Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Advisory Committee on Reactor Safeguards 522nd Meeting
Docket Number:	(not applicable)
Location:	Rockville, Maryland
Date:	Thursday, May 5, 2005
Work Order No.:	NRC-353

Pages 1-247

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

522nd MEETING

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THURSDAY,

MAY 5, 2005

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Graham B. Wallis, Chairman, presiding.

COMMITTEE MEMBERS PRESENT:

GRAHAM B. WALLIS, Chairman

WILLIAM J. SHACK, Vice Chairman

GEORGE E. APOSTOLAKIS, Member

MARIO V. BONACA, Member

RICHARD S. DENNING, Member

THOMAS S. KRESS, Member

COMMITTEE MEMBERS PRESENT (Continued):

DANA A. POWERS, Member
VICTOR H. RANSOM, Member
STEPHEN L. ROSEN, Member
JOHN D. SIEBER, Member

ACRS STAFF PRESENT:

JOHN T. LARKINS, Executive Director
ASHOK C. THADANI, Deputy Executive Director
THERON BROWN
SAM DURAISWAMY
JENNY M. GALLO
NOBLE GREEN, JR.
MICHAEL L. SCOTT

NRC STAFF PRESENT:

JAMES BONGARRA, NRR
PAT HILAND, NRR
P.T. KUO, NRR
J. PERSENSKY, RES
GREG SUBER, NRR
DAVE TRIMBLE, NRR
AUTUMN SZABO, RES

ALSO PRESENT:

REZA AHRABLI, Entergy
JOHN F. GROSS, DOE
A. DAVID HENDERSON, DOE

ALSO PRESENT (Continued):

TED IVY, Entergy

DAVE LACH, Entergy

NATALIE MOSHER, Entergy

PAUL S. PICKARD, Sandia National Laboratories

MARK RINCKEL, AREVA Framatome

ROGER RUCKER, Entergy

MIKE STROUD, Entergy

ROBERT M. VERSLUIS

GARRY G. YOUNG, Entergy

C O N T E N T S

P R O C E E D I N G S

(8:30 a.m.)

CHAIRMAN WALLIS: The meeting will now come to order.

Good morning. This is the first day of the 522nd meeting of the Advisory Committee on Reactor Safeguards. During today's meeting the Committee will consider the following:

Final review of the license renewal application for Arkansas Nuclear One, Unit 2;

Draft final revisions to standard review plan, Chapter 13, entitled "Conduct of Operations";

Advanced reactor designs for hydrogen production;

Significant recent operating events

Proposed options for addressing ACRS proactive initiatives on safety management;

And the preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Dr. John T. Larkins is the Designated Federal Official for the initial portion of the meeting.

We have received no written comments, no requests for time to make oral statements from members of the public regarding today's sessions.

A transcript of portions of the meeting is being kept, and it is requested that the speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so that they can be readily heard.

I will begin with some items of current interest. In the handout that you have, you'll notice that there are three SRMs. There's a speech by Commissioner Lyons, and there's testimony by Chairman Diaz before the United States Senate.

On behalf of the committee, I would say it gives me personally great pleasure. I would like to congratulate Dr. Larkins, the ACRS Executive Director who has been selected to receive the NRC Honorary Meritorious Service Award.

Congratulations.

(Applause.)

CHAIRMAN WALLIS: We will now proceed with the meeting. I will call upon my esteemed colleague, Mario Bonaca, to lead us through the first item, which is the license renewal for Arkansas Nuclear One, Unit 2.

DR. BONACA: Thank you, Mr. Chairman.

We're here now to do a final review of the license renewal application for Arkansas Nuclear One, Unit Two. We met as a subcommittee on December 1st, 2004, to review this matter.

At the time we had an interim SER that already contained no open items so that it went along towards closure of the commitments for license renewal. We are here now with a completed SER and final SER, and so I turn to Dr. Kuo for going into the presentations.

DR. KUO: Thank you, Dr. Bonaca.

This is P.T. Kuo for the record. I'm the Program Director for the license renewal and the environmental impacts program. To my right is the team leader for the audit review at the ANO-2 and at my far right, Greg Suber. He's the Project Manager for the staff review for this project.

And Greg is going to lead the presentation today with the support with all the staff that are sitting in the audience.

As, Dr. Bonaca, you pointed out, in the draft SER they contend no open items for this review. In Greg's presentation, he's going to go through some of the highlights of the review, and he's going to discuss some of the issues that may particularly interest you.

So with that I would like to turn the presentation first over to the applicant, and then it will be followed by the staff presentation. Any questions?

(No response.)

MR. YOUNG: Good morning. I'm Garry Young with Entergy, and I'll be making the presentation for the licensee in regard to the application for Arkansas Nuclear One, Unit 2.

First of all, I'd like to introduce some of the team members that are here that were involved in helping prepare the material that was in the application.

Mike Stroud, who is our Project Manager over here.

Natalie Mosher, who was our licensing lead for the project.

Ted Ivy, who is our mechanical lead.

Reza Ahrabli, who is our civil structural lead.

Roger Rucker, who is our electrical and I&C lead.

Also we have Dave Lach here, who's a Project Manager with our license renewal group.

And Mark Rinckel with AREVA Framatome, who was our Class 1 lead for the mechanical.

With that I'd like to go on into the presentation. I'm going to go through each one of these topics and provide a little additional information, kind of a summary of some of the information that was presented in the subcommittee as well as some additional information that was requested by the subcommittee at the last meeting.

And at any point if there's any questions or additional information, please stop me, which I'm sure you will, and we'll discuss it right then.

For a general description of the unit, it's located in west central Arkansas near Lake Dardanelle. Lake Dardanelle is the source of the makeup water for the cooling tower on Unit 2.

It's a Combustion Engineering pressurized water reactor. Bechtel was the architect-engineer. The construction permit was issued in 1972, and we went into initial operation in 1978.

We have about 27 years of operating experience at this point. We have a 3,026 megawatt thermal capacity and 1,023 megawatts electric.

And Arkansas Nuclear One, the two units together provide over 30 percent of the electricity needs of Arkansas. And this is just a map to show physically where we're located, pretty well the middle of the country and the southern part of the middle of the country.

A brief summary of our operating history. We did a power uprate in 2002. It was a 7.5 percent uprate, which increased our capacity by 210 megawatts thermal. We also replaced our steam generators in 2000, which was part of a prerequisite for doing a power uprate. In addition, we were having a lot of problems with tube plugging on the steam generators. So there were several reasons that they were replaced, and were placed them with Westinghouse units.

DR. SHACK: A question.

MR. YOUNG: Yes.

DR. SHACK: Is this really a Westinghouse steam generator or is it a CE steam generator relabeled?

MR. YOUNG: It is actually Westinghouse, yes. I mean, they're all the same company now, but --

DR. SHACK: Right.

MR. YOUNG: -- this was a Westinghouse design, not the Combustion Engineering. That's my understanding at least.

DR. SHACK: This is not a lattice bar? This is a quatrefoil or something?

MR. YOUNG: Do we have anybody that knows that detail? I'm not certain. Worry.

CHAIRMAN WALLIS: So you made a hole in containment?

MR. YOUNG: Yes.

CHAIRMAN WALLIS: And took out the old one and put in new ones?

MR. YOUNG: Yes, yes, right. It was a major, major job for us, but, yes, we had to cut a hole in containment and put them in. Okay?

Some performance trends over the last few years. The capacity factors have increased from about 71 percent in 1992 to about 97 percent in 2004. The trend was a steady increase during that period of time, typical for the nuclear power plants during that time period.

We've also achieved some dose reductions at the plant due to some activities that were targeted. Our outage doses were reduced from about 175 rem in 1995 down to 93 in 2003. Obviously when we did the steam generator replacement, we actually had an increase that year.

CHAIRMAN WALLIS: Have you been reducing your time of outage as well?

MR. YOUNG: Yes, sir.

CHAIRMAN WALLIS: By how much?

MR. YOUNG: Well, right now we're down into the 20-30 day range typically unless we're doing something major like a steam generator or vessel head or some other, you know, special change, but a typical outage is between 20 and 30 days now.

Also, our non-outage dose has been reduced over the time from about 49 rem in 1996 to about nine rem in 2004. Again, somewhat typical for the industry based on some targeted activities to reduce overall dose from the operation of the plant.

And I've got a number of initiatives. These are things that have been done to the plant to upgrade or improve the plant either due to issues related to aging or obsolescence. For example, we've replaced our feedwater control system in 1997 with a digital control system. In 1999 we replaced the condenser tube bundle. It was a copper-nickel alloy and we replaced it with titanium.

We replaced the moisture separator reheater tube bundle in 1999. It was a copper-nickel alloy and was replaced with stainless steel.

Also, again, we replaced the steam generators. They were Alloy 600 and we replaced with Alloy 690 tube material.

We also did a high pressure and low pressure turbine upgrade in 2000 to improve steam flow path and other efficiency improvements. We replaced some electrical penetration modules in 2000. This was an upgrade to improve the leak tightness of these particular electrical penetrations.

The containment operates at a slightly higher pressure with the power uprate, and this was one of the needed improvements to allow for that higher design pressure.

Our flow accelerated corrosion piping program has included and still includes piping replacements. As we go through time and do our inspections, we replace piping that has been eroded or corroded with a chrome moly or a FAC resistent material, and not only have we been doing that, but we're continuing to do that.

We have --

CHAIRMAN WALLIS: What's the criterion for replacement? Is there a certain percent of wall thickness or something?

MR. YOUNG: There is a criteria for when we have to replace it, but we're periodically going through and replacing some of it preemptively before we get to the point of reaching the limits for continued operation.

DR. RANSOM: What are some of the typical places where you had to replace piping?

MR. YOUNG: Extraction steam lines, for example. I don't know. There's several other. It's all associated with one of the flow paths associated with the steam, especially the --

DR. RANSOM: Where you have droplets or --

MR. YOUNG: Yes.

DR. RANSOM: -- condensate down?

MR. YOUNG: Yes, yes.

DR. BONACA: When did you last inspect the reactor vessel head?

MR. YOUNG: At the last outage, which was -- let's see. That was earlier this year. A couple of months ago, yes.

DR. BONACA: Okay, and you had no indications?

MR. YOUNG: Right. We did a full bare metal inspection on the vessel head, and there were no leaks, no indications of leaks.

DR. BONACA: Okay. Now, if I remember doing the presentation during the subcommittee, you told us that the insulation is going to be modified.

MR. YOUNG: Yes.

DR. BONACA: Although you're going to replace the head in 2006?

MR. YOUNG: Well, yeah, the head, right now we're in the process of procuring the head in 2006. It will be on site, ready for installation. The actual installation may be as late as 2008 or in that time frame.

DR. BONACA: What's happening on Unit 1? I mean, I noticed just yesterday there was an announcement that Unit 1 had been -- a nozzle was leaking at the vessel head. Unit 1 has had a number of leaking problems, right?

MR. YOUNG: Yes, yes, and on Unit 1 the vessel head is on site and is scheduled for installation at the next outage, which is this fall.

DR. BONACA: All right.

MR. YOUNG: Okay. We talked about the vessel head. The service water piping, we're replacing that piping or continuing I should say to replace it. We have been replacing sections of piping. Some of it we're replacing the carbon steel with stainless steel especially on the smaller diameter piping due to -- well, we've had problems with service water piping since the plant went into operation, and we've been replacing that piping, and we will continue to as part of an overall replacement in upgrade programs.

And as I mentioned before, we're continuing to replace the flow accelerated corrosion susceptible piping, and that will continue as long as there is piping that's subject to flow accelerated corrosion.

DR. SHACK: Your service water piping problem is MIC?

MR. YOUNG: The original problems were MIC, especially in the small bore piping, and since the initial identification of those problems, we've changed our chemistry program to add additives to address the MIC problem. So we're continuing to refine and revise our chemistry control to deal with both MIC and other corrosion.

We use lake water for our service water, and it's not very pure water. So there's a lot of issues with that.

DR. SHACK: And the replacement piping is a conventional 300 series austenitic?

MR. YOUNG: Yes, it's conventional carbon steel. For the large --

DR. SHACK: Oh, carbon steel?

MR. YOUNG: For the large diameter piping and then for some of the smaller piping, stainless steel, and we've got --

DR. SHACK: Three hundred stainless?

MR. SIEBER: That's a once through system? Service water?

MR. YOUNG: Yes, service water is.

MR. SIEBER: And so the chemical treatment that you're using is just chlorination?

MR. YOUNG: Chlorination and Ted Ivy is here. He's very familiar with that.

MR. SIEBER: Otherwise you're going to use a lot of chemicals, and they're going to end up in that lake.

MR. YOUNG: Yes, that's one of the problems we have with the chemistry, but Ted.

MR. IVY: My name is Ted Ivy. I'm with Entergy.

The service water system, the chemical treatment we use in addition to chlorination, we also use a dispersant and also a corrosion inhibitor, and you're right. It is once through, but with our corrosion inhibitor the amount of chemicals we use, yes, is rather large, and it's rather expensive, but it's required because of the aggressive nature of the lake water, and that's why we've had this continuing program of pipe replacement.

And we've essentially replaced all of the small bore stuff less than six inch with stainless steel, 300 series, and over the years since that point in time when that was finished in late and mid-'90s, we've been going actively after the large bore piping which we're replacing like with carbon steel, but the big gain we think we're getting from the corrosion inhibitor we're use now is with the existing carbon steel because we are using this now, which in the early '80s there was very little treatment for the existing carbon steel piping. So they experienced a lot of degradation at that point in time.

So our expectation is that the life of the replacement pipe will be a lot better than it was before.

MR. SIEBER: Now, the large pore piping is buried piping, right?

MR. IVY: Not all of it. We have a lot of large bore that's actually inside the building that is accessible to where we could do UTs to identify the condition of the internal as representative of that.

MR. SIEBER: The bulk of it is buried in the ground, right?

MR. IVY: The largest majority of the very large bore is, yes. I think we had ECP.

MR. SIEBER: How can you tell if it's leaking? I mean, you don't measure. You don't hydro it because there always has to be flow through it.

MR. IVY: In most cases what we found and even on the buried piping that if we have a leak usually it will show up as it percolates up through the ground, and we've had several instances that we've been able to find it with that method, and that's usually about the only way we can do it.

We do --

MR. SIEBER: So your detection system is when your hip boots get wet all the way up to the seat of your pants that it's probably leaking.

MR. IVY: Yeah, and as with the current industry standards with all buried piping, that's about the best anybody can do.

MR. YOUNG: Yeah, we do have a program underway right now because of some of those concerns with the current operating condition to study the buried piping and look at options for improvement, such things as coating the pipe. I guess in situ form is a product that's available to actually coat in place the large piping, but there's a number of options being studied, and that's underway right now as part of our overall concern, you know, about the buried piping, particularly the service water piping, which is subject to the aggressive service water.

MR. IVY: And I might add that the overall wall thickness of the buried piping is not significantly degraded. The biggest concern we have is with small pits.

MR. SIEBER: Pits. Well, you know, these problems are not unique to Arkansas. Almost every plant that has a service water system that's fed from anything other than the ocean has this kind of a problem. And to me its significant as related to license renewal that the problem is addressed because detection by looking for wet spots on the ground is not a good method.

MR. IVY: No, and that's why we're doing the studies with our buried piping at the whole plant for both units actually to determine what actions we needed to take for long term because of license renewal, yes.

MR. SIEBER: Yes. Some licensees have service water piping that's big enough to put a person that's in there, and so they do crawl throughs, and if you can't get a person in there, you might want to put a TV camera in there and run it through. You can't do any surface prep on the inside. So any kind of volumetric exam is sort of out of the question, and it's a serious problem and cannot be ignored.

MR. IVY: Yeah, we have sent cameras on our emergency cooling pond return header line because we have done periodic cleaning and have gone in and looked at the overall condition of the pipe.

The largest portion of the buried is the stuff that goes to our emergency cooling pond supply and returns, and we have done visual inspections on those because you can't get access to them.

The ones that actually come from the discharge at the pumps are very difficult to access except during outages because we always have to have at least one loop in service all the time.

MR. SIEBER: That's right.

DR. BONACA: Well, are or can lead-down tests be performed on those components? Are they isolated, pressurized, and then observed, the leak-down rate observed?

MR. SIEBER: Well, you can't isolate the main headers, you know. You need service water all the time. Once you irradiate the fuel, you've got a heat load and you've got to deal with it.

And leak-down is sort of tough because the valves in that system --

MR. IVY: Are not water.

MR. SIEBER: Well, they're typically fire header valves.

MR. IVY: Well, ours are --

MR. SIEBER: They just slow things down. They don't reach --

MR. IVY: But their not leak tights. So you would get leakage, and you couldn't tell whether it was coming through the valves or necessarily from the piping.

MR. SIEBER: If you had shut the valves and pressurized it, the pressure would die off just like that.

MR. IVY: But most of our valves on the system, there are several of them that do have leakage criteria limits, and we actually have to test those, but we don't actually pressurize the whole header.

DR. RANSOM: Are these safety related components?

MR. SIEBER: The service water system is safety related components.

MR. IVY: Yes, it is.

MR. YOUNG: Yeah, this is obviously an issue that we're trying to deal with under our current term to get things, you know, addressed before there's a leak, and we have had some historical problems with leakage in the page, and now through our corrective action process, we're developing some new approaches.

We brought in the structural integrity to help us do some studies. They're piping experts and, you know, to provide recommendations, and again there are some options that we're looking into to further improve the piping and improve the reliability of the piping.

MR. IVY: And we have done some coating on Unit 1. We actually coated one of the lines back in the late '80s, early '90s, a return header, and it has held up very well for the last 12 years.

MR. SIEBER: As far as you can tell.

MR. IVY: No, we inspect it every refueling outage. Send a camera up to make sure the coating has not come loose.

MR. YOUNG: Okay?

MR. SIEBER: Thank you.

MR. YOUNG: Okay. The next topic is our commitment implementation for license renewal, and we talked about this a little bit at the subcommittee meeting, but we provide a little more information in this presentation.

We have 34 aging management programs that we committed to associated with license renewal. Nineteen of those 34 programs are already in place, and that represents 56 percent of the total, but I wanted to add in here that that's actually much greater than 56 percent of the activities that we do associated with our commitments for license renewal.

And what I mean by that is some of these 19 programs that are currently in place include such things as our preventive maintenance program, our in-service inspection program, and our chemistry program, which include a very large number of components and structures in the plant.

And the new programs or the enhanced programs generally tend to be focused on a very few components. So if you look at it on a component for structure basis, we have much greater than 56 percent of the activities already in place and working.

We do have 15 new or enhanced aging management programs that are part of the commitment that are yet to be done.

DR. BONACA: Let me ask a question. During the subcommittee, one of the inspectors told us that when they were looking at the structure, monitoring a masonry wall problem which is already implemented --

MR. YOUNG: Yes.

DR. BONACA: -- they found that the initial baseline examinations were not documented properly. The first five-year examination was not performed, and qualification for personnel responsible for walk-downs were not established.

Could you explain to me? I mean, because we only heard the view of the inspector, and I think it would be good for the committee to hear your view.

MR. YOUNG: Okay. Yes, we wrote a condition report on that item and took some corrective action. It turns out that there was a misunderstanding about when to start. This was associated with a program that has just started about a little more than five years ago, and at that time, the engineers that were involved thought a baseline had been done, and they were waiting to do the five-year inspection, but as it turns out when they went back to pull the records that there were no records of the baseline.

There has been some inspections, but not a full baseline. So we wrote a condition report to get that taken care of.

The qualification issue dealt with the

fact that we were requiring that a civil engineer do the walk-downs, but we hadn't documented that in our procedure to say that there was an actual requirement for that person. It just said an inspection would be done.

So, again, we revised -- the corrective action was to revise the instruction to specifically say what the qualification was for the person doing the inspection.

DR. BONACA: Yeah. Now, this problem is identified by the inspector.

MR. YOUNG: Yes.

DR. BONACA: Okay.

MR. YOUNG: Yes, during the audit, I believe. I think that's --

DR. BONACA: The reason why I asked is that although now has been, you know, they did the 2004 report on the ROP, identified what they call a substantive cross-cutting issue concerning problem identification or resolution, and I was wondering if this was one of the problems there..

MR. YOUNG: I don't believe this particular one was because that issue had to do with some other corrective action. You know, I think one, in particular, that hadn't been even documented in the corrective action program.

DR. BONACA: Yeah.

MR. YOUNG: I don't believe this was one of those, although it certainly could have been.

DR. BONACA: Yeah. We asked these questions about PI&R because I think it's a critical program --

MR. YOUNG: Yes.

DR. BONACA: -- to report to the extended operation.

MR. YOUNG: Absolutely.

DR. BONACA: It is not one of the license renewal programs, but is really the backbone of all license renewals.

MR. YOUNG: Well, actually we included the corrective action program as one of our aging management programs. So we do take credit for it, and you're right. It's probably the most important because it's the one that catches new things that might come up that we don't specifically already have targeted, and things like service water, if we find a leak that's outside the bounds of our existing inspection program, then it becomes part of our corrective action program.

DR. BONACA: Thank you.

DR. POWERS: You've explained how you corrected the specific issues, but the genesis of these issues are things like you said: miscommunications, confusion, inadequate records, things like that. How do you make sure this sort of thing doesn't happen other places?

MR. YOUNG: Well, the overall corrective action program includes a lot of independent assessment of the trending and tracking, as well as looking at other areas of record keeping in the plant, and in fact, that was part of this issue that was mentioned earlier.

And the resolution of that or the current activities to address that have been to provide some additional training to the people at the plant to specifically call out these examples where the corrective action process was not used correctly, and basically to apply the lessons learned from the past. Where did we make our mistakes and why, and what can we do to improve that?

In addition, the plant management now has regular meetings. I think it's on a weekly basis, to look at the trending of the corrective actions, to reinforce the expectation that any sort of issue at the plant that's identified should be written up as a condition report so that we can then track and trend and determine if there's an overall problem.

And then our QA department, in addition, does periodic independent assessments to see if there's some issues. So it's mostly just improving the visibility of the program to the plant personnel, and then the management continuing to reinforce the expectations for writing condition reports.

And I think the region may have some additional comments on that based on their inspections.

DR. POWERS: I hope so.

DR. BONACA: They will.

DR. POWERS: I'd like to hear what you have to say when the opportunity arises.

MR. YOUNG: Okay.

DR. SHACK: Just on the aging management program, one of the sort of unusual features that you have is a nickel alloy cladding on your bottom head, and I didn't really see any particular inspection program for that. How is that actually treated?

MR. YOUNG: Okay. Mark Rinckel from AREVA Framatome is our Class 1 mechanical expert. I hope he's got an answer for us.

MR. RINCKEL: Yes. Mark Rinckel from

AREVA.

That was identified as nickel based alloy that would be placed in the Alloy 600 inspection program. So that's one of the items. Right now it does receive visual examination when you pull the internals out. So that's, you know, what you're doing now.

DR. SHACK: But that's with VT-1, right?

MR. RINCKEL: VT-1, yes.

DR. SHACK: That isn't an enhanced VT-1 or anything?

MR. RINCKEL: No, huh-un. That would be a fallout of the Alloy 600 program and looking at that particular item and seeing if it has high susceptibility and risk and so on and so forth.

DR. SHACK: So that's a kind of remains to be determined.

MR. RINCKEL: That remains to be determined, un-huh.

CHAIRMAN WALLIS: And we also talk about some other inspection commitments. There's the matter of the shutdown heat exchanger tubes. There seemed to be some problem. You can't use traditional eddy current methods or there's some other method which wasn't clear to me that's going to be used. What is the method that's going to be used to inspect those tubes?

MR. IVY: It's called remote field testing.

CHAIRMAN WALLIS: Yeah, what does that mean?

MR. IVY: I'm not an expert on UT. The problem is that these tubes are made out of an E-BRITE material. They're ferritic stainless. So traditional eddy current techniques don't work. The FRT has been used in the industry, and I'm not real familiar with exactly how they do it.

CHAIRMAN WALLIS: This remote field testing?

MR. IVY: Yes. It's a type of eddy current, but it compensates somehow for the ferritic portion of the stainless to where it doesn't throw the signal off.

CHAIRMAN WALLIS: And there's plenty of experience with it?

MR. IVY: Yes, there is. It has been used for quite a few years.

CHAIRMAN WALLIS: And then the other thing is how do you inspect these flexible hoses that you are going to inspect internally?

MR. IVY: What we'll do with the hoses besides doing a visual inspection externally and internally is --

CHAIRMAN WALLIS: How do you inspect them internally?

MR. IVY: Depending on the size of the hose and if it's fairly long you can either use a probe to look down the inside of the hole to look for any cracking. At the same time we'll also take the hose loose and physically manipulate it to make sure that it's still flexible and doesn't crack when we move it. That's what our plan is right now. We may end up doing some additional things besides that.

CHAIRMAN WALLIS: So you stick a probe up in there, and if it's a very long hose, you have to disconnect it and do something else?

MR. IVY: Yes, we would have to disconnect it from the line, yes.

DR. POWERS: I'm dying to see the training for somebody flexing the hose to see if it cracks.

MR. IVY: Well, as far as manipulation is to make sure that it's flexible and that if you do because most of the hoses, they sit there for a long period of time, and they don't ever get moved around. After you flex it, you would do the inspection to make sure it did not crack as a result of that, which would be an indication that --

CHAIRMAN WALLIS: The aging process is a sort of cracking of the outside or something?

MR. IVY: Or the outside or the inside.

CHAIRMAN WALLIS: Well, it will be interesting to see if the calibrated works. And just looking at it, too, I'm not sure how that's going to work.

MR. IVY: Well, and the reason we put that in there is because if you just pull the hose off and look at it and if it hasn't been moved or touched for years, you're probably not going to see anything, but if you do -- if it has become brittle and you do flex it, it is much more likely to crack at that point in time to where you can actually visibly see the cracks.

DR. POWERS: One would think the degradation would be very substantial by the time it cracked in your hands.

DR. RANSOM: Are these periodic inspections or are they one-time?

MR. IVY: These will be periodic.

DR. RANSOM: What kind of time interval?

MR. IVY: I don't think -- we haven't specifically set one at the present time. What we'll probably do is do these initial inspection, and based on the overall condition if we do, of course, find them cracked at that point in time, if we replace them, we will have to do it much more either -- we may actually even commit based on what we find or go ahead and decide to replace them periodically instead of doing a visual inspection. If we find damage to them, it's probably just easier to replace them on some five-year frequency or eight or ten years, depending on the age of the hose.

MR. YOUNG: Okay. And regarding the 15 programs that are still to be implemented, five of them are enhancements, and we have draft procedure changes currently underway for those five. We have ten that are to be created prior to entering the period of extended operation, which is 2018, and our current schedule is to complete the implementation of these ten new programs prior to 2013, which is five years before the period of extended operation.

We have a work-off schedule in which we're doing, you know, roughly one or two programs per year. So it's kind of a linear progression between now and 2013, and the only programs that we're holding to the end of that period are the ones that we're waiting for results from such programs as the MRP to provide guidance or EPRI, which is working on some inspection techniques for some of these programs which currently we don't have as an industry. But all of the others will be done earlier than the 2013 date.

Regarding the tracking of these commitments, we have or have had, I should say, 1,500 commitments for ANO-2 tracked in our commitment management system over the past ten years, which is an average of about 150 commitments per year that we normally deal with.

These 15 new commitments for ANO-2 will be added to that program, and of course, using the raw numbers here means there's slightly more than one per year between now and the period of extended operation, although we're actually working them off at a faster or planning to work them off at a faster rate than that.

But this was just to show that in our commitment management system, we already have a very large number of commitments that we routinely handle, and we will just add these to that system.

The system itself, the commitment management system, is routinely inspected by the NRC. They have a procedure or guidance document, LIC-105, which is where the inspection is done. The most recent inspection and the only inspection that's been done so far was in May of 2003, and the NRC came in and audited our commitment management system and concluded that it was working as expected, and the commitments were being implemented on a timely basis.

So these commitments, these 15 will be added to that system and will be subject to continuing inspection, and I believe LIC-105 shows an inspection frequency of every three years or something on that order, and of course --

DR. BONACA: A programmatic commitment may include many different commitments.

MR. YOUNG: Oh, yes.

DR. BONACA: At the beginning I was thinking, you know, in terms of individually 15, but you'll have quite a workload.

MR. YOUNG: Well, the way we've got it worked out because each one of the program owners is responsible for implementing these new programs and changes, and the workload on each individual owner is fairly low. It's only like one or two program changes, you know, over the next few years.

DR. BONACA: True, true.

MR. YOUNG: So at least from our view, and I'm just talking about from the licensee viewpoint, the workload is not very significant, and we've already given them all of the criteria that was committed to in the application and then has been revised and agreed to through the safety evaluation. So they have a pretty good handle on what needs to be done and when, and now they're in the process of working through that.

Okay, and in summary, I'd just like to say that we're taking the appropriate actions for the safe, long-term operation of ANO-2 through both our equipment upgrade efforts and through our aging management programs, and regarding the commitment management system, I think we're confident that we'll insure the timely implementation of these new and enhanced programs, and of course, as I mentioned, it will be subject to routine inspection as part of our normal inspection process.

So that's all I had on the presentation. Are there any other questions or comments?

Okay. Thank you.

DR. BONACA: No question.

MR. YOUNG: Thank you very much.

DR. KUO: Thank you, and Greg Suber will be making the staff presentation.

MR. SUBER: Good morning, everyone. Good

morning, Chairman Wallis and members of the ACRS. I'd like to thank you for this opportunity to speak on license renewal for ANO-2.

My name is Gregory Suber, and I am the Project Manager for the ANO-2 license renewal application review.

I would like to briefly outline my presentation so that you'll know where I'm heading. I will begin with an overview of the major highlights of the review.

The second portion of my presentation will include a discussion of the regional inspections followed by an overview of the safety review.

In the third portion, I will discuss several current operating issues that are of interest to the committee.

And I will end with a statement of the staff's overall conclusion.

In a letter dated October 14th, 2003, Entergy Operations, Incorporated, submitted an application to review the operating license for the ANO-1 Unit 2 reactor. The NRC staff performed a safety evaluation in accordance with the rule and issued an SER with no open items or confirmatory items on November the 5th of 2004.

The staff issued the final SER on April 8th of 2005, and concluded that ANO-2 has met the requirements of the rule.

As a result of the staff's review of the LRA, the inspections performed by the region, several components were brought into scope for license renewal and some components that did not state aging effects in the application the staff found aging effects requiring management for those components. A few of these components were added after the SER was issued in November and will be discussed later.

CHAIRMAN WALLIS: Can I ask you about scoping?

MR. SUBER: Yes, sir.

CHAIRMAN WALLIS: I noticed that the primary and secondary moisture separation equipment of the steam generator are called consumable items do not support an intended function of the steam generator. This must mean a safety function. I mean obviously they have a function.

So PWRs have steam dryers and BWRs have steam dryers, which have recently become in scope, the cause of events with them, and it was concluded that pieces of them might have some safety effect. Would these PWR steam dryers come in scope some day if something were noticed about them? If there were cracks in them or something? What's the difference?

MR. SUBER: Linda, can you address that question, please? Okay. Excuse me. Mr. John Tsao is going to come and address that question, please.

MR. TSAO: this is John Tsao from Materials and Chemical Engineer Branch.

I review the steam generator portion of the license renewal. So far the industry experience has not shown any steam dryer in the PWR have any cracking problem. So as of now it's not a part of the license renewal.

DR. BONACA: Well, I think also, I mean, we haven't seen yet very large power uprates in PWRs. We have seen those in BWRs, and that's why, you know, that justified our views that for Dresden and Quad Cities, because of the large power up-rate and the new behavior, I mean, then we have the event of the cracking. And so we may see similar behavior if you have power uprates of 20 percent.

CHAIRMAN WALLIS: With the Waterford power uprate, we spent some time talking about these steam dryers and what was the basis for the calculation and so on.

Maybe this is a thing to watch in the

future.

MR. SIEBER: Well, I don't think it has quite the same importance in a PWR as it does in a BWR. You know, a boiler, for example, main steam isolation is very important because that's isolating whatever is going on in the reactor, including the production of radionuclides from the environment.

In a PWR, the steam generators perform that isolating function, and so the main steam isolation valves are a back-up function, which is a second barrier. So in my mind that's why PWR valves are liable to close slower. They don't have the leak tightness requirements that boilers have, and so damage to a main steam isolation valve is not necessarily a catastrophic event from a safety standpoint.

DR. BONACA: But it still could. I mean, if you had, you know, a failure of a steam dryer with pieces blowing down the line, then maybe we will see at that time, but --

MR. SIEBER: Yeah.

DR. BONACA: -- I think you will have to have a significant power uprate to see some effects of that nature.

MR. SIEBER: Yeah.

MR. ROSEN: Are the main steam isolation valves in PWRs safety related components?

CHAIRMAN WALLIS: Yes, they are.

MR. SIEBER: Yes, they are.

MR. ROSEN: Well, then I think it's premature to judge the degree to which it's important. I mean, if they're safety related, interfered with as the BWR valves, we'll have to be careful.

CHAIRMAN WALLIS: So should we conclude that this is all right for the moment, but as soon as someone finds cracks --

DR. BONACA: They'll have to look at it.

CHAIRMAN WALLIS: -- in these devices, then suddenly they will become safety related?

MR. ROSEN: They're already safety related. That was the point.

CHAIRMAN WALLIS: The dryers are not.

MR. SIEBER: The dryers are not.

MR. ROSEN: So the dryers are not, but the valves are.

CHAIRMAN WALLIS: As soon as there's any evidence that they might break it will become safety related?

MR. SIEBER: No, they won't.

CHAIRMAN WALLIS: They won't?

MR. SIEBER: No, but you may pay much more attention to them.

CHAIRMAN WALLIS: Well, they did become safety related in the BWR.

MR. SIEBER: No, they became within scope.

CHAIRMAN WALLIS: They come within scope. I'm sorry. I'm sorry. Okay. So these dryers might become in scope as soon as anything happened or was noticed about them. Okay.

MR. SUBER: Which is why we monitor operating experience.

DR. KUO: Well, Mr. Chairman, as a matter of a process, in our response to HR's letter on addressing the Quad Cities, if you all recall, we have put in place a process that will require the power uprate review later on. Any time we review power uprate, we will review anything that is related to the aging management program. It will be on top of license renewal. Whatever will be affected will be subject to aging management.

DR. BONACA: Yeah, that's the catchall, and that's the important thing we did at that time, was to ask them to perform an evaluation before entering the license renewal period to determine whether or not the experience at the uprate level would justify some modifications to the commitments for license renewal in May and depending on what we see. So there is that opportunity.

MR. SUBER: Thank you.

To continue with the overview, one aging management program was added as a result of the staff's review. A one-time inspection will be used to inspect the internal surfaces of A-2 components in several auxiliary systems.

DR. BONACA: Before you move on, let me ask you a question. You have the previous slide, and you had a number of components added by different means by the inspection.

MR. SUBER: Yes, sir.

DR. BONACA: What does it say about the scoping process implemented by the licensee? I mean, how were the components missed?

MR. SUBER: Right.

DR. BONACA: Because the reason I am asking the question is that the staff only audits -- you know, even the scoping doesn't look at everything. So the question I would like to remind is that this is the floor in the scoping methodology or is it purely that some items were missed or is it lack of understanding on some issues?

I point out the power transmission conductors. I mean that has to do with station blackout.

MR. SUBER: Well, yes, it does. It has to do with the alternate path for a station blackout. What we concluded --

DR. BONACA: I thought that issue was already closed. I mean insofar as ISG being very clear.

MR. SUBER: Yes, sir. Yes, sir, and what we concluded was that some items were missed, but it was not indicative of a flaw in their methodology as stated in a license renewal application. Most of the items that were added to scope were actually added during the walk-down processes, and they were just simply missed.

But the methodology that they described and the methodology as it was implemented by the applicant the staff approved of.

DR. BONACA: Okay.

MR. SUBER: So there were just simple errors.

DR. BONACA: The question is when the inspectors find a number of discrepancies and they catch additional items to be put in scope, do they expand their inspection or do they simply stay, you know, within the same -- or is the inspection remaining the same as they have planned before?

Is there some criterion that you use?

MR. SUBER: I'll go ahead and let Rebecca Nease or Mr. Jim Drake address that particular concern.

MS. NEASE: My name is Rebecca Nease, and I was a team leader for all three inspections, and Jim Drake was a co-team leader for the first two.

This would be part of the scoping and screening inspection, and when we choose what we're going to inspect, we look at the performance of the plant. We also look at the risk significance of the systems we're going to walk down, and we choose the scope of the inspection at that time.

Again, what Greg stated, I agree with what Greg stated in that it looks like when we walked these systems down, the process was right. It was there were isolated human errors in that they just missed some system interactions or when they walked something down, they missed a little piece of it.

But we did not think that the scoping and screening process was flawed.

DR. POWERS: Rebecca, we have this poor

communication, human errors. I mean, it's sloppy.

MS. NEASE: Perhaps, perhaps. But, again, the process, we didn't find anything in the scope that -- we didn't put anything in the scope that was --

DR. POWERS: What they need is something to do things right.

MS. NEASE: Yes, sir.

DR. POWERS: I mean, what you're saying is that they've got a good strategy. They just don't carry it out well, and they seem to have a history here.

MS. NEASE: Yes, sir, and again, isolated human error though.

DR. POWERS: I mean, it's not. We've got a history here. I've had a litany of these things all morning.

MS. NEASE: Do you want to talk about your QA program when you did your walk-down?

MR. YOUNG: Yes. The scoping that we did, you k now, was very comprehensive and thorough. Some of these items were issues where there was some disagreement on the application of the methodology, and in the discussions with the NRC staff, we agreed with their position to make these changes.

But these are minor and relatively small number compared to the overall scope of the program.

DR. BONACA: Okay. So this was more like different views on how the methodology should or should not include --

MR. YOUNG: Some of these -- some of these -- there were a couple of these that were oversights where we actually had a component that we had not included in our application, that when we looked at it again, we realized that it should have been.

There were a few though that were just disagreements on the application of the methodology. They were very isolated.

MR. SUBER: And if I could interject, the components that were brought into scope were A-2 components. So they were not, you know, safety related components. They were components, and there probably is a gray area where we, the staff and the applicant, may disagree as to whether that component actually could affect the safety related component and be brought into scope.

And what we did is we looked at their methodology, and we had a discussion about making that judgment, and the applicant agreed with our argument in many cases. I'm sure in other cases they didn't, but in many cases they agreed with the staff's argument and the components were brought into scope.

DR. BONACA: The reason why I'm asking the question is it's human that when you have thousands of components and drawings and so on and so forth, you may have something where you debate whether or not it should be captured or not. I was asking about does the stuff maintain a flexibility in its inspection process to expand the process if there are doubts about the thoroughness of the process.

MR. SUBER: Most definitely. In fact, in our schedule we have usually allowed a spot for an optional inspection in case during the inspection things arise or open items arise and the staff feels that they need to spend more time on a particular issue.

We always have the option to conduct a third inspection, and actually in the case of ANO-2 there was a third inspection conducted.

DR. APOSTOLAKIS: I understand how as a result of a review an item can be brought into scope. Can you explain to me how a regional inspection would do that? What does the inspector see? What does the inspection find that brings an item in scope?

MS. NEASE: This is Rebecca Nease again.

And in the scoping and screening

inspection, like I told you, we chose the scope of the inspection, and most of what we found was maybe some interaction issues in that you had a system whose failure could affect a safety related component, and in walking down the system, we can see those interactions very readily.

DR. APOSTOLAKIS: So these were primarily common locations of components or --

MS. NEASE: Well, we walked down every -- when we chose the system to walk down, we walked down the entire accessible portion of that system. So anything that was accessible we did walk down.

DR. APOSTOLAKIS: No, but you were looking for possible interactions.

MS. NEASE: Yes. We were looking for possible interactions. We were also looking for age related degradation, maybe some leaking and some corrosion, things of such nature.

MR. SUBER: The big advantage to the regional inspections is that when the staff does a technical review in house, everything is on the drawing or stated in the license renewal application, and it's hard to tell how -- make judgments on these spatial interactions.

DR. APOSTOLAKIS: So it's really spatial

interactions of your review?

MR. SUBER: It's mostly spatial interactions, and in fact, the actual inspection procedure has been revised to emphasize inspecting and walking down special interactions for non-safety related components that may affect safety related components. That's usually the emphasis of the regional inspections.

DR. APOSTOLAKIS: Now, you mentioned earlier, Rebecca, that you're looking at the risk important components, significant?

MS. NEASE: That's one of the inputs when choosing the systems we'd like to walk down.

DR. APOSTOLAKIS: And you do that by choosing the PRA for the unit?

MS. NEASE: Yes, sir, and there are a number of things that we can use. We also look at the performance of the plant, and for instance we chose fire protection system as one of our systems to walk down because at the time they did have, you know, a white finding from fire protection.

So we do take into account current operating performance.

DR. APOSTOLAKIS: What is the core damage frequency for this unit?

(Pause.)

DR. APOSTOLAKIS: Come on. Don't tell me you didn't expect this question.

MR. SUBER: Yes, we did.

DR. APOSTOLAKIS: You seem to be shocked.

MR. SUBER: No.

MR. YOUNG: The core damage frequency is 7.2 times ten to the minus six per year.

DR. APOSTOLAKIS: Six?

MR. YOUNG: yes.

CHAIRMAN WALLIS: Are you shocked now, George?

DR. APOSTOLAKIS: Yes, I am.

(Laughter.)

DR. POWERS: Well, have no fear, George. You did not get the total core damage frequency for this plant.

DR. APOSTOLAKIS: You don't what?

DR. POWERS: You did not get the total core damage frequency for this plant.

DR. APOSTOLAKIS: Is it internal events?

CHAIRMAN WALLIS: I don't know what it is. Is it internal events only?

MR. YOUNG: Yes, I'm sorry. That was internal events, yes.

DR. POWERS: What about all of the other ways you can damage cores?

MR. YOUNG: Yes, there's a number of other ways, but those are the numbers that we have for our --

DR. APOSTOLAKIS: Well, the interesting question is since the staff is focusing on spatial interactions, I'm wondering whether the PRA itself has those.

MR. YOUNG: Has spatial interactions?

DR. APOSTOLAKIS: Spatial interactions, yeah. That would be the sign of a good quality PRA.

MR. YOUNG: I don't know the details of our model. Sorry.

MR. ROSEN: Has the PRA been peer reviewed?

MR. YOUNG: Yes.

DR. APOSTOLAKIS: Has gone through the NEI process?

MR. YOUNG: Yes.

DR. POWERS: Still let me ask you a question. This plant has got a white finding in fire protection, which their fire CDF?

MR. YOUNG: This is the information I have. The fire CDF is a factor of 12 higher than the internal events CDF.

DR. POWERS: There you go, George.

MR. SIEBER: There you go.

DR. APOSTOLAKIS: Almost ten to the minus five then, huh?

DR. SHACK: No, no, ten to the minus four.

DR. POWERS: Almost ten to the minus four.

DR. APOSTOLAKIS: Six was it?

DR. SHACK: Seven times ten to the minus -- eight times ten to the minus six.

PARTICIPANT: It's almost ten to the minus five with internal.

DR. SHACK: Twelve, eight.

DR. APOSTOLAKIS: Still below the goal.

CHAIRMAN WALLIS: Okay. On this subject, I'm sorry to bring it up, but the words "isolated human errors are not indicative of a full methodology" are right from page 252 of your review, but in there it doesn't state that this was corrected. I mean here on your slide it says these components were added.

MR. SUBER: yes, sir.

CHAIRMAN WALLIS: But in reading your SER, I didn't see that this was corrected. So maybe you need to add a sentence that the error was corrected by adding this into scope.

MR. SUBER: Okay. Yeah, it was discussed in another place in the SER.

CHAIRMAN WALLIS: Another place?

MR. SUBER: Yes.

CHAIRMAN WALLIS: Oh, okay, but then how would I know that I looked in the other place?

MR. SUBER: Okay. Maybe we can try to clarify that.

DR. KUO: Just the one additional comment on the spatial interaction. Because of lessons learned, we realize the difficulties and the challenges of the special interaction between systems. In our recent self-assessment for the scoping and screening, actually we have changed the other process, and that we are now asking the region to do all the A-2 review basically, for them to walk down the plant and look at the spatial system interactions.

DR. APOSTOLAKIS: Does the licensee, as part of the application, address this issue?

DR. KUO: No.

DR. APOSTOLAKIS: Spatial interactions? No?

DR. KUO: Well, we realize that the -- we learn from our lessons in the previous reviews, okay? We made this assessment, and the industry as a whole agreed to that.

DR. APOSTOLAKIS: I think I'm a little confused now.

MR. SUBER: I think Mr. Bill Rogers wants to clarify.

MR. ROGERS: Hi. I'm Bill Rogers from Division of Inspection Program Management.

I just want to address the question about his A-2 addressed in the application, the spatial interaction portion. Yes, it is. I led the scoping and screening methodology audit, and during that audit we discuss the various attributes of A-2, and one of those is spatial interaction. It's a lengthy discussion, and it is addressed during that portion. So it's addressed in the methodology audit. It's also addressed in the regional inspections. So it is covered by --

DR. APOSTOLAKIS: So you're just doing it to confirm what the licensee is saying and maybe find additional issues that you may want to debate with them. That's really what happens.

MR. ROGERS: What we do, sir, is we look at the methodology, what's written in the application. We go further than that. We look at the implementing procedures and have a fairly lengthy discussions on this topic with the applicant during the audit. Often this is an area where there -- as you know, this is an area that's been developing over the years. You know, our position has been one of interacting with the applicants to determine what we feel is, you know, the adequate scope in this area.

So during the audit we have our interaction. We will occasionally have RAIs in these areas, and the applicant has -- let me speak in general for the moment.

The applicants have, in general, in the past have done some additional reviews in the area of A-2, as you have seen, you know, with the RAIs that we've issued and they've responded to. This is a very active area that we follow up in.

DR. APOSTOLAKIS: Okay. Thank you.

MR. ROGERS: You're welcome.

DR. APOSTOLAKIS: The first report on system interactions, by the way, was issued what, in 1978 by a group at Sandia? It was the pioneering group. Remember Jack who had the --

PARTICIPANT: Hickman?

DR. APOSTOLAKIS: Hickman, Jack Hickman, yeah. And I think it was because of the ACRS that he did.

MR. SUBER: And listed on these slides are the dates for the regional inspections.

Next slide, please.

CHAIRMAN WALLIS: How did the inspectors satisfy themselves that this method of looking at a flexible hose and flexing it was an adequate way to figure out if it required replacement or not?

This is number 11 of the commitments in the Appendix A, and I just was curious about why the staff accepted this method of inspection of flexible hoses. Maybe it just went right by you.

MR. SUBER: I believe Rebecca Nease.

MS. NEASE: This is Rebecca Nease again. We did not choose that inspection for our -- to inspect. We have to inspect on a sampling basis, and we didn't choose that. I can't speak for the staff.

MR. SUBER: Is Mr. McNally?

MR. McNALLY: This is Rich McNally from EMEB.

And we felt that the flexing of hoses externally and looking for cracks at a frequency of every five years would be appropriate for that. There's not really an established industry criteria for inspection of flex hoses. Primarily you'd get degradation externally that would be detected by a close visual inspection.

If the internal had a different environment, then removing the flex hose and looking at it internally would be appropriate. We also felt like flex hoses would probably be a component that would be periodically replaced, you know, once it was removed.

CHAIRMAN WALLIS: So you felt this. This means it was essentially a judgment.

MR. McNALLY: Yes.

DR. POWERS: Were the flexible hoses made with a Dupont plastic?

MR. McNALLY: It's made from various elastomers. Could be rubber, could be neoprene, could be other elastomer materials. Some of those are susceptible to degradation through UV exposure or exposure --

DR. POWERS: Oxidation.

MR. McNALLY: -- to oxidation from ozone.

MR. SIEBER: That's like cobalt.

DR. POWERS: These things thermally degrade exposed to oxygen whether there's ozone present or not.

MR. McNALLY: Right.

DR. POWERS: I just wondered what the

manufacturer would say about inspecting his hoses by the "flex and look" method.

MR. McNALLY: Well, i think there are some manufacturer recommendations in that regard to do inspections. This is common in the aircraft industry as well, but traditionally these hoses are not going to last for 60 years.

DR. DENNING: I don't have a feeling for the safety significance of hoses. Are there places where there's a high safety significance that we ought to be worrying about?

MR. McNALLY: Well, I would say if the hose failed entirely that would be highly safety significant. If it's a crack that would be developed where you could detect the leakage or weepage through it, through a walk-down, then that would not be highly safety significant.

There are some that's used in fuel oil systems. They're used in diesel generator air intakes, wherever you have vibration you'd use a flex hose.

DR. DENNING: Now, wouldn't these things be part of a preventive maintenance program or not?

MR. McNALLY: That's true as well, and that's why traditionally a five-year inspection program based on preventive maintenance should be adequate to detect degradation in hoses.

DR. BONACA: But it's interesting that by definition you're looking at long-lived passive components. Would you consider a hose a long-lived passive component?

MR. McNALLY: I would not, but the applicant has an option of including these into their program and doing appropriate inspections and replacing them as the need arises.

MR. SIEBER: It could be long-lived.

DR. BONACA: So unless you have a plan to -- well, I guess I understand what they're doing. Okay.

MR. McNALLY: Yeah, I mean, I would urge industry to consider these for periodic replacement and not consider them long-lived passive components.

DR. POWERS: Let me come back to the five-year interval. It seems to me that the agency spent a substantial amount of money to look at the degradation of polymeric materials in a variety of environments and found there was a synergism between the temperatures and the oxygen in the atmosphere, and even the radiation dose that they were subjected to. There was nothing linear about this, that it was, in fact, nonlinear.

When you set your five-year interval, did you consider that synergistic effect.

MR. McNALLY: Well, in general, these are not used in the high radiation areas. They'd be used where oxidation could be a concern or where chemical for the particular application would be a concern, and we didn't look at the specific materials that were used in each of these applications. That would be something that would be more likely done at the site review.

But we felt that in general these hoses are good for a minimum of five years. Usually the shelf life for these things are ten to 15.

DR. POWERS: Maybe you don't understand what I'm asking here. What I'm asking you is did you look at anything quantitative to set this five-year limit, including the fact the aging effects may not be linear, because of synergism between the various aging processes, or was this just a wild guess or one based on the shelf life, which I can't imagine has any relationship to the aging rate in service at all.

MR. McNALLY: Well, shelf life is just a demonstration that the material in an air environment would be expected to last ten to 15 years, but that's under controlled conditions. We didn't look at any nonlinear relationships. We just felt like in general experience for various elastomers, five years would be a reasonable amount of time to expect their life.

DR. POWERS: It's pretty clear that the agency probably wastes its money on the research because we can avoid getting involved in these complicated synergistic studies by just asking people what's reasonable

MR. SIEBER: There you go.

CHAIRMAN WALLIS: Well, you could put it the other way around, that just asking people what's reasonable is the inappropriate approach, that one should use the results of the study.

DR. POWERS: One might think that.

MR. McNALLY: I mean staff is collecting industry data on elastomers that we will use.

DR. POWERS: This is research that the agency sponsored itself as part of the aging program.

MR. SUBER: Thanks, Mr. McNally.

Here we have the results of the inspections. Any item that remained open for the scoping and screening and the AMR inspection was closed on the final inspection that we called an open item inspection that was performed on February the

17th.

And as a result of that inspection, all unresolved inspection issues were dispositioned.

Okay. Now I'll give an overview of the SER. As previously stated, components were added to the scope of license renewal by the staff's review and as a result of regional inspections.

Subsequent to the issuance of the SER in November of 2004, two groups of components were added. The first was a group of A-2 components that were added to the review as a result of the clarified response to a question on the applicant's scoping and screening methodology.

The second was a number of spare parts that were stored in a warehouse and used for hot shutdown repair after fire in a fire protection scenario.

On to the overview for Section 3. Also in response to the regional inspection, the applicant added a commitment for the non-EQ inaccessible medium voltage cables, to include testing of all inaccessible cables, in addition to any measures taken to prevent exposure to significant moisture.

The applicant expanded its commitment for buried piping to include an inspection within ten years after entering the period of extended operation and took an option to credit any opportunistic inspection occurring within that time frame.

DR. APOSTOLAKIS: Okay. So they have agreed to the change.

MR. SUBER: Yes, sir, they've agreed to the new change involved.

DR. BONACA: Looking at the previous statement you made of a non-EQ, inaccessible, medium voltage cables.

MR. SUBER: Yes, sir.

DR. BONACA: Have they specified? They haven't specified yet the way they're going to test these cables, right?

MR. SUBER: No, I don't believe they've actually developed the methodology for testing the cables.

DR. BONACA: But that's good. They committed to test them all.

MR. SUBER: Test them all, yes, sir.

CHAIRMAN WALLIS: I'm a bit puzzled by this. I'm sorry. This business of excavating varied components, what you said doesn't seem consistent with the SER where it stated that excavating such components solely to perform inspections could pose undue risk of damage to protective coatings.

And so it's not proposed to excavate components to perform inspections.

MR. SUBER: Yes. Their commitment, they initially had a commitment only to perform opportunistic inspections. They subsequently expanded that commitment to inspect within ten years of the extended period of operations.

CHAIRMAN WALLIS: So maybe I misunderstood the SER. Maybe there was something in there which has been superseded by something later?

MR. SUBER: Yes, it's superseded by the commitment that was added.

DR. BONACA: Yeah, that statement is identical to the one we had in December where they essentially said, "We're not going to do any inspection unless we have an opportunistic."

And now they have accepted to do a ten-year inspection in case they have not performed before some opportunistic, but my understanding is that there is frequent digging down there. I mean, these opportunistic inspections occur.

MR. SUBER: Yes, and during the review, that was one of the reasons the staff accepted their position initially is because they did have a history of excavating this piping, and they also had good documentation for when those opportunistic inspections occurred and the state of the coating during those digs.

Okay. As demonstrated by the data on this slide, the below ground environment at ANO-2 is not aggressive. However, the applicant uses a combination of opportunistic inspections and periodic inspections of concrete in the service bay to monitor the condition of inaccessible concrete exposed to groundwater, and that's also a commitment.

For an overview of Section 4, during the December 1 meeting an issue was raised concerning the applicant's of 48 EFPY for the reactor vessel TLAAs. The staff performed an additional calculation using 54 EFPY and found that the applicant met the acceptance criteria for the upper shelf energy -- the next slide -- and the applicant also met the screening criteria for PTS.

MR. ROSEN: And it's my understanding that all future applicants will use the 54 EFPY.

DR. KUO: That is correct, Dr. Rosen.

DR. BONACA: Although I believe the next one coming, which is D.C. Cook, also used 48, right?

DR. KUO: I'm sure they will have the data for 54, too.

DR. BONACA: Okay. The option they have is also, you know, rather than just to come down in capacity factor, which they --

(Laughter.)

DR. BONACA: -- which they won't do, but you know, that's why I think it's important to stay with 54 in all these plants.

MR. SIEBER: That are running at 80 percent power.

MR. SUBER: For the Alloy 600 nozzle repair TLAA, the applicant stated in the staff's review determined that fatigue --

MR. ROSEN: Did you skip the prior slide?

MR. SUBER: No, sir. The prior slide was just a statement of the PTS.

MR. ROSEN: All right.

MR. SUBER: Which also showed that the applicant met the screening criteria.

CHAIRMAN WALLIS: By a huge margin for 54.

MR. SUBER: Yes, sir.

MR. ROSEN: But they also did it at 54.

MR. SUBER: Yes.

DR. BONACA: Now, this is the repair that took place in 2000.

MR. SUBER: Yes, sir.

DR. BONACA: Okay. There were several nozzles that had to be repaired.

MR. SUBER: Yes, sir.

DR. BONACA: And they did the half --

MR. SUBER: They did the half nozzle repair, yes, sir.

DR. BONACA: And so the concern here is for those incipient cracks that may remain under the repair.

MR. SUBER: Yes, sir.

DR. BONACA: Okay. And so this is very plant specific.

MR. SUBER: It is very plant specific, correct, and as I stated, the staff determined the same as the applicant that the fatigue crack growth analysis remains valid through the period of extended operation.

DR. BONACA: Have we seen this similar cracking issues for other Combustion Engineering pressurizers?

MR. SUBER: Mr. Medoff?

DR. KUO: Let me ask some of the Material staff.

MR. MEDOFF: This is Jim Medoff with the

Material staff.

There are a number of occurrences of CE facilities having cracks in their nickel alloy partial penetration valves, and they've been submitting relief requests for mechanical nozzle seal assembles or half nozzle repairs.

There have been topical reports submitted on behalf of the industry, and the staff just issued its SE on the latest advise report, which I think is WCAP-15673. So the aging mechanisms are addressed in the staff's SE of the topical report.

DR. KUO: Okay. Thank you.

MR. SUBER: Now I'll move on to the third part of my presentation, which deals with the performance summary. I would like to take a moment to touch on a few issues that are of interest to the committee.

In March of 2004, at the end of cycle assessment, a substantive cross-cutting issue was identified in the area of problem identification and resolution. Inspection findings were indicative of implementation problems in the following areas: identifying and entering problems in the corrective action program; prioritizing and evaluating conditions; and implementing effective corrective actions.

In March of 2004, a significant determination of white was made for a finding that was identified during the triennial fire protection inspection in June of 2001. The finding involved the use of manual actions to operate equipment necessary to achieve and maintain hot shutdown in the event of fire in selective fire zones.

As a result, ANO-2, well, actually the entire ANO facility entered the regulatory response column of the action matrix.

In March of 2005, the substantive cross-cutting issue was closed and the applicant returned to the license response column of the action matrix.

DR. BONACA: So this is just -- yeah, okay. I haven't seen the document that reports this closure, but it has been closed?

MR. SUBER: Yes, sir. It was closed at the end of cycle assessment.

DR. BONACA: So an inspection has been conducted focused on this issue.

MR. SUBER: Yes, sir.

DR. BONACA: And they have determined that the corrective actions implemented to correct the PI&R have been effective?

MR. SUBER: Yes, they have. In fact, if you go to the next slide --

MR. ROSEN: One moment. They closed both the fire protection one or not?

MR. SUBER: yes. The white finding associated with the fire protection issue was closed, and the substantive cross-cutting issue was also closed as a result of the supplemental inspection, the IP-95001, and I think Ms. Linda Smith will give you a little bit more information on that.

MS. SMITH: Good morning. I'm Linda Smith. I'm the Branch Chief from Region IV. I'm here really kind of for two reasons. One is my group is responsible for the inspections of the license renewal, and I also have programmatic responsibility for the region, for implementation of the problem identification and resolution inspections.

Okay. If we could go back a slide, Greg.

Okay. I'm going to separate them out and talk about the substantive cross-cutting issue first, and then I'll talk about the white finding.

The substantive cross-cutting issue was opened in March of 2004. There were problems with identification and also for prioritization and evaluation, and it was fairly substantial problems, well, from a QA point of view.

One of the things, that they had done is they had changed their definition of what type of corrective actions needed to be in the program. So they weren't identifying everything they really needed to.

So what happened was they put in some good corrective actions in place, and we've even verified that now. We've had two things happen. We've had an end of cycle meeting where we've reviewed the results, the current performance, and what they do in the end of cycle meetings in the current performance is they look at all of the different issues that have come up during the cycle and if they start to see trends where people aren't following through and doing all of the problem identification and resolution, they would identify one, and they use that same system to close a substantive cross-cutting issue.

What they say is, "We no longer meet the entry conditions for a substantive cross-cutting issue because now the performance is improved, and so they close it, and that's how you close a substantive cross-cutting issue.

DR. BONACA: Would you have a follow-up inspection later on to verify that the cure has been effective in the long term?

MS. SMITH: Yes. We have a routine inspection that's done every two years, and not really so much by design but by how it just turned out. We just recently completed that inspection, and the results were much better. They had on the order of 7,000 condition reports had been identified, and it was like 30 or 40 percent more than the year before.

DR. BONACA: That is for both units?

MS. SMITH: Yes. It's a common inspection.

MR. ROSEN: Is that a per year number?

MS. SMITH: Pardon?

MR. ROSEN: Is that a per year number, 7,000?

MS. SMITH: Yes, and so what they're really --

MR. ROSEN: Excuse me. For two units, 7,000 for two units?

MS. SMITH: Right, right. And so that's a high number. That means they're really doing a good job of putting things into the system now and working through things. They still had some problems with prioritization and evaluation, but not so much as to not be able to say it was an improvement. I mean, there's work to be done, you know, but I think you can say that of most facilities.

Any more questions about the substantive cross-cutting issue?

Okay, and the fire protection issue, the second one, we had this where we entered the response band because of the white finding. Then we did do the follow-up inspection that Gregory was talking about, the 95001 to confirm that they were okay there.

We did confirm their immediate and their intermediate corrective actions were good, and we reviewed their plan for doing pretty much a reanalysis of their program, and it looks like they're on track to do that.

Any other questions?

Okay. Thanks.

MR. SUBER: All right, and if I could, I'll close with some excerpts from the biennial PI&R inspection, which as you see was just completed and released.

The inspection noted that the overall effectiveness of the applicant's corrective action program had shown significant progress and improvement in the last six to nine months. Specifically, the report concluded that the applicant's processes to identify, prioritize, evaluate, and correct problems were effective, and that an adequate safety conscious work environment existed at the facility.

DR. BONACA: You know, I don't question. I'm pleased to hear this because clearly PI&R is so important to license renewal, but six to nine months seems to be a very short time to assess such a change, you know, when you have a statement of substantive problems.

So I imagine that you will have some follow-up inspection as I was talking about to verify that, in fact.

MS. SMITH: Yes, we actually are always following up every six months. We either have an end of cycle or a middle of cycle, depending on which it is, reassessment of what the performance is. So that's a continuing, ongoing program.

And in addition to that, we have every two years the problem identification and resolution inspection. So we feel like it's bounded.

DR. BONACA: Thank you.

MR. SUBER: So in conclusion, the staff has determined that ANO-2 has met the NRC requirements for license renewal.

This concludes the staff's formal

presentation, and I thank you for your attention.

DR. BONACA: I thank you for your presentation. I think it was well organized.

Any questions from members?

If none, thank you again for your presentation, and I'll turn it over to you, Mr. Chairman.

CHAIRMAN WALLIS: Thank you very much.

I'd like to thank the presenters and the committee for keeping us almost exactly on time. Doubtless we will continue this throughout the day.

We will take a break until 10:15.

(Whereupon, the foregoing matter went off the record at 9:58 a.m. and went back on the record at 10:17 a.m.)

CHAIRMAN WALLIS: Let's come back into session.

We're now going to hear about revisions to the standard review plan. I'd ask my colleague, Steve Rosen, to lead us through this one, please.

MR. ROSEN: Sure. Thank you, Dr. Wallis.

The current requirements for control room staffing are contained primarily in Title 10 CFR 5054(m), the introduction of advanced reactor designs, and the increased use of advanced automation technologies in existing nuclear power plants will likely change the roles and responsibilities and composition and sizes of the crews required to control plant operations.

The current regulations regarding control room staffing which are based on the concept of operations for existing lightwater reactors may no longer apply. So applicants for an operating license for an advanced reactor and current licensees who have made significant changes to existing control rooms will need to submit applications for exemptions to the current staffing requirements, which are in 10 CFR 5054(m), as I've said.

To prepare for this, the staff has drafted a revision to the standard review plan, Chapter 13.1.2 to 13.1.3, which is called "Operating Organization," and that revision to the SRP refers to guidance in the new NUREG, NUREG-1791, for guidance for assessing exemption requests.

And the staff is here to talk to us about that NUREG-1791, which is really where the substance is, and I'll turn it over to Jim Bongarra to lead the discussion.

MR. BONGARRA: Before I begin, Mr. Rosen, I think my Branch Chief Pat Hiland has a word or two that he would like to make, if that's --

MR. ROSEN: Please.

MR. HILAND: Thank you, Jim.

My name is Pat Hiland, and by way of introduction, this is my first ACRS presentation I've attended. I just moved here in November. I have spent the last 21 years in Region III in various positions until I took over my new job as a Branch Chief here in headquarters.

First of all, I'd like to thank the committee for the time that they've set aside this morning to listen to this presentation. I think you'll find the topic very interesting.

This has been a joint effort by the part of both NRR as well as research, and the main presenters are Jim Bongarra, as you already have met, as well as Ms. Autumn Szabo from the Office of Research.

Sitting to my left is Mr. David Trimble. He is the Section Chief within my branch over the operator licensing who Mr. Bongarra works for, as well as to my far left is Mr. J. Persensky, who is a human factors specialist out of the Office of Research.

As you've heard --

DR. APOSTOLAKIS: Who is not here for the first time.

MR. HILAND: Okay. They may not be. I saw a lot of handshaking, and everybody was probably wondering who I was.

But anyway, I think you'll find the topic interesting. The staff has gone through and done a good job at revising the standard review plan, as well as the associated guidance contained in the NUREG, and our end result here is we're seeking the endorsement of the committee for those revisions.

And thank you. with that I'll turn it back to Jim.

MR. BONGARRA: Well, thank you, Pat.

Before I begin, I would just like to briefly acknowledge several people really who have contributed to this project in addition to Autumn Szabo, who has been the Project Manager for this effort.

We had three principal investigators for this effort: Mr. Chris Plott, who is also in the audience, from Micro Analysis and Design, and his colleague, Tom Eng; and Dr. Valerie Barnes, who is with the Performance, Safety and Health Associates. These were the three principal investigators for developing the newer reg.

And in addition, I'd also like to acknowledge two other folks from my section who essentially participated in some early reviews off drafts of 1791 and the standard review plan: Mr. Rick Pelton and Ms. Clare Goodman. And also of course, J. Persensky, who is the senior advisor in Human Factors in the Office of Research contributed as well. I hope I haven't left anybody out.

MR. TRIMBLE: Jimi Yerokun.

MR. BONGARRA: And Jimi. Thank you. Jimi Yerokun, who is the Section Chief in Research. Thanks, Dave.

Meeting purpose.

DR. APOSTOLAKIS: It sounds like a pretty big project, isn't it? All of these people involved.

MR. BONGARRA: A lot of management oversight.

DR. APOSTOLAKIS: What's the result? You should have five -- anyway.

MR. BONGARRA: Okay.

DR. APOSTOLAKIS: Why is it so big?

MS. SZABO: There were a number of project products that actually were generated as a result of this effort.

DR. APOSTOLAKIS: I'm sure they were.

MR. PERSENSKY: Plus this has also taken some time. So some of the people had roles earlier on, but no longer have a role.

Actually Dick Eckenrode, you should have mentioned him, too.

MR. BONGARRA: Well, I didn't want to go through the whole list of people, but they're in the -- several acknowledgements, of course, are in the NUREG itself.

But moving on here, we're here today to ask the committee to endorse two documents basically as Pat said. The first is a revision to Section 13.1.2 and 1.3, the operating organization of Chapter 13, Conduct of Operations of the standard review plan for NRR, and a companion guidance document, NUREG-1791, which is titled "Guidance for Assessing Exemption Request from Nuclear Power Plants," licensed operator staffing requirements that are specified in 10 CFR 5054(m).

I just mention that this NUREG is, indeed, referenced by the revision to the standard review plan. Dr. Apostolakis?

DR. APOSTOLAKIS: Why is it the NUREG? Isn't guidance usually a reg. guide or something? Still part of the standard review plan?

MR. BONGARRA: Well, we're starting at sort of a ground level, if you will, with developing this guidance document, and typically what we have done in Human Factors is to essentially develop our guidance in the form of NUREGs as opposed to reg. guides. That's just been a kind of mode of operation that I think we've had over the past number of years.

I'm not saying that it's necessarily the best one, and we've actually been talking about as an aside possibly looking at elevating, if you will, the guidance that we have in several of our NUREGs that we've been using over the years into reg. guides or some other document.

But for the moment, because of the nature of this particular effort, we're looking at this as a NUREG.

DR. APOSTOLAKIS: That's fine.

MR. BONGARRA: And as I say, it is referenced in our standard review plan as guidance.

With regard to the agenda, we've got four topics we'd like to cover this morning, and I'm going to briefly cover the first three, and Autumn will discuss essentially in detail NUREG 1791.

Let me just begin by providing a little bit of background here in the form of defining essentially what we mean by staffing. As the slide indicates, staffing in a broad sense refers to roles, responsibilities, composition, and size of crews to control the plant under all modes of operation.

Now, for purposes of our discussion today, we're going to limit --

DR. APOSTOLAKIS: I'm wondering really -- I mean, obviously this is something that the agency has been doing for a long time, right? Documenting all these things. Is this really consistent with a performance based regulatory system? I mean us getting involved into what the roles should be, the responsibilities, the qualifications?

What happened to performance based regulation? Let them do it the best way they can, and if the plant is functioning okay, why should I care about the qualifications of the control room operator?

MR. BONGARRA: Well, I think we're at a crossroads to some degree here. What I'm referring to at the moment is essentially what the current regulations are, essentially identifying for the requirements, and it's certainly a possibility that in the future that we may very well -- and that's really what this whole issue is addressing, is the case where applicants or licensees may very well be taking exemptions to what essentially are very prescriptive at the moment qualifications or statements regarding staffing for controls rooms.

And I don't, you know, differ with you, I guess, in that regard, but when you ask the question why, I guess my answer is that's what we have had in the regulation. The future will determine how we proceed.

DR. APOSTOLAKIS: Another point. About 15 years ago, there was a study going on on safety management, safety culture, all of that stuff, organizational factors, and a former member of this committee raised the issue of the qualifications of senior management, and he was told in no uncertain terms that this was something the agency would never do, would never address.

Why are we addressing it for lower level people, like the control room operators? So the vice president is beyond regulation, whereas the control room operator is?

MR. BONGARRA: I think this --

DR. APOSTOLAKIS: Are we taking advantage of the weak?

CHAIRMAN WALLIS: Well, George, the same thing on this committee. You don't have to have any real qualifications to be an ACRS member.

(Laughter.)

DR. APOSTOLAKIS: This is a true observation for the time, but let's address this.

MR. ROSEN: Let's let them go on and we'll keep those --

DR. APOSTOLAKIS: No, I'm really curious.

MR. ROSEN: -- keep those questions in mind.

DR. APOSTOLAKIS: Why is it a no-no talking about the qualifications of a senior manager, but it's okay to talk about the qualifications of control room operators?

MR. ROSEN: We're looking at a regulatory feature. It's in 10 CFR. What we're trying to deal with is what's in 10 C --

DR. APOSTOLAKIS: Ours is not to ask you why.

MR. ROSEN: Well, I think we are about to ask why, but we thought we might let them -- give them a chance to give their --

CHAIRMAN WALLIS: But it's kind of improved, George.

MR. ROSEN: -- give their discussion.

DR. APOSTOLAKIS: This is what this

committee is all about.

CHAIRMAN WALLIS: It's going to improve, George, because they're going to replace five operators by four and one computer, and asking the qualifications of the computer is not a very good question. So they're going to replace it by a better system.

DR. APOSTOLAKIS: I think it's unfair, but anyway.

MR. BONGARRA: Well, I would be hard-pressed, too, to follow up with Dr. Wallis' response, too, about qualifications. So I'm just going to go back into my --

DR. POWERS: It's also useful to remind Professor Apostolakis that life is unfair.

DR. APOSTOLAKIS: Yes. Now, this is the best explanation that I've heard today.

(Laughter.)

MR. TRIMBLE: This is Dave Trimble, too, Operator Licensing Section Chief.

And while we are talking about some historical, you know, how we got here and questioning whether it was perhaps the way we would go if we had to do it all over again, there is a special interest, too, in the operators in that they are licensed by the staff and, therefore, going through that licensing process, we have to have criteria and qualifications.

DR. POWERS: It is also true that on occasions the agency has found upper management unfit to serve in the operation of a nuclear facility, and so it's not that they ignore them.

DR. APOSTOLAKIS: But it's not as formal as this.

DR. POWERS: Well, I think if you get banned, it seems pretty formal.

MR. PERSENSKY: J. Persensky from Research.

The issue of other people, this project is aimed particularly at the licensed operator. Fifty, fifty-four (m) only talks about licensed operators. As far as other people are concerned, there are other ways of addressing them, and management is primarily addressed right now in ANS 3.2, which is endorsed by Reg. Guide 1.8.

So that there are some issues that we do look at when it comes to other than the licensed operators.

MR. BONGARRA: And that's, I think, a good lead-in, if I may, to continue here stressing the fact that, indeed, what we are looking at here are -- our focus is on licensed operators, and again, that's not to say that we're not concerned with the roles and responsibilities and qualifications and composition for plant staff, for example, outside the control room. We're not saying that they're not important.

However, the focus of this particular project and where we see the immediate needs being is to essentially provide the staff with guidance with regard to licensed operators and control room staffing.

As we mentioned, I guess, earlier here, the current regulation that governs control room staffing is 10 CFR 5054(m), which specifies the minimum requirements for on shift operators and senior operators, and that's in the form of the table in the regulation.

Essentially the regulation does, indeed, prescribe the number of operators and senior operators based on the number of units that are operating, the number of units in a plant configuration, and the number of control rooms per unit. As the slide indicates, the current regulation is, indeed, as we've said here, prescriptive in nature for both the numbers and qualifications of licensed staff that are required to be on shift.

We also mention that the regulation does, indeed, reflect essentially the philosophy we have had over the years for lightwater reactors. Needless to say, with the advent of new reactors and the NRC's design certification process under 10 CFR 5052, I think the industry has made it very clear to us, the staff, that the staffing requirements in 5054(m) may very well not be applicable to new reactors.

For the staff's --

DR. APOSTOLAKIS: By "new" you mean --

MR. BONGARRA: Advanced plants --

DR. APOSTOLAKIS: -- Gen IV?

MR. BONGARRA: Well, Gen IV and --

DR. APOSTOLAKIS: AP 1000?

MR. BONGARRA: -- the revolutionary or the evolutionary and the revolutionary or passive reactors.

DR. APOSTOLAKIS: So even AP 1000? I see.

MR. BONGARRA: That entire group, if you will, of what we used to call advanced reactors and now I think the term is new reactors.

DR. APOSTOLAKIS: So from the staff's experience with new plant design certification reviews, essentially applicants for new plants are considering various alternatives to especially staffing of control rooms for these plants. We've seen proposals that indicate control rooms for new plants will quite likely be modular in design and certainly highly automated.

The whole concept of control boards and back panels as we know them today and analog instrumentation and chart recorders that spew out paper tables is a thing of the past essentially. Digital instrumentation and compact work stations essentially will become --

CHAIRMAN WALLIS: You're talking about new control rooms really rather than new reactors.

MR. BONGARRA: Well, in this case, we're talking about new control rooms that would be essentially a component of a new reactor.

CHAIRMAN WALLIS: Could your new regulations apply to existing rectors with quite different control rooms?

MR. BONGARRA: Yes, sir.

CHAIRMAN WALLIS: It could?

MR. BONGARRA: It could, indeed, and I will make reference to that as well, but by all means. As a matter of fact, I was going to mention that in the sense that not only new plants, but there are human system interfaces that are essentially changing for current plants as well.

Back to your question, Dr. Wallis, in the recent few years we've seen several operating reactors who have been upgrading essentially their instrumentation and controls from analog to digital controls and displays. Now, in my opinion, anyway, I don't think it's as likely to happen with an operating reactor as it would be for a new reactor that a licensee versus an applicant might come into the NRC for essentially an exemption to 10 CFR 5054(m).

However, as you mention, that's certainly not out of the realm of possibility. I might also just mention as an aside here with regard to operating plants and the upgrades that have been going on, there has been a project as well, and I think -- well, I know that Research and NRR have been involved to some degree with it. It was a joint project between DOE and EPRI to develop industry guidelines to essentially help the industry to develop standards for and criteria for upgrading their control rooms.

So that effort is certainly an ongoing effort and something that has the industry's attention as well as ours.

Well, with the advent of new technologies and nuclear plant system design, incorporating passive safety features and in the use of digital instrumentation and controls, the role of the nuclear power plant operator will also undoubtedly change. We've talked to the committee on several other occasions, I think, about some of the possible ways that the control room operator's function might change, for example, from essentially a hands-on doer, if you will, to more of a supervisor and a monitor of plant critical safety parameters, for example, and how it might also be possible in the future for perhaps only one or two individuals to have responsibility for operating more than one nuclear unit.

So these are some of the ideas, if you will, that have been proposed, and I'm sure that there are many others that might be proposed as well.

So with these influences in mind, the staff several years ago realized that it will be likely faced with challenges to current regulation in 10 CFR 5054, that is, to the staffing requirements for control room operators.

So to that end, NRR asked research to assist in helping the technical staff to address these anticipated challenges to 5054(m). Essentially we needed a regulatory tool that would be flexible enough to allow us to effectively address a variety of potential staffing configurations.

Now, I said anticipated challenges because, and I want to make a point of that, because essentially to date the staff has only seen preliminary proposals for changes to control room staffing from the experience we've had with design certification reviews for new plants.

I might also add that in our design certification of these new plants, AP 1000, AP 600, et cetera, all of the applicants have essentially committed to the current requirements in 10 CFR 5054(m).

The staffing requirement for certified plant designs has been treated for all the applications we've received as essentially a COL action item. Basically, it's the decision of the combined operating licensee or applicant to follow or not the regulation in 10 CFR 5054, the requirements in 10 CFR 5054(m).

So that's why I'm emphasizing the fact that it's anticipated. We have yet to receive any real request for modifying to staffing requirements.

MR. ROSEN: I guess I don't understand what you just said. You said it was a decision of the licensee to follow or not 5054(m)?

MR. BONGARRA: Yes.

MR. ROSEN: Well, what do you mean by the "not"?

DR. POWERS: You know, you can always seek an exemption.

MR. ROSEN: Oh, seek an exemption at some point.

MR. BONGARRA: Seek an exemption, that's right. I'm sorry. They have --

MR. ROSEN: Either file or seek an exemption.

MR. BONGARRA: Yes, exactly. I appreciate the clarification.

With this said, and I guess kind of in anticipation of a question that may come up later, and I think Dr. Apostolakis already kind of hinted at it, why did we choose to essentially revise the standard review plan and develop a NUREG and not perhaps go to a proposed rulemaking, and I think that's exactly it. It's, wow, we felt basically that we're a little early in this process to do that.

So this is really a first step, and if, indeed, things change over time, I would assume that the possibility is always there for perhaps modifying the current regulation, but it's much too premature to do that, at least in our thinking.

MR. ROSEN: "Supplement" I would choose to use, would be the word rather than "modify," because the existing regulation still applies to the whole fleet, the existing fleet.

MR. BONGARRA: It does.

MR. ROSEN: So you'd have to supplement it with something that says in case of something different than what we have, then do this.

MR. BONGARRA: That's true.

MR. ROSEN: But you have to leave the existing structure in place for the existing fleet.

MR. BONGARRA: That's correct.

This slide basically shows the NRC references there are particularly relevant to the topic of staffing. I'll just quickly mention the fact that the last two documents that are displayed on this slide, the NUREG CR-6838 and NUREG IA-137, are really predecessor reports to NUREG 1791, and the project team used these two documents really to build on on preparing 1791.

NUREG-137, the study of control room staffing levels, I believe, too, was briefed back in 2000 to the committee.

CHAIRMAN WALLIS: I'm intrigued by the

title. I'm sorry. It says here, "Technical Basis for Regulatory Guidance." Because in reading your regulatory guidance, it seemed to me it was almost entirely qualitative, sort of a checklist of qualitative questions, and I don't know how that becomes a technical basis.

What do you mean by "technical basis"? A "technical basis" to me means you've got some quantitative evidence and some sort of analysis and so on.

MR. ROSEN: Well, that's the 6838 document and not --

CHAIRMAN WALLIS: But that's referred to in 391. I just wonder what you mean by a "technical basis" because it seemed to me it was all sort of qualitative questioning, checklist type stuff, and in 1791 I didn't see any technical stuff.

MR. BONGARRA: Well, I guess my interpretation of "technical basis" in this case is the fact that we did research to support the fundamental criteria that we have in 1791. There are bases, if you will, for the criteria.

For example, and I'll mention this again, the criteria that are incorporated in 1791 are not very much different from criteria that we've been using right along for several years and that appear in our NUREG-0711, which is the human factors engineering program review model.

The concepts, the overall process has a literature supported base to it, and in my opinion, that's what we're meaning by technical basis. There's also some evidence and more from the standpoint, I think, of what was done in the study for NUREG-137 that actually had some case studies and experiments, if you will, done to look at different staffing configurations and to determine what kinds of impacts there would be in varying these staffing configurations on the control of a plant.

So that's my interpretation, sir, of what we mean by "technical basis." If anyone else has a comment that they would like to add onto that.

DR. POWERS: The fact that J. is sitting at your table here suggests I know the answer to this, but do you derive any benefit in establishing your technical bases from the studies that are done at the Halden reactor

MR. PERSENSKY: Well, if you look to IA-0137, you will find that, in fact, it was developed based on studies at the Halden reactor where we, as Jim mentioned, literally varied the number of staff.

We varied the control room configuration. We varied the amount of automation and passivity of the responses. So --

DR. POWERS: I wonder if that isn't the technical basis that Professor Wallis was looking for.

MR. PERSENSKY: That may be in part in the sense that that did help to drive us towards the fact that we should be using a more flexible approach because of the results that we received. In NUREG CR-6838, part of what we were looking at, if you look at two very broad areas, one was to look at what is coming downstream as far as what would we expect the various new reactors to look like. How would they perform? What are the kinds of changes we should expect?

So the basis there, though it is qualitative, it was based on what should we be expecting and what are the kinds of changes from what we have now on the street and what we would expect in the future so we could be prepared for what's coming downstream.

The other part of it how have other people looked at staffing. From a human factors perspective, there are many other industries and applications where the issue of staffing has been addressed using various techniques. So we were looking at techniques and methods for addressing the issue of staffing.

For instance, the Navy has been looking at reducing the number of people necessary to run a naval ship by huge amounts, like 70 to 80 percent cuts in staffing. So we looked at that as an analogy to determine what methods they were using, what approaches they were using.

So that's why though it may be more qualitative, those were the bases for why we took the approach we did.

DR. POWERS: J., I actually can't resist asking this question, and you'd probably be disappointed if I didn't. In your studies at the Halden reactor, how does a Finnish operating crew on a Norwegian reactor apply to the U.S.?

MR. PERSENSKY: Okay. This is deja vu all over again, as we say.

(Laughter.)

MR. PERSENSKY: Let's get it straight though again. They were Finnish operators operating a simulator in Norway that is based on their own Finnish plant. So the model for that particular simulator is the Loviisa plant. The operators --

DR. POWERS: Which is a Russian plant,

right?

MR. PERSENSKY: Yeah. The operators were Loviisa operators, and we collected data both at the site from their on-site simulator, as well as at Halden, because their on-site simulator is much more like a standard plant, whereas the Halden simulator is much more like what we might consider as an advanced control room because it's a glass cockpit control room.

And as far as their reactions, their responses, the way they respond to an accident, I would say is not a whole lot different than our operators would in a U.S. situation, given many years of observation of these types of experiments, we don't see great differences in the way the operators actually respond to the same kind of incident.

DR. POWERS: Have you ever done the one-to-one comparison? Take the same accident at the Halden simulator, look at your Finnish operators working on it, then come do it at a comparable -- I guess it would probably be like an ice condenser plant, if anything else, and do the same there and see if you see anything that's at all different.

MR. PERSENSKY: We've never done a formal study to look at those differences.

DR. POWERS: Well, you and I have had this debate before.

MR. PERSENSKY: Deja vu all over again.

CHAIRMAN WALLIS: Well, I asked this question because when we get to the meat of this in sort of Section 10 and 11, where you're actually trying to apply criteria and make judgments and decisions and determine acceptability, what I see is criteria which very often say the methods should be appropriate or reasonable or valid methods have been identified.

But there's no indication of how a reviewer would decide that something is appropriate or reasonable or valid. Maybe there's a technical basis for those decisions, but I didn't see it. That's why I asked this question.

Maybe we'll get to it later on.

MS. SZABO: Actually, we plan on discussing Step 10 much later in the presentation. So you will. I can try to address that question then.

MR. BONGARRA: Okay. Let me then just go to the next slide here, and I'm simply trying to emphasize here how this particular NUREG relates to other human factors engineering guidance that's available to the staff.

Essentially as you can see, this NUREG is on a par with other recognizable guidance for the staff, such as NUREG-700 and NUREG-1764, which we briefed to the committee last year. That has to do with reviewing crediting of human actions in licensee amendment requests.

Each of these guidance documents, as the visual shows, is subordinates to NUREG-800, the SRP, and NUREG-0711, which is the human factors program review model, and indeed, as Autumn will discuss shortly, NUREG-1791, and I think I mentioned this earlier, applies several fundamental steps to address staffing exemptions, and truly, I don't believe it really applies anything that's significantly different from what the staff has been doing for, as I said earlier, the last good number of years.

And lastly, before I turn things over to Autumn, I just want to mention to the committee that both the SRP sections and NUREG-1791 were sent out for public comment in 2004. There are only minor edits essentially to the standard review plan sections, as the slide indicates.

And I might also add that OGC has, indeed, reviewed both the SRP and the 1791 guidance document. They had a few, once again, relatively minor comments, and essentially we are going to incorporate those comments into the NUREG, and they indicated to us that with those comments being incorporated, that they would have no legal objection to either of the documents.

With that said, let me just turn this over to Autumn.

MS. SZABO: I'm now going to talk to you NUREG-1791 in more detail. As you can see here in the slide, I'm not going to go through every single step. This is really the list of steps that we're looking to discuss in NUREG-1791.

I'd like to stress that this is a logical process, and it follows NUREG-0711, the human factors engineering program review model, which is a much more higher level document as shown in the previous slide.

The actual audience for this document was NRR reviewers when they get an exemption request to 10 CFR 5054(m). The guidance in this document is really intended for them to go through and do a comprehensive review.

To add a little bit more to Jim's prior discussion, if we have a newer plant, it might make more sense for them to follow through every single step in detail versus if they get a plant which only requires, I guess, portions. They might not necessarily have to review every single step in this process.

So really the intent behind NUREG-1791 was to allow some flexibility when reviewing an exemption request. Jim has done a really great job of trying to provide the basis. So again, I'll entertain questions as I discuss this.

DR. KRESS: How are you going to tell us what a functional analysis and a task analysis is?

MS. SZABO: Sure, absolutely. As a matter of fact, the functional requirements analysis and allocation will be coming on later in the discussion. If you don't mind, could I delay that question until then?

DR. KRESS: Sure.

MS. SZABO: And then we can talk more about task analysis as well. So we'll make a note of that.

Each review step contained in NUREG-1791 actually includes kind of an overview and introduction, a discussion of that review step, and why it needs to be addressed. It talks to data and information that would be required to support the review step. Again, maybe not all pieces might be required, depending upon the level of exemption they're asking for. This is intended to be a flexible process. So there is still some level of subjectivity with the NRR reviewer.

The review criteria is also included, which provides basic criteria, things that we would expect to see in order to provide a more comprehensive overview of what the licensee has done.

In addition, there's also additional information that typically includes other references and resources that would talk to previous research studies that we've done, other NUREGs that have been published that support a lot of the steps that we have in here.

Some of the specific examples that I'm going to point out now, as I stated previously, we're not really going to talk in detail to every single step. Step 2, one example, is the review of the concept of operations.

Really the intent behind the concept of operations is a description of how the design systems and operational characteristics relate to a licensee's organizational structure, staffing, and management framework. This really is intended to try to provide an overview and provide some context really to the reviewer when they begin the review to understand what's the point behind the plant design, some of the systems' interactions, as well as operator interactions and how all of the systems really operate as a cohesive unit.

As you note in here, there's a new term we've coined, the role of control personnel. Control personnel was selected not to forego current licensed operator staffing, reactor operators and senior reactor operators. First, to describe what we term as a control personnel, individuals licensed to manipulate controls that affect reactivity of a power level of a reactor, manipulate fuel, or direct activities for individuals who are licensed as such.

The reason why we decided to use control personnel is because, again, we're not sure what kind of exemption requests that we're going to be getting it. It's quite likely that there's a lot of I want to say paradigms that are associated with reactor operators and senior reactor operators and that terminology. It's quite likely that there could be some things that come into question under Part 55. It could come in as an exemption request.

Again, we're not addressing that specifically in this guidance, but we aren't ignoring the act that they're quite heavily relying upon one another.

DR. APOSTOLAKIS: Who are the reviewers in this case, Autumn? Are the reviewers engineers or human factors people?

MS. SZABO: The reviewers would be human factors.

DR. APOSTOLAKIS: Human factors. Engineers don't get involved at all?

MS. SZABO: Well, I'm going to kind of defer that one to Jim. Jim?

MR. BONGARRA: Indeed, the principal reviewers are the human factors staff. I mean, if we have questions that are of a technical nature that we feel as though we need some assistance with, we would go to other technical review branches for that information, but this is principally guidance for our folks in human factors, and again, it's part of Chapter 18 -- sorry -- Chapter 13 on staffing, which is our responsibility.

DR. APOSTOLAKIS: So these are human factors experts in the Office of --

MR. BONGARRA: NRR.

DR. APOSTOLAKIS: -- Regulations.

MR. BONGARRA: Yes.

DR. APOSTOLAKIS: So you will not be involved in this because you are research.

MS. SZABO: At some point, you never know what can happen, George. I mean, they may call me to try to assist with some license interviews at some point.

Generally this step would tend to include design operating characteristics of a plant, control personnel number and staffing levels across shift. Again, very general, high level things to try to get a comprehensive overview of the intent behind the exemption request.

Rules and responsibilities on control personnel, and again, including automation interactions, which would be pretty key.

DR. APOSTOLAKIS: So these scenarios that you have there, these are accident scenarios, right? "Defines and evaluates scenarios impacted by exemption request," that's what it says. These are accident scenarios?

MS. SZABO: Actually, you're prompting my next question. So if I may let me start to --

DR. APOSTOLAKIS: That's what I am asking, yeah.

MS. SZABO: Absolutely. Let me start

answering that question for you.

DR. APOSTOLAKIS: Okay.

MS. SZABO: And if I don't answer that, please bring that up again.

DR. APOSTOLAKIS: All right.

MS. SZABO: Step 5 actually is the review of the requirements analysis and function allocation. Ultimately when we do a function requirements --

DR. POWERS: Let me interrupt you because I'm struggling here just a little bit with Step 2.

MS. SZABO: Okay.

DR. POWERS: If we anticipate getting exemption requests because we're making greater use of digital technologies in the control operations, our difficulty we have in control in digital operations is we don't know how to anticipate the things that can go wrong in that control technology. If we can't anticipate that, how can we anticipate what the role and responsibilities of the control room operator will be?

MS. SZABO: When you say "we anticipate," I assume you're talking about NRR.

DR. POWERS: It's the collective "we."

MS. SZABO: Or us as NRC? Okay.

DR. POWERS: It is not the royal "we." It is the collective "we."

MR. BONGARRA: I think that certainly is a very important question, and I think what we're trying to do is position ourselves to have, again, a tool to determine the effectiveness, the adequacy of any exemption to this staffing requirements.

Now, with regard to what you just asked in terms of how do you anticipate what staff is going to be required if you can't truly anticipate what the accident --

DR. POWERS: What goes wrong.

MR. BONGARRA: -- what can go wrong. I think this is truly tied up in the whole issue of verifying and validating the use of the digital technology to begin with, and what we would expect is that there would be an analysis done by the applicant.

For example, to look at the effect of potential software common mode failures, we would expect that that type of an analysis would be part of a design submittal, to begin with, to support --

DR. POWERS: But this is predicated on understanding that engineering will not do the human factors stuff is what you're saying.

MR. BONGARRA: Correct. We don't do this review in a total vacuum. We're just the principal implementers of this particular aspect of the review. But certainly we would expect that there would be support from, for instance, the INC to insure that these systems work the way that they're supposed to work.

CHAIRMAN WALLIS: This will be part of the technical basis presumably. If you're going to replace some of the operators by computers, then you have to understand how computers behave just as you have to understand how operators behave, to perform the functions that you're trying to perform.

And if you are replacing the operators by robots, you'd have to do the same things, but then you would have much more of a technical basis presumably because --

DR. APOSTOLAKIS: I'm not sure that anybody is replacing the operators. Are they replacing operators?

CHAIRMAN WALLIS: If you have fewer operators.

DR. KRESS: They're reducing them.

CHAIRMAN WALLIS: If you have fewer operators.

DR. APOSTOLAKIS: That's too strong a word.

DR. KRESS: Yeah, that's too strong, but the question I have is what role does the PRA play in this. You know, I could envision a plant coming in with the 1.174 process and say we can reduce our operators to this level, and it only increases their CDF this much, and we fall within the 1.174 guidelines.

But I don't see where PRA is showing up in your review process at all. Is it not part of it?

MS. SZABO: We actually didn't include probabilistic risk assessment in the human factors engineering review. Later, I believe it's under Step 9. We eventually talk to human reliability analysis, but, again, we talk to that because it winds up becoming more or less an artifact, if you will, of the staffing design.

DR. SHACK: So your scenario are your design basis accidents. Is that what you're really looking at?

DR. KRESS: Yeah, I'm still struggling with what the scenarios are.

MS. SZABO: Oh, on the functional requirements and function allocation?

DR. KRESS: Yes.

MS. SZABO: I'll start the presentation

again. No problem.

CHAIRMAN WALLIS: Can I say that Dr. Kress has hit on the same sort of thing that I was asking earlier? If I go to Section 11 -- I know you're not there yet -- but the bottom line is the reviewer has to determine that the new system has at least the same level of assurance that public health and safety are maintained as the current regulations require.

Now, how is he going to make that measurement? If it's a CSF measurement, then we have something quantitative we can look at. We can say that the new system is just as good in terms of risk as the old system.

But lacking some measure, I just don't know how this reviewer is going to decide that we have the same public health and safety as we had before.

MR. BONGARRA: I think this would be a case where we would, indeed, be evaluating or not evaluating; we would be assessing to some degree with other review groups input for this particular design. Again, we're not doing this in a vacuum.

So, for example, if a licensee came in or an applicant came in and was justifying the reduction of their staff for their particular design, they very well may refer to either risk information specifically or some risk insights that they've already gathered by doing these analyses.

And that would prompt us, for example, if it was information that we felt was insufficient enough to give us the information that we need to make a determination, we go to the risk folks and ask them: does this make sense to you? Have they actually achieved a reduction in core damage frequency or LERF or what have you based on what they've said, or do we need more information from them to give us a better understanding of that?

DR. APOSTOLAKIS: I'm not sure that there is a human reliability model that will give you answers like that. I don't think that -- this is probably a judgment, Graham. I mean, it's, you know, the traditional regulations.

DR. BONACA: Well, I envision there will be -- I mean, I envision simply for them a new concept where you would have certain requirements for the operator to step back and not to do anything in response to anything because everything happens in an automatic fashion and so that could be a justification for saying, "I don't need to have a contingent of three individuals or four individuals in the control room because, in fact, under high stress situation in response to events, we're asking them to step back rather than to take action.

You know, that kind of thing, it seems to me, you never know how risk informed information would help, but maybe.

MR. BONGARRA: Well, again, it's risk information, but it's also combined with, and I think one of the steps that we have in here is essentially a very important one, is the verification and validation. We need evidence from them to demonstrate or that demonstrates essentially that under various conditions that we're talking about here, accident scenarios, normal, abnormal operations, et cetera, that these changes to the staffing requirements can, indeed, handle those conditions.

So we're not just making a --

DR. APOSTOLAKIS: Can you explain this "evaluate scenarios"?

MS. SZABO: Yes.

DR. APOSTOLAKIS: What's the purpose of these?

MS. SZABO: Functional requirements analysis and functional allocation, ultimately what the intent behind functional analysis is -- we'll start with that -- is to identify processes and activities to achieve a goal of prevention or mitigation of safety related consequences, if you will, that safety related consequences.

DR. KRESS: Does this involve emergency operating procedures?

MS. SZABO: It potentially could, yes, in addition to just normal operating scenarios, as well, both.

DR. DENNING: Yes, but isn't that really where the rubber meets the road, is whether the staff is able to address really the most difficult things, which are the design basis accidents, but also into the beyond design basis space where you have to go to emergency operating procedures and things like that?

And I think one of the things we've been struggling for here is the question are there any quantitative measures that you have, and it seems that the most logical quantitative measures would relate to simulator demonstration where you go into a simulator and you have a crew of five or a crew of four, and you demonstrate that they have the same capability to respond to the entire spectrum.

Now, that gets difficult with future plants that aren't there, and you don't really have the simulators, but it would seem that that's the type of thing that would give you a real quantitative basis for these judgments, whereas everything that I'm seeing here is very qualitative.

MS. SZABO: We actually talk to a little bit of quantitative evaluation, if you will, in Step 10. There is qualitative evaluation as well as quantitative, both. So I think, again, I know I keep pushing this back, but I do believe that some of these questions might get answered as we progress through the presentation.

DR. APOSTOLAKIS: Can you give me an explanation of what scenarios are? Because these guys here assume that you're going beyond design basis. Is that correct?

MS. SZABO: Oh, we're using normal operating conditions as well as --

DR. APOSTOLAKIS: Accident.

MS. SZABO: -- as well as the accident scenarios.

DR. APOSTOLAKIS: Is that design basis accidents or beyond design basis? Are you moving into PRA space, in other words? Was there all sorts of scenarios, or are you limiting yourself to design basis accidents?

MR. BONGARRA: Yeah, we're not doing

anything to change the way we handle Chapter 15 related issues here.

DR. APOSTOLAKIS: So that's design basis.

MR. BONGARRA: That's design basis. There's nothing that's --

CHAIRMAN WALLIS: I don't understand this because these new reactors may well not have design basis accidents.

DR. APOSTOLAKIS: But this is not only for new. I mean, what reactors -- I mean, this is lightwater reactors, isn't it?

MR. BONGARRA: Well, it's both.

MS. SZABO: This is for upgrades to -- well, we're calling it significant upgrades -- to current lightwater control rooms, lightwater reactor control rooms as well as advanced reactors.

DR. APOSTOLAKIS: I mean, you are probably covering Gen III. I mean AP 1000, ABWR. I don't think the intent here is to talk about IRSI and the gas cooled fast reactor, which is way into the future.

MS. SZABO: Well, really the intent overall of this procedure in the first place is so that we would have a very flexible process to cover a wide scope and range. So ultimately this process really could eventually be applied to some of the Gen

IV exempt requests that would --

DR. APOSTOLAKIS: Yeah, but the Gen III reactors will have design basis. They do have design basis. So, you know, let's not get into that.

But the important point is that you are limiting yourselves to DBAs, design basis. You're not going beyond that. You're not going to proceed to a small LOCA with all sorts of components failing, and the question then is why not.

DR. BONACA: Well, no, I'm sure that they have to.

DR. APOSTOLAKIS: They say no.

DR. BONACA: But the applicant, typically an applicant right now relies on EOPs and SAMGs, for example for whatever is being done in the control room. Now, behind those you do have PRAs that have been used to identify the scenarios and all that kind of stuff.

So a departure from those, I mean, an applicant would have to come in and say, "Well, you know, I'm not going to have any more of this."

It seems to me --

DR. APOSTOLAKIS: Well, I'm confused now. I mean, the ACRS says, no, they go beyond design basis and the staff says, no, we don't. So what is the answer?

DR. DENNING: Well, let's hear what the staff has to say.

DR. APOSTOLAKIS: The staff says DBAs.

DR. DENNING: Did you really mean it?

DR. APOSTOLAKIS: Do you want to --

(Laughter.)

DR. APOSTOLAKIS: Do you really mean that or I'm going beyond?

DR. BONACA: I'm looking at page 252.

DR. APOSTOLAKIS: Say that again.

DR. BONACA: I'm referring to page 5252.

DR. SHACK: Five, two, five?

DR. BONACA: This is as broad as it can be. I mean, it's a catchall. I mean, I don't expect that this thing is --

DR. APOSTOLAKIS: I tend to agree with you, Mario, but I mean, if they say this isn't, then you have --

DR. BONACA: This looks like everything is --

MR. ROSEN: I don't understand how you can do a function allocation and not consider beyond design basis space. I mean, there are functions for the operators to take in beyond design basis space.

So if you're doing a true complete function allocation, you're going to go all the way from normal operation through beyond design basis.

DR. BONACA: And in fact, that is so broad that it involves equipment operators. I mean, I would have to address those, too, here because, you know --

DR. APOSTOLAKIS: There are two issues here. One is the rational thinking, which is what you and Steve just expressed, and the other is what the staff is saying. Can we -- not necessarily rational.

I mean, all I'm saying is can we have a clear statement from the staff as to what scenarios are being evaluated?

DR. SHACK: If you look on page 60.

DR. KRESS: Of what?

DR. SHACK: Three, three, one of NUREG-1791.

MR. ROSEN: Give me a chance to get there. Three, three, one.

DR. SHACK: "The NUREG should confirm that the following operational conditions were analyzed or that adequate rationale for not analyzing the conditions was provided. Normal operational events, including plant, should start up, shut down, and refueling of significant changes in operation power.

Failure events, including instrument failures and HSI failures; transient accidents; reasonable risk significant and beyond design basis events derived from the plant specific PRA."

MR. ROSEN: Well, that's the answer.

DR. SHACK: "Conditions to challenge plant safety functions as a result of interconnections and interactions among systems.

DR. APOSTOLAKIS: That's the answer.

MR. BONGARRA: It sounds like I stand corrected then.

DR. APOSTOLAKIS: I've never seen such willingness on the part of some ACRS members to help the staff.

(Laughter.)

MS. SZABO: Thank you very much.

DR. APOSTOLAKIS: Everybody is jumping in trying to help. Okay. Now we know.

Now, allocates tasks appropriately.

MS. SZABO: Yes.

DR. APOSTOLAKIS: Wow.

MS. SZABO: Well, let me go back into a little bit more about the functional requirements analysis. Ultimately the intent is to gain a high level understanding, again, of the objectives. Now, granted it's not as high as the concept of operations has assessed previously. This is more focused primarily on the control functions, if you will.

Again, this is going to be impacted also by the performance requirements and constraints of design.

It also provides a framework for understanding the control of the plant.

Now, I'm going to talk a little bit more about allocation. Ultimately what that does is once you've done an overarcing review, a function requirements analysis, you defined the various functions that are responsible. That's when you start assigning. You start assigning to control personnel, as we've defined here, or you start assigning it to automation, as the case may be.

Ultimately, when we say "allocates tasks appropriately," we took this a little step beyond. The function allocation would be performed first, where we talk about the high level overview again, that particular control function assigned to, say, for example, the control personnel.

When you allocate tasks appropriately, you basically wind up going into a detailed task analysis, if you will, which is actually talked about under Step

6. A detailed task analysis is extraordinarily thorough. It is very granular in a sense where it picks apart every little piece, part, various equipment, time and timing requirements.

This actually to some degree might talk to some of the qualitative things that you were interested in previously.

DR. APOSTOLAKIS: So this is detailed because somebody has tried it on a simulator or is it because people look at it and say, you know, this is what the operator is going to do and this is reasonable?

Why do you say "extraordinarily detailed"? I mean, how do you know?

MS. SZABO: I've done one before.

Well, typically in function requirements and function allocation, again, that's the general function. We provide what the scope of the control function is.

When you go the next level down the task analysis would look at the sheer function of what a task analysis is about and what it does. Is it actually -- it breaks down into those functions in extraordinary detail. Often task analyses winds up being the basis for procedures, training, various human system interface design.

DR. APOSTOLAKIS: But at which point are you asking the question, if you're asking the question, physically how are you going to do this? Are you going to walk there and push a button or you're going to stand here?

Is that happening at any point in time?

MS. SZABO: Actually we are going to be talking about that in Step 11 where we talk about staffing plan validations.

DR. APOSTOLAKIS: Boy, Step 11 is really something, huh?

MR. ROSEN: That's what they do. They work through the actual detail of what someone does. and where.

MR. PERSENSKY: If I may --

MS. SZABO: Well, and actually if I can point very quickly to something in NUREG-1791 that will talk to the level of detail, there's a table in here that really does extremely explicit, I guess, criteria, 262, Table 2, task performance criteria.

J., you can add detail at this point here if you'd like.

MR. PERSENSKY: I understand that this is in here, but you know, currently and ever since post

TMI human factors requirements went out, the plants have been developing task analyses for current plants in order to develop their training, and it's part of the INPO accreditation requirements, in order to do procedures, in order to do control room upgrades, and actually I know that there's a process going on right now for the licensing, operator licensing.

This was all a whole basis for a lot of the human factors changes that came about, was function task analysis. So this is not really anything new.

The difficulty in this situation is when we're applying it to new plants where you may not have everything on the ground yet. So you have to make certain assumptions, and that's where we're trying to drive them, is to not lose that effort in terms of doing function task analysis because that's how you decide who does what and whether it's done by people or it's done by machines.

MR. ROSEN: And how you train the people.

MR. PERSENSKY: And how you train them, how you write the procedures for them, how you decide on what qualifications.

DR. APOSTOLAKIS: Wouldn't there be a difference though, J., between a review of an existing

LWR and saying AP 1000 where you don't have a control room?

MR. PERSENSKY: Yes, there would, and you have to make certain assumptions. One of the things is this is laid out in a nice step-wise fashion. In fact, there's a lot of iteration that goes through if you look to the IEEE standard that's referenced, 1023. There's a process, but there's a lot of iteration depending on where you are in the design process.

So if you're in an early design process, you're making certain assumptions, and you're taking sort of big blocks. That's where we're talking more about functions. As we get closer to either mock-ups, simulators, or in some cases using human performance simulators, that's when you get into the more detailed tasks.

Until you have something to test and to run these tasks on, it is hard to get to the detailed tasks, but there are certain assumptions that you make, certain assumptions that engineers make in the design process. During design I think, "I'm going to design this for a two-person operation," or I'm going to design it for a four-person operation.

So we have to look at this as an iterative, long-term process. It's not bang, here it is.

MR. TRIMBLE: Yeah, this is Dave Trimble, Chief, Operator Licensing.

It could be that this exemption process could end up being a driver to cause would-be applicants to think all this thing out in advance so that they could get the exemption approved at the time of COL and avoid any legal potential challenges later on.

And so it could be a driver to think it all through and actually develop and build the simulators before embarking much further on the process, construction.

MS. SZABO: Okay.

DR. SHACK: In the sequence of things, I mean, the buy is going to have the control room at the plant all built when he walks in and asks for this exemption, right? He doesn't ask for this -- when does he ask for the exemption in the process?

MR. BONGARRA: I think the answer is we're still developing it, but I hear and I have to confirm this, but I think the idea is to get the exemptions done at the beginning of the process.

DR. SHACK: So even before he has a control room in place, he's going to come in and ask for an exemption.

MR. ROSEN: As part of the COL?

DR. APOSTOLAKIS: Yeah, otherwise it would be too expensive, would it not?

MR. PERSENSKY: Yeah, one of the drivers for this work, in fact, was a letter from Exelon when they were considering the PBMR. In one of their white papers, they indicated at that point that they anticipated seeking an exemption.

So whereas Jim indicated most of the evolutionary reactors, the vendors who were selling those reactors have not asked for an exemption, but have left that to the stage at which a potential licensee would come and say, "Okay. I really want to run it with fewer people than 10 CFR 5054(m) calls for," because of these reasons, and actually what we're trying to do is to give them the basis for coming in and saying, "This is why I'm asking for that exemption."

MR. BONGARRA: As the committee may be aware, NEI is in the process of engaging the staff on the review of a document that's NEI 04-01, which essentially is a guidance document to the industry to assist them in preparing COL applications, and as I say, this is a draft document. It's something that we're working with the industry on. At the moment, the industry is making the assumption that by the time an applicant, a COL applicant, is ready to submit their application, they will have, indeed, identified the scope and responsibilities of each or the main control room positions considering -- and I'm reading from this document -- "considering the assumptions and results of their task analysis."

So that's what the industry is proposing at the moment.

MR. ROSEN: So they're going to do it up front. They're going to do their task function allocation and task analysis up front, and that way they're going to have to have a basis upon which to apply for an exemption, and some reasonable likelihood that they'll have whether they could get it or not.

That won't make sense to me.

MS. SZABO: Moving ahead, getting into Step 10 --

CHAIRMAN WALLIS: I'm sorry. This we have here is not the same as the one I reviewed, and it says it was completed in June 2005.

MR. ROSEN: That's next month.

CHAIRMAN WALLIS: It seems a little miraculous. I'm sorry because some of the quotes I've given you from the document that aren't in this one here.

MS. SZABO: Well, did you request our hard copy early on?

CHAIRMAN WALLIS: I got something on a CD, which I read and studied, and it's not the same as what I've got here in some -- the details.

MR. ROSEN: Yeah, this one says date published, June 2005.

CHAIRMAN WALLIS: It says manuscript completed June 2005.

MR. ROSEN: Yeah, right, and date published

CHAIRMAN WALLIS: Yeah, okay.

MR. ROSEN: The electronic copy says the same thing though.

MS. SZABO: That's why I'm confused.

CHAIRMAN WALLIS: There are some words that I took out of my copy which are not the same. It's just I'm sort of saying it in passing.

And one of the things that was taken out was this same level of assurance of public health and safety and maintained as the current regulations require. That has now disappeared from your document. So that's the whole basis of my asking what's the measure of public safety so that if someone has decided that's too dangerous a thing to say and it has been excised from the document.

MS. SZABO: Actually what page are you referring to?

CHAIRMAN WALLIS: Section 11.

MS. SZABO: What's that?

CHAIRMAN WALLIS: I don't want to distract you. You've got to finish your presentation.

MS. SZABO: Well, and I'd like to determine whatever that error is. So --

CHAIRMAN WALLIS: I don't know that it's an error. It just seems to me that someone has decided that facing up to what's the measure of health and safety was too tricky. So we'll cut it out of the document.

Okay. Anyway, where is it? Did I miss it?

DR. DENNING: It's here. It's the last bullet on --

CHAIRMAN WALLIS: Is it hidden somewhere?

DR. DENNING: -- 11.11.1.

CHAIRMAN WALLIS: Oh, it is there, but the words are slightly different. Okay. Okay. That's all right. That's all right. I'm sorry.

DR. KUO: Continue.

MR. SIEBER: Well, you solved that problem.

CHAIRMAN WALLIS: Again, my apologies. Straighten me out.

(Laughter.)

MS. SZABO: Thanks. Thank you, by the way, for your assistance in trying to help me resolve some of these issues.

To get into more detail about Step 10, reviewing the staffing plan validation, again, the staffing plan validation we're anticipating would be submitted by the licensee. Ultimately we would want to evaluate their staffing plan and what they're proposing on the exemption request, using what we call performance based tests to determine whether the staffing plan actually meets performance requirements and supports safe operations.

As it states here in the bullet, we actually were hoping that they would give appropriate consideration to dynamic interactions between the staff print and various other systems saying computer automated systems and such.

CHAIRMAN WALLIS: I think that's very important. The applicant, it's on the top to the applicant to make these performance based tests.

MS. SZABO: That's correct.

CHAIRMAN WALLIS: And to determine the measures and criteria, and then to submit these in a logical way. You're not going to tell him what the measures and criteria should be apparently. It's up to the applicant to determine those things.

MS. SZABO: That is correct. We're anticipating that the applicant would come in with whatever measures they decide to use. In the guidance document itself, we actually talk about more or less things that, I guess, would be considered acceptable in our current state of knowledge, if you will.

CHAIRMAN WALLIS: As far as you haven't given more guidance on what these measure and criteria should be?

MS. SZABO: We actually gave a little bit of guidance in here where we talked to what we call situational awareness and cognitive workload. The technical basis document, NUREG CR-6838, actually talks in a little bit more detail in the appendices operation. So some of that literature searching and, I guess, the qualitative element of the technical basis is actually talking 6838 in more detail.

We talk about that at a high level here

just to do it for posterity's sake, if you will.

MR. ROSEN: But the bottom line, the big picture statement has got to be -- confirm this, if you will -- that adequate numbers of qualified people are available to take action in a timely manner.

MS. SZABO: Absolutely, and accurately without omitting any actions. Qualify that temporarily.

MR. ROSEN: That's the global statement of what's adequate.

MS. SZABO: That's correct, and of course, that's going to be, as you know, conditioned, plant dependent.

MR. ROSEN: Of course. And because of a timely manner, plants with very slowly developing scenarios are designed, in fact, to have very slowly developing scenarios have more time to bring in adequate numbers of people to take action in a timely manner.

MS. SZABO: Absolutely.

MR. SIEBER: So that they could have different staffing plan and different concepts of operation.

MS. SZABO: Absolutely. We actually asked the staff to look at the operational condition sampling, the measures and criteria proposed by the licensee. Again, we talked to time, accuracy, and omission of actions per se as potential measures, if you will, observable actions, if you want to call that quantitative, as close as we can get it when you raise two measures.

And actually we were also proposing that the assessment should include a range of operational conditions. Typically that, of course, would challenge the operator, as well as the behavior of the plant and the systems and show, again, human performance variability.

Now, talking in more specifics under the human performance variability, and I'm just going to mention this very briefly, we actually talked to cognitive workload, and cognitive workload is the degree to which cognitive and perceptual capabilities are taxed. Cognitive workload has been studied for a very long time, and there's a significant amount of literature discussing it. So we're actually looking to if they could submit something to the effect that if this taxed operator load, it would only be in their favor.

Situational awareness, again, another common human performance tool. Situational awareness, for those of you who are not aware of that, is individual's mental model of what has happened, what the current status of the system is, and what will happen in the future, mental model being, I guess, more or less the understanding of the personnel, if you will.

CHAIRMAN WALLIS: Can you measure cognitive awareness?

MS. SZABO: I'm sorry. What?

CHAIRMAN WALLIS: Can you measure cognitive awareness?

MS. SZABO: Cognitive workload or situational awareness?

CHAIRMAN WALLIS: Cognitive awareness did you say?

MS. SZABO: Cognitive workload or situational awareness. We actually have a number of subjective measures that have been developed under subjective.

CHAIRMAN WALLIS: Can you measure what's in the mind of this operator?

MS. SZABO: Through various means, absolutely. Interviews and things of that sort, yeah. Again, there's a significant body of literature.

Actually there's a discussion focus,a

gain, as I stated in NUREG-6838, and again, if anyone is interested and they'd like a copy, I can get you a copy of that.

We recommend that you cover these information, these measures through potentially as we know it now four different methodologies. A tabletop analysis, which is generally where experts gather and then try to do estimation of times and such. Data from operational experience, other plants that may have similar control rooms, similar configurations or even the same plan.

CHAIRMAN WALLIS: It's got to be difficult with the first one.

MS. SZABO: Tabletop?

CHAIRMAN WALLIS: The first one. It's going to be difficult to get an operational experience with the first prototype.

MS. SZABO: Absolutely, and that was actually a concern, is that there isn't a lot of operational experience available, but it's a good point.

Of course, what we call human in the loop simulation studies where we actually have the operator go and perform some of the tasks and such to validate, again, the staffing plans as well as human performance modeling where they basically construct models based off of various task analyses or task analyses based methods, such as task network modeling to explore the staffing plan and challenge the operator.

Those are the only examples I planned on talking about. So I hope I've answered everyone's questions here.

NUREG-1791 actually went out for public comment along with the standard review plan, 13.1.2 and 13.1.3. We had one public comment that we received actually from somebody of a foreign nature, which was interesting.

The three, I guess, major things that came out of the one comment was they requested some clarification on the terminology that was used in the NUREG. They also asked for the clarification on intent, and there was a concern about the exemption request review process specified in 10 CFR 50.12 and how that coincides with potential issues with a failure of the proposal/exemption, which I believe we've discussed at some level here previously.

MR. ROSEN: I don't understand what you men by given the failure of the exemption.

MS. SZABO: Well, the comment pretty much talked to the fact that there's a lot of design effort that winds up going in in the front end, as you're aware of the bathtub curve in terms of cost and such, where there's going to be a lot of systems engineering processes, a lot of iteration and such.

The original, I guess, interpretation from the person that sent the comment was that the design would be completed; we'd go through all of these detailed analyses and reviews and such, and then we'd throw, you know, the exemption request to the NRC.

What happens if, you know, we've gone through all of this design analysis; we've gone through all of these justifications; we've gone through this process, for example, and now all of a sudden, you know, we don't have 5012 any longer, you know; we can't meeting 5012 or the NRC decides not to grant our waiver; what then?

We've wasted all of this money and all of this time only to potentially have to go back and review, you know, everything all over again and potentially redesign the whole system.

The answer to that is we actually have a pre-application process that the Commission has encouraged where if there are questions that a licensee or vendor may have, they could actually come in and meet up with the staff and list some of their proposals and such and we basically would sit there and work with them and try to figure out what some of their basis for their decisions were.

CHAIRMAN WALLIS: I'm thinking about AP 1000, and we approved a design and there's a design certification that's now out for public comment or something. It seems to me that the control room and how it's operated and all of that was not really a part of our review.

DR. KRESS: No, and it was one of the exemptions to put out to the COL.

CHAIRMAN WALLIS: And yet it is something which is really going to be perhaps key to the operation of this reactor. I mean, they do have to have a really good control room. They do have to have adequate people in it and so on, and yet it is not something that we --

DR. KRESS: That was one of the high tech items put on the COL.

CHAIRMAN WALLIS: -- not something that we considered.

MR. BONGARRA: That's, indeed, correct. It's a COL action item and hence the fulfillment of it was deferred to the COL.

MR. THADANI: The control room staffing

for the AP 1000 was one of the items, the DECS item which would be handled the COL. So right now is the design certification. It does not have it.

MS. SZABO: So in summary, there's been very minor changes to the standard review plan, as Jim discussed previously, that really just reference NUREG-1791. There were a few changes to NUREG-1791 based off of the one public comment that we received, and ultimately NUREG-1791 provides regulatory staff with guidance to review exemption requests to 10 CFR 5054(m), staffing requirements.

If there's any questions.

DR. DENNING: I have a few concerns, and those are related to the degree of subjectivity of the evaluations as I see it, and it seems to me that here we have a regulation. You have to have a pretty strong case to provide exemption to that regulation, and I think that you want some real objective demonstration that you have a similar level of risk to what we have now.

And I think that it would be very difficult to do it on a purely PRA based method because PRA doesn't do a very good job of this particular type of thing, but I think simulators do, and so were it in an existing plant that wanted to make a change, I could see how they could develop a case where they ran the simulator with X number of people and then they changed what the task assignments were, reduced the number of people, ran that through the simulator over the full spectrum of these challenges and demonstrated that they're just as good with the one as with the other, perhaps with an improved INC system and like that.

I would like to see things of that nature as clearly for future plant designs. It becomes more difficult there, but I see a problem at the conceptual design level certainly. I mean, the problem is that these plants will not have the simulator, I fear, at the COL time.

So can you get the same level of assurance, and I don't know whether you can or can't,b ut I'd certainly rather see -- I'd like to see some guidance that expects that degree of demonstration whether it's a full scope simulator or whether it's an analytic simulator. You know, certainly you'd like to see a full scope simulator and have them demonstrate it like that.

So I have concerns that it's so subjective. Even though you go through all of the task analyses and that type of thing, which I think is a minimum requirement that you have to do, but I'd like to see something a little more objective that demonstrates that they really can operate the real system with a reduced staff.

Whether you can provide more guidance than that I don't know, but I certainly see how you could do that for an existing plant that changes its INC system.

MS. SZABO: Well, if I may, I just wanted to talk to that very quickly. I mentioned very briefly earlier about one of the things that we recommend actually is human computer simulation. There's actually a number of human computer simulation tools that are available out there that are based off of task networks, task analyses, if you will, and task network modeling.

That could very well provide some level of objective insurance, of course, depending upon how well you model and some of the assumptions that you use when you build those task network models, but that could reasonably be considered to be an objective measure.

We actually have done a number of studies here at the NRC where we've looked at human performance simulation directly actually in concert with the staffing studies that we've done sine the early '90s.

I'm not sure if that really talks to your concern.

DR. DENNING: Well, that's certainly the direction that I'd like to see it. I'd just like to see it more obvious here in guidance that we expect that type of thing to be done, and it's not just paper studies or task analyses without some objective demonstration against some kind of a tool that they really can do it.

CHAIRMAN WALLIS: So you'd like it spelled out in Sections 10 and 11 a bit more clearly.

DR. DENNING: Yes.

MR. PERSENSKY: Section 10 goes into some detail on that. It may not get to the detail of specifying. In fact, we purposely tried to keep this as flexible as possible, but Section 10 does talk about the use of various types of simulation, both as Autumn mentioned, the human performance simulation, but there are other ways of doing it as well.

In fact, I just returned from a Halden meeting where they have been using virtual reality to simulate the control room and are collecting a great deal of information in some of the changes that they have been applying for the Swedish plants where they use a virtual control room as opposed to a real control room as a way of verifying some of those types of information.

So we were trying to be as open in this process to allow for the technologies that are coming downstream without specifying specifically that you have to have a full scope hardware simulator, so that there are elements here, and again, as I mentioned earlier, some of this is going to have to be iterative in terms of where they are in the design process.

DR. SHACK: I guess that's my confusion. You know if I can see the iterative process for them as a designer, you know, I mean, if I was a designer of a control room, I'd have this document in front of me. I'd know what my target is. This is what I have to be able to demonstrate to you, and then I go off and I go through my design until I'm confident that I can meet it.

You know, so I go through that. I'm not sure why you have to accept his conclusion that he's going to meet it before he actually builds the plant and the simulator and can demonstrate in a more concrete way that he can really do it. But, I mean, i can understand how he has to do this all up front iteratively.

But you're not going to be going through iterations. He's going to bring you the case and you either accept it or you don't, or he has to go back and do some redesign or requalification.

MR. PERSENSKY: Well, the process here as with the entire licensing process is we allow for RAIs. If they don't provide the information that we feel is necessary, we go back to them and ask for more information.

So that becomes part of the iteration.

MR. BONGARRA: I think it's also possible that an applicant realizing what it is we are expecting them to have and what they're basically telling us at least in this draft NEI document that they will have, they'll realize perhaps that they need to come in and discuss things, as Autumn was saying on a preliminary basis.

I mean, we encourage that kind of dialogue.

DR. SHACK: Well, I guess what makes me feel better is that, in fact, when you license the operator, he is going to be on the simulator, and he's going to have to pass a whole batch of tests that look a whole lot like what he's going to have to do to qualify this thing, and if the operator can't pass those tests, then, you know, you're going to have a problem qualifying an operator for this thing.

So there is, I guess, a back-up that will actually work on the real simulator and provide some sort of more quantitative, to me, confidence that this is going to actually work.

MR. SIEBER: I think it's sort of interesting if you take a today plant and a single operator and put a design basis accident or beyond design basis accident on that plant. That single operator is likely able to handle it, and so the requirement typically is for a single unit you have two in case one of them drops over dead. You still have another operator there, plus a supervisor basically to read the procedures to them.

The real question is when you talk about modular reactors where you might have two, three, four, five reactors. How many people do you need then? What assumptions do you make about one reactor having an accident? What's happening to the other ones?

You know, I worked in a coal plant at one time, and if one of the boilers got in trouble, all the operators would go to that boiler and the rest of the plant would go winging off into the distance, you know, and if you had two of them, you couldn't handle it, too confusing.

And so the tricky question is how are you going to deal with modular reactors where you may have two or three or four of them undergoing different accidents at the same time. And I didn't see that addressed.

CHAIRMAN WALLIS: It's so unlikely in the PRA. You don't have to respond to it.

MR. SIEBER: Yeah, right.

MR. ROSEN: Yeah, i think having multiple different accidents in different plants is unlikely, but having an accident in one plant, a trip and transient on the other resulting from the accident because of a disturbance on the electrical system due to the loss of the output of the first plant perhaps while another plant is going through refueling operations perhaps is quite likely.

MR. SIEBER: I don't think so.

DR. APOSTOLAKIS: I don't think -- I mean, modular reactors, we'll revisit that in the future. Nobody is going to build AP 1000s as --

MR. SIEBER: Well, that's one way to get rid of the problem.

MR. ROSEN: Well, I don't think we're going to revisit this part in the future. This is the basis for the future.

MR. SIEBER: This sets the ground rules.

DR. APOSTOLAKIS: When somebody proposes to build modular reactors, I think there's going to be a major rethinking of everything.

MR. ROSEN: But this definitely will be on the table presumably.

DR. APOSTOLAKIS: I know. This document, by the way, you're asking us to write a letter, right?

MR. ROSEN: Yes.

MS. SZABO: Correct.

DR. APOSTOLAKIS: Is this document being reviewed by anybody else right now? Is it subject to change?

MS. SZABO: Ah-ha.

DR. APOSTOLAKIS: Well, I'm tired of reviewing things that are subject to change.

MS. SZABO: Actually the Office of General Counsel might be providing their comments.

DR. APOSTOLAKIS: Yeah, but they are looking at other things. How about the committee to review CRGR, whatever it is?

MS. SZABO: CRGR has not yet reviewed this yet, but we are currently requesting a waiver for that review because this is not considered a backfit.

DR. APOSTOLAKIS: I think we have to do something about it, Mr. Chairman. We cannot review documents that are subject to somebody else's review and change, and this has happened in the past. You know, the final document was not the one we reviewed.

Anyway, that's not your problem, of course.

MR. BONGARRA: Well, we did anticipate. We did send a letter out to CRGR. We actually sent two letters out to CRGR. The first one asked for a waiver up front before we actually sent this material out for public comment, and they accepted that.

And we sent out another letter to them a few weeks ago, requesting a response from them as to whether they would want to review this or not, and we have not heard at the moment back from them.

DR. APOSTOLAKIS: What I don't understand is not just today, but very often the staff comes before the ACRS before the CRGR, and I don't understand that. Is the CRGR much more difficult to put stuff on their agenda, or what? Why are they the last ones? Aren't we supposed to be the last ones?

DR. KRESS: No.

DR. APOSTOLAKIS: Well, when you approve something, Tom, I mean, you have a reasonable expectation that that's what's going to be published.

DR. KRESS: We approve what we have before us.

DR. APOSTOLAKIS: Now.

DR. KRESS: If it gets changed, why, then there's a decision whether it's a substantial change or not, and then it will come back to you.

DR. APOSTOLAKIS: Because then it would come back to us because it was a substantial change. I don't recall a single case.

CHAIRMAN WALLIS: This is something that's a generic problem.

DR. APOSTOLAKIS: It's a generic problem.

DR. KRESS: It's an issue.

CHAIRMAN WALLIS: This one is going to be so perfect that it's not going to get changed.

DR. KRESS: Yeah, I, for one, don't want to wait till everything is perfect and not done subject to any change.

CHAIRMAN WALLIS: We've got the June version here anyway. So it has already --

DR. APOSTOLAKIS: But you would expect it to have come through the reviews of the staff.

MR. ROSEN: Yes, we have next month's version of it.

CHAIRMAN WALLIS: Are we ready?

MR. ROSEN: I think so, Mr. Chairman. Unless there are any other burning comments here that have to be dealt with, I will turn it back to you. I don't see any.

CHAIRMAN WALLIS: Thank you very much.

I'd like to thank our presenters for putting up with our questions and sometimes our uncertainties or confusions. Thank you very much for that.

MS. SZABO: Thank you for the opportunity to present to you and for all of your comments and questions.

CHAIRMAN WALLIS: We'll take a break for lunch, and we will return at one quarter to one.

DR. APOSTOLAKIS: No, 1:50.

CHAIRMAN WALLIS: No, no. I think we're -- to meet the schedule, people are going to be here expecting us to meet.

MR. ROSEN: Twelve, forty-five?

CHAIRMAN WALLIS: I think we ought to meet at 12:45.

(Whereupon, at 11:51 a.m., the meeting was recessed for lunch, to reconvene at 12:45 p.m., the same day.)

AFTERNOON SESSION

(12:48 p.m.)

CHAIRMAN WALLIS: Let's come back into session.

We're going to hear about advanced reactor designs for hydrogen production, and Dr. Kress is going to lead us through this one.

DR. KRESS: Yes. I was asked by some members why we're doing this. It's one of our proactive type of initiatives to keep the Commission informed for technology advancements in this area. Eventually I think this country will, in my opinion, go to a hydrogen to replace in the transportation sector anyway, and to me that means we're going to have to make a lot of hydrogen, and the most environmentally friendly way to make hydrogen is to make it out of water.

If you make it out of anything else besides water and then you subsequently burn it in the using area, you're going to deplete the air of oxygen. And so if you make it out of water and put the oxygen back into the area, you get a net zero change. So if you're going to make it out of water, it's going to require a lot of energy and it's going to require high temperatures. It sounds like a ready made for nuclear power to me, and I think DOE has the same feeling.

They've looked at some of their Gen IV concepts and I think at least an independent technical review group decided that there's less uncertainty and less risk in terms of technological risk if you do this with a gas cooled reactor.

Now, I think they underestimated the risk -- overestimated the risk due to the molten salt type reactors, but of course, I'm biased there as you guys know, but anyway --

DR. POWERS: Well, I mean, the issues of high pressures, the issues of large pumps and things like that.

DR. KRESS: Exactly. They were worried about materials issues, but I think they underestimated how far advanced that is, but in terms of us, what we should be thinking about is if you're going to use a nuclear power plant to generate maybe both power and hydrogen, that's an unusual situation, and we need to start thinking about what the regulatory requirements might be and what the safety implications are, and I think at this particular point in time what DOE would like out of us is some sort of initial feedback on what we think these regulatory issues and safety issues might be and whether or not new research is needed or new analytical tools or new regulations.

So those are the kind of things I think we want to start thinking about when we listen to this, but with that semi-introduction, I'll turn it over to John Gross to get us better oriented.

MR. GROSS: Hello. I'm John Gross, the current acting --

DR. KRESS: We will need you to either speak into a microphone or wear one if you'd like to wear one.

MR. GROSS: Sorry.

DR. KRESS: Thank you. That's for the benefit of our transcriber.

DR. POWERS: For the benefit of those that don't speak Tennessee, "war" means "wear," for the rest of us.

DR. KRESS: Yes. Thank you for that.

MR. GROSS: I'm John Gross, the Acting Associate Director for the Office of Advanced Nuclear Research for the United States Department of Energy.

I'm about to speak to speak to you regarding the hydrogen initiative that we have going in DOE. I have with me three individuals, Rob Versluis, Dave Henderson and Paul Pickard to whom I'm going to do two things: one, direct the presentation after I do a brief introduction of how we're organized; and, second, field your questions.

I won't dwell on this slide. I'm going to address program and personnel. Paul Pickard from Sandia National Lab will address hydrogen production technologies, and the coupling interface between the reactor and hydrogen production system.

Rob Versluis will then follow up with the discussion.

I'd like to address how we're organized. This is for your future reference. Hopefully it helps paint a picture of how we do things within the Office of Advanced Nuclear Research.

Above the dotted line is DOE's organization. We have three programs in the Office of Advanced Nuclear Research. The Advanced Fuel Cycle Initiative, which addresses fuel element design, fuel mixtures, interface to the reactor through the core.

Generation IV initiative is directed by Rob Versluis and covers the Generation IV reactor system design.

The third program Dave Henderson is our program manager, and here's your area of interest today, which is our nuclear hydrogen initiative.

Our mandate in the Office of Advanced Nuclear Research is to prudently and appropriately spend appropriated congressional funds at the same time that we implement the President's nuclear agenda.

We're doing that for Generation IV and nuclear hydrogen by performing partly R&D necessary to develop reactor systems for the future. Below the dotted line is where the work actually occurs. We're forming work at the national labs in consortiums of the national labs, universities, and industry -- I'm sorry?

CHAIRMAN WALLIS: Below the dotted line you have what looks like management people all from different labs from the people who are doing the work under them.

MR. GROSS: Correct.

CHAIRMAN WALLIS: Is that deliberate?

MR. GROSS: Yes, and I'm about to address what that layer is.

CHAIRMAN WALLIS: Okay.

MR. GROSS: So the work actually happens at the labs where they manage it. Between the labs and DOE is the layer that you see on the screen. This layer represents our interface to the labs. It's composed of national technology directors and technology directors. To your right you'll see the nuclear hydrogen initiative.

Paul Pickard serves a dual role, and he'll be speaking to you shortly. He's our technology integrator for the nuclear hydrogen initiative, as well as national technology director for energy conversion systems under Generation IV. Therefore, he has a foot in both doors of Generation IV and nuclear hydrogen, which, in fact, is where we need to have system interface.

The role of the technology directors is basically they're in the center of developing the R&D programs, coordinating the interface between us and the labs, DOE and the labs, and they're effectively the people intimately involved with the research.

We have a whole series of directors, and our next slide -- I'll jump probably between these two -- shows your our vision of how the three programs within advanced nuclear research interface. Generation IV has categories of interest for us, which is the very high temperature reactor, fast reactors of a few designs, as well as the super critical water reactor.

Under AFCI, fuel cycles looks at separations, reactor transmutation and accelerated driven systems. The nuclear hydrogen initiative is currently performing research in thermochemical systems, electrolysis systems. In fact, there's a hybrid version of the two, and it also looks at system interface, which is how do we get heat, energy basically, from the reactor system to the hydrogen production process.

Some of the research there, a lot of the research is focused on piping interface, the heat exchanger. Materials is the key area for us in all of these programs.

DR. APOSTOLAKIS: Now, you call this NHI.

MR. GROSS: Nuclear hydrogen initiative.

DR. APOSTOLAKIS: Yeah. Presumably there are other hydrogen initiatives within the department that are not nuclear.

MR. GROSS: Correct. Within the Department of Energy there's a higher level program. This is strictly nuclear oriented. Fossil energy is involved.

DR. APOSTOLAKIS: And they're considered in fossil energy and all.

MR. GROSS: Yes.

DR. APOSTOLAKIS: And there is no need to talk to each other there?

MR. GROSS: In fact we do speak with each other. Dave is constantly in touch with the higher level DOE program.

So to come back here momentarily, there is, in fact, interaction, information exchange, and great cooperation between the three programs within the Office of Advanced Nuclear Research: AFCI, Generation IV, and nuclear hydrogen.

We coordinate with the labs through various national technology directors, and the work moves forward.

This slide shows our vision, our current concept of two parallel processes. One, Generation IV and nuclear hydrogen initiative is shown at the top. This is nuclear energy production.

The lower graph shows our perception of how waste and how it's handled will proceed with time. Today we're basically near 2000. By 2010 we hope to have coming on line a decision to select a fast reactor technology.

Somewhere between 2010 and 2020, we would hope that the United States deploys its first advanced lightwater reactor system. By about 2017, 2020, right in there, we hope to have a demonstration, very high temperature reactor system come on line.

Generation IV is essentially targeted to systems that can come on line roughly in the years 2025 and beyond to replace the phaseout of existing reactor systems in the United States. That's coincident with the lower graph which shows the Secretary of Energy is required by Congress to make a decision by about the year 2010 regarding the need for the U.S. and a second repository for waste. He's free to make that decision earlier. The decision has not yet been made.

Hopefully Yucca Mountain will open about 2010 and become a repository, a national repository for waste. It would begin to take on waste from ultra high burn-up fuel cycles developed by our AICI program. Those are once through cycles.

As we approach 2017, we would like to bring on line alternative fuel cycles which become more proliferation resistent and are being used in thermal reactors.

Finally, near the end of this graph we've converted fully to a closed fuel cycle in which fast reactors are processing transuranic elements producing very little waste in self-sustaining --

DR. APOSTOLAKIS: Let me understand this a little bit.

MR. GROSS: Sure.

DR. APOSTOLAKIS: When you say select fast reactor technology, one of the criteria, maybe the major criteria will be how that technology can help you with a nuclear hydrogen initiative or are they two separate things?

MR. GROSS: It's related. Part of our decision is to incorporate how well this -- part of the decision to select which reactor technology is related to the hydrogen program.

DR. APOSTOLAKIS: The selection --

MR. VERSLUIS: May I jump in on this one?

MR. GROSS: Yes.

MR. VERSLUIS: The PHDR is dedicated to the hydrogen program. The fast reactors, their primary mission is to be able to close the fuel cycle and go to a fully sustainable, self-sustaining closed fuel cycle, and also in a transition period to transmute lightwater reactor fuel for spent fuel.

So the fast reactors, they may have a role as well in hydrogen generation, but that's not their primary role.

DR. KRESS: Right now we should be focusing on the VHTR, I presume.

MR. GROSS: Yes.

DR. POWERS: Can I ask you an ancillary question, somewhat off the mainstream here, but one that's kind of important to us? When you talk about ultra high burnup fuels, could you give us an idea of what you mean by "ultra high"?

MR. GROSS: Sure. I'll let Rob address that.

MR. VERSLUIS: Yeah, we have a program underway to develop lightwater reactor fuel that goes to a higher burnup, and we are looking at between 60 and 80 --

DR. POWERS: Okay. So not too far beyond what we're thinking about. We're looking at like 75 for that, but we've heard about German work claiming that with new clads they can get up to 100.

MR. VERSLUIS: We are not particularly involved in what the industry is already doing.

DR. APOSTOLAKIS: Dana, when you say "we," you mean the agency?

DR. POWERS: Well, the Reactor Fuels Subcommittee has an active interest in high burnup fuels and fuel clad interactions and their susceptibility to reactivity transience and thermal transience. In fact, in October we have a subcommittee meeting scheduled on just exactly that stuff and has an impact on 5046 revisions through the acceptance criteria, which I'm told will be different.

MR. VERSLUIS: May I add that our interest in the high burnup, lightwater reactor fuel is primarily in the area of transportation fuel, in other words, MOX plus other actinides, and of course, that's a way to transmute some of those nasty isotopes, and the higher burnup we can reach the better.

DR. POWERS: We're certainly getting an introduction into MOX and whatnot for your operations at Catawba.

MR. GROSS: Finally, for this introduction I'm presenting, again, our current vision of the evolution of the hydrogen economy. There isn't a lot that I could really say about this. R&D begins. It's going on for about 15 years or so, followed by transition to the marketplace, expansion of markets and infrastructure.

DR. APOSTOLAKIS: Hydrogen economy means what? What is a hydrogen economy?

MR. GROSS: It means that the economy of the United States has initially begun to convert to an energy source based upon hydrogen and move away from energy sources based upon fossil fuels.

DR. APOSTOLAKIS: But this energy will be primarily for transportation? Are you talking about electric? Not electric.

MR. GROSS: No, no. It would be hopefully in the long term, it would be across the board, but --

DR. APOSTOLAKIS: Really?

MR. GROSS: Yeah. Regarding the time it would take for this to happen, that's not something that I could actually realistically address.

DR. APOSTOLAKIS: Dr. Kress mentioned transportation. Is this the primary mover?

DR. KRESS: I can't imagine it being used for much else. Now, of course, there's fuel cells that can be used for all sorts of little things, but I don't envision. I think the big use and the place where it's needed most is in transportation. That's where we get all of the greenhouse gases and --

DR. APOSTOLAKIS: And oil. We use a lot of oil.

DR. KRESS: We use a lot of oil, burn a lot of oil.

MR. VERSLUIS: Gentlemen, this is an area that will be covered in the presentation that will follow.

DR. APOSTOLAKIS: Fine, fine.

MR. GROSS: At this point I'm going to pass the presentation to Paul Pickard, who is with Sandia and is our technology director for the Nuclear Technology Integrator for the nuclear hydrogen initiative, as well as the national technology director for --

DR. POWERS: Mr. Chairman, before the speaker starts, I point out that I have worked with Dr. Pickard for the last 30 years and including on that I have consulted with him on some of the hydrogen programs, and so member should bear that relationship in mind as they evaluate any of my comments that I make.

(Laughter.)

DR. APOSTOLAKIS: Which you will still make.

DR. POWERS: I promise to give him just as hard a time here as I do at Sandia.

MR. PICKARD: I'm not sure whether that was good or bad.

CHAIRMAN WALLIS: You will not be allowed to enter into a friendly discussion.

DR. POWERS: We've never had one of those.

DR. APOSTOLAKIS: That's not going to be very difficult.

MR. PICKARD: Thank you.

As John and Rob had mentioned, the Department of Energy is looking at a range of reactors for the next generation. The kind of goals that we had in mind for these things included several, including sustainability, the preservation of the resource, safety goals, performance and economic goals.

And among these goals was the desire to look at the energy products that you can make with these advanced reactors, and clearly one of these is the higher temperatures that are available from these reactors allow you to generate energy more efficiently, generate electricity more efficiently. You can use higher temperatures, and you simply do a more efficient job.

These higher temperatures though also allow you to consider some hydrogen production technologies that would not be allowable with water reactors. Thermochemical cycles generally require temperatures in the neighborhood of hundreds of degrees. Five hundred is a minimum, but generally in the range of 1,000 degrees.

The most common cycles we look at today are sulfur based cycles. They require the decomposition of sulfuric acid, and that starts becoming effective in the eight or 900 C. range.

So some of these cycles require new generation of reactors for that, and that is why the VHTR is a high priority, looking at how we would couple to these potentially more efficient and potentially more cost effective hydrogen production technologies.

Also, high temperature electrolysis is a possibility. The electrolysis of steam rather than water, where you use part of the energy for steam generation, and then the electrical requirement goes down so the overall efficiency can go up.

So the goal of the current program is to look at how you most effectively take advantage of this higher range of outlet temperatures that are represented by the Gen IV reactors. Their ranges I have showed here are not hard and fast. They are notional ranges that are the ranges that the DOE as well as their international partners have considered for these reactors.

The VHDR is clearly the highest temperature system considered in the range of 900 to 1,000 degrees. An extension of gas cooled reactor technology, high temperature gas reactors.

The gas fast reactor which is of significant interest to the French CEA, they are looking at systems in the seven or 800 degree range. Clearly that is a concept that is still being formulated. The fuels and the temperatures for that are still being considered.

The molten salt reactor is on this list. It is not being actively pursued within the international or the DOE --

DR. KRESS: When you say molten salt reactor, you're talking about molten salt cooled or is this a true molten salt reactor?

MR. PICKARD: This is actually molten salt. A Gen IV reactor is a molten salt.

DR. KRESS: It's a Class A (phonetic) fuel, but molten salt.

MR. PICKARD: This would be the fuel dissolved in salt.

DR. KRESS: Okay.

MR. PICKARD: But there is significant interest in an alternative cooling or as an alternative coolant for a graphite cooled graphite reactor with the salt cooled, allowing you to maybe go to a much higher temperatures or -- excuse me -- much higher powers.

DR. KRESS: Is that on this list?

MR. PICKARD: That's not one of the current Gen IV concepts as such, but it is one of the concepts being considered for the VHTR. The VHTR can consider both gas cooled and molten salt cooled concepts, and Rob has current activities going on to evaluate the advantages and disadvantages of those.

The lead fast reactor currently is looking at lower temperature designs. This is a very small reactor, kind of the nuclear battery concept looking at lower temperatures, but very small, convectively cooled, passive systems that would be a market for developing countries, systems that would run on the same core loading for 20 or 25 years, require no involvement of that nation, essentially fast reactors with very low power densities.

MR. ROSEN: What is the peak extension of your bar on this chart, meaning on lead fast reactors?

MR. PICKARD: I'm sorry?

MR. ROSEN: What is the extension of your bar on lead fast reactors to the right?

MR. PICKARD: Oh, currently the materials issues limit that to temperatures down in this five to 600 degree range, but they are talking about alternative concepts and materials that could extend that.

So of the range of things that are being considered by investigators, I include that because that's what they're hoping to get to, not because they have a means to get there right now.

The sodium fast reactor is not being actively pursued in this country because that is considered much more a developed technology the Japanese and French are still interested in. We are as well, but the temperature range and the technology there is better established.

The super critical water reactor is still an active concept looking at very high temperature water reactors in the range of 500 or 600 degrees.

The kind of conversion technologies we're looking at for hydrogen, thermochemical cycles range in the neighborhood of a minimum of 500, and many of them go up much beyond 1,000 degrees. The ones we are interested in are those that are compatible with the reactors that are being considered.

Calcium bromine is a cycle developed in Japan in the last ten or 15 years that can actually operate in the 750 range.

DR. SHACK: Now, are the fossil people looking at even higher temperature conversion cycles?

MR. PICKARD: I will get to that, but really the fossil people are primarily looking at conversion of steam methane reforming or using that as a feedstock, as well as the heat source, and that's one of the aspects that nuclear could consider supporting.

The high temperature electrolysis, basically this is your steam electrolysis. You use some thermal energy to generate steam, and that provides part of the energy to associate the water and, therefore, it can be and we estimate roughly ten to 15 percent overall more efficient. Clearly an advantage.

It also requires though high temperatures.

DR. POWERS: Well, do you not have the potential problem with steam that you do with water?

MR. PICKARD: You have less.

DR. POWERS: Less?

MR. PICKARD: The advantage of high temperature electrolysis includes both the fact that you generate part of it thermally and, therefore, don't have the conversion losses, but to sell the losses, the Ohmic losses and polarization losses are lower.

On the electrical side, we will not talk about this today, but the use of high temperature Brayton cycles, closed Brayton cycles is being considered. Helium Brayton cycles for the VHTR is being looked at. Clearly materials problems are less with the helium.

This is a technology that we know about in terms of turbine compressor designs, and for the very high temperatures the helium closed systems are what we're looking at.

When you look at the intermediate temperature ranges though, there are other systems that look to optimize at somewhat lower temperatures, and the super critical CO_2 system is one we're looking at. It's a recuperated Brayton cycle, but because of the properties of CO_2 down near the critical point, you can actually get more efficient cycle because you're coming closer to compressing this as a liquid.

DR. POWERS: You would go unstable, too.

MR. PICKARD: Say again.

DR. POWERS: You can go unstable, too.

MR. PICKARD: There are challenges with that cycle nevertheless.

DR. POWERS: I mean, there's a bifurcation across the phase boundary.

MR. PICKARD: You've got to be very

careful. That is a challenge. Control and stability of this cycle are what we're looking at.

On the other hand, it also allows you to consider something in the neighborhood of 45 percent net efficiencies of plants in the neighborhood of 550 or 600 degrees. So it is a cycle that is at least conceptually quite simple that allows you to take better advantage of these middle temperature reactors.

DR. KRESS: In the hydrogen production concepts, are you giving any thought to this thing I mentioned in the introduction, that if you're not putting oxygen back into the air when you burn hydrogen that you're slowing depleting the atmosphere of oxygen? Is that a consideration in deciding which one of these production techniques you use?

MR. PICKARD: Well, everything we're looking at is splitting water.

DR. KRESS: Splitting water. So it's a net zero change in reality.

MR. PICKARD: The research program for the nuclear side is looking at water. I mean, obviously the --

DR. KRESS: Well, some splitting of water though sequesters the oxygen in a solid form as an oxide. You're not looking at those, I hope.

MR. PICKARD: In every case we're looking at, the oxygen is a gaseous product that's either going to be used somewhere or dispersed.

DR. KRESS: Or you're going to use it somewhere.

MR. PICKARD: Right.

DR. KRESS: I worry about using it because using oxygen generally puts it in a sequestered form.

DR. POWERS: If the entire mankind's production of fuel could change the oxygen concentration by a detectable amount.

DR. KRESS: Yeah, I think it could, and you'd only have to change it a little bit for lots of things not to be viable anymore. You know, how well do things survive on the top of certain amounts where the oxygen is not very much lower?

I think it's a consideration that probably nobody is thinking about, and that's why I brought it up.

DR. APOSTOLAKIS: But I'm trying to understand what your point is, Tom. Are you making a sustainability argument here?

DR. KRESS: Yeah, over a long-term sustainability.

DR. APOSTOLAKIS: So you're saying that we will be losing oxygen?

DR. KRESS: Instead of curing the CO_2 problem and the acid rain problem, we're just depleting the atmosphere out of oxygen, and at some point people can't live and other things can't live if the oxygen gets much lower than it is now. And if you're using hydrogen --

DR. POWERS: You're going to depopulate Nepal.

DR. KRESS: Well, that's where you're going to start.

But anyway, that's my concern in life, the sustainability in the long term, and you know, maybe now is the time to think about when you're making this hydrogen how you make it.

DR. APOSTOLAKIS: According to Paul, all of the technologies they are considering have the same --

DR. KRESS: But you may end up with oxygen that -- what I want to do is release it back to the atmosphere and, you know, they want to use it probably for something, and that's the thing I worry about.

DR. POWERS: One of the biggest headaches, you don't have a market for the oxygen product out of these things.

DR. KRESS: Yeah, that's true.

MR. PICKARD: This overwhelms the potential oxygen market. If hydrogen production were really to work, we overwhelm the oxygen market.

DR. KRESS: You know, just turn it loose back to the atmosphere.

CHAIRMAN WALLIS: Tell him some places where it can do some good, such as an ACRS meeting room.

DR. KRESS: Oh, that's an idea.

DR. APOSTOLAKIS: Unless the ACRS itself is sequestered.

MR. ROSEN: I think it would keep these old ACRS members alive.

MR. PICKARD: I think I'd better move on.

PARTICIPANTS: Yes.

DR. APOSTOLAKIS: Because we have reached that point.

MR. PICKARD: I did want to just say something about the hydrogen market. I do realize we're talking about a hydrogen economy some time in the future that uses hydrogen for fuel cell that's an environmentally benign fuel, but the current hydrogen market is already large. We make a lot of hydrogen.

It is a role for nuclear power that even today would be comparable to our nuclear fraction. Tomorrow it could be much larger.

The U.S. demand is like ten million tons a year. The world demand is about 50 million tons. That's mostly used in ammonia production, but the increasing component of those hydrogen usage, independent of any hydrogen for fuel cells, is in oil refining.

The petrochemical industry, we don't see this because it's internal to that industry, but as the grade of crude continues to sour, there's more and more hydrogen needed to refine that into a gasoline that's usable, and that has been a rapidly expanding market.

And if you extrapolate that to the Canadian oil sands where the grade of oil coming out is very low, the requirement for hydrogen, at least the Canadians have mentioned numbers like the entire North American supply of natural gas could be used to refine that very large resource of Canadian oil sands if we were to exploit that, if it were to be exploitable.

So the expansion of the hydrogen market is really -- I mean these other things will also clearly increase in use, but oil refining and the lowered rate of oil that's going to be refined in the future is one key market.

And I point that out because the kind of market we're talking about here is not a distributed market. It's a large, centralized plant, much like a nuclear plant could be appropriate for it. So the department has considered the nuclear option a good one for these applications that are probably going to come along earlier.

It does not require the hydrogen economy or infrastructure to say that this hydrogen is going to be there. To give you an idea, somebody mentioned the transportation issue, and the numbers are out of date, but they give you an example. If you assume that hydrogen is going to be the source of fuel for transportation for the miles we drive, based on the current alkaline electrolyzers, it takes about 50-plus, 53 or four kilowatt hours per kilogram of hydrogen.

Kilogram of hydrogen is just a little more than a gallon of gasoline, but the energy content is roughly the same. So it takes about 50 kilowatt hours to make a kilogram of hydrogen like a gallon of gas in terms of energy.

CHAIRMAN WALLIS: You're talking about in terms of efficiency?

MR. PICKARD: Say again?

CHAIRMAN WALLIS: What's that in terms of efficiency, energy efficiency?

MR. PICKARD: Well, that assumes that the higher heating value hydrogens like 39 kilowatt hours and 73 percent for the alkaline electrolyzers, which is about the best you see quoted. So the use of electricity is fairly efficient. To make the electricity, obviously, you've lost something.

CHAIRMAN WALLIS: Right.

MR. PICKARD: That says that if you took the miles we drove -- and this is now almost ten years old. It's a bigger number than this now -- and you assume you were going to get 50 miles per gallon as the average and you made this with the highest efficiency you can think of, that looks like 300 gigawatts of electric if you made that by conventional electrolysis.

If you dropped down to at least the mileage my car seems to get, I mean, this is starting to look like 1,000 nuclear plants of gigawatt size to make the hydrogen for today's market if we were to use all of that for transportation.

It is a large potential area of application, and when you do it with hydrogen there, or whether you use that hydrogen in petrochemicals to augment liquid fuels, which we have the infrastructure for, either way you're going to end up with a lot of --

CHAIRMAN WALLIS: Well, a gigawatt is 1,000 megawatts; is that right?

MR. PICKARD: Say again?

CHAIRMAN WALLIS: A gigawatt is --

MR. PICKARD: A gigawatt is 1,000 megawatts, correct.

MR. ROSEN: Typical big plant.

MR. PICKARD: Yeah. The 100 plants we have, we're talking about something large compared to that to do this job.

The amount of hydrogen we make in the U.S. today primarily from steam methane reforming would still require something on the order of 50 gigawatts of electric energy to make -- if we made it by conventional electrolysis. There's a lot of natural gas, a significant fraction of our natural gas. I've heard as low as five, but I think it's more like seven percent goes into making hydrogen for refining petrochemicals.

So I think from the nuclear side we look at the applications as evolving in the future, but there will be a near term application, and the goal of the nuclear hydrogen issue then is to look at could you use nuclear as the prime source for that. What is the benefit of that?

DR. KRESS: The nuclear plants producing electricity nowadays do pretty well at about 33 percent efficiency cycle. Do you really think you have to get up to 60 percent or thereabouts?

I'm concerned about these high temperatures. If you backed up off, I presume you have to have these high temperatures for the conversion of hydrogen.

MR. PICKARD: If you use the thermochemical cycles or high temperature electrolysis.

DR. KRESS: So it's not the efficiency that you're worried about there. It's the conversion.

MR. PICKARD: We use the efficiency simply as an indicator of the cost impacts here. Some that's more efficient requires less energy, less plant to get there. And for things we don't quite know how to do yet, that's one good early indicator, is where the process is efficient.

I mean, alkaline cells are 70-some percent with 35 percent. That looks like an overall efficiency of 25 percent. In the high temperature electrolysis, assuming you had a next generation reactors that did 40 or 50 percent, you can make that 50 percent better.

So I don't think it's a fundamental issue, but it's a matter of how good can you do this.

I did want to mention that this is part of the overall DOE hydrogen program. Any component of the hydrogen program is just one of the ways that DOE is looking to make energy. The hydrogen economy looks good except for it's hard to make it. We don't know how to store it and we don't know how to distribute it, but --

DR. POWERS: The best way to transport hydrogen, put it on the back of a carbon atom.

(Laughter.)

MR. PICKARD: And that's what we're currently doing, and we pump it around or haul it around that way.

So DOE is looking at the renewables. I mean, they're looking at everything they can do with the renewables, including biomass, solar, wind, wind probably being an electrolyzer kind of concept.

The fossil program is also looking at those things, but they're looking at for carbon free or carbon neutral schemes, looking at sequestration technologies.

Currently most hydrogen is made by steam methane reforming, a high temperature reaction where you use part of the gas to provide the heat and the other 70 percent or so is the feedstock.

It is conceivable that nuclear could support that by providing the heat source, the high temperature heat source for that, but it's still a fossil dependent technology, and therefore, the nuclear program is not addressing that.

Conventional reactors today could also support conventional electrolysis in just the mode we talked about, an alkaline electrolyzer at a 33 percent efficiency, and of course, it really does come down to cost. Whatever the cheapest electricity dominates the cost there.

I mentioned a number. It's probably good to just keep that in mind. If you need 50 kilowatt hours of electricity to make a kilogram of hydrogen, which is about a gallon of gasoline, five cent a kilowatt hour electricity means you spent -- it is about 270 in terms of energy just for the electricity cost.

There is also a cost, of course, to capitalize that plant, but generally we talk about current hydrogen being on the order of three dollars a kilogram if you wanted to make it by conventional means now with conventional electrolyzers.

And that's three dollars a kilogram at the plant, not distributed or involved in something, which used to sound more pricey than it does now when you talk about a gallon of gasoline, but it kind of gives you an idea that the ways we could do it now are in the several dollars per kilogram equivalent of gasoline at the source.

What we're looking at is advanced methods, better efficiency methods that might make that better, and the kind of things we're looking at are thermochemical cycles and high temperature electrolysis, and these are really the elements of the current nuclear hydrogen initiative program.

CHAIRMAN WALLIS: So if you take this hydrogen and make methanol that you make now, do you lose a lot of the available energy or heating value or whatever you want to call it? Because methanol is a lot easier to transport than hydrogen.

MR. PICKARD: Yes or even ammonia or

something else, right.

CHAIRMAN WALLIS: Well, you can burn methanol in a car.

MR. PICKARD: Yes, and, well, currently what we do is put the hydrogen in gasoline. I mean, that's almost half of the hydrogen we make goes into gasoline.

CHAIRMAN WALLIS: That seems to be the sensible thing to do.

MR. PICKARD: And because of the value of the gasoline, the value of the hydrogen is -- I mean, you're not burning that directly, but it is a high value product that you're using to make another high value product, and what we're trying to do is look at can you make it out of a relatively low value product.

The technologies we're looking at in the hydrogen program, on the nuclear energy side looking at high temperature electrolysis, basically using a cell very much like a fuel cell operating in reverse where you apply a voltage rather than generate a voltage, because of its efficiency obviously high temperature electrolysis would be a modular scaling system if you're going to build an industrial size plant.

Typically right now we're limited to ten or tens of centimeters kind of per facility because of differential expansion so that you had envisioned an electrolysis hydrogen plant on a commercial scale being made up of modules of stacks of these individual cells and those modules being repeated over and over again, literally a million of these cells would be made. So the economies of scale would be a mass manufacture rather than scaling.

Thermochemical cycles, these are simply a series of chemical reactions that end up with something you can decompose the hydrogen at a lower temperature than direct association.

There are lots of these cycles. The ones that we're looking at are the ones that have been generally focused on in the past because they have worked. Many of these are difficult to make work.

The reason you look at that is because at least the fewer thermochemical cycles are things that are purely thermochemical. There is no electrical --

CHAIRMAN WALLIS: Sulfuric acid at 900 degrees C. with water around?

MR. PICKARD: Yes.

CHAIRMAN WALLIS: Does this corrode things?

(Laughter.)

MR. PICKARD: That's the kind of statement I've heard.

DR. POWERS: Well, I mean, to give you precision on the sulfuric acid, it's so pure it's not a special --

CHAIRMAN WALLIS: Well, you've got some water there, too.

DR. POWERS: It's the diluter forms that act bad.

MR. PICKARD: I'll mention this a little bit, but yes, I think when you look at the challenges of thermochemical cycles, it seems like we always end up with a series of species that are very corrosive, and you have to deal with very high temperatures. So there are significant materials challenges in making thermochemical cycles. They have been demonstrated, but in glassware in very small scales.

Either one of these technologies that we're looking at, both require high temperatures and, therefore, a high temperature interface with the reactor. So the materials of construction, the heat exchanger materials, the heat exchanger effectiveness is an important area.

So the three primary areas include this systems interface area, and we'll talk a little bit more about that.

I want to just take two or three viewgraphs and tell you about what we're doing in each of these areas. The high temperature electrolysis, as I said, we're looking at this because it does have potential for a higher efficiency than conventional electrolysis.

You do use part of the energy. Maybe at eight or 900 degrees about a quarter of the energy is thermal. That fraction of the energy did not have to convert to electricity and lose the conversion losses.

The cells are also somewhat more efficient. The resistance is lower. They still have the same kind of Ohmic and polarization issues, but they are lower.

I think typically people like to quote numbers at 90 percent or better in terms of those Ohmic and polarization losses, some of which can be reused.

CHAIRMAN WALLIS: this picture, is that a picture of something that operates at 950 degrees C.?

MR. PICKARD: Close to that, yes. These are -- the materials here are basically the same kinds of materials being developed in the fuel cell program. Solid oxide electrolytes primarily, yttria stabilized zirconia, some rare earth porous electrodes.

The NE side is, although we do have some different requirements, primarily on our side, we're looking to the fuel cell program, the much larger program to look at the development of materials and fabrication techniques, all of which are difficult here, but have been done.

And because of that leverage, we do have cells that are currently working both in single cells and in stacks.

The issue with the high temperature electrolysis, we do know that technology works. There was not a question of that. It's a matter of can you engineer it and provide a cost effective solution, much like the fuel cell program. The device sounds good, but longevity of that and cost of that. Currently these are nominally order of magnitude or more expensive than you'd like to see, and the question is as you develop them and mass manufacture them, do those costs come down?

And the fuel cell program with DOE does have very, very visible guidelines and targets for what they want to get. One of the advantages for us is that it does allow a somewhat wider temperature range. Temperature ranges are bounded, but nevertheless, it's not as important to have extremely high temperatures here. At least there's a wider range of possible temperatures.

And it also is basically a steam process. There is no hazardous chemicals, no acids or halogens to deal with.

CHAIRMAN WALLIS: Now, where it says "air," is the air just a way of carrying the oxygen away or something?

MR. PICKARD: Yes. In this case, that's what is going on. I just wanted to give you a feeling for the magnitude of the energy. On the right side of this curve, on the left side, is the energy requirement, the total energy requirement for electrolysis, as well as the changing electrical versus thermal demands here.

So as you get towards these eight or 900 degree temperature ranges, maybe 25 percent, and that's a significant part of the efficiency improvement.

If you map that into where these cells might operate, at the low end where there's essentially no throughput of hydrogen, those are the idea efficiencies you can get to. By the time you add enough over voltage to drive reasonable production from the cells you've invested in, we're talking about for energy conversions of something like 40 percent in the middle of this curve, and you're out in one and a quarter volts or something like that.

You're talking about overall percentage efficiencies on the order of 40 percent, which are substantial improvements in overall efficiency, but the issue here is how much does that cost you. The cells are more expensive, and the high temperature management is going to be more difficult.

In terms of how you would configure this, there are many configurations you could consider, and one of the activities on the nuclear energy side is to look at how would this be coupled to the reactor.

CHAIRMAN WALLIS: Very funny units. A cubic meter of hydrogen, that means at atmospheric conditions?

MR. PICKARD: Yeah, those are SVP. I had to work those out, too. Sorry. Yeah, the configurations that could be considered, this one shows a combined plant, a high temperature reactor that uses part of its energy in parallel to generate efficient electricity, and at 850 at least the numbers are in the upper 40s as targets, mid to upper 40s.]

But part of the energy then goes into the thermal component to generate steam for the steam electrolysis. Clearly you do not have to use the same reactor to do that. The high temperatures are really only needed for the steam. One can buy electricity off the grid at whatever the lowest cost is and configure these as dedicated rather than multi-purpose plans, but this is one configuration that was considered for NGNP.

Basically steam is a source to the high temperature electrolysis. The hydrogen generator is recuperated. That energy is recuperated into the incoming waters that make up --

CHAIRMAN WALLIS: May we use this on an exam for a thermal dynamics course?

MR. PICKARD: I was going to say we have started looking at what these configurations would look like.

CHAIRMAN WALLIS: I can take this home and use it as an exam on a course?

MR. PICKARD: Okay. The two elements of our program really, one is looking at what kind of system would you do. How do you manifold and manage the thermal energy here? Because that is a non-trivial exercise. We're talking about a steam generator now at 800 or 850 degrees C.

Significant issues there materials-wise, but nevertheless also looking at how do you use this electrolyzer. The DOE program is focused on the fuel cell application and the nuclear energy effort is focused on the electrolyzer application.

DR. POWERS: You're not focused really on the materials for the electrolyzer at all.

MR. PICKARD: It hasn't been as much of an issue. There are significant issues. The steam is a steam-hydrogen mixture. So it stays in a reducing environment, but there are still issues in recuperating the heat exchangers that they have shown there, recuperating oxygen energy. At these temperatures you still have issues, not the dramatic issues you have with thermal chemical cycles.

DR. POWERS: What kind of separation between the hydrogen-oxygen mixture that you're producing here? It may not be mixed by design, but by accident it can be.

MR. PICKARD: It introduces a scenario that we --

DR. POWERS: In this vulnerable little reactor that you've got.

MR. PICKARD: Yeah, it introduces scenarios like that that you've got to consider. I think the stack that's shown on the right, this is actually an Idaho National Laboratory experimental stack that shows these are kind of seen closing through on one set of channels. Air sweeping the oxygen flows through on the other set of channels.

So as you can see on the bottom here, seals, interconnects are important issues here, and those are challenges. You're operating at very high temperatures in steam environments, and I think many of the cell configurations are looking at it to try to solve those sealing and materials issues here.

Idaho is currently looking at a variety of small scale experiments to just understand the physics of the cell, but obviously the goal here on our side is to engineer this into a stack, into a module that can be a building block either for a much larger plant.

So the thermal management, the manifolding sealing as well as the cell operation is a key issue.

Currently, I think these experiments have been running for the past year at Idaho. This cells that's shown there, these are ten centimeter nominal dimensions for that stack, and this cells produces about -- I think the experiment produced about 50 liters an hour for a period of time.

The same stack with the right operating voltage is going to be run at nominally 100 liters per hour. Very small scale, but these experiments are in progress.

I also wanted to say just a few words about thermochemical cycles. Obviously the desire here, many of the thermochemical cycles have been looked at in the literature, and in large measure these are things that have been looked at at low levels in the analysis. This has not been a focused program. A lot of work done in the '70s. As soon as gas prices dropped, almost every program in the U.s. also terminated.

The Japanese continued to work and have been working continuously since then so in many cases, are well ahead of us in the thermochemical cycle area.

The reason you look at these things is because many of them do project to 50 percent efficiency, meaning thermal energy can be used directly to produce hydrogen at a 50 percent efficiency without any electrical conversion.

Now, some of these are hybrid cycles that use one thermochemical step and then electrolysis step, and the goal of those is the electrolysis step generally is a much lower energy requirement than water electrolysis. So you still are dominating the efficiency of the process by the thermal step.

Generally at least chemical engineers like fluid processes. They scale with volumes, and when you think of very large scaling, this is different than the modular scaling, and I think one of the advantages of taking both of these to develop is that it gives you a chance to examine the modular scaling economics as well as the volume scaling economics.

I think that's something -- we have advocates on both side, but I don't think we know what the best approach is yet. You can find a lot of ways to add a chemical equation so that they sum to water equals oxygen and hydrogen. Most of those don't work. There are kinetics issues and there are side reactions or they take just too high temperature.

Of the hundreds of cycles that are out there, only a few have been demonstrated and integrated, and the sulfur cycles have been the leading ones of those. Sulfur cycles include sulfur iodine, which I'll describe in a minute, and hybrid sulfur, combination thermal electric, but all of them seem to require very high temperatures, six, 700 degrees as a minimum, generally more like eight or 900, and they all seem to involve fairly corrosive species. So they are all challenge for materials as well as the chemical process.

MR. ROSEN: You know, Paul, one of the things we worry about a lot here is the effect of toxic gases on operating crews.

MR. PICKARD: Yes.

MR. ROSEN: So you might want to keep that in mind.

MR. PICKARD: Yes. I will show you at least what we anticipate inventories to be, but, yeah, those are among the key concerns here, and it's going to be one of the issues we want to understand when you pick technologies to move forward with.

The safety issues, the implications of those safety issue down the road are things you want to know about going in, not after the fact.

There are some cycles out there not demonstrated that at least have been analyzed, have either better efficiencies or less toxicity or in some cases simpler, but they have not really been demonstrated to a level that we could try to engineer at this point.

And so there is a part of the program that looks at alternative cycles, and this is the part that we would like to involve the universities in. It's looking at thermochemical cycles, flow sheet analysis, basic thermophysical property measurements and so forth. There are things that universities could support.

There's no commitment to experiments in those areas, but you want to look at them and make sure you have picked the ones that are most likely to succeed.

So the sequence of things we go through here, obviously all of these start with flow sheet analysis, trying to understand where the data deficiencies are and doing the basic energy balances on looking at what the projected efficiencies could be and the complications.

We are currently in the phase of starting to do experiments on individual component reactions that we hope to do integrated lab scale experiments in the next couple of years, and those would be at kind of a basis for a go or no go decision on whether the performance of that and the practicality of that warranted a larger scale demonstration, a pilot scale demonstration.

Lab scale experiments are benchtop. They involve kilowatts of energy. We would consider a pilot scale experiment to be more in the neighborhood of a megawatt kind of demonstration, something that you would allow the -- so that the engineering could be evaluated.

And obviously for those that successfully go through pilot scale experiments, then there's a follow-on stage of more commercial prototype kinds of demonstrations, and obviously there could be many stages of this, depending on the experiment results.

I want to just describe briefly the two that we are working on as the baseline cycles is the kind of highest priority cycles, sulfur iodine on the left and hybrid sulfur on the right. Both of these cycles start with the decomposition of sulfuric acid. Since either of the base reactions are relatively low temperature, you need eight or 900 degree energy to decompose the acid.

The acid is actually decomposed in stages. You form SO_3 first in the five or 600 degree range. Then you catalyze that reaction to form SO_2. So there's kind of a sequence of reactions you go through.

As you go up in concentrations and temperatures, the materials issues do change. If you look at the best materials at the lower concentrations or lower temperatures are not the materials you'd use at the higher temperatures.

So both of these start with the decomposition of the acid to basically for SO_2. In sulfur iodine, which is shown in this middle section of the sulfur iodine, that SO_2 has reacted with water and iodine, and that then forms two acids, sulfuric acid again and then HI.

The HI is then sent -- the HI forms as a heavy phase, and I've shown the ideal equations, of course, and they're not this pretty in reality -- to form that separation you need an excess of iodine. there are almost nine moles of iodine in this for each mole of HI that's actually formed.

There's also an excess of water. So there's quite a bit of fluid in this process as you might expect, but the separation of this and an excess of iodine allows you to separate the HI to go to a decomposition section, and the sulfuric acid then back to the sulfuric acid section to be recycled again.

So the net input here is water and heat. The net output is hydrogen oxygen if everything works. Obviously, in the non-idea world there are corrosion products and other things that you are going to have to --

CHAIRMAN WALLIS: There's no water that

goes with the H_2SO_4?

MR. PICKARD: Say again?

CHAIRMAN WALLIS: There's no water that goes with the --

MR. PICKARD: Yes, there is. Yeah, the current flow sheets have significant water on both sides of this, and that's a significant issue. This middle reaction occurs at about 120 degrees. It's called the Bunsen reaction, this primary reaction. So for what you put into that reaction you've now got to heat back up again.

If you carry water along with it, there's a big inefficiency. So thermal management and water control here is very important to the efficiency of these things.

The HI can be decomposed thermally at five, six, 700 degrees, depending on the efficiency. It can be catalyzed, and that's another issue, the catalyst for this reaction, as low as 300 or 350, and the current experiments are looking at that using a platinum catalyst.

Both of the end reactions on sulfur iodine are catalyzed in the long run and, therefore, you need a catalyst that survives these environments and these temperatures for the duration to do that.

The alternative cycle we're looking at has the same front end, the same sulfuric acid, but basically it takes the SO_2, mixes that with water, and with an excess of water, and then that is electrolyzed to form hydrogen directly.

The sulfuric acid that's formed from that is then returned. A much simpler cycle, it does require an electrolytic step. You do have electrolysis to form the acid and the hydrogen.

We're looking at both of those. These programs are cooperative, collaborative with the French CEA. This will be the most interactive collaborative project I think we've had. We're actually looking at examining these three component cycles in separate locations, bringing them together at one location in the future, and forming an integrated demonstration.

Obviously, we'll have challenges in making sure these things integrate.

The work that's going on in the U.S. is the high temperature reactions for the sulfuric acid and the electrolyzer and the HI sections. The French are working on the Bunsen reaction.

These things are also undergoing experiments. I just give you one example of the SI component reaction section experiments. This is the sulfuric acid decomposition. Obviously there are some long-term materials issues that we're going to have to address. We want to start experiments. So we're simply using the best materials we knew of for these temperature ranges and conditions.

In this case, we built boilers out of Hastelloys. These are primarily super alloys. Incolloys; Ceramid is a 6-10-6-11 kind of alloy with high silicon.

The things that really look good in these applications are what we all would like to get to, and of course, the ceramics look best for long durations here.

The Japanese who are maybe ten years into this program are focusing most of their effort on ceramic heat exchangers, silicon carbide base heat exchangers. Primarily a silicon carbide heat exchanger -- well, let me show that briefly here.

Where the reactor actually touches the process cycle shown over there on the right of the yellow boxes here in the very high temperature section, they are looking at silicon carbide heat exchangers for that, counterflow heat exchangers, helium, or high temperature fluid in one side, and the process fluids, the sulfuric acid and its composition products in the other side.

Those would be a direct heat exchanger. Those would be insulated and then put in a high pressure boundary so that it would be a fairly corrosion resistent, but still not a metallic structure device.

So this kind of shows where the reactor heat has to be input to the SI cycle or to the hybrid sulfur cycle, and the reason for selecting this particular version is because it is limited to just one set of heat exchangers that have to be -- that contact the intermediate heat exchanger.

The kind of things we're starting to look at within the program include metallic heat exchangers. At MIT they're looking at metallic structures that actually the catalyst is built in very corrosion resistent, a platinum imbedded 617 kind of alloy.

But we're also looking at silicon carbide or composite silicon carbide kinds of materials as being the most corrosion resistent and likely to be the most successful over the very long run.

Obviously those things are going to take time. We are doing the experiments that are modular so that you can replace components when you have something better to use.

I also want to just briefly mention the alternative cycles. One of the things you do worry about is the thermochemical cycles, and we don't know what temperatures they require, but generally ones that are most developed are very high temperature. Nine hundred degrees C. or more is what you'd like to have.

And so there is interest in identifying the range of cycles that could be applied to the full range of Gen IV reactors. So although those are not under active development, they are going to be analyzed.

I will just give you a list of some of the ones we identified when we first surveyed this that could possibly be used and that we will be doing analysis on to examine whether those lower temperatures or higher efficiencies can be taken advantage of.

Copper chlorine cycle could theoretically operate as low as 550, making it a candidate for any of the intermediate temperature range fast reactors. Obviously that cycle has not been demonstrated.

There are issues with all of these that we need to look at before we decide to do any work on them.

The chlorine cycles, the copper and iron chlorine both in the 650-550 range are of interest. There are others, and we have seen literature values as high as nearly 70 percent. When you do the energy balances, it could be there.

Actually, our expectation is you probably have issues there that keep those from being practical, but you do want to know if there are any cycles out there that are either higher efficiency or lower operating temperatures, and the one that we have settled on is the most likely near term candidates.

This is just an example of the kind of cycles we came out with. There is an activity at Argonne National Laboratory that is coordinating a look at a wide range of cycles in somewhat more detail to understand whether any should be actively pursued in the program.

All of the things I have discussed so far in terms of technologies do require high temperature heat exchanger with a reactor at some point. There's 900 degrees C. for the thermochemical reactions. We may be able to lower that with some other technologies, including membrane applications, but generally we have a very high temperature loop.

And for the hydrogen system you generally are looking at intermediate heat transfer loop as the interface between the reactor and this.

For the electricity, clearly you can consider direct cycles. For the hydrogen there will be an indirect cycle here. That will be an intermediate heat transfer loop that isolates the hydrogen process to some degree from the nuclear plant.

The configurations that are being considered, I think down the road one would consider dedicated options as the most likely. You would either have a hydrogen thermochemical plant or an electrical plant or a process heat plant for the hydrogen. But one could consider combinations as I showed in the diagram earlier. Those could be used to trade off electricity demand versus hydrogen production, but right now the issues are -- technical issues that we have to address are largely the same for both.

And when you do think about these things, you do have a combined plant. The safety technical issues for those plants, you have to consider the effect of one on the other, and we are just starting to start looking at those implications.

It is clearly less of an issue for the high temperature electrolysis, but it still has a very high temperature interface. A significant issue for the thermochemical cycles, these potentially more efficient and lower cost, but more difficult cycles.

The goal here, of course, in our view was to identify the approach you'd have to take to be able to regulate these plants separately, to consider them separately. The chemical and nuclear plants would be regulated under their appropriate or applicable framework, and what we're doing is now starting to do the process of what do you have to do to make that happen.

You have to understand what could happen in this chemical plant, you know, how bad could that be. How could it affect the nuclear plant? What criteria do you use?

And so this process of starting to understand this kind of map of impacts of one on the other, and then what do you have to do to provide that isolation in terms of either separation distances or engineered features or other features? It's trying to understand that landscape that is currently being started up in the program.

DR. POWERS: You certainly have nuclear plants located adjacent to large chemical facilities. Waterford comes to mind.

MR. PICKARD: Yes.

DR. POWERS: I mean, it's surrounded within yard. In fact, its emergency response area and the chemical plant response areas are coincident. They work together. I mean, there's nothing in the regulations that precludes that.

MR. PICKARD: right.

DR. POWERS: It's just additional work on the plant operator.

MR. PICKARD: It is, and clearly you have to do additional work on these kind of cycles to do that. So I think our approach, and I'll get to that in a minute, is to start looking at the chemical industry database. What kind of safety experiences are out there that could kind of give us a clue as to what kinds of accidents, both initiators and consequence.

We might have a plant like a thermochemical plant or a high temperature electrolysis plant. So that is at least the approach we're trying to take. The kind of issues that come up clearly, especially when you --

DR. POWERS: One of the problem I'm sure that you're going to encounter is the safety analysis that the chemical industry likes to do is not exactly aligned with the probabilistic risk assessment that we like to do for the nuclear power plants. We do the chemical process when we do nuclear facilities, and then we got to PRA over the nuclear plant and we can keep them nicely separated.

But here you're going to have to make a mesh, and they don't mesh very well. The problem is the summation over sequences, that the chemical industry doesn't sum and we do sum.

MR. PICKARD: Yeah, and I think that's a real important issue. I think we're also aware of the combination of these plants. There are different approaches, methodologies, and you've got to make sure what we come up with accounts for that bridge.

Bridging that gap is important, but it's, I think, where you start at least. You start with -- you know, separation distance is one of the ways you can provide some barrier here, and you know, when you think of transporting 900 degrees C. heat, that's a little different, not a trivial issue, and these aren't engineering studies, but you do take a quick look at whether you can separate these significantly and what kind of impact --

DR. POWERS: I don't think you get any -- I mean, the separation where you don't have to worry is five miles. Okay? I mean, the way it's written in to the regulation, at a nuclear plant you don[t have to worry about a chemical facility that's beyond five miles. That means separation is just not going to buy you anything.

MR. PICKARD: And we're probably not going to go that far. So right. I think what you do is the analysis you have to do, if you can find these in the curve where that analysis gets easier as you are farther away, not five miles, that's what you're trying to discovery. Are there sensitivities that you can leverage by being a certain distance?

I did want to show you a couple of curves. The heat losses that you have to take would clearly be a direct impact on efficiency if you had to transport a long distance. At least from the early scoping analysis, it really doesn't look like those are fundamental issues.

We just looked at a model of a concentric pipe where you use the central pipe as the hot leg going down to the process plant and that process heat exchanger, and the return outer leg is at some lower temperature on the order of 500 C., and you just look at what kind of insulation in terms of conventional insulator you have to invoke to minimize the percent power loss. In terms of the energy you're transporting, what percentage of that could be lost?

And this just shows that percent versus the transport distance in meters, and by the way, this parameter over on the left-hand corner, the thickness to the diameter, all they're saying is .1 or one or 10 percent of the thickness of that diameter pipe in terms of the surface area, in terms of the thickness of insulation, and the assumption here is something like low density zirconia.

And in this case, they did model stand-offs for the inner pipe and they did model a structure every 20 meters or so, but you can see that if you're willing to put reasonable insulation on this, you can transport that energy quite a ways without too much loss.

I don't know if the costs by the time you engineer all of this are in line. We haven't really done that, but you do think that the issue of separating this by some substantial distance is not going to be a significant energy loss mechanism. You've still got to consider that, but it's not a fundamental flaw.

MR. ROSEN: That's an interesting model, but the plant guy in me says, "Well, how do I inspect that inner pipe?"

MR. PICKARD: Yeah, that's right.

MR. ROSEN: You meet the in-service inspection requirements that are in there.

MR. PICKARD: There's a big issue there. Of course, the reason for doing it this way was so you could minimize the pressure drop across that boundary. You can have the outer temperature colder and so the pressure boundary is colder and the inner pressure boundary is hot, but not a big delta P.

And this is not the only way to do that, of course. We just wanted to kind of give you an idea that you can separate these things in terms of an energy loss by a significant amount.

This is a little more dramatic than it needs to be. If you looked at the pumping power losses, that's a little bit of a different situation. If you looked at the same transport distance and how much pumping power it takes to move that energy, if you're going to use helium, and helium, of course, is one of the candidates for this, it's not out of the question, but if you want to keep losses very low for

600 megawatts being transported, this looks like a 3.-something meter pipe to do that in this model.

Whereas if you used a molten salt, and, Tom, you're probably aware of the issues here, but obviously the heat capacities and the pumping powers are much smaller so that it looks like if you want to get a long distance away from a pumping power aspect, the molten salt or liquid coolant is going to be a lot easier.

On the other hand, that at these temperatures does introduce some materials issues and other issues you've got to deal with, but it does show that it's not out of the question to do either of these in terms of sizes, and whether you do it as one single pipe or multiple, you'll know, but if you're going to transport this energy a long way with very minimal losses, you do have a significant size pipe to minimize the pumping power losses.

Nobody has set a criteria for how low that needs to be, but obviously you'd like this not to be -- you['d like to be less than a percent kind of number.

DR. POWERS: One thing that has always bothered me if you're going to hydrogen production because you don't think you have enough natural gas, where are you going to get the helium?

MR. PICKARD: Where are you going to get the what, Dana?

DR. POWERS: Helium.

MR. PICKARD: Oh, the helium. I will admit to not having looked at the economics of either the piping system or the helium inventory that would be required for a structure of that size, and obviously those are the two kinds of candidates people are looking at right now to do that.

DR. POWERS: I think natural gas is our primary source of helium.

MR. PICKARD: Yes.

DR. POWERS: And if you don't have enough of it, we going to get --

DR. KRESS: I suspect since you're not throwing away the helium, you're just recirculating it, it's not a big inventory.

DR. POWERS: The helium throws itself away. That's the problem.

DR. KRESS: Yeah, you would have some losses, but it's not like you're using it all up like you are the hydrogen.

MR. PICKARD: Well, I think the only point here was neither of these look necessarily straightforward, but both of them look possible with appropriate engineering. So the fact that you can separate these plants by some distance, you have some control over that.

When you look at the safety issues, what can the chemical plant, the hydrogen plant do to the reactor? When you think of first the hydrogen, and we don't really know what kind of inventories you would have to have associated with these things, you would obviously try to minimize that.

But a 600 megawatt plant producing hydrogen at 50 percent efficiency, whether that was electrolysis or thermochemical, that makes a couple of kilograms of hydrogen per second, and therefore, the inventory of this, regardless of how you configure this, is a large number of kilograms of hydrogen, and the appropriate amount of oxygen goes with that.

So you do have to think about how this is temporarily stored, the pipeline, the handling of this as a major factor in this overall process and not just the chemicals that make it up, but the storage of this large volume of gases that you've got to deal with.

Obviously the oxygen issues are different, but you've got unprecedented amounts of oxygen potentially available if these kind of things come to pass, and the issues are different. It's not detonation, but you can burn a lot of stuff with an oxygen cloud hanging the ground here.

MR. ROSEN: Plus PWRs today operate with a hydrogen over pressure. So it's not an unknown --

MR. PICKARD: It is not an unknown thing.

MR. ROSEN: But of course these inventories are much larger.

DR. POWERS: Isn't the transient overcooling a problem for your gas reactor? Because or your temperature coefficient of reactivity?

MR. PICKARD: Transient overcooling?

DR. POWERS: Yeah, transient overcooling.

MR. PICKARD: I think those stabilities have to -- the power densities are low enough. You know, the time constants are so forgiving and the thermal capacity is so large I think those kind of things are -- I mean, I haven't done that, but I would be reasonably sure that would be manageable.

DR. POWERS: I mean, we certainly may run into problems with things like the pebble bed because of transient overcooling.

MR. PICKARD: Well, prismatic pebble bed, they will have similar issues.

DR. POWERS: Yeah, you cool the coolant

down, suck the heat out of the coolant, and your reactivity goes up so high that you have your control problem.

MR. PICKARD: Yeah, the loss of load is not such a concern with these power densities and heat capacities, but I don't know if Rob has a comment on that or not, but the issue needs to be looked at clearly. A strong negative temperature and you do have that.

Of course the other obvious thing, particularly for the thermochemicals, is the chemical hazard from these things. There's lots of iodine and SO_2 and SO_3. I mean, it's an obvious point, but for a plant even of a 600 megawatt thermal size, there's no question you end up with large quantities of these things.

The configurations here are very preliminary. We don't have any engineering designs, but if you just look at what current flow sheets have and the inventory and the residence times that might be implied by the flow rates we're considering, even for those size plants, the 600 megawatt thermal, you do end up with ton of these materials you've got to deal with.

It's not so overwhelming. I mean, eight

tons of sulfuric acid is still only a few cubic meters, but this number is kind of the bottom end of what we would consider for these plants. By the time you get the configured and controlled, there could be a lot more.

It just says you've got to pay attention to this kind of a threat. You've got to be aware of that and analyze those differences.

As I said, the processes or early stage of design, we know a lot more about what the configuration of the high temperature electrolysis might look like than the thermochemical cycles, but as research progresses, you'd like to use the early look at these factors to give you an indication about how these things weigh on ultimate technology choices.

I mean there are lots of options we could be doing research on. You'd like to have this information available as well as performance and cost information.

I just wanted in summary here. The process is in place now. We have started looking at these things. The current activity is starting to look at what the current chemical industry experience can tell us about these things in terms of what goes wrong in plants that have at least relevance to our situation, and how bad can it be and what kind of mitigation and consequences do they expect.

Somebody mentioned the methodology here that has to be looked at. You do have to start developing this methodology in terms of the criteria framework requirements we have in front of us, as well as the methodology used to do that.

And obviously coming from the nuclear regulator side, we tend to look at the PRA as a valuable tool here in combining this, but there's a lot of work to do to establish this kind of combined technology that we've got to apply here.

We are starting this process, starting to do scoping analysis with very preliminary models, looking at the consequence models, not so much on initiation frequencies, but just looking at what kinds of tools do we need to develop to do that.

This work is being focused at INEEL, but this work will be going on for quite a while.

I think this was already mentioned. We do think it's extremely important to involve the chemical industry, the people with relevant experience in this area, in the safety analysis and work we're doing.

I think another one that we haven't thought much about but need to consider is the security issues. That's more and more important in other areas, and we need to look at are there security implications here that influence the way we can configure this plant or the accidents we've got to consider.

And this kind of scoping analysis that was started, trying to get a feel for the landscape, just how bad could it be. What could it do to the nuclear plant? What's the benefit of being either farther away or separating these by more than the usual few hundred yards here? Or what is the benefit of engineered features here? Are there things we can do to help mitigate some of these consequences?

I think we do the scoping analysis, and then we look at these assumptions we've been making, the approach we're taking to see if that needs to be changed.

Well, this is just a summary. We've said all of this. This approach we're on, those studies are really going to go on in FY '05 and '06. We've started them this year. We hope to have a lot of work done in the next year and a half or two.

We do want to make this inclusive. We do want to start incorporating the chemical industry viewpoint into this, but the methodology has to be something that we can use to project at this stage what kind of technologies have hurdles that we need to know about.

I think the goals are by the end of '06 to have a better handle on this and process we can discuss as an approach, the cost, economics and performance of these kind of strategies.

That was all I had. Any questions?

DR. SHACK: Yeah, I had a question about the relationship with the next generation nuclear plant, and I know that there has been a lot of uncertainty as to funding for that, although I mean here that perhaps the funding will be available, and how that relates to this time frame in that at some point you have to go out with specs. for the next generation nuclear plant. There are implications to control room design, to maybe confinement/containment concepts.

How does that all fit together from a time schedule with your advancement of selection of--

MR. PICKARD: And obviously I'll leave it for Rob to talk about the Gen. IV program.

DR. POWERS: It seems to me that we're focusing a lot of attention on the separation distance between chemical process and reactor process. I mean, the regulatory system is not set up for this. So you're going to have to mess with the regulations here for these things, but as it's configured now, I don't think you're getting any mileage on separation. I think it's things like control room design and mitigation systems that are going --

MR. PICKARD: Engineering features or design features.

DR. POWERS: Engineering features that are going to get you something.

Because I think as the regulations are written now, the separation to the "no never mind" distance is so far, and that's all there is. there's no never mind and mind a lot. There's no gradation there.

DR. KRESS: I guess the question would be if you had an explosion, a hydrogen thing, what could it be and how would you determine the effect on the reactor?

DR. POWERS: I think the things that I would focus more on would be the control room survivability in the event of a release of all that sulfur dioxide or something like that.

DR. KRESS: Yeah, that would be the other issue.

DR. POWERS: And the way that thing is written right now is SO_2 shows up in the control room reg. guide, but they're thinking in terms of pounds, not tons. I mean, they do have rail car transport, and that you have to consider that mass and frequency out to five miles. You don't have to consider anything beyond five miles on the theory there would be sufficient warning.

Okay? Now, I mean five miles is just intractable here. It's just too far.

DR. KRESS: One thing separation doesn't help you on is if you have a loss of heat sink scenario. It doesn't matter how far away you are.

DR. POWERS: I think for the gas cooled reactor, I think it's overcooling not undercooling that's a problem.

DR. KRESS: Yeah.

MR. ROSEN: The control room environmental design right now in current lightwater reactors is very, very limited. It's taking air, filter it, and give it to the operators and isolate the air and go into recirc. when you have a threat.

Now, that doesn't mean all control rooms have to be designed that way. I mean one could side with a different concept, some kind of a two-stage design or a double isolation or control room around the controllers or environment around the control room and basically depart from the existing design if you're going to have a big threat like these tons of materials.

I don't see that conceptually as a very difficult enterprise.

MR. PICKARD: You know, I think the approach that we're trying to take is understand what the features or impacts of those things are because the mitigation approach to a hydrogen may be Quite different than you'd want to do for the SM-2.

We just don't know where the knees in those curves are yet.

DR. POWERS: Well, I mean, in some cases you're going to have to invent because the regulations right now, they don't have knees. I mean, they're not continuous functions. They're step functions. I mean that's simply because nobody has ever had to confront it. And so you have to come in and say, "Well, yeah. I've analyzed this, and here's what you've got."

And the staff is accepting them, those kinds of arguments. They just don't exist, right?

DR. DENNING: I had a question and maybe Dana is the best one to answer it, and that is if you look at BLEVE type of situations, can you really get that with hydrogen or is it so BLEVE type of concerns where you have a gas cloud that goes out and then you get ignition?

DR. POWERS: No.

DR. DENNING: Because the hydrogen is so --

DR. POWERS: So diffuse that it just doesn't do anything, yeah.

DR. KRESS: You have to confine it and mix it with --

DR. POWERS: Hydrogen, hydrogen is really tough to get to. The SO_2 is the one that bothers you a lot more here because it's heavy and it's train following and everything else on that, and it's not only combustible, but it's poisonous as all get-out.

MR. ROSEN: Well, again, that goes back to control room design, including where you put the intakes. If you put them down low, you're in trouble. If you put them up high you get an advantage.

DR. POWERS: Yeah, there would be an advantage to high intakes.

DR. DENNING: Maybe it's a good use for the oxygen.

DR. POWERS: Yeah.

MR. VERSLUIS: Well, gentlemen, good afternoon. My name is Rob Versluis, and I entered here into the firing zone because I heard NGNP and threats. So I'm here to try to answer any questions that you might have.

Although just sitting here listening I think maybe you give it another 15 minutes and we've got a control room design that --

(Laughter.)

MR. VERSLUIS: -- that will get us out of this problem.

But anyway, I haven't actually really prepared any presentation. I have some slides in case questions come up, but let me give a little bit of an overview of where we are with the NGNP.

It is one of the six concepts from the road map, and so there is an R&D plan. The U.S. has adopted some of that R&D plan and works together with other countries to achieve the R&D, and we are in the middle of working out with other countries how we do that so we can get the benefit of using each other's facilities and joint expertise.

We have a notional schedule for the NGNP which says that we'd like to have a demonstration plant built and operated somewhere between 2017 and

2020, and it's good to have a notional schedule so that we can at least do some planning, but I have to say that the signals that we are receiving both from the administration and from Congress are somewhat confusing. So I'm not entirely sure that that is not going to change the plan.

DR. DENNING: In which direction?

MR. VERSLUIS: Well, up, down? Up or down, right? It's not likely to be a lot sooner I don't think even though there is pressure for building something faster.

Well, I don't want to particularly speculate on that.

But we have an R&D program underway today, and we are coordinating --

CHAIRMAN WALLIS: I want to ask you. Is there any precedent for DOE plans 20 years in the future ever having been fulfilled in the past?

MR. VERSLUIS: Well, you're asking the wrong guy. I haven't been with DOE long enough, but I guess the answer is that 20 years is a long time.

CHAIRMAN WALLIS: I just wonder if there's any precedent for you guys having planned that sort of thing over the past 50 years and the plan having succeeded.

MR. VERSLUIS: Well, we have built, successfully built back many --

CHAIRMAN WALLIS: Yes, but was it according to the plan or something else happened?

DR. POWERS: I think you're referring to DOE's nuclear weapons programs probably, has a pretty good track record.

CHAIRMAN WALLIS: That's because they're not interfered with by committees like this?

(Laughter.)

DR. POWERS: They have their own set.

MR. VERSLUIS: Well, we couldn't do anything without a plan. We have a plan.

(Laughter.)

MR. VERSLUIS: And we actually have a quite well defined plan for fuel development, and we are getting underway with materials development. We have not made any final selection. We have done trade studies on what the design concept could be. For example, lately the liquid salt cooled version of it has been kind of popping up, and we're doing preconceptual studies to see what the issues are. There are clearly strong tradeoffs there.

I mean, we start with having to -- the salt freezes at some high temperatures. So that is a big inconvenience, to say the least.

At the same time, you don't have to go to high pressure. You have ambient pressure. The whole system can be -- the reactor itself, the transport system, and the hydrogen plant are all at ambient pressure or at least some --

DR. POWERS: I've got a business.

MR. VERSLUIS: The heat transfer characteristics are very much more favorable for liquid salt. So there are a number of tradeoffs that we'd like to study before deciding where to put that money, so to speak.

So that's at a 40,000 feet level what we are currently doing. We have an R&D program. We are spending, I would say, close to $25 million a year on it. It's a significant program.

We have other countries like Japan and France that are also seriously looking at materials and fuels issues. So we are very much in need of a decision, if you will, as to what the way forward should be.

And when I say "we," I mean the administration. That's not just the Office or Nuclear Energy that drives that.

That is more or less what I wanted to say about where we are. Are there any other questions?

DR. DENNING: Well, what about specific things like contractor and this kind of stuff for GNP. Are those things going to happen in the near future, I mean, other than INEEL?

You know, we hear about a contractor that's going to be award of a contractor.

MR. VERSLUIS: We expect to be using contractors to help us select the concept or design concept that we will be dealing with, and of course, down the line, down the road we will be working with design and construction contractors.

The exact acquisition strategy is still under consideration within DOE. We have defined several potential strategies, and they are being evaluated.

DR. DENNING: It strikes me that we have a major energy crisis, and yet there hasn't been the commitment by the government because of other things, the commitment of resources to really make it happen, and it seems to me like, you know, we have gas cooled reactor technology. I mean, we could really do this program much quicker than 2017, I think, if the dollars were there. And a large reason that the program is such a long-term research program is that the country is not ready to make that commitment.

Is that true? Particularly if you look at the electricity generation part of it versus the hydrogen production, is that true or not true?

MR. VERSLUIS: Well, I guess I'd like to answer that in two ways. The first way is that we have been speaking here only about Generation IV program and the hydrogen program because that was the subject of today's meeting, but in fact, there is a very high priority within NE, but also within DOE and the administration to get new advanced lightwater reactors built because that is step one. You know, whatever we are looking at if we don't get that step done, I don't know that there is going to be a step two.

So let's not lose sight of the fact that there is at least in terms of statements and support from the administration and increasingly also by other means financial support and our NP 2010 program. There's clearly a commitment by the administration to make that happen, to help a revival of the nuclear industry.

In terms of the next generation, and we have, in fact, clearly two needs here. The intermediate term need that we have been talking about today is being prepared for an energy system that uses electricity and hydrogen as the main electricity energy carriers, and nuclear could play a good role in that, and that's what we've been talking about.

For that the gas cooled or the very high temperature reactor would be the best candidate, but there is also a second activity, which is I would say taking place at a lower level, which is the fast reactor activity, which is actually going to be more important in the future, in the long term future. So those two legs we have for our program.

The gas reactor, while there has been a lot of technology development, to build a commercially viable, licensable, high temperature reactor today, there is a lot of things that still have to happen, things that have not actually been happening to today's standards, and that includes the development and qualification of fuel, manufacturable fuel according to the standards that are acceptable; fuel that can go to high burnups and higher temperatures.

We don't have the codification of the materials that we see and we will be using. We have made a selection of materials that we think would be required, but even if you look at the designs that are today being named as near being built in the United

States, you'll still have big codification issues, for example, the pebble bed reactor, the PBMR from South Africa that could not be just built in seven or eight years either.

So there are still a number of things, and you know there are other things, too, the helium turbine; there are a number of things that still have to happen before you can actually get one that is a commercial demonstration and it is licensable by the NRC.

DR. KRESS: Let me give you a couple of initial reactions. Number one, I think it overcomplicates things to generate electricity and hydrogen together. I think you ought to have a dedicated reactor to produce hydrogen.

MR. VERSLUIS: I agree.

DR. KRESS: Okay. Number tow --

DR. APOSTOLAKIS: In what way?

DR. KRESS: Don't worry about producing electricity with it. Just use it for heat.

DR. APOSTOLAKIS: I understand, but why does it complicate it in any way?

DR. KRESS: Well, you have to have turbines and you have to have electrical powers going in and out, and you have to have all sorts of extra things with a reactor that makes electricity. You have to have a different class of people running the thing, a different set of maintenance.

DR. POWERS: I don't know of any chemical process, continuous chemical process that likes to start and stop and start and stop.

DR. KRESS: Yeah, that --

DR. POWERS: This idea of you make hydrogen at night and electricity during the day, the chemical process just is not going like that at all.

DR. KRESS: It's not going to like that at all. So that would be --

DR. DENNING: Tom, could I raise an issue though or a question? And that is as far as the next generation nuclear plant, the demonstration plant that's built, I absolutely agree with you in general, but as far as if you're going to build a demonstration plant, then it seems that you might build it dual purpose so that you can use it for both of those things to check out the turbines and --

DR. KRESS: If you're just checking out things, that's all right.

MR. PICKARD: I think we agree with your --

DR. KRESS: That would have been fine.

Another impression is I get the impression that all of your hydrogen side, production side, you're thinking about collocating it on site of the reactor. I don't know. I'm not a chemist, but are there systems that one could use the reactor to produce something not quite as hazardous to hydrogen and take that off line and use it to produce hydrogen?

A question I might have is how do they make aluminum. Don't they use aluminum oxide an Al203, a bauxite?

MR. SIEBER: Yeah, they dig it out of the ground.

DR. KRESS: They dig it out of the ground. It's an oxide.

MR. ROSEN: It's a big carbon electrode.

DR. DENNING: Yes, it's a big electricity generator.

DR. KRESS: Well, you could do that off site and make aluminum say out of this and bring the aluminum -- I mean, you could use the nuclear plant to do this conversion of the oxide to aluminum, and I think you would have a less hazardous system there.

Then you take aluminum off and use it to combine it with steam at high temperatures and made hydrogen and the oxide again, and bring the oxide back.

But you know, I didn't see any concept. I don't even know anything about these concepts because I haven't thought them out, but if you could figure out a way not to have the hydrogen production system right there with the reactor, I think you simplify your risk analysis.

CHAIRMAN WALLIS: Well, the easiest way to do it is to make electricity of course, and send the --

DR. KRESS: That may be it.

MR. VERSLUIS: Well, if such a material existed, it would be an important energy carrier. I mean that's what you're talking about. You're talking about carrying energy from one place to another, and as far as I know there aren't very many good candidates, and electricity and hydrogen are the best ones.

DR. KRESS: The other impression is I do think you have to have a -- you're talking about separating the regulations. I don't think NRC will allow you to separate out completely the hydrogen production if it's on site. You're going to have to factor it into some sort or risk assessment, and it's not going to be separate from the NRC side. It may be separate from other parts, but NRC will want you to do them together. I don't think that's --

MR. ROSEN: A chemical plant may be happy to have a nuclear plant next door and not care too much about it, but the converse will not --

DR. KRESS: The other way is -- that's exactly what I meant to say, yeah.

MR. SIEBER: Think of the happiness of the terrorists.

MR. VERSLUIS: But you're not saying that the chemical plant would need to, let's say -- let me put it the other way. The chemical plant has its own set of regulations from the chemical industry under which that is going to have to be regulated.

DR. KRESS: Yeah, NRC won't care.

MR. VERSLUIS: The NRC will want to know a full statement of the potential impacts of anything that goes wrong in that chemical plant, and I think we certainly are aware of that.

DR. KRESS: But other than that, does anybody else before we close out?

MR. VERSLUIS: I wanted to come back for a minute to your earlier statement about losing oxygen in the atmosphere. This has come up actually in the context of --

DR. KRESS: It has come up?

MR. VERSLUIS: It has come up not in our arena so much as it is in sequestration of carbon dioxide because that's where you lose oxygen. You take it out of the atmosphere. You stick it in the ground. If you do that on a really, really big scale, I guess it could -- people have said, yeah, you've got to worry about it, but it doesn't come into play in our system.

MR. ROSEN: But you don't have greenhouse gases anymore.

MR. VERSLUIS: that's right.

MR. ROSEN: But you don't have any oxygen.

MR. SIEBER: We're all going to freeze.

DR. POWERS: My Canadian buddies like this global warming business a lot. They may want those greenhouse bases.

DR. KRESS: Thank you. this was extremely interesting.

DR. SHACK: That's very much.

DR. KRESS: I think useful to us, and so we look forward to further iteration.

DR. SHACK: Are they doing tradeoffs versus batteries, for example? This whole process makes a battery kind of attractive.

MR. VERSLUIS: We haven't talked a lot about economics here, but it's very important in our considerations, and you know, that is really the answer to your question. How do all of these various technologies stack up in terms of a large production and compare that with --

DR. SHACK: There's a whole infrastructure that has to go with this.

MR. VERSLUIS: The energy distribution infrastructure that we have today is optimized for fossil fuels, and so that's the first question. You know, it would have to be changed. How does that happen.

But it is now optimized now for hydrogen.

MR. SIEBER: I take it that if you could solve all of these engineering and materials problems and build the process, that it would not be economic in today's marketplace, right?

DR. DENNING: Did you say "would" or "would not"?

MR. SIEBER: Would not.

DR. SHACK: It depends on how successful you are.

MR. VERSLUIS: I think it's probably fair to say, but the Generation IV program is, in fact, a program that has a very long view. We try to place ourselves in 2015 and kind of imagine what the world will look like then because those are the time scales we're really dealing with.

MR. SIEBER: Well, electricity production, I think, is economic. Going to a hydrogen economy as a replacement for petroleum products right now doesn't appear to be economic.

MR. VERSLUIS: Because we don't have the technology right now.

MR. SIEBER: right.

DR. POWERS: It seems to me that I wouldn't jump immediately to the transportation aspect of it. I think the point that was made earlier, there is a huge and a growing demand for station sources of hydrogen and a good, capable petroleum refinery size that we have in the United States is about one nuclear plant's worth of hydrogen. So you know, a static source of hydrogen, it's very impressive.

The crude that we get from Venezuela just almost doesn't pour.

MR. SIEBER: That's right.

DR. POWERS: I mean it's the best approximation of coal.

MR. SIEBER: Well, the interesting thing

is you can expand the current petroleum resources by using hydrogen as an additive to that, and that could add hundreds of years of supply onto that resource.

MR. ROSEN: But you have to get the hydrogen somewhere.

MR. SIEBER: That's right, and so this is where this kind of process would fit in in an economic sense, as I see it.

CHAIRMAN WALLIS: I think in order to work out the economics, you have to look at the economic costs of the environmental effects of all of these processes, once you can get to that stage with producing so much energy.

DR. POWERS: Just locate it in Vermont. There are no consequences there.

CHAIRMAN WALLIS: Anything else?

We're going to take a break. I'd like to ask my cognizant federal official whether we need the transcript after this. I think we're doing internal -- aren't we doing internal ACRS things after this?

We have Jack Sieber and we have this corrective initiative. We don't need the transcript.

DR. LARKINS: I don't think so.

CHAIRMAN WALLIS: So we do not need the

transcript. I'm going to take a break, and since the members love to take breaks longer than 15 minutes we'll break until three o'clock.

(Whereupon, at 2:39 p.m., the meeting was concluded.)