right.

25 CHAIRMAN KRESS: It seems to me like such

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1 a curve encompasses all of the accidents, the whole  
2 spectrum.

3 DR. KADAK: It attempts to cover them all.

4 CHAIRMAN KRESS: If you meet some sort of  
5 regulatory requirement on this, and it may have to  
6 have confidence limits or something, and then  
7 encompasses the whole shebang, doesn't it?

8 DR. KADAK: We're trying to cover the  
9 regime of accidents possible for this technology.  
10 Okay? And looking at the categorizations placed under  
11 A, B, and C, it appears to cover logically what one  
12 would need to worry about, but I can't --

13 CHAIRMAN KRESS: So if you just tell the  
14 designer or the license applicant that he has to meet  
15 this curve -- I call it a curve -- at a certain  
16 confidence level, what else do you need?

17 DR. KADAK: I guess --

18 CHAIRMAN KRESS: The thing that seems to  
19 be missing to me is defense in depth. We can get into  
20 that later.

21 DR. KADAK: Where I get hung up is for new  
22 technologies doing that is going to be extremely  
23 difficult.

24 CHAIRMAN KRESS: Because it requires a  
25 pretty good PRA.

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1 DR. KADAK: It requires a good PRA.

2 CHAIRMAN KRESS: And a good knowledge of  
3 the phenomena that go into the accident sequences.

4 DR. KADAK: Yeah, and a lot of data that  
5 supports the probability --

6 CHAIRMAN KRESS: Which is the part that's  
7 usually tempted to be covered when you have that  
8 situation by defense in depth. That's why I keep  
9 harping on we need a firmer definition of defense in  
10 depth and how it fits into a regular or a system like  
11 this, for example, with new technologies where you  
12 don't really have core melts, and you don't really  
13 have the standard barriers against fission products.

14 But, anyway, that's another subject.

15 DR. KADAK: Well, my sense of defense in  
16 depth is how much margin do you have to, say, core  
17 melt or in this case release.

18 CHAIRMAN KRESS: Yeah, that's a sort of a  
19 defense in depth.

20 DR. KADAK: Sort of.

21 CHAIRMAN KRESS: It's not my definition.

22 DR. KADAK: Okay.

23 DR. WALLIS: What's your measure of  
24 margin?

25 DR. KADAK: I hate to say this, but

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1 engineering judgment.

2 DR. WALLIS: That to me always is an  
3 ignorance factor than --

4 DR. KADAK: Absolutely, and I'm just  
5 suggesting that when you introduce new technologies,  
6 there will be a lot of uncertainties which you cannot  
7 precisely calculation.

8 DR. WALLIS: Your engineering judgment is  
9 maybe ultimately different from somebody else's. So  
10 how do you explain or argue with that person?

11 DR. KADAK: It depends on the design.

12 DR. WALLIS: I think you have to be  
13 quantitative in some measure which you can agree upon.

14 DR. KADAK: If you can do deterministic  
15 analyses and show that the worst situation as was  
16 presented, I believe, yesterday is acceptable and  
17 analytically, deterministically. That's why it's not  
18 purely a probabilistic approach.

19 Using the best tools that you have and, in  
20 fact, being able to, as I will get to, the license by  
21 test scenario to demonstrate such things, I think your  
22 confidence levels will be greatly increased, and  
23 that's the bottom line.

24 What makes me very nervous is just relying  
25 on numbers with confidence levels because as we know,

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1 even with our PRAs things happen that are not in the  
2 PRA.

3 DR. KADAK: Okay. If I could catch up to  
4 where I was, okay, then if you'd just back up that  
5 one, I want to -- to develop the defense in depth  
6 basis using the natural physical attributes of the  
7 designs, what that basically means is if there are  
8 significant natural physical attributes and not so  
9 much reliance on active systems or passive systems  
10 that must function, you are in a much better position  
11 to develop the confidence level you need relative to  
12 defense in depth, and you can argue about how many  
13 barriers or whatever, but that is a key part of this,  
14 and that's a key direction, I believe, that the  
15 regulators ought to encourage relative to new  
16 technological develop, and that is natural physical  
17 attributes.

18 CHAIRMAN KRESS: I interpret that  
19 statement to mean that there's probably less  
20 uncertainty associated with determining the risk of  
21 those than when you have a complicated system with  
22 lots of barriers and lots of active --

23 DR. KADAK: That's the point. We want to  
24 try to limit those active --

25 CHAIRMAN KRESS: Therefore, since you have

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1 less uncertainty and higher confidence in the risk  
2 results, the less defense in depth might be needed?

3 DR. KADAK: Again, the less defense in  
4 depth is not the right term.

5 CHAIRMAN KRESS: Is that too big of a step  
6 to take?

7 DR. KADAK: Now, the point is to  
8 demonstrate the defense in depth exists and give  
9 credit to natural physical attributes, I think is the  
10 direction that I would be heading.

11 And then to whatever degree possible,  
12 establish confidence levels in the analysis using risk  
13 assessment method.

14 Next slide, please.

15 All right. License by test. Depending  
16 upon the technology, and in my case it would be sort  
17 of the pebble bed for an example, build a full size  
18 demonstration facility. Perform these critical tests  
19 on those components that you identified as dominant  
20 risk contributors.

21 DR. WALLIS: I don't quite understand  
22 that. Are you going to have a near core melt or a  
23 near containment failure in order to do a critical  
24 test?

25 DR. KADAK: Let's just say, for example,

1 if LOCA is a major accident sequence --

2 DR. WALLIS: Do you have a LOCA in your --

3 DR. KADAK: You would perform a LOCA.

4 DR. WALLIS: You would perform a LOCA.

5 Okay.

6 DR. KADAK: Or to the degree, at least,  
7 that you can validate your computer models and  
8 methods. And that's why these physical features  
9 become very important.

10 DR. POWERS: Have you imagined what the  
11 environmental impact statement on this federally  
12 funded examity (phonetic) is going to look like?

13 (Laughter.)

14 DR. KADAK: Sure, and what I didn't  
15 mention and I probably should was that for the purpose  
16 of this research, combination research demo facility,  
17 we put a containment on it.

18 DR. POWERS: Well, I thought you just put  
19 it in Idaho and nobody would care.

20 (Laughter.)

21 DR. KADAK: For the record, Idaho is a  
22 beautiful state, has lovely people.

23 (Laughter.)

24 DR. KADAK: Nature abounds.

25 DR. POWERS: Probably do \$10 million worth

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1 of improvements in New Mexico.

2 DR. KADAK: Okay. So clearly it's a  
3 research facility that needs to have a containment,  
4 but the purpose of the containment is to prove you  
5 don't need one, if that, in fact, turns out to be the  
6 result.

7 DR. POWERS: How would you do that? I  
8 mean, suppose you ran this test and, indeed, it did  
9 just fine, and some skeptical guy like Ed Lyman over  
10 there came along and said, "But if you'd done a  
11 different test" --

12 DR. KADAK: Well, that's what I want Ed  
13 Lyman to work with us. When I said all interested  
14 parties, I'd like to have Mr. Lyman, Mr. Lockbaum, and  
15 Mr. Gunther involved in this because I think that's  
16 part of the process.

17 DR. POWERS: And still no matter what test  
18 you did, somebody else could come along and say, "But  
19 if you'd just done this other test."

20 DR. KADAK: Yeah, but Mr. Lyman will be  
21 explaining to this other person why these test series  
22 are adequate, not me.

23 (Laughter.)

24 DR. WALLIS: Well, I think the problem you  
25 get into --

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1 DR. KADAK: Sorry.

2 DR. WALLIS: -- is the basis of scientific  
3 testing is to try to disprove your hypothesis.

4 DR. KADAK: Yes, or to prove it. I think  
5 you'd like to try to prove it.

6 DR. WALLIS: Of course, by the very fact  
7 that you could disprove it, you would have had an  
8 unacceptable release presumably. So it's a little  
9 difficult to design that crucial test to disprove a  
10 hypothesis that it's safe.

11 DR. KADAK: Well, again, there's a reason  
12 for the containment, and obviously you'd be a little  
13 more creative about the type of test you run so that  
14 you understand what the possible outcomes would be,  
15 but theoretically it's conceivable, and it obviously  
16 depends on the plant and type of design.

17 DR. WALLIS: I guess we're asking these  
18 questions because we're kind of intrigued by the idea.

19 DR. KADAK: Good.

20 DR. WALLIS: But we're skeptical.

21 CHAIRMAN KRESS: Yeah, one purpose --

22 DR. KADAK: Wonderful, marvelous.

23 CHAIRMAN KRESS: -- we attribute to  
24 integral tests are to -- two purposes: one, to see if  
25 there's something going on that we hadn't thought of;

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1 two, to validate our computerized analytical tools so  
2 that they can be used in an extrapolatory sense to  
3 cover the things we can't do inn the test.

4 Would that be your view of what this test  
5 might do for you?

6 DR. KADAK: Next slide.

7 The needs. Why? To validate analysis.  
8 Okay? To shorten the time for paper reviews; to try  
9 to prove in quotes what's debatable; to reduce  
10 uncertainty, and this is very important; to show the  
11 public and the NRC, and I include them as the public  
12 in this case, that the plan is, in fact, safe.

13 And that's what it's all about. Can we do  
14 the -- you know, can we try to melt the core? If we  
15 believe that we can do it without melting the core,  
16 yes.

17 DR. WALLIS: So what you should do is you  
18 should give an operator carte blanche to try to melt  
19 the core, and he or she will fail. Is that your test?

20 DR. KADAK: Depending upon the design,  
21 yes. I mean, theoretically that would be the test,  
22 but I would structure it more carefully than that.

23 (Laughter.)

24 DR. KADAK: See, we're going to hear about  
25 radiological sabotage in a few minutes, I'm sure, and

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1 maybe that's the test that Ed would like to run, but  
2 we don't know yet.

3 Yes, I'm sorry.

4 DR. GARRICK: Andy, we have a bit of a  
5 model for this in that we once had something called a  
6 national reactor testing station, and we once had  
7 something called the borax experiments, and we once  
8 had something called the spurt experiments, all of  
9 which have a kind of familiar ring as to what they  
10 wanted out of those experiments in terms of what  
11 you're describing.

12 Does that experience, just from the  
13 standpoint of answering the questions of one scenario  
14 versus another scenario, I want to test my scenario,  
15 Dana wants to test his scenario, and so forth; is that  
16 experience relevant at all in what you're proposing  
17 here?

18 DR. KADAK: I'm not sure, but I recall  
19 some of them actually wanted to break fuel like no  
20 fuel.

21 DR. GARRICK: Right, but they were talking  
22 about various degrees, and they tried very desperately  
23 to come up with an experimental program that gave them  
24 the biggest bang for the buck possible, and what they  
25 were really trying to do was get closer to a

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1 quantification of the loss of coolant accident, and  
2 better parameter information with respect to the  
3 containment and so forth.

4 DR. KADAK: Clearly, you know, that  
5 experience would be certainly helpful, but again, I  
6 don't have all of the answers. I'm just giving you an  
7 idea of what I think might work, but how to exactly do  
8 it and what to build on, I just am not all that  
9 familiar.

10 What I hope to do after this presentation  
11 is you're so excited about this concept that you'll  
12 ask the NRC staff to work with us to try to figure it  
13 out.

14 MR. LEITCH: Andy, I have a question about  
15 your second bullet up there, shorten the time for  
16 paper review.

17 DR. KADAK: Yes.

18 MR. LEITCH: I'm not exactly sure what you  
19 mean by that. Does that mean that the paper reviews  
20 would not be as detailed or not exist at all --

21 DR. KADAK: No, no.

22 MR. LEITCH: -- in lieu of this test?

23 Or talk a little bit about would the paper  
24 reviews be less detailed than they would normally be,  
25 and if not, how would the time be shortened?

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1 DR. KADAK: See, that depends on what  
2 licensing action you have. Let's just take the most  
3 recent paper review, AP 600.

4 MR. LEITCH: Okay.

5 DR. KADAK: All right? I'm told -- I do  
6 not know -- it took roughly ten years. I'm told, but  
7 do not have the number confirmed, it cost around \$249  
8 million, which included a lot of testing as well.

9 And the end of that process was a  
10 certification, a piece of paper. What I'm suggesting  
11 here is for \$249 million I could probably get part of  
12 a plant built that looks like a research facility that  
13 could be used to answer some of these tests, some of  
14 these questions.

15 In terms of submittals, I don't see much  
16 different in terms of what the design is. The  
17 submittal would largely be here's the design. Here's  
18 why we think it's comfortable and appropriate, and  
19 here's the testing program that we're planning to  
20 perform here to validate these areas that are in  
21 question or to validate some computer code.

22 So the approval would be more of an  
23 approval to conduct tests on a facility than to grant  
24 a license or a certification. That certification  
25 would come after the test had been completed,

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1 hopefully successfully and whatever design  
2 modifications made.

3 So I think in time scale, we're probably  
4 going to be about the same, say, five to ten years,  
5 you know, including the building the plant. What you  
6 will have at the end of that process not only is  
7 certification, but also a plant that theoretically is  
8 workable.

9 DR. WALLIS: Are you asking for a kind of  
10 full scale LOFT test?

11 DR. KADAK: Full scale LOFT test, I  
12 suppose in the sense of a LOCA. There will be others  
13 on a facility, and one of the things it avoids is  
14 remember the scaling issue that you've had to fight  
15 over? I mean, clearly the scaling issue sort of goes  
16 away if you do a full scale plan or a large enough  
17 scale to be able to say scaling is not a factor.

18 DR. POWERS: I still get hung up over  
19 these. When George does a PRA, he comes up with more  
20 sequences than I can count, and you're going to have  
21 to validate all of them?

22 DR. KADAK: Not all of them, no.

23 DR. WALLIS: Well, some significant  
24 fraction of them?

25 DR. KADAK: You'd validate obviously the

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1 dominant accident sequences that are really important  
2 for public health and safety. That's the ones that --

3 DR. POWERS: So maybe 12, 13 major full-  
4 scale tests?

5 DR. KADAK: Probably.

6 DR. POWERS: And what happens if, I mean,  
7 just one of them kind of goes awry?

8 DR. KADAK: Fix it. You make the design  
9 change. That's why it's called a research facility.

10 DR. POWERS: Well, cleaning out a full  
11 scale facility contaminated with radionuclides does  
12 not strike me as a low cost operation.

13 DR. KADAK: Well, clearly you wouldn't do  
14 these if you had any question in your mind that it  
15 wouldn't work.

16 DR. POWERS: Oh. So there's a certain  
17 level of uncertainty that I can't have.

18 DR. KADAK: That's right. I mean, clearly  
19 you wouldn't build a plant that you didn't feel could  
20 withstand the test.

21 DR. POWERS: You're going to have a hard  
22 time buying the insurance policy.

23 DR. KADAK: Well, that's why we have this  
24 containment. I mean, no --

25 DR. SHACK: Well, somebody has got to

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1 clean up the mess just in case it goes wrong.

2 DR. KADAK: Well, again, the confidence  
3 level basically is that of the designers and the  
4 engineers after a lot of review and approval to say  
5 that this thing will work.

6 I mean, clearly, you wouldn't do anything  
7 stupid, and that's the point. If you have confidence  
8 in the technology, you could do this. Maybe not all  
9 technologies are amenable to this kind of an approach,  
10 but those technologies that have the kind of margins  
11 that I think exist relative to the melting or fuel  
12 failure certainly could try.

13 But let me continue and you can get the  
14 full scope here.

15 MR. SIEBER: Well, who would finance the  
16 demonstration plant?

17 DR. KADAK: Good question. It is a  
18 research facility, bottom line, and if, in fact, it's  
19 as broad a scope as we are talking about here, I think  
20 it's a legitimate government expense.

21 DR. APOSTOLAKIS: I think that's the way  
22 you lose Mr. Lyman.

23 DR. KADAK: Well, he's going to be a  
24 player.

25 DR. APOSTOLAKIS: You wanted him to work

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1 with you, but --

2 DR. KADAK: But he could be a player. I'm  
3 saying that, you know, there's obviously some industry  
4 money that's going to be required as well, but how  
5 much of it is research and how much of it is  
6 application and certification relative to usable  
7 technology is the matter to be discussed, but clearly,  
8 you know, this kind of facility would be, I think, a  
9 government supported --

10 MR. SIEBER: Well, it seems like it would  
11 be very expensive, and in a competitive environment  
12 I'm not sure that licensees would be willing to ante  
13 up a lot of money.

14 DR. KADAK: Well, let me just give you  
15 some rough numbers. If my numbers about AP 600 are  
16 right, that's, say, 250 million. I've done some  
17 preliminary cost estimates to engineer and design this  
18 facility would be around 500. A 50-50 split sounds  
19 fair to me. It may not be the right numbers, but  
20 that's kind of what we're talking about.

21 MR. SIEBER: In this facility you would  
22 have active fuel in it?

23 DR. KADAK: Oh, yeah.

24 MR. SIEBER: So you would have to license  
25 it just to have the facility, would you not?

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1 DR. KADAK: That's, again, part of the  
2 process. The licensing basically is the thing that  
3 Graham was talking about. What is the NRC review and  
4 approval process?

5 So it would be licensed, if you will, as  
6 a research facility.

7 Okay. Let me move on. The test that I  
8 think would be required are, you know, you're never  
9 going to get away from the traditional performance of  
10 component. There will probably be some small scale,  
11 integral tests to verify so that we don't have this  
12 scenario about cleaning up fuel, but you then would  
13 use these risk based techniques to identify the kinds  
14 of accident scenarios that are important, critical  
15 systems, critical components, some integrated tests  
16 which may be in a smaller scale.

17 Next slide, please.

18 And the test that I was considering may be  
19 more. I don't know if it adds up to 13 quite, but  
20 loss of coolant, depressurization, natural  
21 circulation, see if we can get it or not. In our case  
22 we don't want it.

23 Rod withdrawal, reactivity shutdown  
24 mechanism, cavity heat up and heat removal, and then  
25 other key component failures that you find become

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1 dominant in the PRA.

2 DR. WALLIS: Now, if you just look at loss  
3 of coolant, there are all kinds of sizes of breaks in  
4 all sorts of places.

5 DR. KADAK: Yes.

6 DR. WALLIS: So what you presumably would  
7 do is you'd do a lot of analysis ahead of time and say  
8 this is the one we're really worried about?

9 DR. KADAK: Could do that.

10 DR. WALLIS: Then you're going to miss Dr.  
11 Kress' point because, you know, the whole purpose of  
12 doing the test is to find out things that gave you a  
13 surprise.

14 DR. KADAK: We could do it by expression.  
15 I mean, this facility, my hope would be it would be  
16 designed in a way that it is, in fact, a research  
17 facility with different abilities to blow down by  
18 size, if that's the --

19 DR. WALLIS: So loss of coolant might be  
20 a whole sequence of tests.

21 DR. KADAK: Could be, yeah. Again, I have  
22 not designed it, but in concept, yes.

23 So next slide, please.

24 Additional tests. Oh, here. I guess I  
25 put up to my 14 or 15 now. Balance of plant failures,

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1 the traditional things that we worry about in  
2 liability space, turbine over speed, failures of  
3 various components, rod ejection or rapid withdrawal.  
4 I'm not sure we want to do a rod ejection per se.

5 Cavity heat-up. Again, we want to  
6 validate the core physics models.

7 DR. POWERS: Let's look at that control  
8 rod ejection because it's a fun one to look at. The  
9 scenario that we're now worried about is one where the  
10 fuel had extremely high burn-up. How are you going to  
11 do that in your test?

12 DR. KADAK: That would have to be outside  
13 of the reactor. We can't do that for -- you know.  
14 There would be a whole series of fuel tests as part of  
15 this program.

16 Next.

17 DR. POWERS: Well, and the problem that  
18 plagues the right ejection accident is an argument  
19 over how it propagates within the whole course. So if  
20 you do this test at the FABRI (phonetic) facility with  
21 one rod, that doesn't answer the question. I need a  
22 whole bunch of rods.

23 DR. KADAK: Well, I think we could do like  
24 I said, a rapid withdrawal, and we could model it from  
25 the standpoint of what we expect as a reactivity

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1 transfer and to see whether those codes, in fact --

2 DR. POWERS: I mean, that's where the  
3 argument is, is whether the codes are right or not,  
4 and whether they give you the right amount of heat  
5 going into the clad and not into damaging fuel.

6 DR. KADAK: Well, the first is the  
7 reactivity. Then we can go to heat, right?

8 DR. POWERS: No. This is a time scale  
9 where those two are very coupled together.

10 DR. KADAK: Okay. Then xenon, we talked  
11 about xenon.

12 DR. WALLIS: Some would argue that the  
13 technologies are fine, and that most of the major  
14 accidents are caused by people doing something out of  
15 ignorance, stupidity, whatever.

16 I don't see that as part of your testing.  
17 I'm not quite sure how you would test it anyway.

18 DR. KADAK: Oh, we could do your earlier  
19 scenario.

20 DR. POWERS: Graham, I'm shocked. People  
21 don't make mistakes out of ignorance and stupidity.  
22 It's an error shaping factor.

23 (Laughter.)

24 DR. POWERS: Forcing factor. You've got  
25 to learn this language, sir.

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1 MR. LEITCH: Andy, would you be talking  
2 about fully integrated tests here? For example, if I  
3 may ask the question this way. In the start-up of a  
4 normal power plant, there are those who would advocate  
5 walking up to the generator breaker at 100 percent  
6 power and opening it and seeing what happened. I  
7 mean, I always thought that was a little like testing  
8 para chutes, and what I'm saying --

9 (Laughter.)

10 MR. LEITCH: -- we would demonstrate that  
11 the turbine would trip and that it had contacts that  
12 would make the reactor scram, and we would demonstrate  
13 separately that the reactor would scram.

14 But I mean, I really think some of these  
15 integrated tests would unnecessarily put the plant  
16 through perturbations that could be demonstrated  
17 piece-wise. And I'm just wondering if you have  
18 thought about the piece-wise demonstration of this or  
19 would you be talking fully integrated tests?

20 DR. KADAK: I think what the final test  
21 program ends up being is that which is judged to be  
22 such that it can demonstrate where the safety concerns  
23 are. Now, if there's too much of a strain, for  
24 example, and the plant could just trip a breaker and  
25 see what happened, and people say, "Well, I can get

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1 the same information from these separate tests," I  
2 think that would be fine.

3 I'm not here to design the test, but I  
4 think that would be part of the process, working with  
5 the regulator to develop what evidence do they need to  
6 show the plant can do what we think it can do.

7 So it doesn't have to be the crazy.

8 Okay. The next slide, please.

9 Continuing on with the test so that it's  
10 more than 15, dual performance, which gets to Dana's  
11 question about, you know, high burn-up, cycling, most  
12 heat-up, most accident heat-up, ingress to validate  
13 this chimney question, and water ingress if you'd look  
14 at the reactivity effect and the possible fuel damage.

15 My sense is those would be done probably  
16 outside the core on varying degrees of fuel and  
17 varying size of the facility, and I think the Germans  
18 have done many such tests already.

19 Next slide.

20 Well, what I started talking about was a  
21 prototype, and as a suggesting, using the pebble bed  
22 reactor as such a prototype. It's built full sized  
23 with the containment as I mentioned.

24 Implement the structure test program, and  
25 as part of this process, and I call it a process, we

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1 would develop what rules might be appropriate for  
2 introducing new technologies that don't have, you  
3 know, 25 years of regulatory history.

4 So we would not only test the facility,  
5 but also see if this process that I've outlined can  
6 work with new non-water technologies, for example.

7 And if, in fact, the process works, apply  
8 it generically to other technologies. That was sort  
9 of the idea.

10 And then if all goes well, you have a  
11 certified design, and you have a reactor that's sort  
12 of the fleet innovator, if you will, for the next 40,  
13 50 years, however long the fleet exists.

14 Next slide.

15 Will this answer all of the questions,  
16 categorically, no, but at least it gives us a good  
17 shot at answering hopefully the most significant ones,  
18 but in combination with all of these subtler component  
19 tests and small scale tests, we'd probably have a  
20 good, relatively high level of confidence about  
21 critical safety performance.

22 Next slide, please.

23 Will this license by test instill public  
24 confidence? I say yes, in the sense that it gives the  
25 public -- giving the public and the media an

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1 opportunity to observe these tests, hopefully the  
2 confidence in this technology will be increased so  
3 that you avoid -- and I'm sorry, George -- ten to the  
4 minus pick a number is not understandable for public  
5 communication, although it may be very well understood  
6 here, but it doesn't really work out there. They'd  
7 like to see this thing work, and if successful, the  
8 core doesn't melt --

9 DR. WALLIS: Do you think using words like  
10 one in a billion would be more appropriate?

11 DR. KADAK: You know, one in a billion  
12 people still win the lottery, you know. So what does  
13 that mean?

14 DR. POWERS: I think in pursuing this  
15 viewgraph, you ought to look at the experience they  
16 had at the Phoebus (phonetic) facility, which was  
17 doing an experiment, which amounted to melting down 21  
18 fuel rods, two of which were fresh fuel and the rest  
19 of them were irradiated, and the public responds prior  
20 to the first test there, and how eager they were to  
21 watch that particular test.

22 DR. KADAK: I'll look it up. I'm not  
23 familiar with it.

24 CHAIRMAN KRESS: They had people with  
25 placards marching around.

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1 DR. POWERS: They were invading the test  
2 site.

3 DR. KADAK: Well, it could happen here,  
4 too, but hopefully we will engage them long before and  
5 get them to buy into the objective of all of this, and  
6 if this approach works, I think it will encourage the  
7 development of what we would all a more naturally safe  
8 reactor.

9 Next slide, please.

10 Well, how about the traditional regulatory  
11 approach? I think we need to just ask a few people,  
12 which I've done from time to time, and maybe they can  
13 answer your questions about, you know, how well that  
14 worked for them.

15 As you know, with the MHPGR, Candu and  
16 Canadians, I think Westinghouse will have a nice  
17 authority to tell them, and I think the AP 1000 is  
18 still an open issue, and answers are not always  
19 possible to the extent that it can always satisfy the  
20 staff.

21 And I am very familiar with bring me the  
22 rock process. I don't think it's very effective, and  
23 maybe this approach is an alternative to that work.

24 So with that I'd like to conclude and  
25 answer any other questions in the house.

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1 DR. POWERS: I'm intrigued by your  
2 students looking at the pebble bed reactor. Do you  
3 have any of them looking at the potential for that  
4 particular machine to be used for the fabrication of  
5 239 plutonium?

6 DR. KADAK: We looked at proliferation.  
7 Yes, we did.

8 DR. POWERS: Find out anything?

9 DR. KADAK: Yeah. In a normal operating  
10 elevator reactor, the number of pebbles required to  
11 accumulate eight kilograms of plutonium at end of life  
12 is roughly 250,000, and the isotopics at that level  
13 are very uninteresting for a nuclear weapon.

14 If you're deciding to do that, well, let's  
15 only run the pebbles through one pass to accumulate  
16 eight kilograms. That's around 800,000, which makes  
17 it an unlikely target for delivery.

18 You could be clever relative to the  
19 technology, but in that case, as in all nuclear  
20 technology, you need extrinsic measures to detect --  
21 as you recall, the system is a closed system, does not  
22 have a spent fuel pool, and so even at that point it  
23 would be very difficult to get, but we've looked at  
24 that, and we need to be real careful in that area.

25 At some point I hope you invite me back to

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1 talk about our work because it's really quite  
2 interesting.

3 CHAIRMAN KRESS: Other questions?

4 DR. KADAK: My new collaborator.

5 MR. LYMAN: Ed Lyman, NCI.

6 Here's a practical question. So you're  
7 proposing that the test facility go with a containment  
8 which is not the same containment that the pebble bed  
9 is planned to have?

10 DR. KADAK: Only because it's a research  
11 facility.

12 MR. LYMAN: Right. So I've heard the  
13 argument that the passive cooling of the pebble bed is  
14 incompatible with a leak tight containment and it  
15 would interfere with, for instance, the design base  
16 LOCA heat removal. So --

17 DR. KADAK: Well, we'd have to look at  
18 that to see whether or not and how we could make it  
19 compatible for this particular facility. We'd have to  
20 look at whether, in fact, we need to make additional  
21 modifications to the facility to accommodate the  
22 passive cooling feature.

23 MR. LYMAN: But if it could be done for  
24 the test, then it could also be done for the real  
25 thing, I guess, if you had to.

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1 CHAIRMAN KRESS: Yes, ma'am. Please  
2 identify yourself.

3 MS. FABIAN: Hi. Teka Fabian from Nuclear  
4 Waste News.

5 It's not as exciting as melting down the  
6 core, but I'm wondering if as part of your conceptual  
7 design process you've done the sort of things that the  
8 fusion materials program has done, is looking forward  
9 to end of plant life and looking at lower activation  
10 materials that are easier to dispose of, possibly  
11 easier to resmelt and reuse in a nuclear facility,  
12 designing the plant for decommissioning using robotics  
13 and remote technology; if any of this has played a  
14 part in the design process.

15 DR. KADAK: Not at this stage, although we  
16 are following what's going on in Germany as they're  
17 decommissioning their AVR reactor.

18 Clearly, one of our initial objectives was  
19 to design a plant with decommissioning in mind, also  
20 having a lot of personal experience about  
21 decommissioning the Yankee Row plant. So I'm very  
22 sensitive to that issue.

23 But we haven't really looked at it, and  
24 we're not really at that level of detail yet.

25 MR. HOCKRITTER: Larry Hockritter, Penn

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1 State.

2 As an AP 600 design certification  
3 survivor, I'm familiar with the testing that we had  
4 done and a number of questions that we got from the  
5 NRC, which were large.

6 But when you structure a test program,  
7 usually you build on separate effects tests to try to  
8 identify and create a model that you then put into an  
9 integral code, and then you use integral tests for  
10 verification of that model.

11 I think one of the problems that we have  
12 in the water reactor technology world is that we don't  
13 have very good integral systems tests. The loft  
14 tests, which are the largest integral systems tests,  
15 that we've all used for a code validation, there's a  
16 lot of questions on the accuracy of the  
17 instrumentation, which are really measuring versus  
18 what you think you're measuring, and so forth.

19 And there may be a lot of potential  
20 problems for that in this type of a program unless  
21 it's very, very structured very carefully, and then if  
22 you add the instrumentation that you want to add, you  
23 can start to distort the things that you're trying to  
24 measure.

25 So I think that you're -- I like the idea.

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1 Okay? But I think that you really have a background  
2 of tests that you're going to have to provide in  
3 addition to a large, full scale test where you build  
4 the technology so that you can have confidence then in  
5 the code that you'll use to predict the test, which  
6 you'll then try to run in the facility.

7 Otherwise you may have some unpleasant  
8 surprises.

9 DR. KADAK: I think a lot of that stuff  
10 that we're talking about, some of which at least I  
11 should say has been done in Germany, we don't know.  
12 I don't know, first of all, and like it's sort of the  
13 code of record essentially is based on, which really  
14 has no experience in the United States, but we're  
15 learning how to use it, and that's got a lot of models  
16 built into it and has been benchmarked against some of  
17 the tests that they've done in Germany.

18 We would hopefully use that data, disrupt  
19 your test, but I think your point earlier is exactly  
20 right. This is a research facility. In order to be  
21 effective, it's got to be well instrumented, and that  
22 is going to cost much more money than just building a  
23 straight power plan.

24 MR. HOCKRITTER: That's right, and you'll  
25 have conflicting objectives in the design of the plant

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1 versus the measurements that you want to make. I  
2 mean, that's the problem that LOFT had.

3 MS. HAUTER: Wenonah Hauter, public  
4 citizen.

5 Who should assume liability for this test?  
6 How does Price Anderson play into this? What kind of  
7 radiation releases is it appropriate to expose the  
8 public to? And should there be a public process,  
9 public hearings and so forth to determine if this is  
10 something that the public would want to buy into?

11 DR. KADAK: Let me answer the last  
12 question first. I think clearly the public has to buy  
13 into this process, and relative to the public  
14 hearings, you know, I'm not all that familiar with how  
15 that would occur, but my sense is it would have a  
16 licensing proceeding, but it would be a licensing  
17 proceeding, licensed and experimental facility, and if  
18 successful, probably another licensing facility, say  
19 it's ready for operation.

20 The Price Anderson question, I'm not an  
21 expert on Price Anderson, but, you know, depending  
22 upon who ultimately ends up being the builder, whether  
23 it's the DOE or some private government partnership,  
24 those people would obviously have to pay the insurance  
25 costs for that.

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1 In terms of releases, again, you would  
2 design the test such that they would be essentially  
3 over this.

4 DR. POWERS: On the other hand, we could  
5 test the validity of our consequence code.

6 DR. KADAK: That's on your nickel.

7 DR. SLABBER: Mr. Chairman, just Johan  
8 Slabber.

9 Just a comment in support. I'm not  
10 claiming and proposing that part of the PBMR  
11 demonstration unit in South Africa will be used as  
12 part supplying all of the information to Andy Kadak,  
13 but part of our objective as a demo. unit, and it's  
14 not a prototype; it's a demonstration unit; it will be  
15 instrumented to such an extent that critical  
16 parameters during transience, like load rejection, may  
17 be loss of coolant, could be measured, and this is not  
18 making an open statement.

19 We've got quite a good technological base  
20 for proposing something like this because in an AVR,  
21 they have done loss of coolant simulations, as well as  
22 reactivity excursion experiments. It is documented,  
23 and they found, and this is, again, coming back to the  
24 integrity and the quality of the few, that they did  
25 not observe any significant increase in releases,

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1       although the core was filled with fuel, with a  
2       variable degree of quality and burn-ups, and they've  
3       also substantiated the reactivity predictions, the  
4       temperature coefficient predictions.

5               So, in fact, there is a base where we can  
6       stand on to claim that some of the tests that are  
7       proposed in such a reactor has got some supporting  
8       evidence in Germany.

9               DR. KADAK: Just as a follow-up, to the  
10       extent that it's appropriate and doable, I think many  
11       of these tests could be done on the south African  
12       demonstration facility. So the concept is a generic  
13       concept suitable for, I believe, any type of advanced  
14       reactor that has certain characteristics.

15              CHAIRMAN KRESS: I'll take one more  
16       question, Larry, and then we need to move on.

17              MR. HOCKRITTER: One of the things that we  
18       dealt with a lot in the AP 600 was looking at  
19       uncertainty, uncertainty in the predictions,  
20       uncertainty in the analysis. Do you know if they've  
21       done that with these code for the pebble bed in  
22       Germany?

23              DR. KADAK: I don't know. Perhaps Johan  
24       knows better, but I have not been able to get at some  
25       of the qualifications.

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1 MR. HOCKRITTER: I know our class also  
2 looked for that type of information, and we weren't  
3 able to find that either.

4 CHAIRMAN KRESS: That's a good comment,  
5 Larry, because I think having pinned down the  
6 uncertainties in, for example, you fission product  
7 release models is key to whether or not you really  
8 need a strong containment or weaker containment, and  
9 it has to do with how certain you are in your risk  
10 analysis results.

11 So I think it was a really good comment.  
12 So with that --

13 DR. KADAK: Could I just make one final  
14 comment?

15 CHAIRMAN KRESS: Yeah, go ahead.

16 DR. KADAK: I don't think we should get  
17 hung up on the fact that we're putting this  
18 containment on a research facility as implying that  
19 you need one. Again, the purpose is to show that the  
20 fuel and the performance of the plan is such that you  
21 don't need it. End the debate.

22 CHAIRMAN KRESS: Okay. With that, let's  
23 move on to the next part of the agenda.

24 DR. POWERS: Mr. Chairman.

25 CHAIRMAN KRESS: Yes.

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1 DR. POWERS: I notice that Sandia National  
2 Laboratories may be some partner in this presentation.  
3 I'm not familiar with this particular work, but  
4 sometimes I associate with people from that  
5 laboratory, and so members should discount anything I  
6 have to say.

7 CHAIRMAN KRESS: We usually do anyway.

8 DR. POWERS: I noticed that.

9 CHAIRMAN KRESS: And I don't see why  
10 anybody would associate with people from that  
11 laboratory.

12 DR. APOSTOLAKIS: And, Mr. Chairman, I  
13 have a direct conflict of interest here. So you will  
14 have to do without me.

15 CHAIRMAN KRESS: You don't have to leave,  
16 George. You can stay.

17 So thank you, Andy, and I don't know who  
18 the next speaker is.

19 PARTICIPANT: I follow George.

20 CHAIRMAN KRESS: You follow George.

21 Okay. George, as I told everyone else,  
22 you have to introduce yourself.

23 MR. DAVIS: Okay. My name is George Davis  
24 with Westinghouse.

25 I always like to start off with saying I

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1 worked in the same place in Windsor, Connecticut for  
2 about 28 years now, and I'm on my third company. We  
3 started out as Combustion Engineering and then became  
4 part of ABB and then last year became part of  
5 Westinghouse, which is an indication of how the  
6 industry is consolidating nowadays and how much things  
7 are changing.

8 I'm not really going to give today's  
9 presentation. The meat of it is going to be given by  
10 Mike Golay. Mike Golay is going to talk about what  
11 we're looking at under a DOE NERI project, Nuclear  
12 Energy Research Initiative, NERI program, looking at  
13 the process for how one would go about applying risk  
14 informed insights into not only deregulation, but the  
15 design of your nuclear plants, such as Generation IV  
16 reactor.

17 But before Mike goes into that, I wanted  
18 to first give you a little bit of a brief overview of  
19 what we're looking at in a group of three projects  
20 that includes this one all tied together.

21 Basically, a couple of years ago we put  
22 together a team of industry labs and university  
23 people. Besides ourselves from Westinghouse, we have  
24 Duke Engineering from the industry side; Idaho  
25 National Lab and Sandia; labs at MIT, N.C. State. In

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1 fact, in one of the other projects we also have Penn  
2 State that should be mentioned up here.

3 And then as we were looking at regulatory  
4 issues, we even had a law firm, Egan & Associates, get  
5 involved so we could bring in some of the insights  
6 from Marty Mulsh to be here at the NRC.

7 Next slide.

8 What I wanted to do first is time to give  
9 you an overview of where we see these three projects  
10 that we're working on going in the long run and how  
11 they fit together, and then introduce that as a lead-  
12 in to Mike's presentation on the actual processes for  
13 design and regulation.

14 The driving force for what we were looking  
15 at in these projects was the issue of capital cost.  
16 Basically when we step back and look at what we see as  
17 the biggest challenges to nuclear plants being ordered  
18 in a deregulated marketplace, we keep coming back to  
19 capital cost as the big issue that we're having to  
20 address.

21 Production costs are looking pretty good  
22 on the operating plants today. Fuel plus operating  
23 maintenance are coming down. If you look at the best  
24 performing plants, they're getting close to that one  
25 cent per kilowatt hour production cost, and with the

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1 consolidation going on in the industry and continued  
2 improve, we don't think there's a whole lot of room  
3 for continued improvement there compared to what you  
4 can do on the capital side.

5 Secondly, there's the issue that with a  
6 deregulated marketplace instead of taking 30 years to  
7 pay back the mortgage on a plant, the investors in a  
8 deregulated market are going to be looking for capital  
9 costs to be paid back on a probably 20 year period or  
10 less, which creates even more pressure to reduce  
11 capital cost compared to what we saw with the old  
12 regulated utility environment.

13 And so basically we come to the conclusion  
14 that if we want to assure that nuclear can be  
15 competitive against other alternatives, such as large  
16 coal plants, where we see coal plant costs going,  
17 we're looking at a need to reduce capital costs on the  
18 order of about 35 percent or so below where we are  
19 with a large ALWR, our System 80 Plus design.

20 If we want those to truly be competitive  
21 against coal plants in the U.S. marketplace for the  
22 long term, and that means we need to be looking at  
23 overnight capital cost as a goal, somewhere around  
24 \$1,000 per kilowatt electric, and being able to get  
25 these plants up and running in about a three year

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1 production period.

2           So what we've done in these programs is  
3 rather than tackle a particular reactor design, we  
4 decided to step back and address the processes and ask  
5 ourselves what can we do to improve the processes, the  
6 tools that would be used for designing and licensing  
7 future plants with Generation IV reactors that could  
8 help to drive down the costs and cut a lot of fat out  
9 of the process and provide designers with the  
10 flexibility they need to be able to really come up  
11 with new, innovative designs and get those licensed.

12           And so we have three projects that we're  
13 working on. The first is looking at risk informed  
14 assessment of regulatory and design requirements.  
15 It's basically looking to develop methodology for how  
16 designers would use PRA insights in the design process  
17 in a much more radical approach than we've done in the  
18 past and how that could also be translated into the  
19 regulatory process for getting plants improved.

20           Next is the area of smart equipment, and  
21 basically there we're looking at methodologies for how  
22 you could put self-diagnostic, self-monitoring  
23 features into plant equipment, such as pumps and  
24 valves, as a way to improve reliability at the  
25 component level.

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1 All of this would obviously have some  
2 benefits from an operating standpoint. The way we  
3 think it would help on capital cost is if we can  
4 address reliability at the component level. Then that  
5 should allow us in the above-program on the risk  
6 informed design process to step back and look at  
7 simplifying on a system level.

8 In other words, if you can count on higher  
9 reliability of the components you're using because of  
10 these smart features built in, self-diagnostic, self-  
11 monitoring features, then you should be able to look  
12 at further simplification and not as much redundancy  
13 being required at the system level if you can  
14 encounter a more reliable components.

15 And in the third project we're looking at  
16 are technologies that can be used for design,  
17 fabrication, and construction of new plants, again, to  
18 reduce the cost of those processes. And there we're  
19 looking at what can be borrowed from the aerospace and  
20 automotive industries and the approaches that they've  
21 been developing over the recent years, again focusing  
22 heavily on computer based application, to do things  
23 like collaborative internet based engineering  
24 activity.

25 We see that as being related to design of

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1 regulatory process in the initial program, the top  
2 program up there, because if you've got designs being  
3 developed on an Internet based collaborative approach  
4 like they're doing in the automotive and aerospace  
5 industries today, then you could talk about in the  
6 future getting to the point where the NRC and even the  
7 public can have some limited degree of access.

8 You may have to have firewalls for  
9 proprietary information in some areas, but the point  
10 is you could have the whole design process a lot more  
11 transparent and open where it could be looked at by  
12 reviewers and the general public as the long-range  
13 goal for where you're going.

14 So even the tools you used in the design  
15 process could have some benefits for the regulatory  
16 approach down the road.

17 MR. LEITCH: George.

18 MR. DAVIS: Yes.

19 MR. LEITCH: Regarding your second  
20 project, I can see how smart equipment may improve the  
21 reliability and safety, but I don't quite see how it  
22 would improve capital costs. In fact, it would seem  
23 to me just the opposite would be the case. Could you  
24 run that past me again?

25 MR. DAVIS: For the individual component,

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1 it would increase the capital cost of that component.  
2 If you put in a smart valve, adding those monitoring  
3 features and the computer software to go with it, it's  
4 going to add to the cost of that valve.

5           However, let's say you've got in an ALWR  
6 like our System 80 Plus. You've got a four train,  
7 high pressure safety injection system. If you can  
8 show high enough improvement in reliability and  
9 individual components, you can go back and question do  
10 I really need four trains of redundancy, if I can  
11 count on the reliability of the individual components  
12 in each system.

13           MR. LEITCH: That would be in a future  
14 generation plant though.

15           MR. DAVIS: Yes, this is all looking down  
16 the road at Generation IV type reactors. I mean, none  
17 of these projects as I see it can lead to processes  
18 that are going to be immediately available and can be  
19 applied today. These are things that would be applied  
20 down the road for Generation IV.

21           Now, we do see some potential that there  
22 could be some spinoff applications along the way for  
23 things like the pebble bed modular reactor, things  
24 that might be developed for that, but these projects  
25 were originally set up with the goal of developing

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1 some very long range programs that would lead to  
2 design activities of Gen. IV reactors in about ten  
3 years.

4 This figure, it looks like the cross-  
5 section of a circular firing squad the way it's  
6 pointed in, but the point here was that in looking at  
7 how you risk inform the process, one could start out  
8 at the very left side of the figure with the  
9 deterministic requirement we have now and then looking  
10 at those case by case, individually like we're doing  
11 with the operating plants and asking where it can be  
12 risk informed, those individual deterministic  
13 criteria.

14 At the other extreme on the right-hand  
15 side, one could go to a more risk based approach where  
16 you design based on the PRA, but recognizing that  
17 state of the art PRAs are such that they're not  
18 perfect and there are uncertainties not only in the  
19 techniques, but in the database for PRAs, that you're  
20 going to have to back up and add some degree of  
21 deterministic requirements in to make the process work  
22 to cover those uncertainties in PRA capabilities.

23 We basically started out in this project  
24 thinking that we would start on the left side and work  
25 across, but we quickly got to the conclusion that the

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1     only way we're going to be able to come up with a  
2     revolutionary new approach is for designing and  
3     licensing plants that were going to allow some  
4     substantial cost savings, was if we went to something  
5     more revolutionary, where we went to a more risk based  
6     approach and then back up to decide what needs to be  
7     entered in.

8             And that's a good example, I think of  
9     where having labs, university, and industry working  
10    together has been a good synergy, because from an  
11    industry standpoint, we started off thinking in the  
12    box on the left side, and the input we got from the  
13    lab university people really caused us to step outside  
14    the box and think more revolutionary on how we needed  
15    to go with this, starting with the right-hand side of  
16    the figure.

17            Basically, as far as these projects are  
18    concerned, because they're rather limited funding,  
19    they'll wrap up next year. They're just intended to  
20    lay a framework or a foundation for where we would see  
21    these methodologies going.

22            The ultimate implementation of these is  
23    going to depend upon several things happening. One is  
24    we're starting to coordinate our effort with NEI. As  
25    you'll hear from Adrian Heymer later this afternoon,

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1 I believe, he's going to talk about NEI's effort, that  
2 they're cranking up a task force to look at developing  
3 a risk informed framework for further plants.

4 And it's our intent to coordinate what  
5 we're doing in our project with them, but we'll have  
6 a representative on their task force, and the goal  
7 would be to make sure that what we do in our project  
8 gets folded into what they're thinking about in that  
9 task force and that we come up with consistent  
10 results. They may not have to match up exactly, but  
11 we obviously would like to try and have some  
12 consistency there.

13 Very importantly, I think we want to wind  
14 up in a situation where the technology road map  
15 activities for the Generation IV reactors, that road  
16 map that's being developed, needs to think about not  
17 just developing new designs, but developing processes  
18 to be used in designing and licensing those Generation  
19 IV reactors, too.

20 So we're hoping that what we do in laying  
21 the foundation for these engineering projects get  
22 reflected in the thinking for the Gen. IV road mapping  
23 effort so that there's some consideration of  
24 processing as well.

25 I might also add as a final point I've

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1 also participated in an IEA activity where they're  
2 putting out a technical document later this year on  
3 optimizing technology for water cooled reactors.  
4 Although it says water cooled reactors, it's really  
5 applicable to all three reactors, and it will embody  
6 a lot of the same philosophies that we're looking at  
7 in the engineering project.

8 With that I'll turn it over to Mike to go  
9 into the discussion on what we're looking at in this  
10 process.

11 DR. GOLAY: Thank you, George.

12 Could we go to the next slide, please?

13 I'm going to speak about the specific work  
14 that has come out of the regulatorily oriented process  
15 among the three that George described, and I'm  
16 reporting on behalf of the overall project and  
17 particularly of the team from MIT, Sandia, and  
18 Westinghouse, where the most active members are listed  
19 here. Half of that team is in the room, and so if you  
20 want to follow up after this meeting and discuss  
21 things with them, they'll be available to do it.

22 Go to the next slide.

23 The thing that we have been focusing on is  
24 really to try to create a comprehensive regulatory  
25 approach that comes up with a method which is both

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1 comprehensive and systematically consistent logically  
2 and can be expected to create incentives such that  
3 designers will naturally have reasons to do the things  
4 which regulators recognize as being important in  
5 coming up with good technologies.

6 So we've looked at it from the point of  
7 view of an overall system to produce electricity  
8 successfully where the designer's task is really in  
9 both areas, and today we're going to focus on the part  
10 having to do with safe production, but we recognize  
11 that the designer has to produce an economically  
12 attractive plant and hopefully corresponding to some  
13 of the goals that Neil Todreas outlined earlier in the  
14 day.

15 So the focus here is going to be over on  
16 safe production, but we want to have the incentives  
17 aligned so that you achieve both of these and do a  
18 good job on safety.

19 What I want to do is begin by posing two  
20 questions to the ACRS, and that is fundamentally the  
21 issue, I think, for the NRC is what do you do in terms  
22 of regulatory reform. The fact that this session is  
23 being held is a recognition that the current process  
24 needs improvement.

25 The fact that every new applicant for a

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1 new reactor concept comes in where a part of his  
2 proposal is a new regulatory treatment is, again, a  
3 symptom of the need to improve things, and so the  
4 issue is not whether improvement is needed, but rather  
5 what should be recommended by ACRS and what role  
6 should NRC play in achieving the improvement.

7 My specific suggestion is that we need an  
8 effort where the overall national effort for advanced  
9 reactors includes a component of regulatory reform  
10 with the NRC being involved, but I think realistically  
11 given the funding situation that the NRC faces, it  
12 probably is not in a position to take the lead.

13 But that's a question I'd like to ask the  
14 ACRS to ponder, and if you feel like offering advice  
15 to do so.

16 And the second thing I want to do is  
17 outline then for you the kind of product that we have  
18 been able to develop so far where essentially it's a  
19 work in progress, where there are some ideas of how to  
20 attack this problem that we'd like to present so that  
21 to the degree that you accept them, they can begin to  
22 soak in, and to the degree that you think we need to  
23 reconsider things, we can get the benefit of your  
24 advice.

25 Some of the fundamental ideas are listed

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1 here, and they're somewhat revolutionary. The top one  
2 is that the process of regulation is guided by  
3 decisions which are made based upon the beliefs of the  
4 decision makers, that is, the regulatory personnel.

5 This idea of beliefs as opposed to  
6 evidence is very important because what we would like  
7 to do is find a way so that those beliefs which  
8 cumulate in the evaluation of a reactor concept and  
9 how it's operated, that one way we can state this is  
10 in a probabilistic format, essentially using for  
11 continuous variables a probability density function as  
12 a way of addressing the relative likelihoods of the  
13 range of possible values that the evaluator thinks are  
14 worth considering.

15 And that when we approach things in this  
16 fashion, what you're naturally led to is that when we  
17 try to formulate acceptance criteria, that we do it in  
18 terms of expected performance and also associated  
19 uncertainties.

20 And Tom Kress already alluded to the idea  
21 of making your acceptance decisions based at some  
22 level of confidence, which would be an example of how  
23 you might approach that.

24 DR. WALLIS: Your choice of words is  
25 interesting. "Belief" tends to be associated with



1 yes/no, I believe, I don't believe, I believe in  
2 nuclear power, I'm against it sort of thing.

3 DR. GOLAY: No, I'm not talking about  
4 values.

5 DR. WALLIS: I know you're saying it has  
6 to be probabilistic. So I tend to agree with you.  
7 It's just the choice of the word "belief" is a little  
8 strange.

9 DR. GOLAY: Let me distinguish. I'm not  
10 trying to speak about values, which perhaps is the  
11 version of that term that you're honing in on, but  
12 rather, in terms of the conclusions that an evaluator  
13 will reach regarding the relative likelihoods of  
14 alternative answers.

15 CHAIRMAN KRESS: It's the Bayesian concept  
16 of probability.

17 DR. GOLAY: Exactly, exactly.

18 DR. WALLIS: A state of knowledge is  
19 usual.

20 DR. GOLAY: Right, exactly, and so what  
21 we're leading to is a formal statement of that in a  
22 formalism that is scrutable by everyone, and what this  
23 really flows from is a conclusion that the problem of  
24 safety regulation is not one of expected performance,  
25 but rather of treatment of uncertainties.

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1           Now, I know this is probably not a novel  
2           concept to the folks here, but if you look at  
3           proposals that we have had for regulatory improvement,  
4           they're almost always focused on what should be the  
5           deterministic expected performance criterion, and then  
6           how the things perform in terms of that, when, in  
7           fact, the big problem is dealing with the associated  
8           uncertainties.

9           And what we've tried to do is turn the  
10          problem around and make sure that uncertainty is  
11          imbedded in what we do from the very beginning so that  
12          it has prominence at the same level of expectation and  
13          is handled in a formally explicit fashion.

14          So that's what's behind what I have there.  
15          We go to the next page.

16          DR. WALLIS: This is an unfortunate term.  
17          I mean, if you tell the public you're uncertain --

18          DR. GOLAY: Yes, and I frankly want to  
19          separate the problem of public communication from  
20          technological evaluation, and the reason is that I  
21          think that I didn't really mean to get diverted on  
22          this, but I have an answer for it, which is that I  
23          think we have made a mistake among engineerings of  
24          falling into engineer-speak where the idea in public  
25          communication is that if I communicate in the

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1 vocabulary which I feel is most valid and with which  
2 I am most familiar, I can also be most effective, and  
3 I submit that the task of public communication is not  
4 one of communicating a message concerning how hardware  
5 will perform, but it is focused on helping the public  
6 in their search for who to trust for dealing with the  
7 technology.

8 And so the format for what we're  
9 presenting here is not amenable to public  
10 communication, but the task that has to be  
11 accomplished in successful communication is really a  
12 different one of giving people a reason to trust that  
13 you will make good decisions.

14 Now, that's my answer. Other people will  
15 have other answers, but I'd like to separate the two.

16 Okay. On the approach which we have,  
17 we're also stating that regulatory questions,  
18 unanswered issues concerning license submittal or  
19 licensee behavior and their acceptance criteria, if  
20 we're going to use a probabilistic framework, then  
21 these questions and criteria have to be stated in that  
22 framework as well.

23 So what we do is really use a  
24 probabilistic treatment as the integrating and  
25 systematic basis of evaluating a submittal, but we

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1 continue to use deterministic models, data, tests, all  
2 of the tool kit of evidence that we've always used,  
3 but use it to support the probabilistic presentation  
4 and to try to incorporate all of the questions which  
5 are relevant to successful performance into what is  
6 essentially a much expanded PRA.

7 This would require that both the license  
8 applicant, who right now has the burden of proof in  
9 terms of evidence, and the regulatory staff in  
10 parallel justify their decisions explicitly in this  
11 probabilistic framework.

12 This is partly in answer to Andy Kadak's  
13 point about the bring me a rock syndrome, and that is  
14 what we would do if you accept the approach which  
15 we're suggesting is that the warm, fuzzy feeling and  
16 the bring me a rock would be translated into state  
17 your evidence in a probabilistic format that we're  
18 suggesting here just as the licensee must do.

19 And as part of this, you're very quickly  
20 led to the need for subjective judgment and  
21 incorporating that into the overall process, which if  
22 you think about it, we do today, but we don't do it  
23 explicitly.

24 And the one use of the probabilistic  
25 format is to provide a vehicle by which to state those

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1 judgments and, again, make them scrutable and to  
2 incorporate them formally into the answer upon which  
3 you base your regulatory decision.

4 That is a subtle thing to do, and it  
5 requires development of processes for capturing those  
6 judgments. Today what we have are informal processes,  
7 but we use them. You know, the ACRS is a good example  
8 of that.

9 CHAIRMAN KRESS: I'm going to ask you my  
10 standard question. In this type of regulatory  
11 framework --

12 DR. GOLAY: Keep going.

13 CHAIRMAN KRESS: -- which I'm very taken  
14 by, how do you see the words "defense in depth"  
15 fitting into that?

16 DR. GOLAY: Fitting indirectly. I'll come  
17 to it.

18 CHAIRMAN KRESS: Okay.

19 DR. GOLAY: Give me about five more  
20 slides, and if I haven't answered it, ask me again.

21 CHAIRMAN KRESS: Okay.

22 DR. GOLAY: Okay, and because  
23 disagreements in these evaluations are inevitable,  
24 some process of resolution will be required, just as  
25 today in the regulatory system we have an appeals

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1 process, but it's formulated more looking at things in  
2 a deterministic fashion. So we anticipate the need  
3 for that.

4 Okay. You see this kind of hierarchy  
5 structure going from high level safety goals down to  
6 inspection requirements and things like that. We  
7 would basically stay with this, but what we would do  
8 is try to handle things, as I say, using PRA as the  
9 integrating method and continuing to focus on the same  
10 kinds of essential safety functions that you want to  
11 achieve.

12 So nothing has really changed in the  
13 structure here, but the way you would go about trying  
14 to show satisfactory performance is what we would  
15 change.

16 Could we go on?

17 CHAIRMAN KRESS: How would you deal with  
18 the issue that Dana gets very concerned about, and  
19 that is the PRAs are traditionally, the ones we have  
20 now, very incomplete. They don't deal with shutdown  
21 conditions very well. They don't include fires very  
22 well, and seismic even is often not treated very well  
23 in human -- would you incorporate those kinds of  
24 missing ingredients into the uncertainty of  
25 distribution?

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1 DR. GOLAY: Yes. Now, basically the way  
2 you would incorporate them is through a statement of  
3 the subjective judgment of those who have to assess  
4 what practices --

5 CHAIRMAN KRESS: That's where your  
6 subjective uncertainty comes into play.

7 DR. GOLAY: That's right. So where  
8 objective evidence reaches its limits, then you have  
9 to go to subjective, as we do today. We just don't  
10 spell it out.

11 DR. POWERS: Let me ask a question.  
12 You're going to expand the capability of PRA to carry  
13 this out. One of the areas you're going to expand it  
14 to carry it out is in the shutdown risk.

15 Now, I presume that you have a plant here  
16 that you say is going to have some history, and during  
17 that history it's going to have various kinds of  
18 shutdowns, those that it planned, which is going to do  
19 a variety of activities that are going to be quite  
20 different, and it's going to have an occasional  
21 unscheduled shutdown.

22 And you can prognosticate all of those  
23 things, all of the different configurations of the  
24 plant that go on during a shutdown, a scheduled  
25 shutdown for refueling and whatnot.

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1 DR. GOLAY: I would say that your task in  
2 those areas has not changed from the task that people  
3 have today; that when you go to consider a license  
4 application, you try to consider the spectrum of  
5 conditions under which it will be operated, and using  
6 evidence appropriate for each condition, judge whether  
7 it will be operated successfully.

8 So that --

9 DR. POWERS: But now we don't try to  
10 quantify --

11 DR. GOLAY: That's right.

12 DR. POWERS: -- those times and  
13 configurations, and yet you want us to do that. How  
14 is this possible?

15 DR. GOLAY: Well, I think that the  
16 development of shutdown risk analysis provides an  
17 illustration of how you do that in, say, a non-power  
18 state, and when you're comparing operations between  
19 those states, you, as Tom just brought out, you  
20 inevitably come to situations where the available  
21 objective evidence is not sufficient for you to  
22 determine, say, which practice is better.

23 Do you do maintenance while you're shut  
24 down or do you do it on line, for example? And,  
25 again, subjective judgment has to come into the

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1 process.

2 And what I'm submitting is that we use  
3 that subjective judgment today. We simply don't spell  
4 out loud the factors the way that we're weighing the  
5 factors, and what's changed with the approach that  
6 we're suggesting is that we state it in probabilistic  
7 terms and incorporate it into the PRA.

8 CHAIRMAN KRESS: Let me expand on Dana's  
9 question a little. What I'm interested in is the risk  
10 associated over the full lifetime of the plant. That  
11 means shutdown number 85 is going to take place n  
12 years from now I need to incorporate into my risk  
13 assessment.

14 Now, since I don't know what that shutdown  
15 consists of, what planned maintenance they're going to  
16 have because it hasn't even come about yet, it may  
17 even be an unplanned shutdown. How do I know how to  
18 incorporate the short time during shutdown, short  
19 compared to other things? That risk, how do I put  
20 that risk component into my risk assessment when I  
21 don't even know what it -- we're dealing with a  
22 change, a variable configuration in time rather than  
23 a fixed configuration, which is what PRAs usually deal  
24 with.

25 How do I deal with that in a PRA? Is that

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1 something that needs a new PRA methodology for?

2 DR. GOLAY: I would submit not, but let me  
3 go to why The first question that may arise is why do  
4 you need research on regulatory reform. Why can't  
5 you just get a few people to go off and think in the  
6 corner for a time and come up with some proposals and  
7 then try them out?

8 My experience has been that you don't know  
9 what is a good idea until you've gone through some  
10 feasibility attempts; that there's an iterative  
11 process here, and that's the heart of doing that kind  
12 of research, to find out what's feasible and then from  
13 that find a good blend of feasible approaches  
14 consistent with an over arching logical framework.

15 In terms of the question you've asked, I  
16 would suspect, without having tried to do the analysis  
17 you said, that, first of all, the level of detail  
18 required is probably not necessary; that approaching  
19 it from the point of view of looking at safety during  
20 shutdown and trying to anticipate a range of  
21 conditions that you think are reasonably plausible,  
22 which is the approach we have today, I think that that  
23 will work.

24 And what I would try and do is turn it  
25 around and try and use a real probabilistic treatment

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1 of the safety, but not to try and anticipate the fine  
2 detail the history of a plant that might occur or  
3 might not occur.

4 CHAIRMAN KRESS: You could use past  
5 experience of what has occurred.

6 DR. GOLAY: That certainly would be part  
7 of it.

8 CHAIRMAN KRESS: The database maybe.

9 DR. GOLAY: Yes, exactly, exactly.

10 Does that respond to what you brought up,  
11 Dana?

12 DR. POWERS: Yea, I was bringing it up for  
13 Tom.

14 DR. GOLAY: Okay. All right. Let's move  
15 on or we're going to be here until four just on this  
16 presentation.

17 George showed this slide earlier, and  
18 essentially where he said that we are in our work is  
19 over on the right-hand side, which is taking a top-  
20 down and probabilistically based approach, and it's in  
21 complement to most of the other approaches that I've  
22 seen, which are really trying to find an accommodation  
23 with the existing approach, partly because they're  
24 driven by the need to get a license.

25 You know, as people say, you don't drain

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1 the swamp when you're to your rear in alligators, and  
2 that tends to be the situation for most of these  
3 projects, although I'm sure that many people are  
4 thinking about the whole range of this.

5 But our starting point is over here, and  
6 that's one way in which as far as we know, our work is  
7 somewhat different from the others.

8 However, the elements that go into it are  
9 the kind that you see always, which are that you want  
10 to find a way to incorporate defense in depth and  
11 safety margin. These are good design practices  
12 regardless of the regulatory approach.

13 And one of the things that led us to the  
14 suggestion we're making today is that we wanted a way  
15 to state the benefit that you get from these various  
16 practices.

17 DR. WALLIS: Do you have a good measure of  
18 safety margin in a probabilistic sense?

19 DR. GOLAY: Yes. If you're using margin  
20 on let us say approach to melting temperature or  
21 something of that kind, what that would translate into  
22 would be to formulate your acceptance criterion from  
23 the design point of view at a very, very high  
24 confidence level so that you insure -- and you, of  
25 course, could say that let us say your 99 percent

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1 level could be somewhat reduced from what you think is  
2 the actual failure point, would be a way that you  
3 would do that.

4 DR. WALLIS: But once you start saying  
5 there's a failure point, you are making things  
6 deterministic, which really are not.

7 DR. GOLAY: Well, I'm trying to relate it  
8 to the current design process.

9 DR. WALLIS: That's right, but I think it  
10 would be interesting to see what you could do with a  
11 definition of margin which got away from these ideas  
12 of having a point or --

13 DR. GOLAY: Right, and what you would do,  
14 as you're hinting, is really to use a distribution on  
15 all of the performance limits, and that would be a  
16 natural evolution that I think we would go to and  
17 probably quicker than I'm anticipating.

18 DR. WALLIS: You would look at the  
19 probabilities of all of those and the consequences of  
20 all of those.

21 DR. GOLAY: Right. That's right.

22 So what you expect is that if people are  
23 using the approach we're suggesting well, they would  
24 have natural incentives to put defense in depth into  
25 their designs partly because they could see a benefit

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1 for doing it when they go and make a regulatory  
2 submittal.

3 The same thing with margin.

4 CHAIRMAN KRESS: How do I decide what  
5 confidence level constitutes an acceptable margin?

6 DR. GOLAY: My short answer is you have to  
7 work on it.

8 (Laughter.)

9 DR. GOLAY: Well, it's partly a social  
10 policy and has to be worked out with --

11 DR. POWERS: We've been working on it, by  
12 the way --

13 DR. GOLAY: -- the regulator.

14 DR. POWERS: -- for four years that I know  
15 of.

16 CHAIRMAN KRESS: I'm glad you said that  
17 because that's my belief also. It involves things  
18 like the loss function, for example, in decision  
19 theory.

20 DR. GOLAY: Right. And so if we're  
21 successful in our work, what we will do is kind of set  
22 some directions for future work to pursue because some  
23 of these, as you know, are very subtle. But if we  
24 accept the overall approach that we're trying to lay  
25 out, that's the most important thing that we really

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1 want to get across.

2 And then there is a lot of research for  
3 professors to do, keeping lab personnel out of  
4 trouble.

5 CHAIRMAN KRESS: Yeah, we've got to keep  
6 them occupied.

7 DR. GOLAY: Right. There you go. Well,  
8 that's never been a problem.

9 Could we go to the next slide?

10 One of the other points that I want to  
11 make is that we tried to come up with a regulatory  
12 approach which would be useful at different conceptual  
13 stages of development.

14 One of the things which I've observed  
15 makes consideration of regulatory change, makes those  
16 discussions difficult is that if you don't state the  
17 level of maturity of the concept, what's approach  
18 becomes a difficult conversation because what's  
19 appropriate in one circumstance may not be in another.

20 But this notion that you're using a  
21 combination of probabilistic analysis and essentially  
22 your best set of probabilistic with deterministic test  
23 experience and judgment at any stage of maturity is  
24 the consistent part. And I'll come back to this in a  
25 minute.

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1           And the idea is that as the maturity of a  
2           concept grows, that the level of detail and our  
3           ability to introduce concepts that we're familiar with  
4           from light water reactors, such as DBAs, design basis  
5           accidents, that that will also grow, but that at an  
6           early stage, some of this may not be applicable.

7           Can we go on?

8           So in this table, what we've tried to do  
9           is put together an illustration of what we're talking  
10          about in terms of different levels of maturity as we  
11          go from an initial concept to the  $n^{\text{th}}$  plant as we have  
12          with light water reactors, where there are many of  
13          them around and where we have a lot of experience  
14          accumulated.

15          And basically the regulatory system gets  
16          into it in the lower three rows of this figure, where  
17          you may have an initial detailed design, but where  
18          it's not feasible to do more than formulate the high  
19          level acceptance criteria, and where our level of  
20          detail in the knowledge of the system is also fairly  
21          limited.

22          The idea that I want to get across is that  
23          as we work our way down the figure and later into  
24          time, that the amount of detail, the number of finely  
25          crafted performance goals that you can come up with,

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1 and your ability to translate those into deterministic  
2 decision rules will tend to grow, but in the early  
3 stages, you tend to stay high level and mostly  
4 probabilistic.

5 DR. WALLIS: It's an interesting idea, but  
6 it seems to me that as you learn more about a plant,  
7 you might actually get less detail than any kind of  
8 plan. You might really know what you have to worry  
9 about and you don't need all of this detail.

10 DR. GOLAY: Conceivably, and we've seen  
11 that, for example. I would say that the evolution of  
12 the passively based water cooled reactors could be an  
13 illustration of that.

14 But one reason for putting this figure  
15 together is to address this question of where does the  
16 design basis accidents and general design criteria  
17 come into the picture here, and I would say it's a  
18 tentative conclusion, not a firm one, that those  
19 really play a role when you get to the detailed design  
20 and later stages of things because when you try to  
21 formulate design basis accidents, you have to have a  
22 design. You have to have a concept in which to think  
23 about and have some seasoning in terms of your  
24 understanding of its weaknesses, things of that kind.

25 And if you look at what we've done with

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1 light water reactors, we've gone through the evolution  
2 shown here, but with not quite knowing it or not  
3 saying it out loud, and especially the reason I've put  
4 this up concerns general design criteria.

5 That is, if you look at the general design  
6 criteria that we have for light water reactors today,  
7 most of them are motherhood statements. They're  
8 essentially do good things, put in margin, put in  
9 conservatism, defense in depth, and so on.

10 There are a few things like have a  
11 containment, have redundant shutdown systems, which  
12 are spelled out, but most of the criteria are not, and  
13 they're formulated in a way which reflects what's  
14 feasible, mostly driven by light water reactor.

15 And one idea which we think is worth  
16 exploring is whether that the formulation of GDCs  
17 should be done at a concept specific basis, reflecting  
18 some accumulation of study and experience.

19 And it bears on the question, for example,  
20 of whether you need a containment for the gas cooled  
21 reactors, and I'm not going to offer an answer for it.  
22 I'm just suggesting that with this framework, you  
23 might delay trying to answer that question until  
24 you've gone through some evaluation in this as opposed  
25 to starting by, you know, God said you have to have

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1 containments, and then from that we go on to other  
2 things.

3 DR. POWERS: And He did.

4 DR. GOLAY: Or She.

5 (Laughter.)

6 DR. GOLAY: Okay. Can we go on?

7 The other point I want to make is that  
8 there's nothing in what we've prepared which is  
9 inconsistent with the cornerstones, with the approach  
10 that the NRC has been taking in terms of restructuring  
11 the emphasis in the design and regulatory concerns.

12 What we have focused on in our work on  
13 examples is over here in the reactor safety part of  
14 the structure, but when we've looked at it, we don't  
15 see anything that would stop you from going to the  
16 other issues. We just haven't had the resources to  
17 work on them.

18 Can we go on?

19 And in terms of setting performance goals,  
20 what we've done, this is an illustration of a master  
21 logic diagram to help you identify initiating events  
22 that would be important in your event sequences or  
23 your accident sequences, as Andy Kadak had suggested,  
24 replacing the design basis accidents by the risk  
25 dominant event sequences has some attraction.

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1           And what we've concluded is that you  
2 really have to break this into two parts. One is a  
3 general treatment at a very high level where you have  
4 certain performance goals, and as we go down in the  
5 hierarchy here of this fault tree, going to finer and  
6 more finely defined events or the concatenation into  
7 creating a public threat, that there's a general level  
8 at which you can set performance goals and where the  
9 safety goals are examples of that, and then below  
10 that, when the details of the concept become  
11 important. The kinds of failures that you worry about  
12 and the combinations of events then will be concept  
13 specific.

14           And so we're seeing a two-step way of  
15 approaching the fault tree and from that the master  
16 logic diagram and eventually the initiating events,  
17 which are of primary importance.

18           So, for example, what's in the handout  
19 figure is kind of our first shot at how you would draw  
20 this for a gas cooled reactor. It's by no means  
21 complete or even correct in every detail, but the  
22 purpose is to illustrate how some of the initiating  
23 events and failure modes that show up are not those  
24 which show up for water cooled reactors.

25           For example, one of the things in here is

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1 failure of the radiative cooling path, which in the  
2 water cooled reactors we don't even worry about. I  
3 mean, when you think about it, this becomes obvious,  
4 but it's an illustration of how you would go about  
5 this.

6 Okay. Could we go on?

7 How much time do I have, Mr. Chairman?

8 CHAIRMAN KRESS: We are supposed to -- you  
9 have about 15 minutes more.

10 DR. GOLAY: Okay. Keep going. I'm going  
11 to skip over the next, I think, three. Right. Stop  
12 there, please.

13 Okay. The last thing that I want to move  
14 to is interaction between the applicant and the  
15 regulator, and what are the implications for the  
16 approach that we're suggesting?

17 And what we're really focusing on is that  
18 when you have an applicant come in with, let's say, a  
19 new reactor design application, what they do, they  
20 submit all of their documentation, of course. They go  
21 through review under the standard review plan, and all  
22 of that is preliminary to what is a negotiation  
23 between the licensee and the applicant regarding  
24 what's acceptable or unacceptable about the design,  
25 and then it's up to the applicant to find a way to

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1 satisfy the regulator.

2 We expect that that process would  
3 continue, but that it would be replaced. Today it is  
4 really focused around how will systems do concerning  
5 design basis events with consideration being given to  
6 evidence from things like the PRA and treatments of  
7 uncertainty and so on, but the DBA has played a  
8 central role in the way things have been structured.

9 What we would do is reverse that and have  
10 the probabilistic integration of the system  
11 performance be the primary vehicle used for the  
12 evaluation, but the much more comprehensive version  
13 spoken about, and that the acceptability negotiation  
14 would be conducted in the context of the RPA, where we  
15 would need consistent procedures, tools, and  
16 termination criteria for this negotiation process.

17 That's for reviewing new designs. We  
18 anticipate that for the regulation of construction and  
19 the regulation of operations, that formulation of a  
20 set of deterministic rules, but based upon risk based  
21 information could be done, and we think that that's  
22 desirable for practical reasons, for people in a  
23 construction site. You don't want them running PRAs  
24 all the time and making decisions.

25 But we're suggesting that if the review of

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1 the new design, that it is a practical thing to  
2 undertake today, particularly when you're looking at  
3 marginal changes in the performance.

4 Okay. Can we go on?

5 And so I want to give an illustration of  
6 how this negotiation or discussion might proceed,  
7 where the idea is that initially a designer would come  
8 up with a plant design satisfying the goals of that  
9 first figure that I showed, producing economical and  
10 safe electric power, and that it's his or her  
11 responsibility to come up with a design that will do  
12 that very well.

13 When the designer, design team, more  
14 realistically, thinks that they have satisfied the  
15 performance goals that have been formulated by the  
16 regulator, they submit their application and it's  
17 reviewed.

18 Presumably there will be some areas of  
19 disagreement regarding the adequacy of the submittal  
20 because that tends to be the nature of the licensing  
21 process. However, what we're expecting is that the  
22 disagreements should be in terms of the expected  
23 performance, safety features, the performance criteria  
24 that were used internally to decide that they would do  
25 well, and the methods and analysis, that is, the data

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1 and models used, and that this process be documented,  
2 again, in the probabilistic terms.

3 Can we go on? We seem to have lost  
4 something here. Yes.

5 DR. WALLIS: Let's try to think about  
6 this. The method of design and analysis is going to  
7 be in probabilistic terms. You mean that every time  
8 you put a correlation in a code, you have to do  
9 something probabilistic with it?

10 DR. GOLAY: Only if it propagated through  
11 into your risk evaluation.

12 DR. WALLIS: It probably does.

13 DR. GOLAY: Yeah. For example, if your  
14 new correlation had a different uncertainty treatment,  
15 you would expect that to be propagated through, yeah.  
16 That's right.

17 Okay. Can we go to the next one? This  
18 one isn't coming through, but what it's meant to  
19 illustrate, I'll tell you what you would be seeing if  
20 it were showing up, which is above the line showing an  
21 iterative risk based design process, and below the  
22 design, showing an iterative risk based review and  
23 feedback of that process.

24 So below the line we're dealing with the  
25 negotiation between the designer and the regulator.

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1 Above the line, we're dealing with the designer trying  
2 to do a good job in the first place.

3 Ah, there we go. Okay.

4 And hopefully when they've gone through  
5 this, they will eventually reach satisfaction on the  
6 acceptance criteria and gain a license.

7 Okay. Let's go on. Oh, no, not another  
8 one. That's the same one. Is there any way to turn  
9 this off and move ahead?

10 DR. APOSTOLAKIS: It was too fancy.

11 DR. GOLAY: Yeah, I can see that. I can  
12 see that.

13 And this is what we foresee that the  
14 designer would be doing, and that is -- and I'm going  
15 to give you an illustration of this, which is start  
16 off with what we call the bare bones design, and this  
17 is only an illustration of how we think it might  
18 proceed. This isn't a requirement for anybody to do,  
19 but essentially create a design to produce  
20 electricity, and then go through and ask: well, what  
21 are initiating events which could cause a safety  
22 problem?

23 And it doesn't just have to be core  
24 damage. It would be in all the cornerstones.

25 To use a PRA to identify the dominant risk

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1 contributors, and from that to identify mitigative  
2 features and systems that could be used to alter that  
3 PRA profile and iterate on this until finally the  
4 design comes to satisfy a vector of acceptance  
5 criteria, which would be formulated at whatever is the  
6 right level for maturity.

7 DR. WALLIS: Couldn't there be a scaler  
8 that says that whatever your PRA produces must be less  
9 than some number?

10 DR. GOLAY: Within a certain area of  
11 performance, that would be the case, but we recognize  
12 that there will be many areas of performance.

13 For example, you may want to have the  
14 frequency of initiating events to be very low,  
15 satisfying one of the cornerstones, and you may also  
16 want to have a very low core damage frequency, as well  
17 as a very low frequency of activation of the off-site  
18 emergency plan.

19 So, in general, we're anticipating a  
20 vector, but each element would be stated in  
21 deterministic terms, and so this is what the designer  
22 would be going through before the submittal and then  
23 afterward, following the negotiation.

24 Okay. Can we go on?

25 One of the things which we want to get

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1 across is, and this figure doesn't do such a great job  
2 of it, is that the formulation of the acceptance  
3 criteria, once you go below that line of concept  
4 specific performance criteria, has to be determined  
5 iteratively because how you divide what's acceptable  
6 in a high level performance goals into a set of  
7 subgoals depends on what's feasible.

8 And so, for example, I want to use the  
9 example of for a light water reactor LOCAs of  
10 different size.

11 Go on.

12 Where when we went through with the  
13 Westinghouse design team for the set of very small  
14 LOCAs, small LOCAs, and large LOCAs with a particular  
15 mitigative system, what we ended up with is this array  
16 of core damage frequency, where you see it's a non-  
17 uniform distribution, and that's the key point we want  
18 to get across in this illustration.

19 So that as you take the overall division  
20 of what's acceptable ways of having core damage, that  
21 you wouldn't necessarily divide them up uniformly  
22 among all of the categories of such events.

23 And that's a reflection of what we are  
24 trying to talk about when we say you have to do some  
25 work to see what is feasible to do, and the answers

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1 will be different from one concept to another.

2 DR. POWERS: When I look at this table,  
3 I'm not sure what numbers I'm looking at.

4 DR. GOLAY: Well, it's the right-most  
5 column that I really want you to --

6 DR. POWERS: Yeah, I know, but I want to  
7 get to that right-most column. Are these -- am I  
8 looking at products and means or something else?

9 DR. GOLAY: Means. These are for purposes  
10 of illustration.

11 DR. POWERS: So mean time a mean equals a  
12 mean? I don't think so.

13 DR. GOLAY: Yeah, I think for purposes of  
14 what we're talking about, but if you want to do it as  
15 the integrated result to the stated confidence level,  
16 we can do it just as well.

17 The key point that I really want to get  
18 across is that you can't simply sit in your office and  
19 decide, well, I'll slice up the risk pie in, let us  
20 say, a uniform way or some way that I particularly  
21 like; that it's always a compromise between what's  
22 feasible and what's desirable, where I would say  
23 what's most desirable would be to try to spread the  
24 risk among sequences as much as you can or not put  
25 your eggs in one basket, but for various physical

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1 reasons, your ability to do that may be strained.

2 DR. WALLIS: Why do you need subgoals? It  
3 seems to me that if you had a plant that had no LOCA  
4 probability at all because of its design, then you  
5 might trade this off and be allowed to have more  
6 probability somewhere else if something else and all  
7 you care about is the total.

8 DR. GOLAY: But you care about the  
9 uncertainty associated with the total as well.

10 DR. WALLIS: Yes, you do, but the total,  
11 the bottom line is the thing, not really how it breaks  
12 up in all these pieces.

13 DR. GOLAY: Yeah. Well, I would say that  
14 another reason why you want to do this is that in the  
15 long run for regulatory convenience and efficiency,  
16 you probably want to move -- try to find risk-based  
17 deterministic decision rules as you reach a high stage  
18 of maturity, and so there will be sort of natural  
19 incentives to formulate subgoals as the concept  
20 matures.

21 And that's the reason we have this in  
22 here, simply to illustrate that you have to go through  
23 this iterative process. It's not to carry it further  
24 than that. Okay?

25 CHAIRMAN KRESS: Would there be a guiding

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1 principle on how to -- this is more or less talking  
2 about rationing the risk among the various --

3 DR. GOLAY: Right.

4 CHAIRMAN KRESS: -- as a defense in depth  
5 concept. One does this because he's uncertain about  
6 each of these results.

7 DR. GOLAY: Right.

8 CHAIRMAN KRESS: And so he wants to spread  
9 that uncertainty out, but is there some guiding  
10 principle one could come up with that says that that  
11 uncertainty, overall uncertainty, ought to be either  
12 minimized by selecting these distributions to optimize  
13 the level of uncertainty of each one so that it's  
14 minimized at the end, or so that it's acceptable, or  
15 is there a guiding principle on how to make this  
16 allocation of risk?

17 That's what --

18 DR. GOLAY: I think we have to do some  
19 work on it before we really know the answer to your  
20 question. My suspicion is that we want to go in the  
21 directions that you're saying, which is to try to make  
22 the distribution reasonably uniform and the total  
23 small at whatever your stated confidence level is.

24 But I'm sure it's more subtle than that.

25 CHAIRMAN KRESS: There has to be some

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1 other principle that tells you how to do this.

2 DR. GOLAY: Exactly. And what I'm  
3 suggesting is the principle is really one of trial and  
4 error to see what it is that's feasible to do.

5 CHAIRMAN KRESS: And, of course, that  
6 would enter into it.

7 DR. GOLAY: Yeah, and I'm doing this  
8 because the message I want to get across is that  
9 formulating a practical system that people can really  
10 use takes some work, takes some sustained resources  
11 and is sometimes pretty subtle.

12 Okay. Can we go on?

13 So I want to go through how we did this,  
14 our team, concerning dealing with LOCA events where we  
15 came up with an improved system over the -- this is  
16 for light water reactor system.

17 Started off with a bare bones system and  
18 then from that added in some mitigative active  
19 systems. So I'm not suggesting this is the best  
20 design you would want to use, but it's one that's  
21 consistent with the active light water reactors, such  
22 as we have.

23 And so we have two high pressure injection  
24 systems, one low pressure system. I won't read all of  
25 this to you, but essentially some of the usual

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1 candidates, passive DC power, shared chemical and  
2 volume control system.

3 And from this, our designers contended  
4 that they had an acceptable design.

5 Can we go on?

6 And so what we're foreseeing for this  
7 negotiation is a process outlined, is in the flow  
8 chart on the next figure, where the applicant thinks  
9 he's done an adequate job and makes the submittal.  
10 Upon review, the regulator says it's not adequate  
11 basically because of a dispute concerning modeling  
12 assumptions, which could be resolved by getting better  
13 data, and the reason is that the core damage frequency  
14 associated with the high pressure category of LOCA is  
15 seen to be too great.

16 One way that it could be solved is to have  
17 a research program, go out and get more data. Instead  
18 the designer decides to alter the design, and what he  
19 does is go and decide he wants to make the response to  
20 high pressure LOCA be one of depressurization, and so  
21 he does this by putting in a train of depressurization  
22 capability in his shop, not going back to the  
23 regulator.

24 The result is that the core damage  
25 frequency is still too high. That is, we have an

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1 acceptance criterion in terms of the core damage  
2 frequency or LOCA.

3 And so in the next iteration, the designer  
4 comes, and he puts in an additional train of  
5 depressurization capability, still finds that it's too  
6 high, and the reasons upon investigation are that  
7 common cause failures involving the cooling system and  
8 the emergency diesels are too high.

9 Could we go on?

10 CHAIRMAN KRESS: Now, go through this  
11 process. I have to have in mind a CDF that's  
12 acceptable for just LOCAs.

13 DR. GOLAY: Yes.

14 CHAIRMAN KRESS: Or for LOCAs of different  
15 sizes, which is kind of a tough number to come by.  
16 You know, I've got an overall CDF in mind, but I don't  
17 know how to fractionate that up among LOCAs and other  
18 things.

19 DR. GOLAY: Right, but what we're  
20 anticipating is --

21 DR. POWERS: Why don't you just do it?

22 DR. GOLAY: Now, we're not saying how the  
23 number was gotten at. We just want to illustrate how  
24 the process would go forward, and if such a criterion  
25 were to be formulated, this is how we would expect it

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1 to be tested on whether it's acceptable.

2 In the very early stages, I think you'd  
3 have trouble formulating that. In the later stages of  
4 maturity, you might be able to.

5 CHAIRMAN KRESS: Somewhere along the line  
6 we've got this.

7 DR. GOLAY: Right.

8 DR. POWERS: Why would you want to wring  
9 your hands over it? Why not just say, as is  
10 apparently done here, "I don't want it above two times  
11 ten to the minus sixth on a LOCA"? Which one is more  
12 capricious and arbitrary?

13 CHAIRMAN KRESS: It might very well be  
14 that my overall CDF goal is, say, ten to the minus  
15 five, and nothing contributes to that except the LOCA,  
16 and I might very well be willing to accept it as ten  
17 to the minus five. That's the confidence level.

18 DR. POWERS: You might well be willing to  
19 after the fact change things, but if you're just going  
20 through this exercise here that he's outlined, --

21 CHAIRMAN KRESS: You're saying you don't  
22 need the -- when you look at the whole system in total  
23 and make some judgmental --

24 DR. POWERS: Yeah, I think you can.

25 DR. GOLAY: I think that may be a

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1 reasonable process, too.

2 DR. SHACK: Well, it's a question of who's  
3 setting these numbers. The designer can set it any  
4 way he wants to, and the question is whether the  
5 regulator then forces those numbers.

6 CHAIRMAN KRESS: Well, my point was should  
7 the regulator come in at this point and have  
8 acceptance criteria related at this low a level or  
9 should he just focus on the endpoint?

10 And I think, you know, that that's the  
11 whole debate.

12 DR. POWERS: Sure.

13 CHAIRMAN KRESS: Should you focus on the  
14 endpoint or should you come in at this point on the  
15 regulation?

16 DR. POWERS: It is what point you come  
17 into.

18 CHAIRMAN KRESS: Yeah.

19 DR. POWERS: We know that they will come  
20 in more than at the endpoint.

21 CHAIRMAN KRESS: And that's why I keep  
22 harping on defense in depth. this is a defense in  
23 depth concept, whereas if you just focused on the  
24 endpoint, perhaps it's not.

25 DR. POWERS: Right.

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1 CHAIRMAN KRESS: And this may be a way to  
2 bring in defense of depth or it may not. I don't  
3 know.

4 DR. GOLAY: Well, that's actually part of  
5 why we picked this illustration, because we're  
6 anticipating that as the maturity grows, there will be  
7 a natural evolution of performance goals formulated at  
8 a lower level.

9 For one thing, it makes the design process  
10 more efficient and should make the review process more  
11 efficient, but that's why also I went through this  
12 business that where you set the goal depends on the  
13 maturity of the concept. There isn't just one answer.

14 But we're assuming that things are mature  
15 enough that we can work at the system level with  
16 system specific or relevant goals, and so the idea is  
17 that after rejection, the designer goes back and using  
18 the kind of risk information we're showing here, keeps  
19 modifying his design until he thinks that he's got  
20 something ready for another path.

21 Could we go to the next figure?

22 Upon submittal, there are two paths that  
23 we consider to be worth thinking about. One is the  
24 easy one down here, is Evaluation 2, which is that the  
25 performance goal is met.

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1           The second may be that, let us say, when  
2           you're trying out a new lower level performance goal,  
3           you may find that satisfying it is pretty difficult in  
4           terms of cost-benefit tradeoffs, and that you might do  
5           a better job at meeting your higher level goal by some  
6           risk shifting.

7           So we see both approaches as being  
8           feasible, depending on the level of maturity of the  
9           concept. But for today we're going to take it that  
10          he's trying to meet the standard, and we'll talk about  
11          how to do that.

12          Okay. Could we go on?

13          Now, this is a table of how in our risk  
14          assessment the core damage due to LOCA, core damage  
15          frequency, changed, and we're listing here the median,  
16          the five percent, 95 percent, and also what we're  
17          calling the risk metric, and that is one of the ideas  
18          I want to get across in here is that we can consider  
19          uncertainty just as easily as we can expected  
20          performance.

21          And so we are taking the postulated  
22          situation that the NRC has said that the acceptable  
23          risk metric will be one involving 75 percent of the  
24          median core damage frequency and 25 percent of the 95  
25          percent core damage frequency and requiring it to be

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1 less than seven times ten to the minus seven.

2 This is just as an illustration of how you  
3 might try to take uncertainty into account in an  
4 explicit regulatory acceptance criterion.

5 And the point is that if you look at the  
6 various entries here, what you see is that as we go  
7 from the initial no depressurization capability down  
8 through the different design iterations, that only  
9 until we get down to two train depressurization with  
10 an improved treatment of cooling water and diesel  
11 failure do you satisfy that acceptance criterion in  
12 terms of this risk metric.

13 But there's nothing harder about  
14 formulating a criterion involving uncertainty measures  
15 than formulating one which is strictly deterministic  
16 as we do today, or in terms of expected performance.

17 The trick is to make sure that the  
18 distributions that you're using reflect reality as  
19 well as you can, and if you do that and propagate  
20 these uncertainties, you should be able to get useful  
21 answers, just the ones we want you to think about.

22 CHAIRMAN KRESS: How is this, the first  
23 metric that you selected, any different than just  
24 specifying a confidence level?

25 DR. GOLAY: We felt we could have done it

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1 at, let us say, a 75 percent confidence level. We  
2 felt that in reality that when people think about it,  
3 what they do is think about the expected performance,  
4 and they try to put on some margin factor for  
5 uncertainty, and we thought this was a way of trying  
6 to capture that.

7 CHAIRMAN KRESS: It fits into that.

8 DR. GOLAY: But how you do it is, again,  
9 some thing that there are different approaches for it.  
10 The main thing I want to get across is that it's very  
11 easy to incorporate treatments of uncertainty, as well  
12 as expected performance here, and given that  
13 regulations about uncertainty, we think that this is  
14 a big contribution, at least potentially.

15 Could we go to the next figure? Other  
16 way.

17 Okay, and this is just a graphic of the  
18 same change in the core damage frequency at different  
19 confidence levels, including this risk metric. The  
20 blue one is the risk metric that we were using, and  
21 you see that it could play the role just the way that  
22 evaluation at a conservative confidence level could  
23 do.

24 So what's the best treatment would be for  
25 future work, but if you accept that the idea is worth

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1 exploring, that is a step forward.

2 Let's go on.

3 Okay. We're almost at the end. Lunch is  
4 in sight.

5 The point is in this example what we tried  
6 to show is how that we can have a natural way for  
7 concern about common cause failures and uncertainties  
8 to lead designers to incorporate some defense in  
9 depth, some use of safety margin, to show how we can  
10 take uncertainty into account in evaluating  
11 acceptance, and that the bottom line is really the one  
12 that is most important, and it addresses what you need  
13 to pay attention to in future research, which is that  
14 there are a lot of practical questions that need  
15 examination here, and to answer them you need trial  
16 examples, such as we just showed you.

17 You need some work to come up with  
18 standardized models, methods, and databases which are  
19 much more capable than those which we have today.

20 And one of the areas which we really  
21 haven't explored -- by "we" I mean everybody in this  
22 room -- very much, but which is quite important, is  
23 methods for treating subjective judgment, for  
24 incorporating it into the decision making process in  
25 a more formal way.

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1           We suggest that through this process, we  
2           may be able to replace the need for general design  
3           criteria and DBAs, and we would probably have to alter  
4           the standard review plan in important ways.

5           So these are all practical problems that  
6           need to be investigated.

7           Can we go to the last slide?

8           So in summary, what I hope you've gotten  
9           is an understanding of a new design and regulatory  
10          process that we propose for development. It's risk  
11          based. It incorporates defense in depth and margin.  
12          We think it would provide a more rational and  
13          consistent method regarding both design and regulatory  
14          review.

15          It provides a method of integrated  
16          assessment which we currently lack except in the  
17          treatment probabilistically in the background of the  
18          process we have now, and it should be applicable to  
19          non-light water reactor technologies in a  
20          straightforward fashion just as to light water  
21          reactors.

22          So in effect, the implicit favoritism  
23          which our current process bestows upon light water  
24          concepts could be removed through this and hopefully  
25          would lead us to somewhat better technological

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1 options.

2 And we feel that the development of this  
3 process should be supported as part of our overall  
4 attack on developing new technology, and that's all I  
5 have to say.

6 CHAIRMAN KRESS: Okay. Are there  
7 questions or comments?

8 DR. POWERS: I guess the thing that comes  
9 most immediately to mind is actually on his first  
10 bullet there, where he says defense in depth when  
11 necessary to address model and data uncertainties.  
12 Don't we do a defense in depth for other reasons?

13 CHAIRMAN KRESS: Pardon?

14 DR. POWERS: Don't we do a defense in  
15 depth for other reasons?

16 CHAIRMAN KRESS: Yes, there are other  
17 reasons for it, I think. What reasons would you have  
18 in mind?

19 DR. POWERS: I guess two things come to  
20 mind, one of which you might put in the category of  
21 model uncertainty is, well, we don't account for  
22 sabotage in the PRAs. I'd just as soon have some  
23 protection against a plausible threat to the plan.

24 The other one is in your probabilistic  
25 studies you always come up with some probability of

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1 bad things happening. Just between you and me and the  
2 gate post, I'd like to have something between me and  
3 the bad stuff when those bad things happen, regardless  
4 of how infrequently they occur.

5 DR. GOLAY: Is that a question?

6 CHAIRMAN KRESS: It's a comment more than  
7 a question.

8 DR. POWERS: He asked for comments.

9 CHAIRMAN KRESS: If you want to respond,  
10 you may.

11 DR. GOLAY: Yeah, I will, and that is  
12 concerning your example of security, I don't know. I  
13 haven't worked on security, and I don't know how you  
14 might try to handle it here.

15 My first reaction is: why not try? I  
16 don't know of anything that would preclude you from  
17 being able to include that successfully, and what I  
18 would like to do is sort of turn the burden around and  
19 make a presumption that we can handle the questions in  
20 a probabilistic framework until we have clear evidence  
21 we cannot.

22 Fundamentally you said that reason for  
23 defense in depth was not wholly treatment of  
24 uncertainty. Yet the examples you brought up were  
25 essentially treatment of uncertainty examples, and if

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1 you think that a practice is beneficial in terms of  
2 getting a good safety result as a response to  
3 uncertainty, then you should be able to state it,  
4 state your belief concerning that fact in a  
5 probabilistic format.

6 So it's not disagreeing about the value of  
7 defense in depth. I'm simply saying it's worth the  
8 try to incorporate anything that you think is  
9 important to the answer in the format.

10 MR. HOCKRITTER: Larry Hockritter, Penn  
11 State.

12 On page 10, you talk about using best  
13 estimate performance, expectations and uncertainties.  
14 And you really have two kinds of uncertainties. You  
15 can have the plant uncertainties, but you can have the  
16 uncertainties in the model that you use to do the  
17 predictions, and with a light water reactor, we've got  
18 40 years of a database, experimental database so that  
19 we can quantify the models and the model uncertainty  
20 so that we have a good handle on that.

21 I don't know how you address that for a  
22 new design like we've been talking about for these  
23 Gen. IV designs where you really don't have much of a  
24 database at all.

25 So that's one question.

1 DR. GOLAY: Should I answer?

2 MR. HOCKRITTER: That was a question.

3 DR. GOLAY: Yeah, with any concept,  
4 regardless of its level of maturity, I'll submit that  
5 as you try to do a risk analysis of comparing  
6 alternatives, let's say, that you ultimately end up at  
7 a point where the available objective data reach the  
8 limits, and you can find this with plenty of light  
9 water examples as well, that what you're really into  
10 is a situation where you -- I think always -- that's  
11 too strong a word because I don't have the basis for  
12 saying "always," but my experience has been so -- that  
13 you end up with a combination of objectively based  
14 evidence and you have to supplement that by your  
15 judgment.

16 And so the only suggestion that we're  
17 making is that you should state that in probabilistic  
18 terms and incorporate it into the PRA so that with the  
19 new concept, you reach that limit much sooner than  
20 with the mature one, but that the general structure  
21 holds up for both.

22 MR. HOCKRITTER: Okay. Well, I can now  
23 turn the question around and say if you would embark  
24 on this type of a licensing process, you could use  
25 this approach to structure the types of test programs

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1 that you would need --

2 DR. GOLAY: Absolutely.

3 MR. HOCKRITTER: -- for a Gen. IV type  
4 plant. So I see a real benefit in that.

5 And then just one other comment. The  
6 examples that you showed, the design examples, I know  
7 on the AP 600 we did use that process where we went  
8 through the PRA. We looked at the performance of the  
9 systems and the system sizes in this case changed.

10 DR. GOLAY: Yeah, and what was lacking in  
11 that example is the regulator being prepared to engage  
12 you in the same vocabulary for making their decision.

13 MR. HOCKRITTER: There was never a problem  
14 with the regulator engaging us.

15 (Laughter.)

16 CHAIRMAN KRESS: Go ahead.

17 MR. PARME: Larry Parme, General Atomics.

18 I have a question in regards to your last  
19 page or near there. You mentioned possibly replacing  
20 the DBAs with the risk dominant events, and overall  
21 I'm supportive of your approach, but in the licensing  
22 approach risk based that we did for the MHTGR, one of  
23 the -- we were looking at that sort of approach, and  
24 we immediately ran into the problem that when you go  
25 and say that the risk dominant events replace DBAs,

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1 you find that certain non-risk dominant events are the  
2 only challenges, if you will, to certain key equipment  
3 or safety functions, and the risk dominant events may  
4 not demonstrate to the regulator the various ways that  
5 your safety functions are done.

6 And I hope you follow what I'm saying. My  
7 question to you is: did you think about this?

8 We had thought about this in the '80s,  
9 found that risk dominant events weren't a true  
10 substitute for DBAs and had to also use the PRA, but  
11 had to find -- pull from our event trees events that  
12 challenged each of the safety functions regardless of  
13 their risk dominance.

14 DR. GOLAY: Right. Let me try and  
15 translate it though, and that is what I think you're  
16 really saying is that there's a concern about the  
17 level of uncertainty associated with your risk based  
18 analysis, such that if you went in and claimed that  
19 you were doing very, very well, it wouldn't be a  
20 credible claim, and that it was necessary to, in  
21 effect, show that you could handle something tougher  
22 is in some way a defense in depth kind of capability.

23 CHAIRMAN KRESS: I would have put that a  
24 little differently. I would say that there are  
25 regulatory objectives that are more than just CDF,

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1 LERF, BES (phonetic) --

2 DR. GOLAY: Sure.

3 CHAIRMAN KRESS: -- ANDERS (phonetic), and  
4 those regulatory objectives can be captured.

5 And you had one little box called FC  
6 curves. If you actually had acceptance criteria on  
7 those, I think it would capture these things that  
8 you're talking about that don't have much to do with  
9 LERF or probable fatalities, but how to function in  
10 being sure that you don't have smaller releases or  
11 worker exposure and that sort of stuff, which can be  
12 captured in F-C curves.

13 DR. GOLAY: That's a good point, and I was  
14 taking for granted that the cornerstones had all been  
15 addressed, which in that era they were not.

16 CHAIRMAN KRESS: Yeah. I hate to do this  
17 because I think this has been one of the most  
18 challenging and interesting presentations, but I think  
19 it's time to go eat lunch.

20 We can return to this maybe in the  
21 discussion. They are very provocative concepts and  
22 some very attractive thoughts.

23 DR. GOLAY: Our team remains eager to  
24 help.

25 CHAIRMAN KRESS: Remember at two o'clock

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1 up stairs in the White Flint II Conference Room rather  
2 than here.

3 (Whereupon, at 12:59 p.m., the meeting was  
4 recessed for lunch, to reconvene at 2:00 p.m., in the  
5 White Flint II Conference Room.)  
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