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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

506th MEETING

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THURSDAY,

OCTOBER 2, 2003

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ROCKVILLE, MARYLAND

The committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 12:30 p.m., Mario V. Bonaca, Chairman, presiding.

COMMITTEE MEMBERS:

MARIO V. BONACA, Chairman
GRAHAM B. WALLIS, Vice Chairman
F. PETER FORD, Member
THOMAS S. KRESS, Member
GRAHAM M. LEITCH, Member
DANA A. POWERS, Member
VICTOR H. RANSOM, Member
STEPHEN L. ROSEN, Member
WILLIAM J. SHACK, Member
JOHN D. SIEBER, Member

ACRS STAFF PRESENT:

SHER BAHADUR, Associate Director, ACRS/ACNW
RALPH CARUSO, ACRS Staff
I. JERRY DOZIER, Reactor Safety Engineer
SAM DURAISWAMY, Technical Assistant, ACRS/ACNW
MEDHAT EL-ZEFTAWY, ACRS Staff
JOHN FLACK, NRC Staff
CORNELIUS HOLDEN, NRC Staff
HOWARD J. LARSON, Special Assistant, ACRS/ACNW
HOSSEIN P. NOURBAKHSH, ACRS Senior Fellow
WILLIAM S. RAUGHLEY, Senior Electrical Engineer

I-N-D-E-X

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

(12:33 p.m.)

CHAIRMAN BONACA: Let's get started and wrap up this briefing on fire issues.

MEMBER ROSEN: Are we on the record or not?

CHAIRMAN BONACA: Yes.

MEMBER ROSEN: Okay. Now, you asked me to go back, Mr. Chairman, and talk again about the fire dynamics tools.

CHAIRMAN BONACA: Not just a complete -- I mean, I thought that --

MEMBER ROSEN: Okay. No, I was on the fourth issue, which is the --

CHAIRMAN BONACA: All right.

MEMBER ROSEN: -- which is post-fire operator manual actions.

CHAIRMAN BONACA: Okay.

MEMBER SHACK: I mean, we can get those on a CD, right?

MEMBER ROSEN: Yes.

CHAIRMAN BONACA: So go to the fourth --

MEMBER ROSEN: They're on a website, actually.

CHAIRMAN BONACA: Okay.

MEMBER SHACK: I can get the programs on a website?

MEMBER ROSEN: I think they said that it was on a website, but what I got was -- Mark Sally gave me the book, a three-ring binder, and a CD-ROM. Probably the easy way is to just ask him -- ask the staff to have Mark Sally get a copy for you.

CHAIRMAN BONACA: Okay. So --

MEMBER ROSEN: Okay. So, then, the fourth issue -- let me just recap. We've talked about 10 CFR 50.48, which is the rulemaking to allow licensees to voluntarily adopt NFPA 805. We've talked about post-fire safe shutdown associated circuits analysis and the resolution of the issues there. We've talked about these fire dynamics tools. And the last issue that came up at the subcommittee was a discussion of post-fire operator manual actions.

Now, there's a rulemaking underway on this specific subject to address what has been found out to be widespread reliance in safe shutdown analyses on manual actions by operating staffs, in lieu of physical barriers and equipment, which is what Appendix R would proscribe.

Now, current requirements don't specifically prohibit manual actions, but criteria for

when such actions can be relied on are needed. We've talked about it in the subcommittee as feasible manual actions. George had a problem with the word "feasible." "Anything is feasible," said he.

But what was really meant was, can the operators, in the time allotted, get to the equipment without having to expose themselves to the effects of the fire, smoke, heat, or radiation, and can do it in a way that's in a procedure perhaps and not something they have to invent or be heroic in order to carry out the action.

Now, you should understand that that rulemaking to allow reliance on feasible manual actions has -- the NEI has petitioned the Commission to simply codify the allowance for feasible manual actions through the direct final rule process. In other words, don't even bother to go through all of the hoops. They want it now, and they want it quick, and that's still on the Commission's table I guess someplace.

Members of the subcommittee listened to the presentations on this subject, and basically suggested that the industry and maybe the NRC staff working together should develop a quantitative technique for evaluating manual actions that

incorporates human error forcing functions into it -- in other words, uses the kind of human error models that we have, which deals with error forcing functions and established threshold values for evaluating the risk effectiveness and acceptability of manual actions.

In other words, take this manual action that's relied upon by a plant, say, and set some -- how likely is it that the guy will be able to carry out that manual action effectively, using the things that are in the handbook on human error reliability prediction.

That's not -- this isn't new. There's a handbook out by Gutland & Swain that's been there a long time, or some other technique that may be equally valid. And so there wasn't any conceptual difficulty with accepting the idea that one could take reliance on human manual actions in fires if they were properly analyzed.

And those were the four issues. As I said, we'll have another subcommittee meeting in February, and I think -- and then a full committee meeting after that, just because we have to give the Commission the benefit of our views on the 50.48 rulemaking.

MR. DURAISWAMY: So we plan to write the report at that time?

MEMBER ROSEN: At that time, yes.

MR. DURAISWAMY: What do you think the timeframe will be approximately for the full committee meeting?

MEMBER ROSEN: February.

MR. DURAISWAMY: February.

MEMBER ROSEN: Okay.

MR. DURAISWAMY: Well, Steve, I think 50.48, we can look at the thing in the November/December timeframe, the draft final rule.

MEMBER ROSEN: Yes.

MR. DURAISWAMY: That's coming to the full committee.

MEMBER ROSEN: Do you think it will come that early?

MR. DURAISWAMY: Yes, sir. They want to come and to talk to us in our November meeting. And if they can't give us the document, it'll be at least December. So either November or December, we'll have red letter on the draft final rule on 10 CFR 50.48 during --

MEMBER ROSEN: Now you're getting me confused, Sam. But the direct final rule is not part

of 50.48.

MR. DURAISWAMY: What?

MEMBER ROSEN: The direct final rule is --

MR. DURAISWAMY: Oh, no, no. I'm not talking about direct. The draft final rule on 10 CFR 50.48 to endorse NFPA 805.

MEMBER ROSEN: Okay.

MR. DURAISWAMY: So that rule we had red letter.

MEMBER ROSEN: Yes, I understand, and that's what I'm talking about.

MR. DURAISWAMY: Yes.

MEMBER ROSEN: That I think will be in February.

MR. DURAISWAMY: No.

MEMBER ROSEN: You're saying it could be earlier than that.

MR. DURAISWAMY: They just said they wanted to come and talk to us in the November meeting or December.

CHAIRMAN BONACA: November or December.

MR. DURAISWAMY: Yes.

MEMBER ROSEN: They'll have to work with you and me, but I think that's -- that's early, but I -- you know, I don't have any -- I'm not against it,

if they can get here that soon. I just assumed that it would be next year, early next year, before they could do it.

CHAIRMAN BONACA: Okay. Thank you very much for the presentation.

And now we have a presentation by Dr. Nourbakhsh on the PIRT process. We had postponed this before, and so we are looking forward to it now. Go ahead.

DR. NOURBAKHSH: Now I want to give you a brief review of the PIRT process, and based on my review of the limitations with it and how we can enhance the process.

MEMBER ROSEN: Would you do that also in the context of what we just heard about proactive materials degradation?

DR. NOURBAKHSH: I will try to touch on it.

As you know, PIRT stands for -- or was initially a step in CSAU methodology, code scaling applicability and uncertainty valuation methodology. CSAU developed as a -- in order to support the revised ECCS rule which was issued in September 1988. The purpose of CSAU methodology/valuation methodology was to demonstrate the feasibility of using best estimate

plus uncertainty approach.

So one step of CSAU methodology was tabulating all of the important phenomena because they wanted to focus on the parameters and phenomena which impact the peak cladding temperature when they wanted to do uncertainty, and at the same time for assessment of experimental programs.

So, by the way, I looked at the PIRT in the -- in order to review it, I just did a station PIRT, and I found out that most useful PIRT was in England, but it even stands for -- it stood for Police Initial Recruiting Test.

(Laughter.)

And the least -- actually, I found hundreds of PIRTs, and the least common was a meeting on PIRT, again last year in England, on physical interpretation of relativity theory. So there was a wide spectrum of PIRTs.

MEMBER ROSEN: Well, we want to hear about that.

DR. NOURBAKHSH: Right. So anyway, what PIRT process, since the initial development of CSAU methodology, has been used in much more applications than it was envisioned for. If you go back to the background of CSAU methodology, that was a well-

understood phenomenon, relatively. A lot of experience in that, a lot of tests, so there was not really -- the knowledge base was quite a lot.

So the only reason for the PIRT in the context of CSAU was just to tabulate systematically all of the phenomena for completeness. It was a brilliant idea to have a systematic approach to identifying the phenomena.

But as we know, in your widespread use of PIRT -- and Research is planning actually using PIRT in prioritizing the research needs for advanced reactor technical issues. I thought this is a good time to look at the past and what we have learned from all of these PIRTs. And by the way, they are very -- I mean, they are costly and resource -- I mean, they are resource-intensive.

And to look at past several years of experience with the PIRT --

MEMBER POWERS: That is one of the comments I have gotten from the NRC project monitors all the time. These PIRTs are incredibly expensive. And when you think about it, you know, some of the fuel supports, they had six meetings with 30 people maybe, maybe less, and we're not talking about like on the order of an FTE.

DR. NOURBAKHSH: On the order of one FTE?

MEMBER POWERS: Yes.

DR. NOURBAKHSH: I have been quoted two FTE or three FTE.

MEMBER POWERS: I won't argue with you on those. One FTE --

DR. NOURBAKHSH: It was one or two, yes, but one --

MEMBER POWERS: And the test runs -- an INPILE test nowadays runs a million bucks. Turn the reactor on; it costs you a million dollars?

DR. NOURBAKHSH: Yes.

MEMBER POWERS: Don't do anything with it. That just turns it on, shuts it back down.

DR. NOURBAKHSH: That's right.

MEMBER POWERS: I mean, that's just what it costs to get the facility to turn it on and turn it off for you is a million bucks, right? So now, is it really all that expensive?

DR. NOURBAKHSH: We are not -- the issue is not expensive, but do we get what we have spent for? I mean, if we enhance the process, the product would be much more useful and much more transparent.

MEMBER POWERS: But you start saying, "I will agree with you" right up front, that if I spend

any amount of money and don't get what I'm after that's expensive. Okay? But to start in and say, "Hey, this PIRT process is really expensive," I don't think it's so expensive.

I think it's actually a money-saving operation. It sure as hell saved the people in the high burnup fuels more than it cost them, because otherwise they -- I mean, it is a gold-plated defense. If somebody comes in and says, "Well, you guys haven't done X in your program," and you say, "We got a panel of world-renowned experts together. They looked at it, and they told us not to do X."

You've just saved yourself an enormous amount of effort right there. That's worth an FTE right there. ACRS sits there and says, "You guys haven't done X." You've got a perfect defense, and we can't say a damn thing about it. It shuts us -- it shuts Peter up.

MEMBER ROSEN: It doesn't shut you up. I know that nothing --

MEMBER FORD: I just grumble all the time, so they don't pay any attention to me.

(Laughter.)

DR. NOURBAKHSH: All right. Okay. The objective in here is to review the PIRT process and

product application and to provide some suggestions for enhancement of the process, basically.

An overview of the PIRT process basically is multi-step. You define what the problem is, what the technical issue is, what are the objectives for this PIRT, whether you are doing it for code development or assessment, or you are doing it for uncertainty evaluation of the code, or some development of some experimental program.

Basically, then you define your system, what are you looking at? Is that in the vessel, or you are looking at spent fuel pool, or basically the third step would be to define the hardware. And then you define the scenario. Basically, what are the boundary conditions for these technical issues? And if it is accident analysis, basically the definition of the sequence.

And then, what are you looking for? What would be -- you are doing it. What would be the figure of merit or definition, evaluation criteria? You are looking for peak cladding temperature, or for PTS we are looking for pressure temperature gradient, temperature basically.

And then, you identify and obtain and review the database which is available on the subject

matter. And then, you come to a -- the meeting. You start with the brainstorming to put all these plausible phenomena on the table. The phenomena, by definition of PIRT, is not -- it could be a process. It could be a variable. It could be anything which may impact the figure of merit or evaluation criteria.

And there is some dependency between all of these parameters, too, but they are not really transparent in -- on those tables. For example, they said on AP600 subcooling margin and boiling and flashing. They are -- basically, your interest in subcooling margin is really important, because it impacts flashing or all of these parameters or things like that.

And then, the last step would be you rank the importance of these phenomena, have done in different levels, could be done highly important, which has a dominant effect on the figure of merit, or low importance or medium. Or you can give a numerical scale one to five, one to seven. And in some cases -- I come back to it -- they use the Sally AHP process to prioritize these. I mean, pair-wise ranking which also has been used to rank all of these phenomena. And then, you document the results.

So it's not really the process per se has

not been documented. I mean, it was an evolving process. It was one step in CSAU methodology, and you don't see the definition of the process or a manual for the process or -- except a paper in Nuclear Engineering Design some years back.

So my observation so far in reviewing more than 20 of them was success in developing PIRT is a strong function of the degree to which supplemental information are well documented. There are various degrees that you could see, but sometimes those implicit assumptions that experts made is not transparent in those presentations. You have to go to appendices, or they were somewhere.

Really, if you wanted to revise a PIRT, you need to do a lot to understand why it was important or why there was a difference of opinion, basically.

So this shortcoming may be partly due to lack of a systematic methodology to capture these -- all of these implicit assumptions that the expert made. And the way these -- of course, the product is not only the tables, it is the supplemental documentation. But that supplemental documentation is not really -- in some of them -- I am not generalizing it -- are well documented.

Sometimes the individual panel members may be expert in some phenomena. In thermal hydraulics, we don't have that problem, because most of these thermal hydraulic issues everybody is familiar with that. When you go to an area which is multi-disciplinary, the chemistry aspect is important, thermal hydraulics, neutronics.

Then, look at burnup credit program. It has -- some panel members may be expert in some phenomena and less familiar with other phenomena. So in order to deal with this reality, they were asked not to vote on the issues that they are not familiar with. But all of these phenomena when you look at them, they are interconnected. They are a network.

When you are saying -- you are asking the bottom-line question, importance of this to my figure of merits, he has to implicitly make some judgments on some other phenomena which he may not be familiar with to come up with to do that ranking. So that is -- I am not sure that this always could be done.

MEMBER ROSEN: Now, before you leave this subject, because I think it's very important relative to the proactive materials degradation PIRT, I mean, there you're going to have a lot of experts. But the field is so robust and broad and important that the --

there will be chemistry experts and materials experts. But even the materials experts will be expert in one aspect of materials and not others.

DR. NOURBAKHSH: Or some mechanical aspect.

In some prior PIRT efforts, again, there are major observation limitations. Pair-wise importance ranking of components for phenomena -- this AHP analogy called hierarchy process. Basically, you go top-down linear to -- you look at your component or the time phase component and under each component's phenomena. And then you rank them, and then there is an algorithm based on ranking value of matrix that they form.

They come up -- the idea behind this AHP is that the people are much -- when you have 20 issues in front of you to rank, it's very difficult. But when you compare them pair-wise one by one of each, it's much easier. So you get the input of the expert pair-wise two at each time -- all of the permutations.

And then, you come up at the end with an idea of to --

MEMBER POWERS: But it doesn't work.

DR. NOURBAKHSH: -- come up with the bottom line.

MEMBER POWERS: It doesn't work. I mean, the whole history of marketing is replete with people doing pair-wise ranking and finding A is better than B, and B is better than C, and C is better than A. I mean, it is replete with that. It fundamentally has that flaw and it, and it -- any time you're looking at multi-attributes you run into this problem.

DR. NOURBAKHSH: Actually, Sally himself recognized that, the man who developed AHP, and later on actually criticized in his recent book AHP, and he came up with something which is called ANP, analytical network IIT, that's looking at all of these interactions because the real practical problems are not linear top-bottom, especially the nuclear safety issues.

We have feedback effects. We have interaction with all of these phenomena and systems that you cannot just ignore them and then --

MEMBER POWERS: It seems to me that --

DR. NOURBAKHSH: -- trying to --

MEMBER POWERS: Well, it seems to me that the thermal hydraulics guys, when they implemented PIRT, did it right. And they said, "Look, formulate some simple models and show me quantitatively how things work, or where the time scales are," some way

to do this in an analytic representation rather than relying strictly on opinion.

And they had some advantages in doing that, but I think that when it's -- when that kernel of an idea from the thermal hydraulics people was taken and applied that the part they threw out was that part. That may be incorrect. Show me how important these things are.

For instance, I mean, I made my attack on some of the recent PIRT activities yesterday. We wrote a diffusion equation for transport through coated particle fuels. And that's a lot like these thermal hydraulic equations you guys get to work with, has a lot of terms in it, has terms due to chemical diffusion, pressure-driven diffusion, temperature-driven diffusion.

And I said, "Okay. Well, you've got all of these things that are important," and they let me get away scot-free with that. And nobody -- nobody at any time asked me, you know, what's the relative importance of these terms? If they had, you know, I would have had to admit that, hey, the only one that matters is the DMCO-driven pressure through the silicon carbide layer.

But they didn't do that, and I think that

has -- the unwillingness to bring over that aspect of the PIRT process gets you into this ranking of opinion -- opinion things in a non-transparent way.

VICE CHAIRMAN WALLIS: In this thermal hydraulics, there's a kind of discussion about the technical stuff. People make presentations and you look at this. So you sort of -- you are informed when you --

DR. NOURBAKHSH: You are well informed, and there is a code. You have a lot of sensitivity calculations in front of you.

MEMBER POWERS: Right.

DR. NOURBAKHSH: When you are going to something you don't have a code for it -- for example, advanced reactors -- and you don't know -- you don't have that much experience with some of these phenomenology, it may not be as easy or at least the use of this is not going to -- I mean, I don't think between nine and six if you have one to 20, to me I think you shouldn't give that much weight between 15 and 20 or 11 and 20. Maybe one is -- maybe that's --

MEMBER POWERS: Can you find a physical phenomenon where you cannot write out a simple time scaling model -- time scalable model. I mean, Zuber says he can scale every damn thing in the world.

VICE CHAIRMAN WALLIS: Can you scale cracking and --

MEMBER SHACK: No way.

VICE CHAIRMAN WALLIS: -- crack growth?

DR. NOURBAKHSH: No, not for cracking.

MEMBER SHACK: If I can write a partial differential equation, I don't need PIRT. I'm home free.

MEMBER POWERS: That's not really true, Bill. I mean, that's --

MEMBER SHACK: Give me an equation. I can do an awful lot with it.

MEMBER POWERS: You can do an awful lot, and -- but they --

MEMBER SHACK: I know how to live with the terms and equations.

MEMBER POWERS: I mean, why would they have invented this PIRT in the thermal hydraulics place, which, damn, do they have a partial differential equation? They've got a hell of a partial differential equation.

MEMBER RANSOM: Although I think in the case of thermal hydraulics mostly they focused on the empirical parts of it, like heat transfer coefficients, triple flow models, that type of thing.

MEMBER POWERS: And I think this is not different from most of these others, that the basic equation you understand -- and I think my question is: is there any physical phenomena where I cannot write down some approximate expression for the -- for what's going on? I didn't say it had to be exact. I said it -- and, in fact, in the guidance on PIRT it says simplified models.

MR. BAHADUR: And you could do order of magnitude analysis to get rid of some of that, like you said.

MEMBER SHACK: You can write down the equation, but you don't know what the terms are. You don't know what the constants and the coefficients are.

MR. BAHADUR: So?

MEMBER SHACK: You know they're not big as a house or small as a -- I think a lot of this -- I mean, the thermal hydraulic people, I mean, they've got these enormous partial differential equations which are exact if you can solve them, but nobody can solve them exactly. So -- pardon?

MEMBER POWERS: They're not exact.

MEMBER SHACK: Well, in the pure form they are exact.

MEMBER POWERS: No, they're not. No, they're not. They don't work after you drop out of the continuum regime. And it happens to you a lot, by the way.

MEMBER FORD: The problem I'm seeing is that you're driving towards -- it does have a simplified algorithm upon which we are going to make our decisions -- the sensitivity to these various inputs.

You mentioned that maybe this discussion should be going towards material degradation. The thing that kills us in materials degradation is that one outlier like core work and core trials for BWR, which does not take into account any simple algorithms.

And under certain situations where you have everything else held constant, it will be a big player. If you change these other constants, it's not a big player. And so it's not a simple algorithm. You can't come up with simple algorithms.

So, therefore, you came back to the idea that you were mentioning about, well, how many experts do you need on this panel who understand enough of all of the parameters which are important? And there's a limited number of experts, and not all of them can do

this, even for one system, the BWR system. If you go into PWRs, forget it.

DR. NOURBAKHSH: But just give you one --

MEMBER POWERS: What? Do you mean there are no experts in PWRs?

(Laughter.)

DR. NOURBAKHSH: I don't want to go through of these details of some examples that -- why this AHP doesn't work. I have elaborated on that on that document I gave you.

But since the initial development of CSAU methodology and PIRT process, there are -- I mean, procedures for expert elicitation. One is NUREG/CR-6372 for probabilistic seismic hazard analysis. There are some aspects of it which would be useful that PIRT benefit from that.

There is a requirement for documentation, the role of technical integrator or technical TFI, what they call it, and different level. Some of these curves, if you put two of the staff members, they could come up with -- if you advance prepare that -- I mean, the question is -- a prudent question is half of the reason as they say.

If you prepare the questions in advance, and then you come up with the -- structure it well,

and then be -- you can do a lot of homework and see what are the information available, where we are having problem of understanding what are really the main issues, then you can bring to focus better these experts and get more use of the -- those times that you are with expertise -- with expert, rather than coming in a kind of brainstorming, half a day, one day, to come up with all of these tabulations of all these phenomena and parameters.

And you really, in the third day, you have to come up with some kind of -- sometimes it becomes more working than forcing them to really understand what is the information and why these judgments are being made.

Something that I found that had a potential is the influence diagram. Really, this is not -- it's called -- I mean, you can call it cognitive mapping, you can call it knowledge mapping, there's all sorts of names for this. And basically, this is something that many people do it in their mind anyway when they come up with some conclusions on something they wanted to make a decision on the judgment.

And these are really influence diagrams. It's a good representation of major factors in the

system and how they influence each other. So it would be a network of representing the thought process of the experts rather than questioning whether this is important on -- with the directive to figure of merit and say why it is important. This impacts this. This impacts this.

If it is material degradation, you go to a little bit of microstructure question -- impact on boundaries or whatever. If it is thermal hydraulics, you go to really much more sub-issues. So it would be a network of notes which represent the factors of importance to the issue, and the directed arc shows the influence.

The qualitative system analysis is in its infancy. But there are a lot of good techniques they are using that we can use that. For example, you could actually -- a lot of this impact or influence, in our field at least, is monotonic. You can say if you increase the temperature, you increase the potential. You could see the trend.

So you can put on this directed arc a plus or minus. That the negative impact -- you increase one, you decrease that. And then, you could put a level -- high, low -- qualitatively. And that qualitative influence diagram has been developed,

which is -- should look at the potential for this.

But even graphical presentation of the implicit assumption that experts make the minimal would be a much more transparent product than a table with a series of HL or 1, 2, 3, 4, 5, in front of them, and then I have to dig up the supporting documents. Sometimes it is not even there.

The example -- it's not really -- I mean, I wanted just to put an example. For example, this is a technical issue and objective, and then you have your hardware. And these are the boundary conditions. The break size or break location or whatever -- each of them influence all of these networks. It's not clear here, you know, why.

But, for example, you put different processes, phenomena, parameters, and how they impact each other. As I say, you can put a plus here or high, low, and then how these finally impact my figure of merits. So you make question -- which one is important? Which is not? So there's a network of -- and they each have a different opinion you can capture, why these phenomena were important to figure of merits, why some experts, why not other experts.

MEMBER FORD: For instance, in materials degradation --

DR. NOURBAKHSH: Materials degradation, here you have your stressors. You have temperature, water chemistry, you have your --

MEMBER FORD: But all of the figures of merit, which I'm assuming --

DR. NOURBAKHSH: No. The figures of merit would be -- three figures of merit. You can still influence these things.

MEMBER FORD: Yes. But the figures of merit, the numbers you are going to put in each box that --

DR. NOURBAKHSH: No, no, they are not numbered. It will be what -- you have an assessment like a matrix of influence of each on all of them, and eventually on these.

MEMBER FORD: Yes. But all of those figures --

DR. NOURBAKHSH: Yes.

MEMBER FORD: -- you have put in those boxes are going to change depending on the values that you put in the other boxes. You're going to have a huge interacting -- it's a pulsating machine. It's going to change. So how -- and it's going to change depending on the system of --

DR. NOURBAKHSH: No. All I'm -- yes. So

that --

MEMBER FORD: How do you put that --

DR. NOURBAKHSH: There is -- actually, I can refer you to papers recently published to address that issue, that -- on the qualitative influence diagram. That when you have one it's impacted by impact of the others, basically, or synergistic effects you could capture them. There are even --

MEMBER FORD: And they can all change depending on the values put in the other boxes. They would all --

DR. NOURBAKHSH: Yes.

MEMBER SIEBER: Well, you're more interested in their relationships than you are what snapshot you're taking --

DR. NOURBAKHSH: But as the first step you wanted to identify the important parameters, basically.

MEMBER POWERS: Peter, I guess I have two questions. I fail to understand what I'm supposed to learn.

DR. NOURBAKHSH: Let me give you a better example, if it's not clear here.

(Laughter.)

MEMBER POWERS: Well, that'll straighten

it out.

DR. NOURBAKHSH: No, no, no, no, no, because you cannot read it. I mean, I don't know whether --

(Laughter.)

MEMBER POWERS: I mean, let me ask Peter a question here, because you see the complexity of corrosion, and I see the simplicity of it. You know, if they're going to ask you a question, "Gee, Peter, is temperature important or not?"

MEMBER FORD: In certain circumstances, yes. In others, no.

MEMBER POWERS: We are talking -- if you looked at the process, they would say, "We are talking about a boiling water reactor operating at the Browns Ferry site, the BWR 4, its 22nd year of life, and it's operating at full power."

MEMBER FORD: And a constant load and --

MEMBER POWERS: Yes.

MEMBER FORD: -- degrees Centigrade, to define --

MEMBER POWERS: Yes. You define the scenario.

MEMBER FORD: And if you go into shutdown --

MEMBER POWERS: No, no, I didn't ask you anything about shutdown.

DR. NOURBAKHSH: No.

MEMBER POWERS: I only asked you about this scenario. I asked you the temperature and --

MEMBER FORD: Under that defined system, as a variable, no.

MEMBER POWERS: Okay.

MEMBER FORD: Because you --

MEMBER SIEBER: How about the cracking they had at Davis-Besse? Was temperature important? Right? Was pressure important? No.

MEMBER FORD: Okay.

MEMBER SIEBER: Is the heat number important? Composition? Chemistry?

DR. NOURBAKHSH: Okay. So you're going to have a different diagram for each component.

MEMBER POWERS: If you look at the -- what they did for the fuel, the high burnup fuel, they said, "Okay. Were high burnup fuel PWRs, ATWS, BWRs?" I mean, they were very, very specific. And within those things they looked at a specific plant.

MEMBER FORD: So you could have a whole --

DR. NOURBAKHSH: For each component you will have one of these, and --

MEMBER FORD: -- and each operating condition will -- sorry.

DR. NOURBAKHSH: Operating conditions are fixed. When you are saying, for example, this is the reactor pressure vessel or upper head, or whatever, you know what is the environment that this is exposed. You know the temperature. You know the water chemistry. The variability between the fleet is not really that much.

MEMBER FORD: So for every system, defined system condition -- material, fabrication, composition, blah, blah, blah --

DR. NOURBAKHSH: You put everything which you define the environments, yes.

MEMBER FORD: Okay, fine.

DR. NOURBAKHSH: And then, you put the degradation mechanisms here or -- and then the figure of merits, what you want it to do, potential for initiation, potential for detection.

MEMBER FORD: You can fill those --

DR. NOURBAKHSH: The time before the initial -- whatever.

MEMBER POWERS: And what I'm struggling with --

DR. NOURBAKHSH: You can put multi figure

of merits, basically.

MEMBER POWERS: What I struggle with heroically is, what am I supposed to do with this Chef Boyardee factory that you've stuck up here?

DR. NOURBAKHSH: Which one?

MEMBER POWERS: I mean, it takes me an hour to sort out where all of the effort is going. I mean, why is --

DR. NOURBAKHSH: Okay. No, no, no, no. I transferred this to a matrix for you. This matrix would be a square matrix. You knew the impact -- when it is zero, you see it doesn't have impact. And then, you put high, low, or one to six, whatever you want. They call it a super matrix.

MEMBER POWERS: Okay. Now, what's different between a matrix and a tabulation that has high, medium, and low on it?

DR. NOURBAKHSH: You see the impact of each phenomena to others, each sub-issue. For example, you see the impact --

MEMBER POWERS: Give me an example.

DR. NOURBAKHSH: Example. You see flashing is important. You see why it is important. Because flashing you see the impact of flash -- depressurization on flashing.

MEMBER POWERS: The impact of flashing on flashing?

DR. NOURBAKHSH: And then -- no.

MEMBER POWERS: I mean, that's --

DR. NOURBAKHSH: For example, you went for a small break LOCA. Let me talk about small break LOCA. Small break LOCA basically you will have to look on the peak clad core uncovery. Basically, you are looking at depletion of water or addition of water, one of these two issues.

So when you are flashing, you remove water. At the same time when you flash, you pressurize. That pressurization has an impact -- well, I'll come to that example.

This is like AP600, and then I come back to here. This is different than -- I don't know why I don't see that line yet. It's different than --

MR. CARUSO: I think what he's trying to do is he's trying to explain this is a documentation process. Okay. Very often --

DR. NOURBAKHSH: This is implicit -- exactly. If they are not different than PIRT --

MR. CARUSO: Right, right.

DR. NOURBAKHSH: -- captures implicit assumption.

MR. CARUSO: Very often you get these groups of wise men together that produce pearls of wisdom, and the pearls of wisdom may be wonderful but people don't always understand how they arrived at those pearls of wisdom. And this is just a way to try to explain and document how those pearls of wisdom got generated. Does that make sense?

MEMBER POWERS: If this is an effort to communicate, I know one individual that it's just failing terribly on. Okay? Because all I'm doing is I'm getting dizzy finding out -- I mean, there's nothing linear about this.

DR. NOURBAKHSH: That is exactly what I was trying to say. It's not linear. It has a lot of feedback effects and a lot of --

MEMBER RANSOM: Well, it seems to me you're moving away from the purpose of PIRT, though. The purpose of PIRT was simply to, in a qualitative framework, to reduce the number of variables, you know, that you must look at.

DR. NOURBAKHSH: That is what these are. I took it from the table. It's half of that table.

MEMBER RANSOM: This is beginning to look like --

DR. NOURBAKHSH: This is why it is

important to my figure of merits here.

MEMBER POWERS: If you see that, I would surely like you to tell me how you see that.

VICE CHAIRMAN WALLIS: This looks to me like the beginnings of a system dynamics model for LOCA, which is a kind of --

DR. NOURBAKHSH: Yes, qualitatively.

VICE CHAIRMAN WALLIS: -- pseudo code where you write down all of these boxes and --

DR. NOURBAKHSH: Exactly.

VICE CHAIRMAN WALLIS: -- say this one affects this one. Instead of writing equations, you write a simple thing -- this one --

DR. NOURBAKHSH: Exactly.

VICE CHAIRMAN WALLIS: -- when this gets bigger, that gets smaller, and here's --

MEMBER POWERS: Well, that's the idea behind neural networks, and that's what it's beginning to look like. We are simply putting --

DR. NOURBAKHSH: That's exactly what it is.

MEMBER POWERS: -- of all of the effects --

DR. NOURBAKHSH: We are not saying that -- we are not substituting these two pairs. We are

saying this is a better way of presenting it. This way you force the experts to give you the exact rationale for their importance.

MEMBER POWERS: If you presented that to me, one of two things would happen. I would be abusive, or I would just turn you off. There is nothing being communicated here.

VICE CHAIRMAN WALLIS: Don't put him on a PIRT panel.

(Laughter.)

MEMBER POWERS: Well, that's the for God's sake truth. Don't ever put me on another one, because I'm so disgusted with what I see as the real problems with it, but I --

DR. NOURBAKHSH: Are you comfortable with the table having a phenomena versus other phenomenon figure of merit at the end? And then, you see the importance of each relative to other ones. I mean, go through a matrix. The column and the -- that's exactly what it is.

MEMBER POWERS: It's wonderfully efficient. It's much more useful to me --

DR. NOURBAKHSH: Yes, yes.

MEMBER POWERS: -- than this.

DR. NOURBAKHSH: It's much more useful.

That's being transferred to a matrix, basically.

VICE CHAIRMAN WALLIS: Well, it's a multi-dimensional matrix that you're talking about.

DR. NOURBAKHSH: But you don't have to do it if you wanted to actually -- one way of doing it -- doing it in multi-layers. A square matrix of identical items and figure of merits.

MEMBER FORD: But this idea of a square matrix with figures of merit, and just coming up with a number off the table, that assumes that it is linear. It assumes that you've got a simple linearized --

DR. NOURBAKHSH: No, no. All that's in the matrix -- you put high, low, or important -- low importance, high importance, or no relevance. You put zero. So you see what impacts what, what influences what, and how these influence the figure of merits.

MEMBER FORD: Okay.

DR. NOURBAKHSH: That's basically capturing implicit assumptions that an expert makes. And then you can make that one, based on that, which experiment in that matrix -- you can actually fill that up, which experiment or which analysis or what is your rationale for that, in a very much transparent way.

MEMBER LEITCH: So every one of those arrows, then, would have not only a direction associated with it, but a relative importance essentially.

DR. NOURBAKHSH: Importance, yes.

MEMBER LEITCH: Okay.

MEMBER POWERS: Your matrix idea is vastly superior to this, because --

DR. NOURBAKHSH: Yes. These are very difficult actually to produce even, but one way of making -- simplifying it, making multi-layers, top-down approach basically. You put the basics and then open the box to go to more details if you want it, to present this. But I wanted to present it a little bit more --

MEMBER POWERS: Apostolakis loves these diagrams. And every time he puts one up, I just throw things at it.

VICE CHAIRMAN WALLIS: It's more the system dynamics people who love these, and this is all they do is draw things like this.

DR. NOURBAKHSH: That's what it is. That's basically the relevance there on --

MEMBER POWERS: If you can replace this with a two-dimensional matrix --

DR. NOURBAKHSH: But that --

MEMBER POWERS: -- where I can readily ready the fact that the liquid inventory depletion has nothing to do with the IRWST injection.

VICE CHAIRMAN WALLIS: But the problem is you've been brought up in these American cities where all of the streets are a rectangular pattern. This is more like a traditional European city, where there are all kinds of ways to get from here to there.

MEMBER POWERS: But we know that the topologists discovered that in Gurtenburg there was not a way to get there without crossing the bridge twice, right?

(Laughter.)

VICE CHAIRMAN WALLIS: Well, you may find the same is true here. I mean, you can --

MR. CARUSO: We actually saw one of -- we actually saw something like this -- that this week at the fuels meeting. Do you remember the slide that they put up about how the fuels codes interacted with one another? You weren't there, but it -- you were there, Peter, and that -- I mean, it looked just like this. It was a spaghetti network.

MEMBER POWERS: We said abusive things to them about it.

MR. CARUSO: And we said abusive things to them. But the point was to show that there were a lot of different factors that interacted with one another in ways that may not have been entirely obvious to the uninitiator.

And they were just trying to explain that this is a complex scenario, this is a complex issue, and there are a lot of different players. That's all they're trying to do.

MEMBER POWERS: In the fuel area, you know, they're trying to say, "Hey, don't go look at this, because it's so complex you'll never understand it."

MR. CARUSO: Well, you know, that's not a good thing to say.

MEMBER POWERS: Well, I mean, that's what they're deliberately trying to say. And I think that's what this kind of diagram does. It says -- it emphasizes the complexity rather than the simplicity.

MEMBER SIEBER: Yes. It's to impress.

MEMBER POWERS: Well, I mean, these are all pretty simple systems.

CHAIRMAN BONACA: Well, in slide 17 you strike a -- you make another statement regarding IDs. Do they help -- so that the individual expert can make

a judgment in their own areas of expertise without making any implicit subjective judgment on the importance of other phenomena? That was the problem you told me.

DR. NOURBAKHSH: Yes.

CHAIRMAN BONACA: Could you elaborate on that, explain to my why it is.

DR. NOURBAKHSH: These are, again --

CHAIRMAN BONACA: Take the Figure 14.

DR. NOURBAKHSH: I mean, this is a very simple system. But suppose some experts are -- these are some of the chemistry issues found in here. Some of them are hydraulics issues here. And they are all interactions between there. So you get only expert opinion and elicitation on these interactions, which is chemistry, without the -- just makes the importance to this without saying how important this is to this, because --

CHAIRMAN BONACA: Okay.

DR. NOURBAKHSH: -- you have to integrate all of these different expertise to the figure of merit.

MEMBER FORD: But in order to do the interrelationships between that block and this block, you need a model to start with.

DR. NOURBAKHSH: It's not a model. You can do it qualitative as the PIRT are doing, just making the importance. This is important, this is important, and there are --

MEMBER POWERS: I like the way we do it on the source term, Tom, which they -- I'll vote for five percent, Tom says six percent, Jim Geseeky says seven, and the French guys says, "No, I'll bid eight and a half," and so he wins because he got the highest number, right?

MEMBER KRESS: This, though, reminds me of the decomposition process they did for 1150. They've taken the complex thing and decomposed it into its parts. And then you could let the experts vote on different parts of this.

For example, just looking at the one that he's got up there, let's say our interest was in the minimum vessel core inventory. We've only got two arrows feeding into that. One of them is makeup, and one of them is depletion. Well, on each arrow you put a .5.

Then, you go to the liquid inventory depletion, you've got one, two arrows going into it, core flashing and core voltage. Well, core flashing gets rid of maybe a tenth of the fluid, and core

voltage gets rid of nine-tenths of it. So I'd put .9 and a .1 on that.

I'd start working my way up this thing, and I'd have numbers on each one of these things. And eventually I think you can combine those numbers and -- to get an importance measure for each one of these things on the bottom thing you're interested in.

CHAIRMAN BONACA: They're trying to make it look like a PRA is what --

MEMBER KRESS: Yes. I think he has an idea here that's worth pursuing. You know, you have to be sure you get all of these lines right, and all of these items on here right.

VICE CHAIRMAN WALLIS: That's what system dynamics people do -- accept and consider these .9's or .1's. They have a kind of equation, and it's either a differential or it's a linear thing, which says that --

MEMBER KRESS: Yes. I've replaced this with --

VICE CHAIRMAN WALLIS: -- by a certain amount of --

DR. NOURBAKHSH: That decomposition comes to your mind if you -- I mean, you do it mentally. You have this picture basically, may be a simple way

of --

VICE CHAIRMAN WALLIS: How is --

DR. NOURBAKHSH: -- to come up with these. And if they're writing for the rationales, they have to explain all of these things, if they have done it correctly. But you force them to -- explicitly to be --

MEMBER KRESS: You'd have to have some sort of mental model of some of these things and integrate with time, actually, with them. I think it could be useful.

DR. NOURBAKHSH: They do it at different times. That's how --

MEMBER KRESS: Do it at different times, yes.

DR. NOURBAKHSH: Different times which are -- the dominant phenomena are not changing, basically. That's how they do it for small break LOCA, initial blowdown and then different phases.

But instead of voting which phase is important, each phase provided the condition to the second phase. You cannot say the way they did it for AP600. The initial blowdown is not important. It may provide some initial condition to initial -- IRWST initiation, for example, phase or ADS blowdown phase.

But there are some actually available -- you can put all of these things there top-down. You will put them in smaller boxes, open them. I mean, the agency actually is talking about knowledge management initiatives, that they wanted to capture the infrastructure of knowledge that --

VICE CHAIRMAN WALLIS: This is an iterative process. I mean, if you're going to do a new analysis of a new reactor with thermal hydraulics, you might start like this. And this tells you the things you have to worry about in your code. So you set up the code, and then you run it and you do all of these things, and you say, when I've done all of this stuff with the code, did it have the sort of -- did the pieces have the importance that I thought they had when I started out? You've got to go back to the loop-around.

MEMBER KRESS: Yes.

VICE CHAIRMAN WALLIS: That's the thing I criticized them for. They treated it as sort of a linear process. But the experts set up the PIRT, and if the expert opinion was wrong, and the code shows it, it never gets fed back at the beginning again.

MR. CARUSO: But you should even be doing this as a design. This is the way an engineer should

do a design of anything. You come up with a model in your mind, you write it down, you think about it, and you iterate it. You have to do that.

DR. NOURBAKHSH: And then, when you wanted to do code verification, it's not whether these phenomena are important. It's whether these phenomena's dependency on other variables is rightly captured in the code.

The code may have all of these phenomena, but the dependency may not be there. The important difference is that we've captured it there.

VICE CHAIRMAN WALLIS: You know, it has condensation but it doesn't consider the effect of the non-condensables, for instance.

DR. NOURBAKHSH: So you don't have to have a busy slide like this. You can go top-down, basically. If you do it correctly, you can go -- you can derive this -- the top-down scaling from these diagrams basically, what are the input and output.

VICE CHAIRMAN WALLIS: Are you saying that the experts together make up this massive diagram?

DR. NOURBAKHSH: No. What I'm saying is you do advance preparation based on the knowledge, and then put that matrix in front of them, and you come up with some suggestions even if you want based on the

information.

VICE CHAIRMAN WALLIS: Well, I could as an expert say, "Look here, you've missed out on one of these blocks, and you can't put it in."

DR. NOURBAKHSH: The complete list, you can look at it. With a matrix, you could see, okay, this condensation has an effect on this. I don't see it in the matrix. This is zero. I have to change it too high. And sometimes there are different opinions. Then you know what to expect, where they are different. It's more transparent.

When you do -- if you have a diagram like this, a draft final, then when you have a test you know the test addressed this part of the diagram basically, addressed this phenomena, this phenomena, and this phenomena. Then, you could see what are the important boundary conditions for this test, whether this test really scales well or not. You know what are the important parameters that should come to the test in order to address this issue.

If you need to do a little bit more work -- but I think it's payoff as well as transparency of the result or capturing the implicit assumptions. And then, revision would be much easier. As you learn more, you can go back and update these things much

easier than updating a pair.

You cannot just change one of these high to low based on one experiment. You know exactly I have learned now -- for each of these arrows, you can actually ask the level of knowledge, too -- high, low, no, or whatever. And then you can capture later on where there is importance and high uncertainty. When we have more knowledge, you go back and redo this.

VICE CHAIRMAN WALLIS: Okay.

DR. NOURBAKHSH: So with each directed arc, you can ask three questions -- how important it is, the rating which is very much positive, negative, then you could see the compensating effect sometimes, in some tests or something like that. And then, the third question the level of knowledge.

Actually, something like that has been done for when they were assessing the impact of Clean Air Act, basically, the process of issues. And DOE actually sponsored something like that, and they actually were in their -- defending their approach. They were saying that we are not generating a black box. This is a glass box. You see everything.

VICE CHAIRMAN WALLIS: Okay.

DR. NOURBAKHSH: So as I said, this provided a better -- a good context for capturing the

implicit assumptions. And they are more transparent, these things, than a table for revision. I mentioned that -- how these diagrams could be used when you have different expertise on different areas in multi-disciplinary type of issues.

And if you wanted, really, to do a ranking of these processes, there are tools available which are basically looking at this super matrix that I mentioned and trying -- again, pair-wise ranking of the super matrix,a nd then come up with the prioritization of each phenomenon or processes.

Basically, what you could make the case for -- I mean, you take into account all of the feedback effects and the interactions between all of these phenomena.

And, basically, that summarizes my presentation.

CHAIRMAN BONACA: Very interesting.

MR. CARUSO: Can I just add one more -- I'm sorry. I just wanted to add one more comment. The former regulator -- when I used to say the word "PIRT" to the industry, this is what they used to think of, and this is what caused them all sorts of aggravation. I used to think this and see dollar signs.

We also used to tell them that PIRT could consist of two engineers sitting around a table one afternoon listing everything that was important. And if that worked, that was just as much a PIRT as this, they thought. And I just throw that out as an observation. I think this is a great idea, but this is just one thought of PIRT in a whole park of potential PIRTs.

DR. NOURBAKHSH: And then, if you have that super matrix, you can put the initial of experiment in the similar super matrix. You see this experiment address the impact of this to this to this to this, where we have missing -- where we are missing as far as database.

VICE CHAIRMAN WALLIS: What you're saying, I think, is that this isn't just at the PIRT stage of, say, evaluating a code. There is also the validation. There's the comparison with experiment. You can do -- you can use this kind of thing as well. You can say, "I've got this experiment."

DR. NOURBAKHSH: Yes.

VICE CHAIRMAN WALLIS: "How does it fit into this kind of a picture? Which of these boxes does it give me information about?"

DR. NOURBAKHSH: Exactly.

VICE CHAIRMAN WALLIS: Right. And that might be helpful when we're looking at review of AP1000 and we're saying, "Look, you're saying these experiments are adequate. But which of them has any relevance to this piece down here which, you know, PIRT says is important?"

DR. NOURBAKHSH: These experiments address these issues. But the boundary conditions are very transparent, what -- you should be using that experiment as a boundary condition, but that you are actually addressing that or not, it's there or not in the test -- separate effect test facilities, basically.

MEMBER POWERS: Well, thank you. That's interesting, and I appreciate your -- quick couple of other questions that come to mind on this. Suppose that I'm the NRC, and I wanted to do a PIRT on what's important in a system. If you get two people together like Peter and I, because we see eye to eye and agree on everything so completely, that obviously gives you an inadequate PIRT, especially in controversial areas.

So you want somebody with orthogonal views on things, or different views on things. And there's going to be a third person into this thing, and you know that Peter and I are such nice guys that we won't

browbeat that fellow. So it's okay.

What is the proper size of a PIRT panel, without getting too unwieldy? If I have -- if I invite the nuclear engineering faculty of all of the nuclear engineering schools in the United States to be on the PIRT, that's probably the unwieldy.

DR. NOURBAKHSH: Previous experience, at least from what I read, some of the Brits' and Gary's work, is that more than four or five was very difficult to get consensus. That's why even in the burnup credit they came up with voting, basically. They were not really -- they could not make -- when you have 20 in the room, it's very hard to make a consensus on the issues.

But this way, you are forced to elucidate the information more rather than elucidate personal opinion. You base it on some information that should be there. And then, when you could see exactly where the holes are, where the missing knowledge is, impact of what on what, rather than -- you could see why these phenomena some people voting it six, the other one three. It's a little bit -- they may have the same opinion on interactions, and this is a better tool for consensus-building, too, in a way.

MEMBER FORD: But you say when you have a

large number of people -- I can understand from a decision-making process it is sometimes bad. The Brits, when they do their materials -- provide to the materials degradation planning for their defense reactors, lightwater reactors, they use 20, 30 people on the panel, put all of the relevant data on the table, and then they discuss as a group as to the relative importance of those packets of data. And they do it very much quicker than one year. They do it in a month.

DR. NOURBAKHSH: But their preparation for that meeting may be quite -- more substantial than what we do for PIRT here. If you prepare it well in advance, and you know exactly what the data is, where the missing elements are, the knowledge base is, and the rationales, a few technical staff could sit down -- which are knowledgeable on the whole integrated issues, basically, a generalist who could sit down and develop the initial structure and the importance. And then, when you have the experts it doesn't take that much time, because you start with a much focused kind of agenda.

VICE CHAIRMAN WALLIS: Do the Brits make more use of academics?

MEMBER FORD: Yes.

VICE CHAIRMAN WALLIS: I think you need some reality check on this. There's nothing like having a --

(Laughter.)

Yes, I mean that seriously. I mean, I think you get people who have been in the business all of their life. They always think that A, B, and C influence D, because it has always been that way. And to have to explain that to some, you know, fair, honest, you know, knowledgeable, smart enough -- if there are any like that -- academics, you know, is a very good discipline to have.

It's a representative of the outside world, and it's useful to have that sort of person -- or not someone who is egocentric and all of that kind of nonsense that you find in academics, but someone who is willing to balance information and say, "You told me this. Now convince me." That sort of thing. So I would just look for that kind of representation on a PIRT panel.

MEMBER KRESS: Give them a psychological test first?

DR. NOURBAKHSH: Yes.

VICE CHAIRMAN WALLIS: Well, the problem in this country with the nuclear business is that

everyone is corrupted. And everyone who is an expert has been hired by either the industry or the NRC.

MEMBER KRESS: Right.

VICE CHAIRMAN WALLIS: It's very difficult to find anybody who you can say is independent.

MEMBER KRESS: They're all corrupt, that's right.

VICE CHAIRMAN WALLIS: They're all corrupted.

CHAIRMAN BONACA: Any other questions for Hossein? Thank you for your presentation. I think it was informative and timely, and we'll see some results soon.

So with that, we have on the agenda here -- we have presenters, but we have also breaks. So I see that there is an intense desire for the members to take a break, so let's get together again at five of 2:00.

(Whereupon, the proceedings in the foregoing matter went off the record at 1:40 p.m. and went back on the record at 1:55 p.m.)

CHAIRMAN BONACA: Okay. We can get back into session.

The next presentation that we have today

is on Operating Experience Assessment Report - Effects of Grid Events on Nuclear Powerplant Performance. And we have I believe two presentations.

MEMBER LEITCH: Yes, that's right.

CHAIRMAN BONACA: All right. All right?

MEMBER LEITCH: All right.

CHAIRMAN BONACA: Yes.

MEMBER LEITCH: Go to me first?

CHAIRMAN BONACA: Sure.

MEMBER LEITCH: This operating experience, this particular quarter we thought it was important to just talk about switchyard- or grid-related scrams. And there's a couple of different components to that discussion.

Let me remind you that we had a discussion of this -- generally of operating experience with the plants in the July timeframe. And during that time it appeared to us as though there was some indication that there were an increasing number of what I call switchyard-initiated scrams. And I'll explain in a minute what I mean by that term.

We were not sure that it was statistically significant, but during that particular three-month time period leading up to July there was perhaps 13 automatic scrams. And I think we -- there were about

seven of those that were related to switchyard issues.

And by "switchyard issues," I mean those things that are beyond the generator breaker, let's say, disconnect switches, main transformers, lightning arresters, protective relay actuations or misacuations, grid reliability problems regardless of their cause, and so forth.

And so we thought that we would keep an eye on that thing for a while and see if there continued to be a trend. And, indeed, it seemed like the trend was continuing. For example, there was a two-week period in -- towards the end of July where there were three scrams from 100 percent power due to grid problems. And I've listed them here as to which ones those are, and I'll go into that in a minute.

But we're concerned about these issues, because when a plant is running along at 100 percent power, and the generator breaker or breakers open, there is a significant challenge to the plant. There are robust safety systems that are designed to cover the plant in that situation and protect the plant in that situation, obviously. But it does challenge a great deal of those safety systems.

So as a result of that, we thought we would have some kind of a presentation, and then in

the more recent days there has been some fairly significant events occur. So I'd just like to go through just a couple of the -- just to mention a couple of the events, so that you get an idea of what we're referring to here, a couple of the events that have occurred in the fairly recent history.

On July 22nd, at Peach Bottom Number 2, there was a main generator protective relay actuation and a unit scrammed from 100 percent power.

Palo Verde, on July 28th, there was a grid perturbation problem, and the one unit scrammed and it sounded like they were very close to losing all three units. But it turned out just to be one unit scrammed.

Salem Number 1 on July 29th, there was a 500 KV circuit breaker failure, and it tripped the unit there. They declared an unusual event.

And since that time, there have been a couple more. On August 3rd, there was a loss at Indian Point Number 2. There was loss of all load and the reactor scrammed from 100 percent power.

And, of course, the one that we're all familiar with -- that's August 14th -- in the northeast blackout there were nine nuclear plants that went down due to loss of offsite power events.

On July 8th, there was an automatic scram from 100 percent power at LeSalle due to a fault in the main power disconnect.

One that may be a little bit of an outlier, on August 23rd at Wolf Creek, there was -- a cropduster plane flew into a 345 KV line, and the plant had to quickly reduce power. They did not scram on that occasion, but I don't know how the cropduster made out. But the plant stayed online.

ANO Number 1, on August 29th, there was an automatic scram from 100 percent power, and that was caused by tripping of the main generator breaker, or, actually, the turbine tripped and the main generator breaker failed to trip, and they had to manually open the main generator breaker to prevent motoring of the generator.

VICE CHAIRMAN WALLIS: How quickly could they do that? They have to act pretty quickly, don't they?

MEMBER LEITCH: Yes, right. Right. This is one of the challenges I'm referring to, yes. And, in fact, one of the challenges is when the main generator breaker opens, all of the turbine valves have to go closed or else you get a turbine overspeed situation.

On September 15th, there was an unusual situation at Peach Bottom. There was actually a dual unit scram, both units from nominally 100 percent. One was a little less than 100 percent due to an electrical transient, and there were some subsequent problems with diesels -- with a diesel generator and a safety relief valve stuck open. And there was an AIT. In fact, I think there presently is an AIT there at Peach Bottom. I don't think we know the conclusions of that yet.

VICE CHAIRMAN WALLIS: Well, these events advise us of latent problems, like if the SRP is stuck open you could say it was a latent --

MEMBER LEITCH: It was a latent problem, yes. It was not related to the scram directly, not -- so far as I know, nor was the diesel -- I think all -- my impression is that all four diesels started and then one tripped. But I don't know the full status of that investigation. It's currently ongoing.

On September 18th, Hurricane Isabel related apparently at Surry 1 and 2. Both units tripped from high power due to loss of power to all circulating water pump busses. So they lost all eight circulating water pumps and manually tripped both units.

On August 20th, again, apparently hurricane-related -- excuse me, September 20th -- Hope Creek Number 1 tripped, automatic trip from 100 percent power, and then later -- Salem and Hope Creek, by the way, share the same site. Later that same day they manually took Salem 1 and 2 out of service for the -- apparently the same related situation, which was a salt buildup on the bus structures.

So now some of these things are perhaps outliers, but it certainly leads to questions about, you know, if you count these up there's probably about 23 or so units that scrammed in the period of, what, two months. And now, admittedly, there's hurricanes and there's blackouts, but I guess there's always been hurricanes and blackouts. You have to deal with those kinds of things.

And one might ask the question -- is there a statistically significant trend here? If there is, does this represent a safety concern? Is there an aging-related issue here? Are we thinking about license renewal? Is there something going on here that's related to the age of some of this equipment? Or is there a change in utility operating practices or maintenance practices with respect to some of this equipment that may be leading to some of this -- these

issues?

So in that regard, we've asked the staff to come in and give us a couple of presentations on this topic. One has to do with the report that was prepared previously. I think it was issued about May 1st, and it deals with the reliability and operating experience of the grid.

And interestingly enough, it deals with it in two time periods, from about I think it's '87 to '96, before a great deal of deregulation took place, and it contrasts that with the experience in the period from '97 through 2002. So we'll hear a little bit about that report and some other information about the more recent operating events that have gone on.

I would say that there is really two sides to this problem. One is, how does the nuclear plant affect the grid? And I think that's mainly what this report that we're going to hear deals with, and that's something that we need to be concerned about. But the other side of that coin is just as important to us, if not more so, and that is, how does the loss of the grid for other reasons impact the operation or challenge the operation of the nuclear powerplant?

So with that, I'd like to turn it over to John Flack, who will take over from here and introduce

the rest of the presenters.

MR. FLACK: Yes, thank you, Graham. I am hoping -- I'm John Flack, Branch Chief from the Regulatory Effectiveness and Human Factors Branch in the Office of Research. And hopefully we'll be able to shed a little light on some of the questions you raised here, which are very important.

Before we get started, though, I'd like to first go over a few things. One is after I'm finished Cornelius Holden is here from NRR and will bring the committee up to date on what's been happening more recently.

And as you've mentioned, Graham, this is really Bill's study that we're looking at today. Bill had started this a few years ago. By the way, Bill came from industry with about 20 years of experience when he came to the NRC in '92. And he actually went to AEOD, which no longer exists as you know, but the function -- part of the AEOD function did come to Research and is in my branch.

We have a small team of about five that look at operating experience and regulatory effectiveness from an independent perspective and do studies. And one of these studies was what Bill was doing on grid, and ironically he was putting together

the pieces just before all of this happened. And you'll see some of the things that he looked at as part of his study that indicated that things were actually changing out there.

And, really, there is a lesson to be learned from that, because if you look at the statistics backward-looking you may not see that change. Everything seemed to be pretty much in order. We were really not getting -- in fact, the number of events had gone down, although we did notice that they were getting longer in duration.

But the fact that if you look at it from that perspective, you'll notice that things were really changing after deregulation. And this is part of what Bill will be talking about today -- how things have changed, seriously changed, during and after deregulation. And that's pretty much part of his study.

So we had received a number of comments on this study, and that also reflects how one sees it from a different perspective. We had an example from one commenter that it really didn't provide a whole lot of value where from NERC -- and this is really less than a month before we had the blackout event -- stating that the events that were cited in Bill's

report basically provide a wealth of information, lessons learned, so it should be taken seriously and acted upon by the Commission.

So you can see the difference of perspectives, I think, that again it bears out I think the fact that if the model is changing one has to really look at that and not solely rely on the statistics that we see from day to day. That we really have to understand it in light of this changing model.

So without holding it up any longer, let me turn it over to Cornie and let him bring you a little bit up to speed on what's been going on more recently.

MR. HOLDEN: My name is Cornelius Holden, and I'm Project Director for NRR. But more recently, I've been working with Sam Collins as part of the task group looking at blackout event, so I thought it would be timely just to fill you in on task group activity, and then tell you what we're doing within the NRC and internal task group as well.

But as you're probably aware, the President of the United States and the Prime Minister of Canada jointly formed a review task group for the blackout event of August 14th. Within that, there are

three working groups. There's a security working group, an electric systems working group, and a nuclear working group. And there is a U.S. and a Canadian counterpart on each of those.

The chairman is in charge of the U.S. nuclear working group. And during phase one of those reviews, the various working groups are trying to determine what happened, what caused the outage and why, and why was the system not able to prevent the spread of the blackout.

There will also be a phase two, which is, how do we prevent future outages? And that will involve input from a variety of stakeholders in that process, and there are still details to be worked out on that. So they -- like was mentioned on August 14th, nine plants tripped as designed and safely shut down as a result of the grid disturbances.

There were a number of other plants that saw the disturbance nationwide, and some plants, because of the way the grids operated, didn't see that. So that's basically where we are on the task group activity there.

Within NRR and Research, we have formed a team to take a look at the events of August 19th, the most recent events that you'll hear about, and Bill

Raughley's report. And we're looking at that to understand what those events tell us, put it into our process to determine what actions we need to take as a result of that, whether it's generic communications or rulemaking.

And we're proceeding on a schedule that will allow these two -- both the task -- the international task group and our working group to transfer ideas from one group to the other, because it may be that out of one group we have ideas for the grid, and the electric working group on -- the task group may have other issues that will come back, and we'll have to put those into our process.

And with that, I just thought I'd lay the groundwork for that.

MEMBER LEITCH: I just wanted to emphasize that, you know, there's a lot higher visibility nationwide I'm sure on the impact on the grid.

MR. HOLDEN: Yes.

MEMBER LEITCH: A big blackout, and so forth.

MR. HOLDEN: Yes.

MEMBER LEITCH: But I think as the Nuclear Regulatory Commission, we need to be looking at -- that is certainly important, but I want to be sure

that we don't lose sight of the impact that that has on the nuclear powerplants. I think it's a real challenge.

I mean, on August 14th, the plants all shut down. Apparently, the diesels started reasonably well, and there was no major problems associated with that. But yet do that often enough and there will be some problems, a la the subsequent events that have happened even a couple of weeks ago at Peach Bottom.

So we need to be concerned about both sides of that coin, I guess, not just supporting the grid -- that's important -- but also if the grid goes down for other reasons, what does it do to the plant?

MR. HOLDEN: And I think the internal working group is also going to benefit from the fact that many members of that group also participated in the nuclear working group for the review of the grid. So there will be a lot of transfer of information that happens there.

MR. FLACK: Okay. I guess we can move to Bill's presentation. Take it, Bill.

MR. RAUGHLEY: I'll just start with the introductory slide here. The topic is grid reliability issues, and people have talked about the report. We're going to focus on those aspects of the

report that deal with the changes going on. If you want to talk about them more along the way, we can.

The topics we're going to give some background in terms of why we did the report, the regulatory expectations, and some background on deregulation. I'm going to focus on the changes to the grid. We did a little more detailed look than we normally do. It was not the traditional look-see.

In the next three bullets we're going to provide insights from the work we did, and I have some backup slides, like I said, if you want to talk about additional topics in the report.

John covered the first report, who we are and what we do. How we got into this is in 1999 the Commission asked the question, "Do we need to take any regulatory action as a result of deregulation? And what actions do we need to take to maintain the licensing and design basis?"

And I wrote a paper and a SECY. The paper was based on a field survey that Reinaldo Jenkins headed. We went through 17 -- or Reinaldo went to 17 rate control centers and 17 nuclear powerplants, and just the basic -- and took a basic overview of what was going on or what the people had planned to do for deregulation.

It was also based on -- we made multiple trips to the California ISO and PJM, and not because they were problems but because they were on the leading edge so to speak of what was going on on deregulation and were fairly open and willing to share with us what they've done. And it was also based on NERC reliability forecast. NERC does a -- annually they do a 10-year forecast, and we made extensive use of that, and then we also used the operating experience.

And what we've tried to do from all of that was postulate what could happen, and, you know, our things we were concerned -- well, I'll get into that later. But one of the recommendations in response to the Commission's question, "What action should we take to maintain the licensing basis?" was that we would monitor and assess the grid impact and nuclear plant performance, and ergo this study was planned. And John talked about the timing of the study.

The next step is we're planning to issue a NUREG in November. We've got comments from the -- stakeholder comments from the May issue of the report. We're revising -- there were some minor revisions to the report to address those that we'll talk about.

Along the way, too -- I didn't put it on here -- is that NRR issued two INs and a RIS having to do with deregulation, just alerting the industry to their concerns. INPO has taken some steps. They've been out kicking the tires, trying to make sure that the plants have been prepared for deregulation, as the follow-on to some of NRR's INs and RISs.

Now I'll come back to the methodology and the report a little ways up.

In regulatory space, we're talking about GDC-17 having to do with the capacity and capability of the offsite power system, and, in particular, minimizing the chance that a loop -- that a reactor trip will cause a loop.

What's important to recognize in determining the system capacity and capability -- I think what's important to recognize about the grid is you can't test the capability of the grid, so you have to analyze it. And you have to be prepared for contingencies that you would expect. Typically, the utility is designed for a -- so that the grid will remain stable for a reactor trip or a single, and even, in some cases, double contingencies.

So what they try to do is bounding analysis. Before deregulation, each utility had a

finite area to manage, and you had a finite number of configurations and the analysis. So you could do -- typically on an annual basis, they did power flows, voltage profile, stability analysis, and based on those revised their operating procedures and got the grid set up for successful operation.

What the station blackout rule identified is the risk factors, the important risk factors, the loop frequency and duration, and the diesel -- emergency diesel generator redundancy and reliability. And the outcome of that was coping times, and most plants subscribe to a four- or eight-hour coping time as a result of that.

In the maintenance rule, we pay attention to A4, where licensees are required to manage the increase in risk from plant activities, such as testing the diesel. And there are subjects that are relevant to what we're going to be -- what we looked at.

As far as deregulation, there's two aspects that we focused on. One was the 1992 National Energy Policy Act, and that encouraged open generator transmission or open generator access to the transmission system and statutory reforms at the state level to promote wholesale generators.

The concerns that result from that with the states, when they deregulated they busted up the traditional utility into a generating company and transmission company, and you introduced more players. So our logic was that with more players you'd have longer recovery times, just more coordination, more parties to coordinate.

And I think a good example of that is Calloway had an event in '99, and they -- the reactor tripped, and shortly thereafter the voltage dropped because of the grid. There was a transmission line -- nearby transmission line congestion. The reactor trip exacerbated that.

In order to recover, it took 12 hours to rearrange, but then the power flows were coming from Canada down to Texas for cold weather where they had lots of generation down to the hot weather. And it took 12 hours to rearrange the grid, to reestablish the proper voltages at Calloway.

The next bullet has to do with FERC Order 888, and that required all utilities to provide for open access generation to the transmission system. What that means is anybody could buy a lot, build a generator, and they'd gain access to the transmission system.

In my report, I make reference to a slide on a DOE website that shows the status of deregulation. This was as of -- this is -- I took this off their website yesterday, but shows up in -- Region 1 basically is fully deregulated. Region 3 is about 50/50. And then -- and it's mixed out in Region 4, and nothing going on in Region 2.

But it's important to remember that even though a state hasn't restructured, all states are subject to open access transmission. So that's an important part of this. Just because you haven't -- your state hasn't deregulated, so to speak, doesn't mean you're exempt from the consequences of deregulation.

And then I want to talk a little about the report that -- the information in the report that is -- just downloaded information in the report I didn't put in the slides. These are really backup slides.

But the overall objective of our report was to see if there was any change in the deregulated environment. And the method we used is -- what I did is I drew a line of demarcation between the site and the grid, and the line of demarcation was across the high voltage terminals of the transformers.

And the plant side I called the plant, and

the grid side was -- there was the grid, and then we busted the grid up into the switchyard and the transmission system. And then we began classification of events. According to R events --

MEMBER LEITCH: Just to be clear, the main transformer was with the powerplant.

MR. RAUGHLEY: Yes. The main transformer is with the powerplant, and the station transformers were with the powerplant.

MEMBER ROSEN: Just line it up, so --

MR. RAUGHLEY: Okay. Sorry.

MEMBER ROSEN: Now let's be a little more specific. The main transformer, high side, is with the powerplant or with the grid?

MR. RAUGHLEY: With the powerplant. The transformer is with the powerplant, and the station transformers, which connect to the offsite system, were with the plant. The generator breakers and all of the high voltage equipment was with the grid. And I called that -- that was part of the switchyard. And then, out beyond the switchyard I called the transmission system.

MEMBER ROSEN: Okay.

MR. RAUGHLEY: So then what we did is then we looked at -- and then we were just looking at

reactor trips from power. We didn't look at anything from zero to power. So this is all reactor trips from power.

Then, we had R events, which are the GDC-17 events, and in particular these were loops, partial loops, or voltage degradations below the tech spec limit. And what we were looking for there is that subset of events where the reactor trip caused a consequential loop.

When the reactor trips, you're depleting a certain amount of watts and bars from the system. And if the system doesn't have enough reserve to recover, you -- you're going to get a voltage drop. If there's not enough reserve to recover, the voltage will stay depressed and you'll experience a loop.

And then, let me jump down to the elements or the traditional loops where the first sequence of events was in the switchyard or the transmission system. R and L events were part of the risk analysis we did. The S and T events -- well, the R and L events are all -- they're all loops and part of the risk analysis. The S and T events are generally not risk-significant, and what we used those for was to get insights.

And the S events were reactor trips for

the first sequence of events -- were in the switchyard, and the T events were reactor trips for the first event in the sequence of events -- was in the transmission system.

And we devoted a page in the report to say -- to point out that this is very different from what we have done in the past. Before the R and the L events, there wasn't any distinction there, just a loop was a loop. And the S and T events were traditionally called turbine trips.

So, and all of these have -- you know, there's -- these are events where there's -- a lot of the events I looked at were traditionally plant-centered events. And what we're doing is looking at the grid aspects of these events, so there's both plant and grid aspects to these events. But the grid did play a major part in the event.

MEMBER LEITCH: In the S and T events, though, although they might be referred to as turbine trips, the initial event is, I would think, a generator breaker opening.

MR. RAUGHLEY: Yes. Yes. An example would be there's one event in there where a fault in North Carolina tripped the circ water pumps at North Anna. You know, and that reduced vacuum and led to a

reactor trip, and traditionally we call that -- I mean, led to a turbine trip. But really, the first event in the sequence was the fault in North Carolina.

MEMBER LEITCH: Yes.

MR. RAUGHLEY: It caused negative phase sequence, current imbalances, and it led to --

MEMBER ROSEN: And this cropduster into the Wolf Creek transmission line is a T event.

MR. RAUGHLEY: Yes.

MEMBER LEITCH: Now, you say the S and T events are not risk-significant? Did I hear --

MR. RAUGHLEY: No, just a straightforward reactor trip is usually a low 10^{-6}.

MEMBER LEITCH: Yes, a reactor trip. But you don't differentiate between that and a generator breaker opening?

MR. RAUGHLEY: It depends why the generator breaker opened. If the generator breaker opened because of a generator fault, then that would be a plant-centered event and I didn't count that there. If the generator breaker opened because of a transmission line fault, or a fault in the switchyard, or a plane flew into the transmission lines, then that would be S and T events.

MEMBER LEITCH: But from a risk

standpoint, I would think a generator breaker opening at full power would be more risk significant than a reactor trip.

MR. RAUGHLEY: No. They're all around very low 10^{-6}-ish.

MEMBER LEITCH: Okay.

MEMBER ROSEN: Well, it might be more significant -- the damage to the plant. The turbine doesn't necessarily react to core damage frequency.

MEMBER LEITCH: Yes. You'd have to postulate a turbine runaway, creating a missile, which now, you know, it's a -- I can understand why it's --

MEMBER ROSEN: Why there's very low probability.

MEMBER LEITCH: Yes, yes.

MR. RAUGHLEY: Collectively, Jerry is going to talk about the numbers of S and T events. He took what I did and carried it through to 2002, 2003, and there are some fine nuances. But just so there's no confusion, we'll let him show you the number-crunching he did on there. It's very revealing.

I will say that the -- in the S and T events, I did a writeup in there on two events. Well, one, I pointed out that there were four multi-unit trips, and we -- Section -- I think it's 3.3.3 in the

revised report and in the old report talks about two events in California.

One tripped -- it was a grid event that tripped two units in one case and four units in another. It tripped two units at Diablo with a four-unit trip and two units at Palo Verde. And they were a cornerstone of the California ISO. They had analyzed those events to death, but they shaped a lot of what the California ISO did.

An example is, as a result of that, they increased their reliability criteria to require that the grid be able to sustain the loss of all generators connected to a common switchyard. Typically, you'd only want one, but that's what the California ISO determined you would need to do to survive an event like that. And, importantly, there was a NERC report that identified 65 corrective actions.

And then, on the R events, the things I want to point out -- that up to the time of the trip the plants were operable. Eight of those 10 events took place in the summer. Seven of the 10 were in the northeast.

And I think there's -- or there are partial loops and tech spec voltage degradations there that normally we ignore. But if you look at those,

they are indicating weaknesses in the grid. I mean, if a unit trip causes a partial loop, it's indicating a potential weakness in the grid.

And as far as other features of the study, it's all based on actual data. I've only made two assumptions where we don't have data for what's the probability of recovering from the loss of all diesels. We have no experience in that area, and we have no experience from recovering from the loss of all -- the failure to recover from the loss of all diesels in four hours. So we make two assumptions there.

And the internal comment there is that I was conservatively low on those assumptions. So if anything, the risk that we came up with might be a little higher.

Another comment on the data that we got was whether there was enough data, and it was suggested that I look at what EPRI did when they analyzed loop events. And they take a short-term look at five years, and it's exactly what I did. I also had two of our statisticians look at our data.

There was questions about, did we have enough data? And, really, we're in the lower part of the statistical interval. So, again, it's non-

conservative, you know, and there's risk and we're non-conservative.

So the things we talk about in the report on what has changed is -- is that there were some events -- the Calloway event and one of the reactor trips -- where there was a consequential loop. It involved increased transmission line loading. And as a result of deregulation, you have -- the open generator access causes changes in the power flow.

The power flows according to the laws of electricity -- Kirkoff's laws. And if you overload a transmission, a nearby transmission line to a voltage plant, what you're effectively doing is increasing the impedance hanging on the terminals of the plant. And that's causing an additional voltage drop, and that's exactly what happened at Calloway and in an event at Oyster Creek.

The other thing we talk about there are lower grid reactive capabilities. We looked at a PJM event. There weren't any loops, but it involved the PJM system, 12 nuclear powerplants. It was two hot days in July, two separate events.

And as they began to -- you know, as the load rose, they went through their voltage reduction and all of their procedures to maintain the system in

the condition they wanted. But as they went through this, the grid started -- didn't respond to what they expected. And they got to the end of their procedures and the voltage was still high.

In the followup, what they found was 54 of the 72 generators that they were expecting to provide -- that didn't provide the advertised reactive capability.

The other thing we pointed out was that the reactor power uprates -- a generator, as a constant KVA device, if you increase the power, you decrease the MVA. The generator is -- let me get a backup slide to -- I saw some strange looks.

This is a typical generator reactive capability curve. Typically, you're rated at .95, and you would be about at a -- you know, .92, .94 per unit power. So if you come up here and increase the power rating, you are on a fairly steep part of the curve. You decrease the reactive capability.

And one generator -- one power uprate at a time is -- it doesn't make a difference. I think in the report I pointed out there have been 62 power uprates, and it has depleted approximately 4,000 megavars in total from the grid. That's significant.

In NERC's comments to our report they

pointed out that that was significant, and they indicated to us that those bars should be replaced. But they -- and I think they were going to pursue that.

MEMBER SIEBER: Well, the amount of reactive that's flowing around the grid is controllable by changing the excitation voltage on --

MR. RAUGHLEY: Yes.

MEMBER SIEBER: And so typically that's what happens. The problem is that you may end up with a unit here and there that's doing a lot of reactor duty and not generating much real power.

MR. RAUGHLEY: That's true.

MEMBER SIEBER: And so you've got current going like crazy, but no megawatts.

MR. RAUGHLEY: Yes. There's a tradeoff there.

MEMBER SIEBER: Because what makes it flow is the difference in phase angles from one end to the other, right?

MR. RAUGHLEY: Yes, on the power. There's --

MEMBER SIEBER: Well, the power is voltage that --

MR. RAUGHLEY: Well, both are voltage. If

you -- you had mentioned this to me before. I just made this up. He had mentioned it to me at the meeting -- our meeting -- before we started the meeting.

If you look at it simplistically, a generator and a load and the reactants between them, the power flow is a function of the voltage, the sign of the angle between them -- and I'll explain what that is -- and the reactants between them.

And if you were to take the motor and the generator at stand-still and take a marker and mark a stationary mark on the shaft on the stationary part of the machine, and do the same thing on the motor, as you load the generator you -- and put a strobe light on it you'd see this -- the generator.

It's like the timing light, for those of you that remember. points on cars. You see the generator would move this way, in the direction of the rotation of the machine, and the motor would move this way. That's the angle they were talking about.

But for constant power, then the voltage is going to drop. So that's why you have an automatic volt. That's why it's important to have the voltage regulator in auto all the time. Then that automatically increases the voltage.

MEMBER SIEBER: Another way to look at it is if the motor is sitting there with no load, but turning and you start putting a mechanical load on the motor, that angle changes between the motor phase and the generator phase.

MR. RAUGHLEY: Yes.

MEMBER SIEBER: And the voltage regulator reduced the voltage, and the turbine throttle valves open up.

MR. RAUGHLEY: Yes. This is called the stability limit.

MEMBER SIEBER: Yes.

MR. RAUGHLEY: Just for your information. And this is the basic equation to all stability analysis.

MEMBER LEITCH: So a lot of these plants that didn't respond in the 1999 PJM episode probably had their voltage regulators on manual.

MR. RAUGHLEY: It was more a function of the fact that it was so hot that it derated the machine, and it couldn't deliver --

MEMBER LEITCH: Okay. So it was --

MR. RAUGHLEY: -- the rated power. And the cumulative effect of that --

MEMBER SIEBER: In the network, the

machine that's dealing with reactor power looks more like a capacitor than an inductor, or it can.

MR. RAUGHLEY: Yes. The next bullet we add this. NERC pointed out to us -- let me back up. Both of these things lead to lower voltages. You know, lower voltages may require different action levels.

The next bullet -- increase in the transmission line relief requests -- when NERC read our report they called right away and said, "Go to our website and click here, there, and the other thing, and look at this curve." And this is transmission line relief requests.

What they are are LERs basically on the system, and they're graded one through six. And about LER 3 require physical actions in terms of curtailing transactions, reconfiguring the grid, and then you get into levels 5 and 6 and they require actions within 10 minutes and five minutes, respectively.

And what you have here is here's '97, and some -- where you have -- where deregulation -- that's when open generator access transmission started. Then you have '98 and '99, 2000, 2001, 2002. So you can see the level of activity increasing.

And the reason NERC pointed out to us --

one of our conclusions was that that -- that the concern should be from May to September, and that's what triggered this, May to September.

MEMBER LEITCH: That's certainly the bigger concern. But even in the winter months, there is a significant increase in the number of relief requests. I mean, you were running along here at whatever that is -- 10.

MR. RAUGHLEY: Yes, per month.

MEMBER LEITCH: And then more recent --

MR. RAUGHLEY: Numbers per month.

MEMBER LEITCH: Yes. And more recent it looks like 60, 70, even in the winter months.

MR. RAUGHLEY: But, again, it's something that supports things that have changed.

MEMBER LEITCH: It's certainly a lot worse in the summer.

MEMBER SIEBER: Well, let me ask a question which will be an opinion, and maybe you don't know and can't answer. But it looks like grid capacity has remained the same, while load is going up.

MR. RAUGHLEY: Yes.

MEMBER SIEBER: And that's due to a lack of investment in the transmission systems?

MR. RAUGHLEY: Yes. There is -- John mentioned we were briefing -- Reinaldo and I and Mr. Calvo briefed Commissioner Merrifield on the day of the event. And one of the things we took to the meeting was a writeup from the New York ISO, and we showed them curves in there.

What you said was exactly in there. It showed the -- that that load was increasing, generation had increased, and that the load had intersected supply, and it showed -- and it had a curve for transmission line investment going -- headed down.

MEMBER SIEBER: And so the reason why the physical situation exists is because the regulatory -- economic regulatory system wanted deregulation. And to my mind, that would mean that the states involved would be the states where economic deregulation occurred, which would be our Region 1 and parts of Region 4.

MR. RAUGHLEY: Yes. Yes. Our --

MEMBER SIEBER: That makes sense.

MR. RAUGHLEY: Yes. I mentioned the --

MEMBER SIEBER: If you go back to that map of the United States, that's the way it looked.

MR. RAUGHLEY: Yes.

MEMBER ROSEN: Well, I guess I'll follow-up that question. If you put that chart back up, the one with the hump in it in the summertime, the number of relief requests, if you split that up by region you'd see no change in Regions 2 and 3, or very little?

MR. RAUGHLEY: I didn't look at --

MEMBER ROSEN: And a big change in Regions 1 and 4?

MR. RAUGHLEY: -- look at that.

MEMBER SIEBER: That would be interesting to do, then, Steve.

MEMBER ROSEN: You didn't do that, you say?

MEMBER SIEBER: No. But it would be interesting to see that.

MR. RAUGHLEY: Yes. All of these transmission line requests are written in terms of the 340 KV line from this town to this town. So you'd have to have a grid of -- you know, a map of the grid and go through and do that. But we could talk to NERC about --

MEMBER SIEBER: Doing it.

MR. RAUGHLEY: I'm sure they've got some database that would --

MEMBER ROSEN: Do you have any sense of where it's the highest?

MR. RAUGHLEY: I think it was in the midwest.

MEMBER ROSEN: Really.

MR. RAUGHLEY: As in Ohio, Indiana, Illinois.

MEMBER ROSEN: That's of some interest, actually.

MEMBER SIEBER: Well, Illinois is deregulated, but Indiana is not. And Ohio is not.

MR. RAUGHLEY: But you've got to remember, the open generator access transmission doesn't -- there's two things going on here that --

MEMBER SIEBER: Well, even if we figured out what the problem was, there wouldn't be anything the NRC could do about it.

MR. RAUGHLEY: That's true. But we'll get into one thing that some utilities have done about it in one of our conclusions.

And the last has to do with the increased coordination times, and the increased time -- there's increased coordination times, and there's -- like I said, the Calloway event that I mentioned. Both the loops and events not involving a loop where you lose

power, the times are all increased.

And I've got another thought on this. As far as the safety issues that come from this, what we did on this is if you look at -- you know, I said we compared before deregulation to after, I think. You know, we started in '97, because that was their first full year of open generator access transmission.

And looking through the before and the after, you really don't see any change if you just look at the data or average the data out over a full year. But what we noticed when we put the data on a spreadsheet was that all of the loops -- all but one of the loops was in the summer.

And if you looked at that in the past, they were evenly distributed throughout the year. There were 54 loops I think, and the past 23 were in the summer. And the rest were in the rest of the year, and now we're looking at nine out of 10.

And it's the same on the risk. If you look at the risk over the whole year, the risk drops. As you start to look at it in the summer, the risk -- you start to see the change. So you don't see the problem unless you look at it in the summer.

And then you have the increased likelihood of an induced loop during the summer. Both the two

events in 2000 -- 201 trips -- is what we had there.

And the long time to recover from a loop -- and there's a couple things going on there. You have the increased coordination time. But if you look at the loops, there's a noticeable absence. There are no short plant-centered loops. If you look at the data before, in the '85 to '96 timeframe, you see a lot of one-minute, four-minute, 10-minute, quick, quick loops. There are no short duration plant-centered loops. All of the loops have to deal with -- there's one plant-centered loop. The rest of them have to deal with either the grid or weather affecting the grid.

As you can see, there is some -- and like I said, all of these have plant aspects to them, but these are the grid aspects.

The other thing -- we looked at the actual recovery time and then the assumed availability. In some of the risk analysis, they assume they could have gotten power back sooner. But really it only makes it -- our concern was for the events more than four hours. It makes a difference of this column. It's -- 66 percent of the events in the risk analysis were more than four hours. And here it's 50 percent, and it really doesn't make much difference to the risk.

MEMBER LEITCH: I would assume some of the problem is not only communication time but also restoration procedures. These are so complex it may be difficult to have discreet restoration procedures.

When you were dealing with a traditional utility that ran the generation and the transmission system in its franchised area, there were pretty specific procedures on how to restore the system. You know, you cut away from your neighbors and you get your hydro plants running, and you throw a feed to your powerplants, and, you know, get yourself pretty well bootstrapped. And now it's a much more complex evolution, it would seem to me. And also, there are so many variables it's difficult to have a discreet procedure.

MR. RAUGHLEY: Yes, it's definitely plant-specific, operator-dependent. You know, you're going to get a wide range of responses. But you can see the shortest event here is 90 minutes. If you use -- if you count the actual time, it's 43 minutes. Where if you look at the data before there is -- most of it is on the average of 20 minutes, and all of those are gone.

And again, procedure-wise, with the plant-centered events you've got full control of the

recovery. You know, when you have an event on the grid, then you've got to get other people on the phone. In the appendix, I went through event 69 in our report. It was a lightning strike, knocked out one line. They had a partial loop. They hastened to recover. It progressed to a loop.

They forgot to reset a relay, so they opened up five more breakers on this end and five more on that end, progressed to a loop, and then they had to get the proper person in to tell them how to get it back. They had to walk it down. They had to do some minor testing. That took a total of eight hours. That's --

MEMBER ROSEN: You've kind of explained why events have gotten longer. But why did the ones that were short go away?

MR. RAUGHLEY: They're under the plant's control. The plants have -- I would attribute it to strong corrective action programs in the plant. If the plant aggressively -- my experience has been plants aggressively pursue reductions in reactor trips that they have control over.

This is a large family of reactor trips that they have no -- they have no control over the weather, or, you know, any changes you have to make to

the switchyard or the transmission system. I think things under their control, that's on their radar screen, they go after it.

I think the carrot for the industry here is in the S and T, you know, all of these -- we're talking 50, 60 grid-related reactor trips. And collectively, in a deregulated environment, you're looking at -- if you're out two days, you're looking at a couple million dollars a trip times 50 is 100 million.

And if you reduce -- overall, if you reduce 50 reactor trips, you know, it's probably eight or nine percent reduction in the overall risk from nuclear power. That's how they have to look at this. That's the carrot to get with the transmission and switchyard people along here.

Our conclusions had to deal with you need to consider the seasonal effects, particularly when you're doing EDG maintenance. There you don't want to do the EDG maintenance and have the diesel on the floor when the grid is degraded. And likewise with the maintenance.

Some utilities we think, particularly the California ISO, there is contractual arrangements between the grid operators and the nuclear

powerplants. And what they've done in California is all of the communication protocols, the design inputs, the design outputs, are all part of a contracted part of the technical specification.

So, for example, San Onofre has a very detailed contract, and they said, "You've told me your grid will behave like this." They've done their analysis, and they've gone back and said, "We need this much bars and watts as a function of time for this condition. We need power back in four hours if we go black," and as a result there's a black -- there's a market for black start -- basically, for an alternate access generator. But everything is in the form of a contract where there's a hard agreement between the transmission company and the switchyard.

And our last thing is you have to do -- to consider real-time parameters. With this open generator access, the stuff is changing daily. California they do -- what we used to do a public service once a year, they do once per shift. They have a team of 40 electrical engineers split over three shifts doing low flows, voltage drops, stability analysis, to make sure they're never in a non-analyzed condition.

MEMBER SHACK: Now, when they had their

contracts, were they maintained during the brownouts?

MR. RAUGHLEY: Yes, I would attribute that that was the actions they had set up with all of the shenanigans going on with the -- you know, they were the ones directing the brownouts, to maintain the grid in a stable condition.

MEMBER SIEBER: But the actual purchase and scheduling of power was outside those contracts, right?

MR. RAUGHLEY: Yes. The actual purchasing and scheduling of power is done on a daily basis. They have a power market that opens at midnight and closes at 7:00 in the morning for the next day. The engineers go through by 1:00. They reanalyze the grid for the results of the power market, and then between 1:00 and 4:00 they direct the -- redirect the bidding in the power market.

MEMBER SIEBER: Let me ask you this question to help refresh myself on the way this really works. If Company A decides to sell to Company B 10 hours worth of electricity at 1,000 megawatts an hour, they will schedule that on some transmission line. The fact is that it won't necessarily go on that transmission line.

MR. RAUGHLEY: Exactly.

MEMBER SIEBER: But it'll go on somebody else's system maybe. And you can't schedule the bars, because you really don't know what the bars are going to be unless you have real-time --

MR. RAUGHLEY: Right.

MEMBER SIEBER: -- flows. Okay. And so how do you manage -- since everything has a limit, how do you manage where everything is going? I mean, I can see how you make your money --

MR. RAUGHLEY: You have to do the analysis and make sure you're in an analyzed condition.

MEMBER SIEBER: You'd have to do the analysis just to make sure that the power even went.

MR. RAUGHLEY: Yes. You've got to do the analysis to figure out where it's going to go.

MEMBER SIEBER: Yes, right.

MR. RAUGHLEY: And you can ship power from Virginia to Massachusetts, and it could go up around the Great Lakes and over. I mean, it's --

MEMBER SIEBER: In the old system, you used to be able to control the ins and outs on your transmission lines by adjusting all of the exciter voltages.

MR. RAUGHLEY: The exciter voltage -- and there's signals on -- there were signals on the inner

ties to bias --

MEMBER SIEBER: Yes, the power --

MR. RAUGHLEY: -- the governor responses.

MEMBER SIEBER: Right. Yes, you would dial in a certain resistance.

MR. RAUGHLEY: Yes.

MEMBER SIEBER: But that's gone now?

MR. RAUGHLEY: I haven't followed up on that. I don't know for sure. I would suspect it has to be for what they're doing.

MEMBER SIEBER: I would think so.

MEMBER ROSEN: Who do these 40 engineers work for? Do they --

MR. RAUGHLEY: They work for the California ISO. They basically manage everything from Idaho down and over. They're looking at that part of the grid -- Washington, Oregon, California, Arizona, New Mexico, and back up. It's a nonprofit organization and participating transmission companies pay them to manage the grid.

MEMBER SIEBER: So getting back to my line of thought, you would probably have to have at least 20 percent excess capacity over your expected peak load in order to be able to handle the variety of routes that the transmissions could occur on.

MR. RAUGHLEY: Yes, it would vary from system to system. I don't --

MEMBER SIEBER: But quite frequently, west to east power goes through Canada, right? From the midwest to the east coast.

MR. RAUGHLEY: Yes. What you're trying to do is the power is more expensive on the --

MEMBER SIEBER: Right.

MR. RAUGHLEY: -- northeast. So, and it's cheap in the south, so you'd like to sell it up in the northeast and make more money.

MEMBER SIEBER: But you may end up with it going through Canada to get there.

MR. RAUGHLEY: Yes.

VICE CHAIRMAN WALLIS: How much does it lose on the way? If it goes 3,000 miles, I think it loses -- the transmission losses must be significant.

MEMBER LEITCH: With the extremely high voltages it's not much.

VICE CHAIRMAN WALLIS: But even so.

MEMBER SIEBER: It's still thousands of amps.

MR. RAUGHLEY: Okay. As far as we issued the report in May, and we also -- at that time, we asked for stakeholder comment. We got comments from

Westinghouse, NEI, and NERC. These are the positive comments. NERC and Westinghouse were very supportive of the report. I think John read NERC's bottom line. NEI looked at it statistically, and they just flat out didn't like it.

And what we've done is we've taken the comments and they've become -- they'll be put in Appendix D of the revised report, and then we'll address each comment. And that will be part of the NUREG, so it's all together there as a package.

So the finale here -- changes in grid performance have occurred since operating in a deregulated environment. That performance can impact the nuclear powerplants, and we need to continue to seek a better understanding of the grid. And that's what the -- and all of this is getting pumped into Cornie's team.

MEMBER LEITCH: You intend to publish a NUREG?

MR. RAUGHLEY: Yes, it's scheduled for November.

MEMBER LEITCH: And it would -- that will communicate your thoughts and recommendations to the industry?

MR. RAUGHLEY: John will --

MR. FLACK: Yes. I think a lot of those recommendations we see coming out of the study are actually being picked up right now as part of the work that's going on with the team. So this is -- Bill is on the team itself, so we have a direct transfer of that information to that team.

We also put the report on the web for access for people to look at. And then, I don't know if Cornie wants to take it from there and talk about the team's efforts and what other recommendations might be coming out of that.

MR. HOLDEN: Yes. I think obviously we're going to have to have public interface on where the team comes out.

MEMBER LEITCH: We have no authority to hire some of these things. These are suggestions, recommendations, but --

MR. HOLDEN: Right. We have no regulatory authority over the grid.

MEMBER ROSEN: But on the other hand, if the staff concludes that a client is not meeting GDCs because of this --

MEMBER LEITCH: Yes, then we have --

MEMBER ROSEN: -- then we have direct authority on that licensee.

MEMBER LEITCH: Yes, we do.

MEMBER ROSEN: Which exercising that regulatory authority could influence their views.

MEMBER LEITCH: Correct.

MR. FLACK: Another option might be a policy of some sort where it specifies our expectations as an agency. But that's being entertained at this point. It's something to think about.

MEMBER SIEBER: Before you disappear, the slide you now have in your hand, could you give us copies of that?

MR. RAUGHLEY: Sure.

MEMBER SIEBER: Okay. I have one other question. On degraded grid, a lot of stations have tap-changing auxiliary transformers. Are they typical -- the typical ones they install in nuclear powerplants? Can they change taps under load?

MR. RAUGHLEY: Yes. Some, not all, probably a third.

MEMBER SIEBER: But they're not automatic.

MR. RAUGHLEY: A third are automatic, and all the rest are no-load taps.

MEMBER SIEBER: Okay.

MR. RAUGHLEY: One thing that has come of

this, you know, after the Calloway event they replaced their transformers with no-load taps with automatic -- bought new transformers.

MEMBER SIEBER: No-load taps.

MR. RAUGHLEY: And put in capacitor banks. After the California events, Diablo Canyon replaced all of their transformers with automatic tap changers. And I think Salem has recently replaced theirs.

MEMBER SIEBER: They can -- the automatic ones can change under load.

MR. RAUGHLEY: Yes.

MEMBER SIEBER: The no-load taps cannot, and that's where you put capacitor banks with circuit breakers, to put them in --

MR. RAUGHLEY: Yes. Some places like Calloway needed both to get it to work right.

MEMBER SIEBER: Okay. And so that is something the agency can regulate. You can force the utility to deal with degraded grid situations where you may have voltage and power available that is below the level at which all of your under voltage relays would actuate.

MEMBER LEITCH: Okay. Thank you, Bill.

I guess we'll ask Jerry to give his presentation. Jerry, have at it.

MEMBER SIEBER: Thank you very much. Good presentation.

MR. DOZIER: Good afternoon. My name is Jerry Dozier. I'm in the Operating Experience Section. The Operating Experience Section is a real-time organization. We look at briefs -- at events early in the morning. By 8:00, we brief these events to the executive team. 8:30 we're in a meeting to discuss the generic implications, and also followup of the events. And then, we also participate with the regions in the agency response, the special inspections, augmented inspection teams, and things of that nature.

And that's what really brought this presentation to being is that the executive team asked that, okay, we have the Riley report. Let's see what's happening now with our grid. This was actually put together before the task force was assembled, so this was some of the early information, although I have updated those graphs to reflect the information to date.

The objective of this presentation is to graphically present recent grid event data. Hopefully, a graph is worth 1,000 words, and some of the data will speak for itself. I will also be

talking about an overview of three recent events and the different agency responses that we have for these different events.

We have a -- you know, we all -- if we have a grid event, we don't always respond to it the same. And so I've got a few examples showing that differentiation, and more of our risk-informed approach to addressing these -- to responding to the events.

As Bill said, in this particular presentation I'm only dealing with the S, which is the switchyard events. That's the 500 KV switchyard right there outside of the plant. That's the S events. T is those things within the -- outside of the transmission grid that's outside of that area.

Now, an R event is -- those events are those that we've had a reactor scram, and by having the reactor scram we lost offsite power. A lot of times what -- and there's only 10 of these events in the period '94 to 2003. But if you look at some of those events, basically what happened was we had the scram, there was something wrong in the switchyard area, and it gave us that loss of offsite power. So that's what we're talking about -- the T, S, and R events.

The first graph we have here, the pie chart, this is the entire period 1994 to present. We see here that basically about 50/50. We have 50 percent of our problems right there in that low area right outside the plant. I'll show a switchyard a little bit later and show -- and maybe that will show -- demonstrate why, you know, with the multiple redundancy we have in this a single failure on the outside grid a lot of times doesn't have a real effect on the -- in a lot of cases don't have a real effect on the plant. And I'll show one of those.

Now, in the period -- if you take 2002 to present, our new information after the Riley event, you'll again see it's about a 50/50 type of situation. In this case, there were zero R events.

The next graph presents the information. The S, T, and R events from 1994 to present. There is a couple of errors on this, and maybe if you ask about the -- you know, there is a little bit of margin for error in this, and I wanted to express it. There were actually nine events that occurred as a result of the blackout on 8/14. So reduce this number actually from 27 events to 25.

But all in all, if you look at 2003, whether or not it's 25 or 27 events, these are 20-

something events that have caused actual reactor scrams within our system.

If you take away the red line there reflecting -- if you take away the blackout that occurred, then really in the 2003 time period you're looking back at '95, '96, you know, maybe even before deregulation and now, may not have been so much different, but Bill talked about, well, the duration of those events had been longer. Maybe the earlier events were shorter duration, loss of offsite power for these later are longer in duration. So it's not quite an apples for apples comparison.

CHAIRMAN BONACA: Yes. But even if you take out those from the blackout, you still have a higher number, don't you?

MR. DOZIER: Yes. It's a little bit higher number, yes.

CHAIRMAN BONACA: And the year is not over.

MR. DOZIER: Right.

CHAIRMAN BONACA: Okay.

MR. DOZIER: So the next question was: why did we have these events in the first place? And this pie chart, if you'll just focus on the three biggest parts of the pie, you'll see one of the bigger

ones was equipment failure. And that one is kind of self-explanatory. Something happened with the equipment.

The next one was a fault occurred. Now this is a lightning strike, salting of the switch gear, things of that nature, raccoon running over the line. Those are the fault types of situations.

The next biggest one is -- and this is a '94 to 2003 period -- the next one is the weakness in the electrical grid. Now that's the area that the station blackout was in, and that's where you would categorize those three events. So you see here a large piece of that pie is attributed to those three causes.

If you break it down into just the 2002 to 2003 period, you'll see that those three have grown -- the electrical, equipment failure, and fault. And so that seems to be the 80 percent of the pie that is causing the most problem.

The next graph and the next series of graphs is the grid events by region. And Bill showed that chart on deregulation in the different regions that had regulation versus those that didn't. I didn't make an attempt to correspond that data, but if you look at this '94 to present data you'll see that

-- and then also right after the blackout everybody was focused on Region 1 and a little bit of Region 3.

But if you look at this and you take the whole period into consideration, you see that Region 4 popped up pretty good in this as far as numbers of events that actually scrammed the plant.

The executive team asked a question. They said, "Well, we've got different numbers of plants in there, so I'd like you to normalize this data to see what really happens." Region 2 in this -- the text box up there under number of plants, you'll see that Region 2 has a lot of plants with 32.

So, really, what happens with this normalization is you get -- Region 2 gets worse as far as -- I mean, gets better -- I'm sorry -- and Region 4 even gets worse when you normalize the data.

Now this is recent data. And actually, if you look over here on the left this is only up to four events. But it does show even that Region 4 had the most number of these grid events prior to the blackout. So I think the big thing is, you know, Region 4 is kind of important, too, in these.

But after you consider the grid events and put those into the equation, you'll see that Region 1 is the dominant winner on getting the bad piece of

this pie. Again, this is just a normalization of the present data, and you'll see here that -- again, Region 1 high with Regions 3 and 4 right there in the -- about the same area.

Next I would like to share a few of the events, go into a little bit of the details, but keep it at an overview level. And the importance of this event is it happened in April. This was prior to the blackout occurring. And just to let the committee know, we were already on a lot of these grid events.

For example, this grid event we had a regional brief where we briefed all of the people -- the members of the region. But anyway, to describe this event, basically though it was -- and this is the big overview, and I'm going to go into a little bit of the details. High winds in the 500 KV switchyard blew a disconnect closed resulting in a partial loop.

I'll show you that disconnect in a few minutes. It's basically just a -- well, I'll show it in just a second.

MEMBER SIEBER: Well, they're gear-driven, though, right? With a crank?

MR. DOZIER: Yes. It's manually -- you do manually turn those.

MEMBER SIEBER: You turn the crank.

MR. DOZIER: Exactly.

MEMBER SIEBER: I don't see how the wind could blow it closed.

MR. DOZIER: Well, it was -- I can go into that just -- in the next picture, if I can --

MEMBER SIEBER: Fine.

MR. DOZIER: Okay. They scrammed on load rejection. The diesel generators energized the safety busses.

Now, what really throws these things into higher risk is the plant response to the event. In this case, the instrument air -- they had instrument air complications. So that bumped the risk up a little bit more, and that's really what -- one of the factors that goes into making it a special --

MEMBER ROSEN: By "instrument air complications," do you mean the instrument air compressors were not on the safety bus?

MR. DOZIER: No. Instrument air is non-safety-related.

MEMBER ROSEN: Yes.

MR. DOZIER: And in this case there was a partial loop. They lost one of the service transformers that fed the instrument air.

MEMBER ROSEN: Right. So the instrument

air compressors didn't have any power.

MR. DOZIER: Right. Right.

MEMBER ROSEN: That's what I was trying to say.

MR. DOZIER: And it's not --

MEMBER ROSEN: The instrument air compressors are not on the safety bus.

MR. DOZIER: Exactly. Exactly.

Okay. And I'll go a little bit into the detail of this event now. This is the disconnect that we're talking about. If you look here, basically this disconnect -- if it was in the closed position, it would come over and latch here. And that's the energize position.

They were working on this breaker that was over here. So this disconnect is in this risen position. It's really designed for about 77 mile per hour winds, but there was a problem with the counterbalance on this particular one.

Now I'll go and show you. Since a lot of these events -- really, if you kind of look at one, you kind of get an idea of what goes on. But in this case, the wind blew this disconnect closed. That was the start of this event.

MEMBER SIEBER: So it must have broken

something in the disconnect.

MR. DOZIER: Yes. There was --

MEMBER SIEBER: A shaft or a pin or something like that.

MR. DOZIER: There was a mechanical problem with it, because it was designed for 77 mile per hour winds. This was only 25 to 35 mile an hour winds.

But, however, we're showing here it was working on this particular date, 5204 breaker. And, of course, this thunderstorm was coming up. The folks that were working on it decided to take shelter in the switchyard house. And at this point, the two disconnects were in the open position.

Now, this switchyard is in the normal -- is showing the deenergized position. But, really, all of these disconnects here are closed throughout this system. I've talked about the redundancy of the switchyard. For example, you have different lines. You have a line coming from Baxter Wilson. That one is independent from the Franklin line, and both of these can feed this bus.

So there's a lot of redundancy in there, and that's why a single failure of an outside power source doesn't have so much effect on our plants.

What's not shown here, too, is there is also a Fort Gibson line, a smaller 115 KV line that's also into it. Notice here that I am talking about a partial loss of offsite power, not a complete one.

MEMBER SIEBER: Was that disconnect the clearance point for the safety corners for the break repair? In other words, when it went closed, did it energize the breaker that was being worked on?

MR. DOZIER: Exactly. Well, they didn't energize that breaker. But what happened -- okay, they had those disconnects open. The next thing is these disconnects blow shut. So you've got a grounding device right here, you know, to protect the workers while they are working.

MEMBER SIEBER: So you can offset --

MR. DOZIER: Right. So when that occurred, you basically caused a short here, which made the -- a ground fault at this particular breaker and this particular breaker. And that was your first loss of this service transformer 21, which does go to the division 2 and 3 safety busses.

MEMBER SIEBER: Right. Got it.

MR. DOZIER: After you had this fault here, there was also some problems in the Baxter, Wilson, and Franklin relay station. They temporarily

had a little perturbation there. That gave the -- a differential current ground fault --

MEMBER SIEBER: Okay.

MR. DOZIER: -- for these areas. Your generator was still coming in from this side over here, but it was seeing so much of the different perturbations it got a load reject.

MEMBER SIEBER: Okay.

MR. DOZIER: Load reject caused the turbine control valves to go closed. Reactor scrammed.

MEMBER SIEBER: Okay. Now, do those have reclosers on them? Or do they just stay tripped? You know, a recloser, once you get a fault, it will go and try to connect it again.

MR. DOZIER: Actually, I'm not sure.

MEMBER SIEBER: Don't know. Okay.

MEMBER LEITCH: I think that's mainly at lower voltages on the distribution system. I don't think these 500 KV or 345, whatever it was, I don't think they have reclosure devices on them.

MEMBER SIEBER: Okay.

MR. DOZIER: Okay. So we have an event here. What did we do about it? The risk analysts looked at it. This was in the E^{-6} to E^{-5} range. That

E^{-5} range came because of the -- like I said, we had some instrument air complications, and so that's why it shot up in that minus five area.

Now, that's the area where we look at doing a special inspection. We look at the numbers. We also have deterministic criteria that are also looked at. You know, is there generic implications to it? Was it a complex event? Was there a personnel issue, performance issue involved? So that's the deterministic criteria that we look at.

So in this case we went in with a special inspection. As mentioned earlier, we did a briefing to the regions on this event to explain and share the lessons learned about the event. After the inspection team went in, basically they did come out with a finding on this instrument air, and it was a green finding.

The next event -- this one just happened the 19th of last month -- the Salem/Hope Creek. You have Artificial Island kind of close to that -- you know, the salt -- this estuary I think. And you had high winds and rough surf during Hurricane Isabel.

We got salt deposits on that which caused it -- caused a fault out in the switchyard. Hope Creek got a reactor scram off that faulting situation.

Salem, on the other hand, they manually shut down. Hope Creek -- they were a little more sensitive to these faults because they had recently installed a digital fault sensing system. But in this case, you had -- this was one event where you have actually three plants going down.

Okay. So what did we do with this event? Well, in this case, it was in the 10^{-6} range. It was right there in the special inspection area, but it was felt like that we understood the salting, we understood the hurricane and what happened. We kind of looked at the licensee action, and then we said, well, we're not going to do a special inspection for this, because we can't really learn anything from it. But we will follow-up as part of the routine baseline inspection.

MEMBER ROSEN: How high were the winds at Salem/Hope Creek?

MEMBER LEITCH: At Salem and Hope -- I seem to remember around 75, but --

MEMBER ROSEN: So it was still a hurricane, minimal hurricane.

MEMBER LEITCH: I didn't think it got to quite hurricane strength, or they would have probably manually shut the units down at that --

MEMBER ROSEN: That's what I'm trying to get at is how high were the winds, and what was their hurricane shutdown procedure?

MEMBER LEITCH: Well, my impression was that the winds in that area -- and I don't live too far from there -- were probably about 40 miles an hour with higher gusts.

MEMBER ROSEN: With the sustained wind, the site never reached hurricane force.

MEMBER LEITCH: They say that -- they were telling me that some of the problem was that they had winds, but not a whole lot of rain. They said that if they had some rain it would have helped this salting situation. So they had the worst situation with the wind blowing the saltwater onto the busses, without a whole lot of rain to wash it off.

MR. DOZIER: And a lot of these plants were in unusual events, which triggers at about I think around 75 miles per hour winds.

MEMBER ROSEN: Well, 73 is hurricane, minimal hurricane on the Saffir-Simpson Scale. And plants usually have a different procedure once they predict sustained winds greater than hurricane strength. Sustained means for two hours or more usually.

So, you know, I'm surprised that -- well, I have to gather from this that they never predicted sustained winds greater than 73 miles -- or never experienced it. And, really, what they experienced was gusts perhaps up there, and, like you say, no rain, but enough wind to whip saltwater onto the insulators.

MR. DOZIER: I think that's correct.

MEMBER LEITCH: I think had it been 75 they would have had to take action based on their emergency procedures.

MEMBER ROSEN: If they predicted that the winds would exceed 75 -- sustained winds in excess of 73 miles an hour, they would have had to shut down and be in at least hot shutdown two hours before that happened. I mean, that's typical.

MR. HOLDEN: I know that Region 1 spent a couple of days before that hurricane reviewing the hurricane response procedures at each licensee facility that was anticipated. So they went up and down the coast in Region 1 and Region 2.

MR. DOZIER: Okay. The next event which Mr. Leitch had already talked about was Peach Bottom. And Peach Bottom -- actually, it was a dual-unit trip, and it was caused by a loss of multiple offsite power

lines, basically a lightning strike and momentary low voltage on the other offsite power line.

This was a pretty complicated event with -- Unit 3 had a -- the MSIVs went shut. The safety relief valves had to open on Unit 3. The safety relief valves, one of them stuck. Also, one of the four diesel generators tripped. This was a pretty complicated event for them. In this case, the risk was in the E^{-3} to E^{-4} range.

And so at that level, we're at a higher level of inspection team called the augmented inspection team, and they were dispatched on 9/24 to investigate, get a sequence of events, and try to fully understand this event. They will -- they have some preliminary findings, but the details haven't really surfaced. Tomorrow they will be briefing the utility on those findings.

I didn't conclude this, because the -- I figure with the task force going on and hopefully they can provide the right conclusion and recommendations for this -- for these grid events.

MEMBER LEITCH: Okay. Thank you, Jerry.

Any questions for Jerry?

MEMBER SIEBER: Good presentation.

MEMBER LEITCH: Any concluding remarks?

MR. FLACK: No, I think that pretty much wraps it up. Bill's work -- well, again, as Bill mentioned, will be out in NUREG form in November we're shooting for with responses to comments that we've received. So we'll be sending copies of those around.

MEMBER LEITCH: Okay. Does any of the committee have anything else? Any concluding remarks?

MEMBER ROSEN: I presume we'll hear a lot more about this.

MEMBER POWERS: Yes, I would expect so.

MEMBER LEITCH: We have put a little picture on the back of the handout that I gave you, a satellite picture of the northeast blackout. I just thought it was an interesting picture.

Okay. Mr. Chairman, back to you.

CHAIRMAN BONACA: Okay. Thank you. That was very informative, very well -- very good presentation.

We are ahead of time. Let's take a break now for 20 minutes, come back at 10 of 4:00, and then we have -- Dr. Powers is going to tell us about the research report.

(Whereupon, at 3:30 p.m., the proceedings in the foregoing matter went off the record.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards 506th Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Eric Hendrixson
Official Reporter
Neal R. Gross & Co., Inc.

A REVIEW OF THE PIRT PROCESS

Presented to:
Advisory Committee on Reactor Safeguards (ACRS)

Presented by:
Hossein P. Nourbakhsh
ACRS Senior Fellow

October 2, 2003

BACKGROUND

- The Phenomena Identification and Ranking Table (PIRT) process was originally formulated as a major step in CSAU evaluation methodology.

- The PIRT process, with some variations, has been used in much more applications that was originally envisioned.

BACKGROUND (Cont'd)

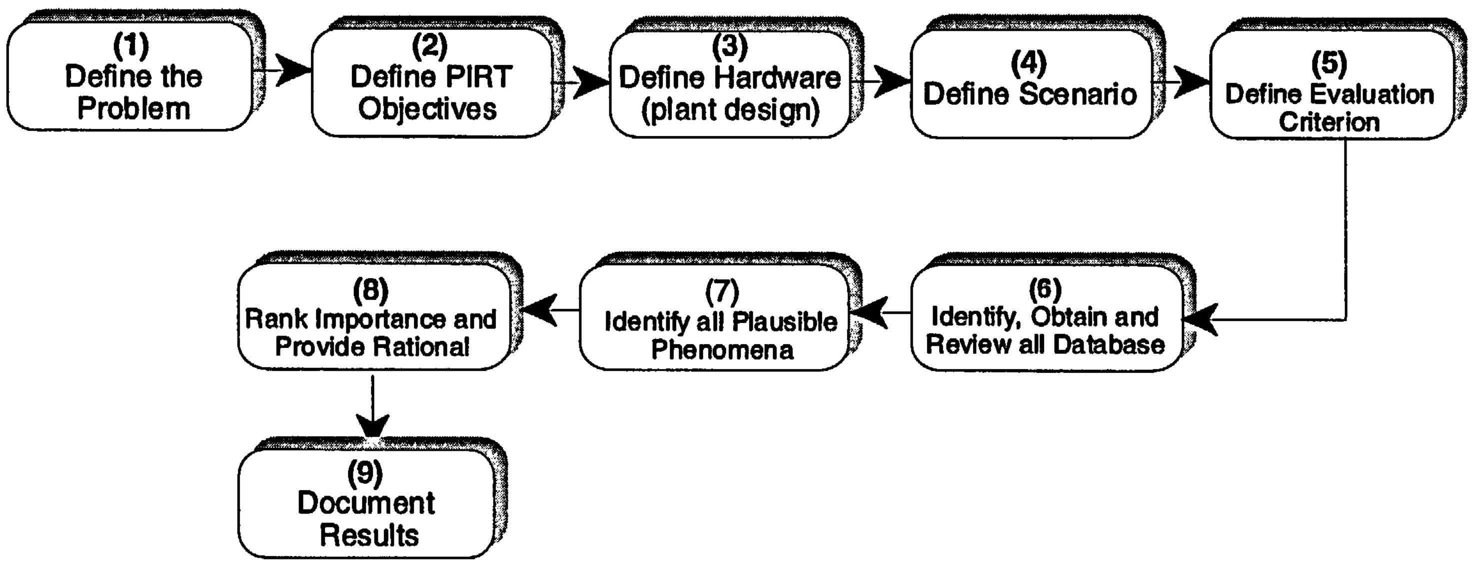
- In view of the wide spread use of PIRT process and its role in prioritization of research needs to address reactor safety technical issues, it is important to provide lessons learned from the past several years of experience with the PIRT process and to identify potential improvements for future PIRT development.

OBJECTIVE

- To review the PIRT process and its prior applications and to provide some suggestions for enhancement of the process

OVERVIEW OF THE PIRT PROCESS

Illustration of Typical Application of the PIRT Process



OBSERVATIONS

- Success in developing a useful PIRT is a strong function of the degree to which supplemental information are well documented. In most of the prior applications of PIRT process the technical basis and rational for importance ranking of many phenomena are not provided in sufficient depth that a reader can easily follow.
  - *This shortcoming is partly due to the lack of a systematic methodology that enables to capture all the implicit assumptions that an expert may make in arriving at an importance ranking for a plausible phenomenon*

OBSERVATIONS (Cont'd)

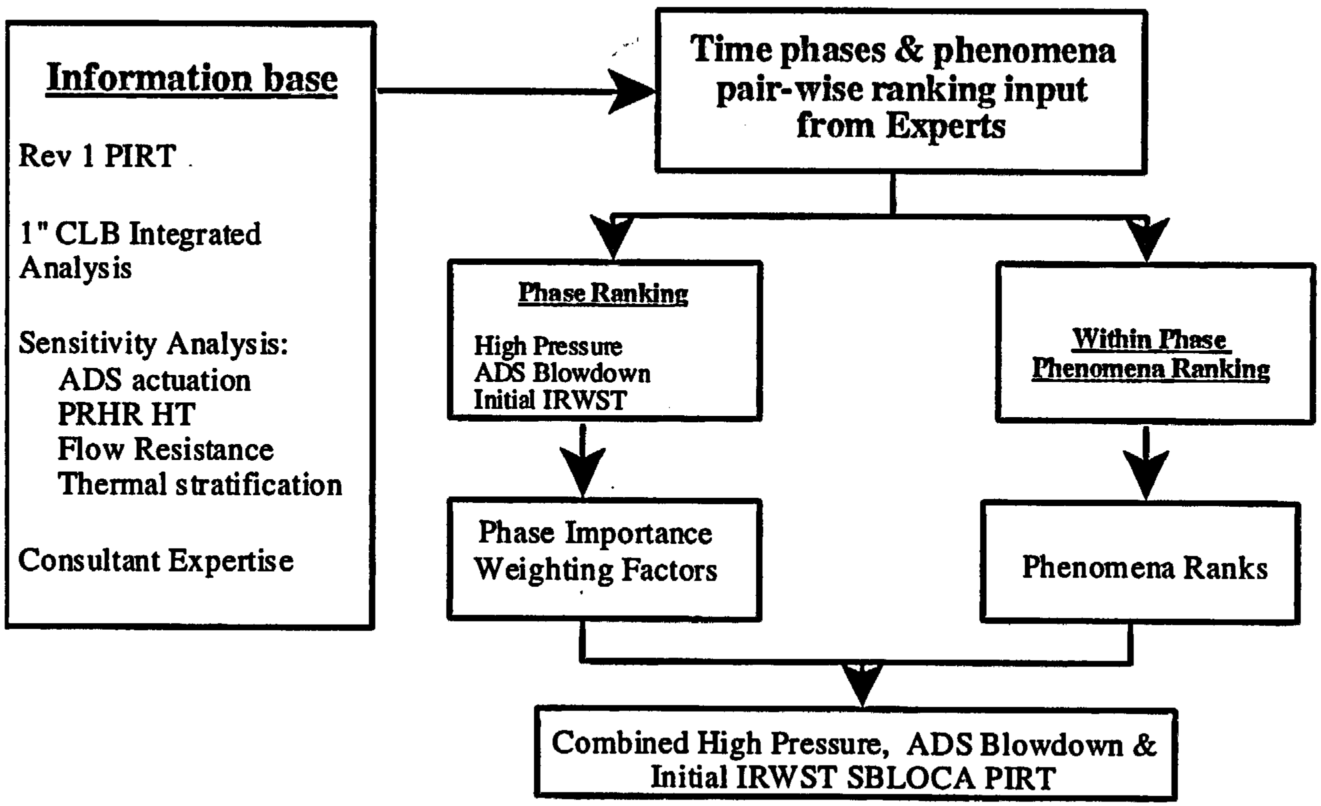
- It has been observed that individual panel members may be experts in some phenomena but be less familiar with others. To deal with this reality, panel members are informed that they need to vote only if they feel they have sufficient understanding of the importance of a phenomenon.
  - *Since the panel members are asked to focus on importance of a phenomenon relative to the primary evaluation criterion, it is not clear whether this could always be done without making any implicit subjective judgment on importance of other phenomena that they may not be familiar with.*

OBSERVATIONS (Cont'd)

- In some prior PIRT efforts, pair-wise importance ranking of components and phenomena and the analytical hierarchy process (AHP) was utilized to determine the relative importance of phenomena and components.
  - *Many reactor safety technical issues involve interactions and feedback structure and do not have the linear top-to-bottom form of a hierarchy but look more like a network. Therefore, collapsing complexity into a simplistic hierarchic structure of few levels, and hoping to capture the effect of interactions implicitly in the form of highly condensed judgments is questionable*

OBSERVATIONS (Cont'd)

Conceptual application of AHP to AP600 SBLOCA short-term PIRT (NUREG/CR-6541)



OBSERVATIONS (Cont'd)

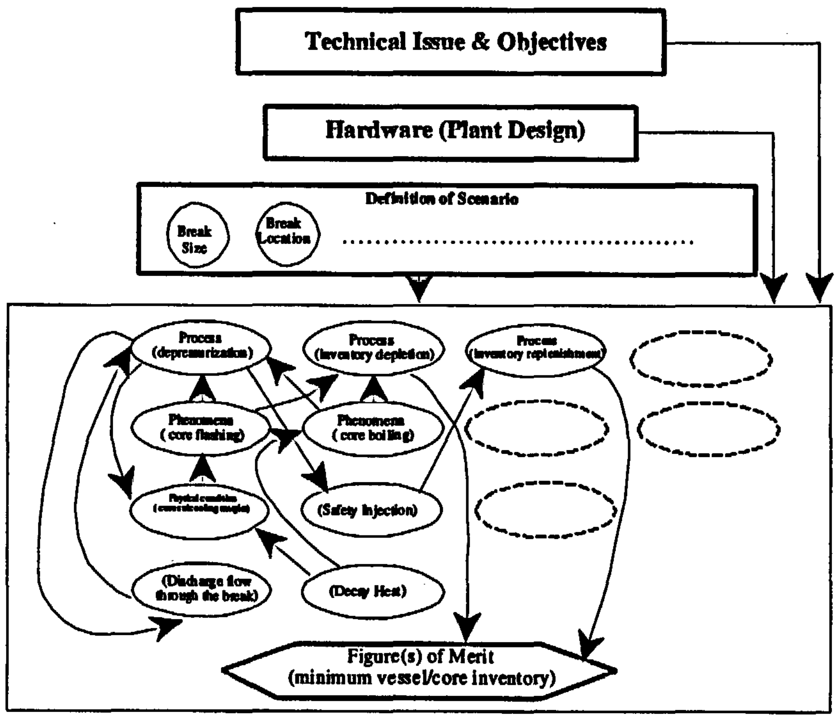
- Since the initial development of CSAU evaluation methodology and its associated PIRT process, procedures for expert elicitation, such as those documented in NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," have been developed. However, the evolving PIRT process does not seem to have benefited from such elicitation procedures.

RECOMMENDATIONS

- System dynamic techniques, such as influence diagrams (IDs), offer an attractive alternative framework to assess the importance of plausible phenomena for resolving a complex technical issue.
  - IDs indicate major factors in a system and what influence these have on each other.
  - Such diagrams provide an excellent tool for representing an expert's thought structures in the form of a network where nodes represent a factors and directed arcs joining nodes represent the relationship between them.

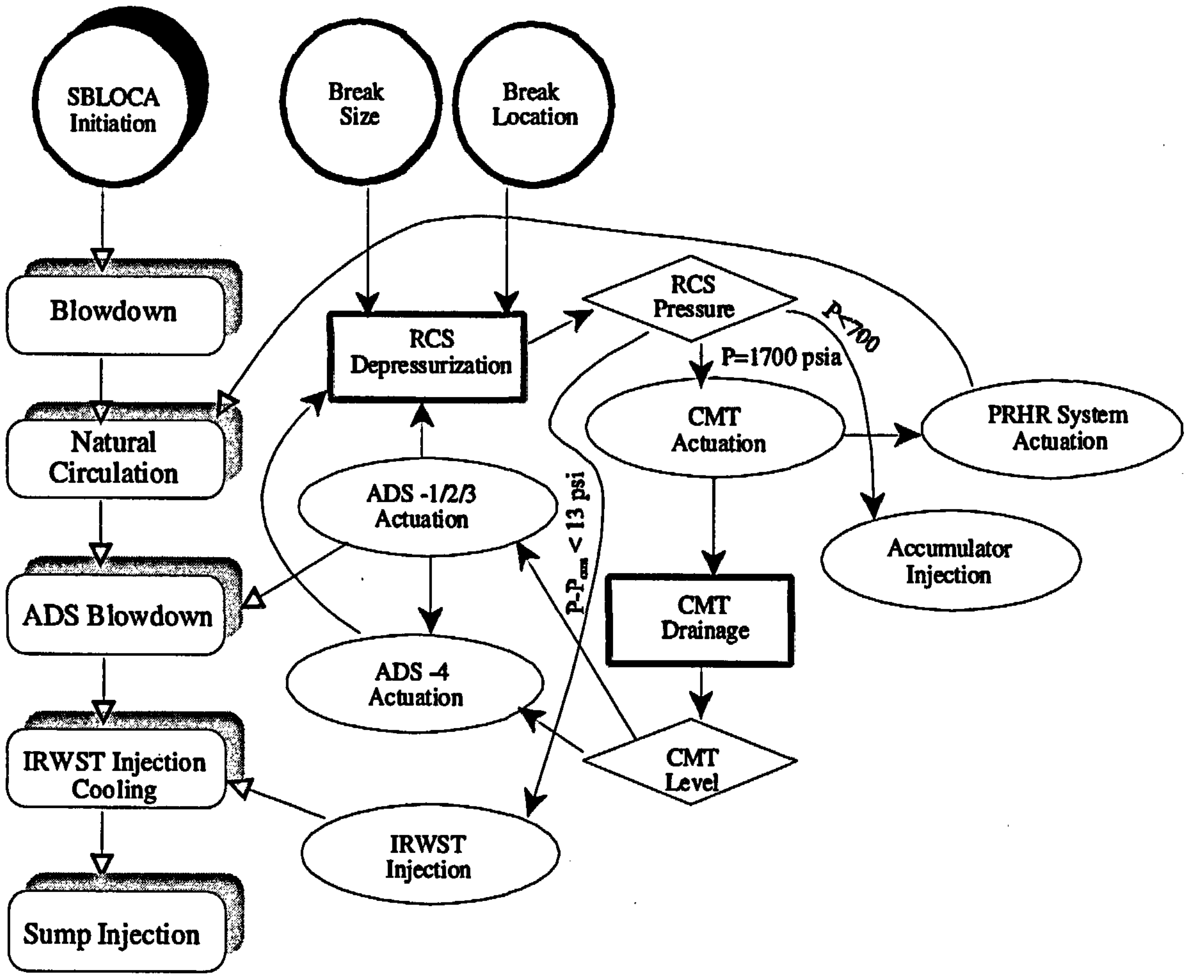
RECOMMENDATIONS (Cont'd)

Conceptual illustration of using influence diagrams to enhance the PIRT process



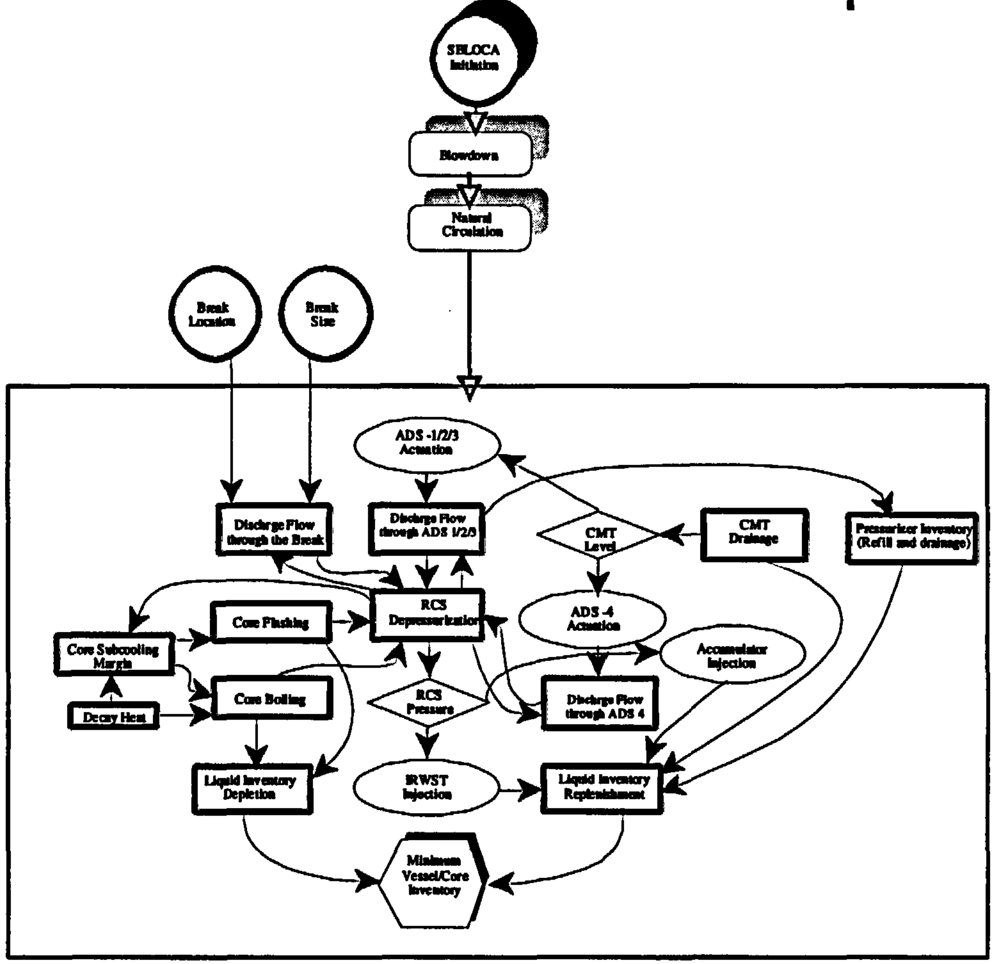
RECOMMENDATIONS (Cont'd)

Transient phases for AP600 SBLOCA PIRT



RECOMMENDATIONS (Cont'd)

Illustrative example of influence diagrams for AP600 SBLOCA short-term phase*



*Incomplete (for illustration only)

THE ADVANTAGES OF USING IDs

- IDs provide a more systematic context for capturing all the implicit assumptions that an expert may make in arriving at an importance ranking for a plausible phenomenon.
    - *Facilitate the development of adequate documentation that can later be utilized for an update or revision.*

THE ADVANTAGES OF USING IDs (Cont'd)

- Elicited IDs provide a more transparent guidance for establishing the requirements in code development, assessment and improvement as well as for evaluation and specification for experimental programs.

THE ADVANTAGES OF USING IDs (Cont'd)

- Using IDs for expert elicitation provides a framework that individual experts can make a judgment in their own areas of expertise without making any implicit subjective judgment on importance of other phenomena that they may not be familiar with.

RECOMMENDATIONS (Cont'd)

- Pair-wise importance ranking and the Analytical Network Process (ANP) may also be utilized, in conjunction with an influence diagram, to determine the relative importance of the processes, phenomena and components.

RECOMMENDATIONS (Cont'd)

- Potential use of the tools borrowed from the realm of qualitative reasoning and causal modeling, in conjunction with a qualitative influence diagram framework, should also be explored to further enhance the PIRT process.

SUMMARY

- A review of the PIRT process, noting its shortcomings, was provided.

- The use of influence diagrams as an alternative framework to identify and prioritize the physical processes which need to be addressed for resolution of a technical issue was also discussed.

Grid Reliability Issues

NRC Office of Nuclear
Regulatory Research

William S. Raughley,
Sr. Electrical Engineer

Agenda

- Background
- Changes on the Grid
- Impact on Nuclear Facilities
- Best Practices
- Conclusions

Background

- Long term review of operating experience
- SECY-99-129, "Effects of Electric Power Industry Deregulation on Electric Grid Reliability and Reactor Safety," May, 1999.
- Monitor and assess the grid
- "Operating Experience Assessment-Effects of Grid Events on Nuclear Power Plant Performance," April, 2003.
    - Initial draft for internal comment 11/02
    - Issued for stakeholder comment 5/03
    - NUREG scheduled 11/03

Background - Expectations

- 10 CFR 50 App. A (GDC-17, Electric Power Systems)
- Station Blackout Rule (10 CFR 50.63)
- Maintenance Rule (10 CFR 50.65)

Background

- In 1992, the National Energy Policy Act (NEPA) encouraged competition in the electric power industry, i.e., open generator access to transmission system and statutory reforms to promote wholesale generators.
- In 1996, FERC issued orders requiring open access to the electric power transmission system.
- Currently, 50% of states sell power in an open market, and have restructured to promote separate generating, and transmission and distribution companies.

What Has Changed on the Grid?

- Higher transmission system loading.
- Lower grid reactive capabilities.
  - PJM 1999 grid event
  - Reactor power uprates
- Changes in grid operating voltage limits and action levels.
- Increase in transmission line relief requests during summer.
- Increase in coordination times to recover from grid disturbance.

Challenging Safety Issues

- Most loss-of-offsite-power (LOOP) events occur during summer months.
- Increase likelihood of reactor induced LOOPs during summer.
- Longer time to recover from LOOP.
- Risk from
  - Low voltage condition
  - On-line EDG maintenance

Best Practices

- Consider the seasonal effects of grid performance on:
  - EDG maintenance and test practices
  - Switchyard maintenance practices
- Establish contractual arrangements between grid operators and NPPs to maintain secure electrical power.
- Use of real-time grid parameters when performing design basis electrical analysis.

Stakeholder Comments

- Recognized the merit in periodically conducting grid assessments.

- NRC and industry should collaborate on an assessment of the relationship between deregulation, grid events, and NPP safety.

- Grid operators may not be fully aware of:

  - the more restrictive NPP bus voltage limits,
  - the grid condition during EDG maintenance,
  - pre-trip voltages necessary for safe shutdown.

Conclusions

- Changes in grid performance have occurred since operating in a deregulated environment.

- Grid performance can impact NPPs:

  - Response to accidents and transients
  - Blackout (coping) duration
  - Challenge safety equipment

- Need to seek a better understanding of grid performance.

Reactor Trip Events Caused by Grid

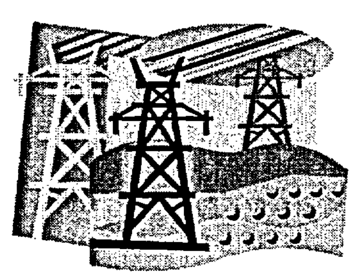
Jerry Dozier

Operating Experience Section

1

Objective

- Graphically present recent grid event data
- Overview of 3 recent events and agency response



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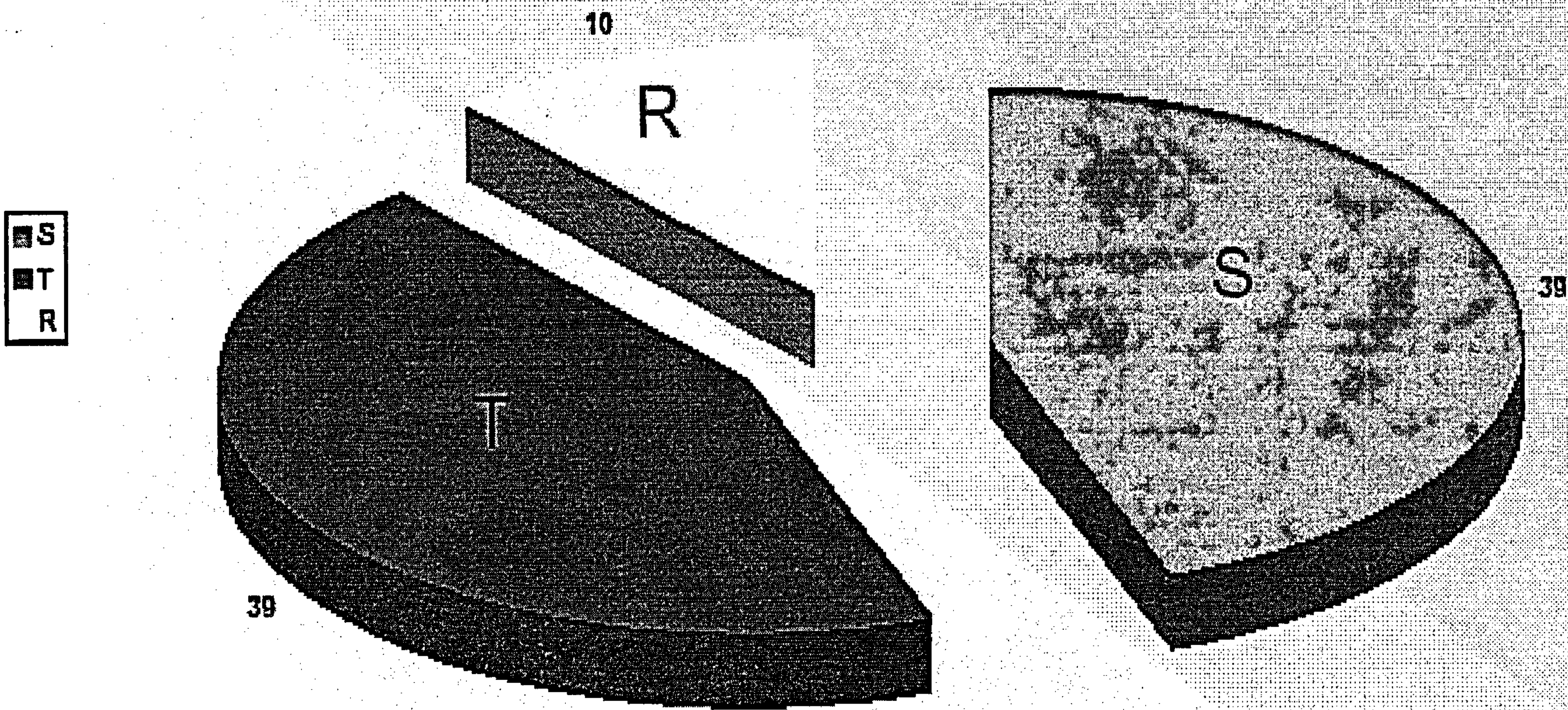
Grid Events Resulting in Plant Shutdowns or Complicating Plant Shutdowns (1994- 2003)

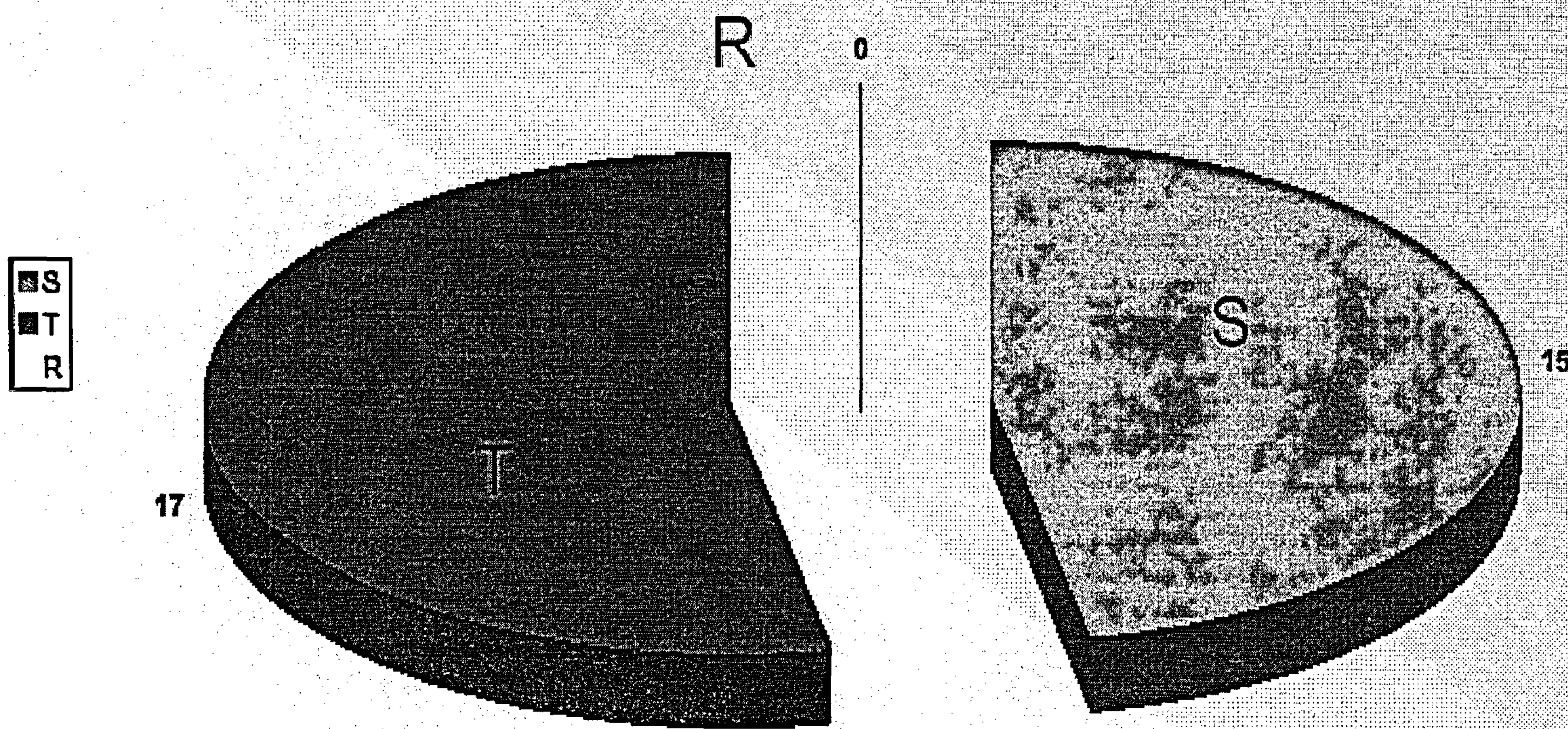


"S" events are reactor trips where the first event in the sequence of events leading to the reactor trip was in the switchyard or substation nearest the plant.

"T" events are reactor trips where the first event in the sequence of events leading to the reactor trip was in the transmission system beyond the switchyard or substation nearest the plant.

"R" events are losses of electric power from any remaining power supplies as a result of, or coincident with, a reactor trip at power.

Grid Events Resulting in Plant Shutdowns or Complicating Plant Shutdowns (2002- 2003)



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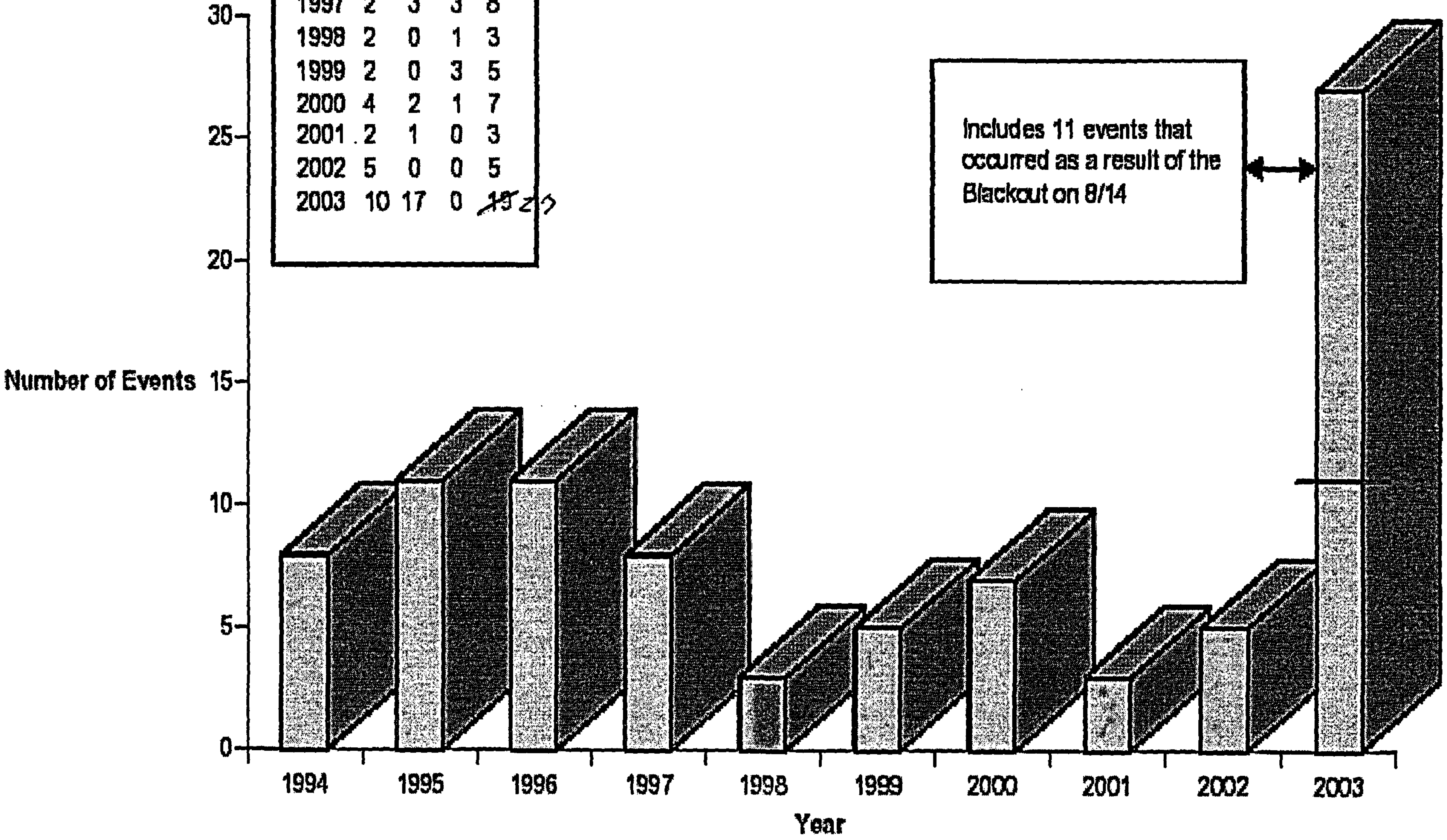
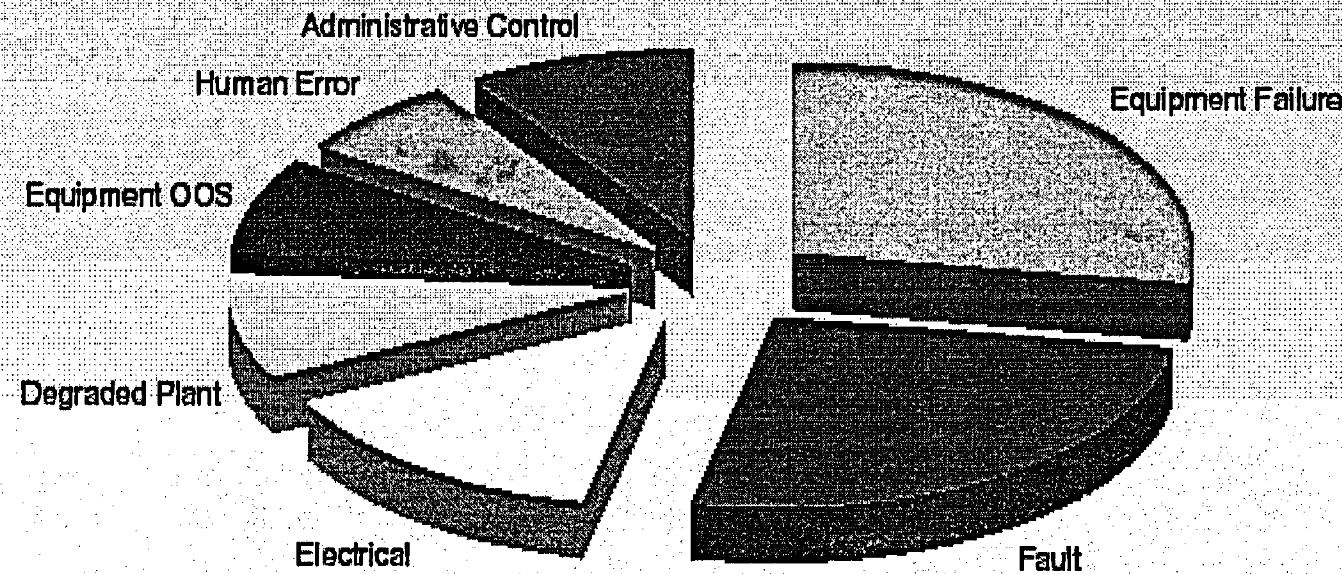
"R" events are losses of electric power from any remaining power supplies as a result of, or coincident with, a reactor trip at power.

Switchyard (S), and Transmission(T) Events Causing or Complicating (R) Plant Shutdowns from 1994 to Present

Date	S	T	R	RS&T
1994	4	4	0	8
1995	6	5	0	11
1996	2	7	2	11
1997	2	3	3	8
1998	2	0	1	3
1999	2	0	3	5
2000	4	2	1	7
2001	2	1	0	3
2002	5	0	0	5
2003	10	17	0	~~19~~ 27

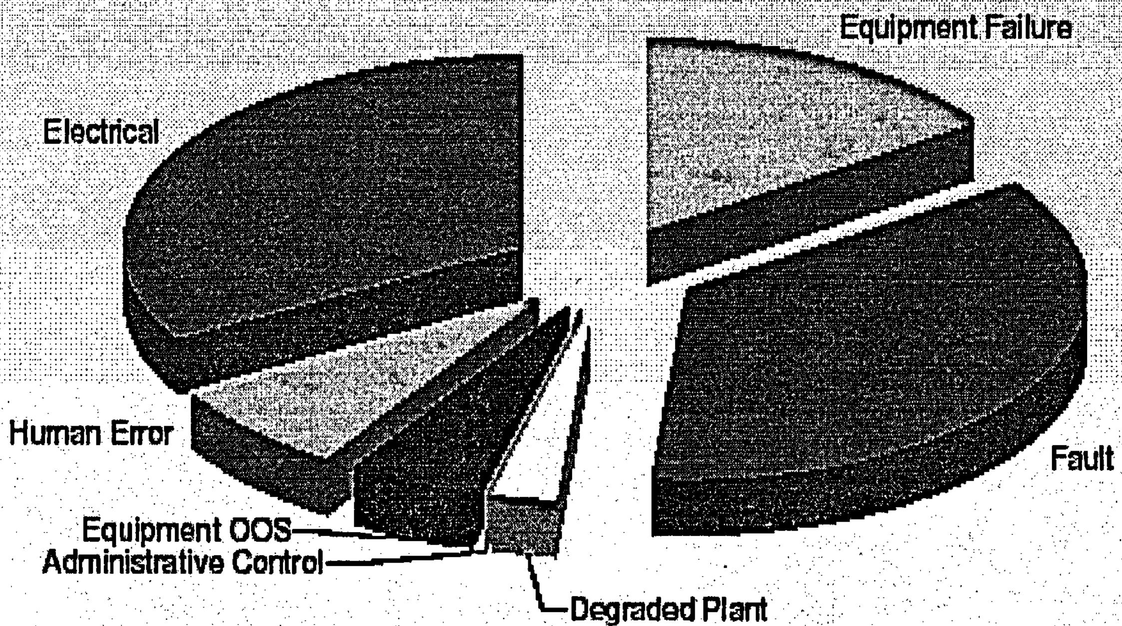


Causes for Grid Events 1994 - 2003



- Equipment Failure indicates switchyard or transmission equipment failed or mis-operated (mis-op).
- Fault indicates switchyard or transmission equipment faulted.
- Electrical indicates a weakness in the electrical capability of the grid (or grid and NPP combined) to support the NPP offsite voltage.
- Degraded Plant indicates degraded nuclear plant equipment contributed to the event.
- Human Error indicates human error by personnel that work for the transmission entity.
- Equipment OOS indicates that equipment under control of the transmission entity were out of service at the time of the event.
- Administrative Control indicates a lack of control of the transmission entity's activities

Causes for Grid Events 2002 - 2003



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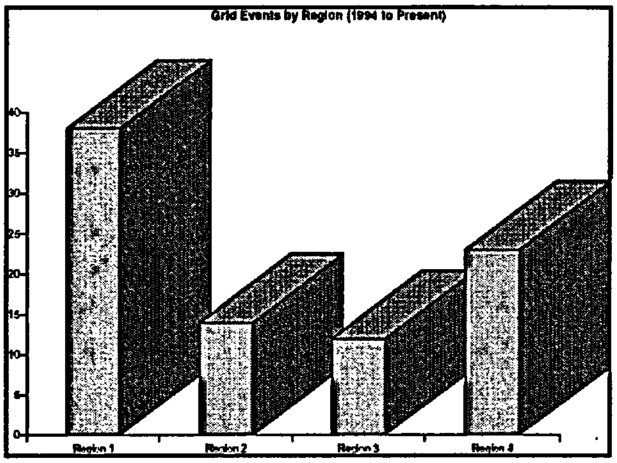
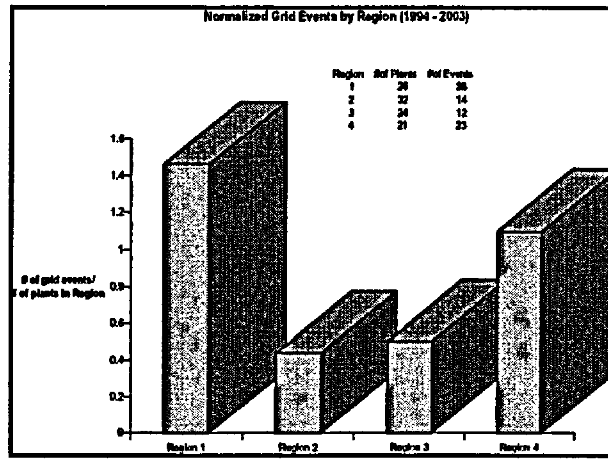
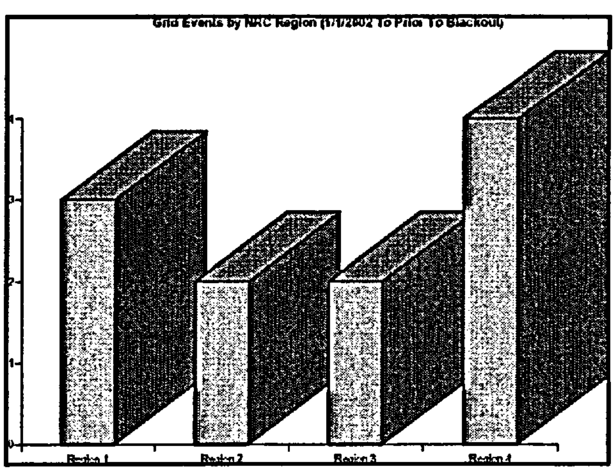
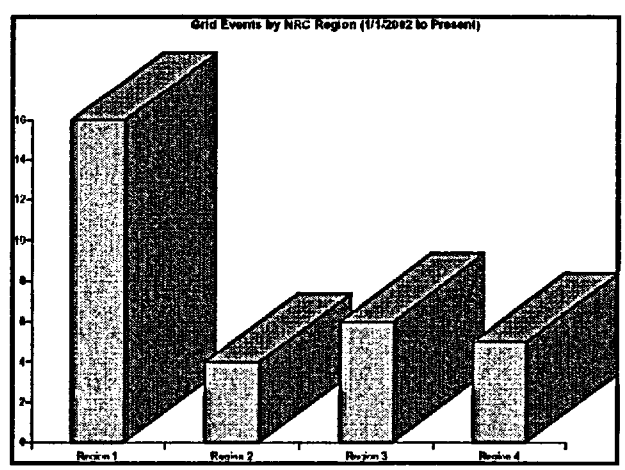
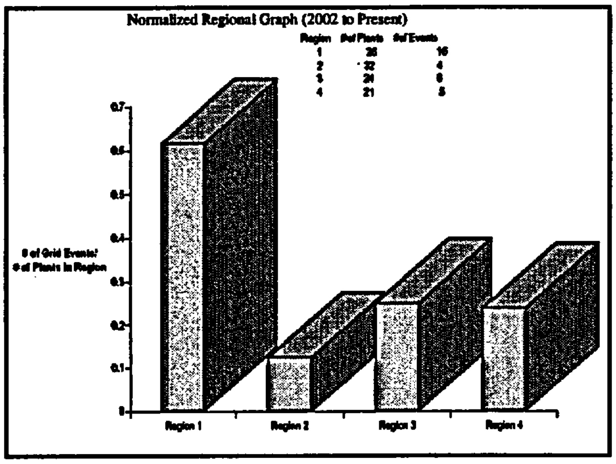

Grid Events by Region (1994 to Present)
40
35
30
25
20
15
10
5
0
Region 1
Region 2
Region 3
Region 4


Normalized Grid Events by Region (1994 - 2003)
Region #of Plants #of Events
1 26 38
2 32 14
3 24 12
4 21 23
# of grid events/
# of plants in Region
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Region 1
Region 2
Region 3
Region 4


Grid Events by NRC Region (1/1/2002 To Prior To Blackout)
4
3
2
1
0
Region 1
Region 2
Region 3
Region 4


Grid Events by NRC Region (1/1/2002 to Present)
16
14
12
10
8
6
4
2
0
Region 1
Region 2
Region 3
Region 4



Grand Gulf

- High winds in the 500 kV switchyard blew a disconnect closed resulting in a partial LOOP (4/24/2003)
- Scram on load rejection
- Diesel generators energized safety busses
- Event is further complicated by the inability to promptly restore instrument air

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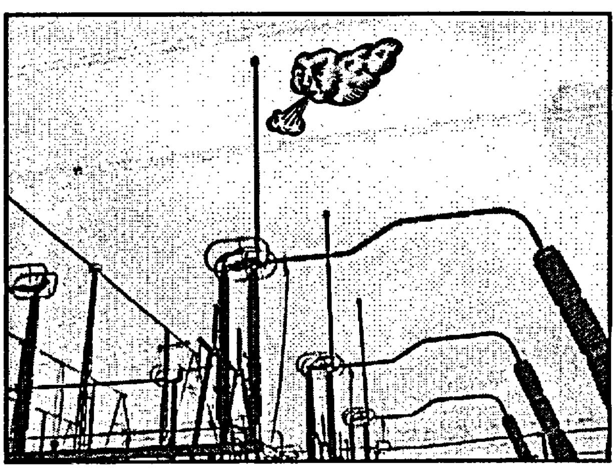

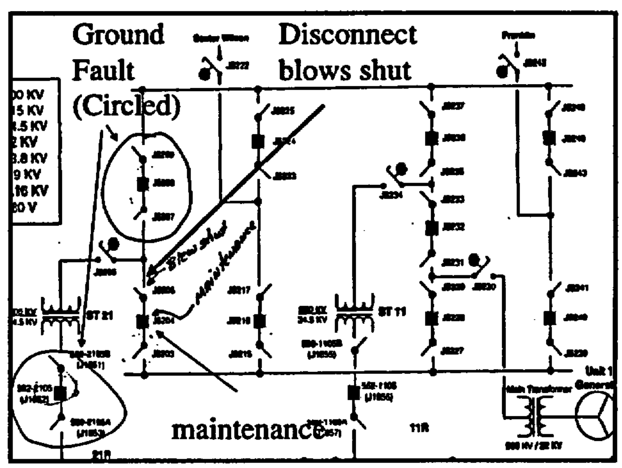

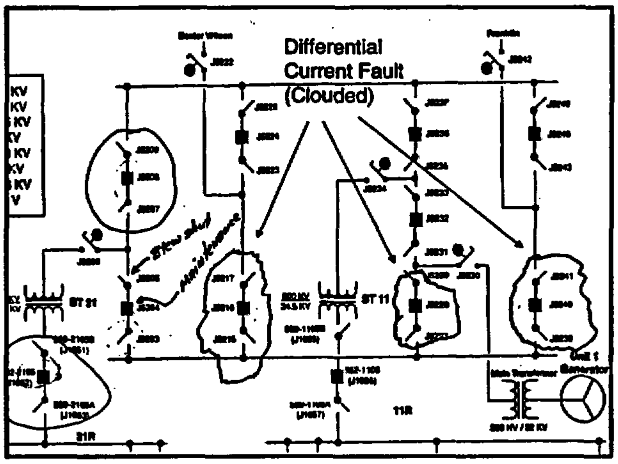

Grand Gulf Agency Response

- **Risk: CCDP Range of 6.9E-6 to 3.3E-5**
- **Special Inspection and Regional Briefing by OES Performed**
- **SIT findings**
  - Failure of Grand Gulf Nuclear Station personnel to provide an adequate procedure for restoring the instrument air system following the loss of instrument air. (Green Finding)

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Salem/Hope Creek

- **High winds and rough surf in the Delaware River during Hurricane Isabel (9/19/03) resulted in salt deposits in the 500kV switchyards at Salem and Hope Creek.**
- **These salt deposits caused electrical faults and arcing in both switchyards. Hope Creek scrammed and Salem manually shut down**

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Hope Creek Agency Response

- The licensee provided adequate justification for their actions and the plant response was well understood. Even though the event was in the lower range for special inspection, it is felt that a special inspection is not justified. However, an electrical regional inspector will followup as part of the routine baseline inspection.

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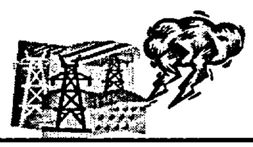
Peach Bottom 2 & 3

- Peach Bottom 2 & 3 - Dual unit trip (9/15/2003). The trip was caused by a loss of multiple offsite power lines (lightning strike) and momentary low voltage on the other offsite power line.



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Peach Bottom Event Agency Response

- CCDP of E-3 for Unit 3 and E-4 for Unit 2.
- The difference between units is due to a stuck SRV on unit 3.
- Because of complications in mitigating this event, an Augmented Inspection Team was dispatched on 9/24 to investigate.

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