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UNITED STATES NUCLEAR REGULATORY COMMISSION'S ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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REGULATORY POLICIES AND PRACTICES SUBCOMMITTEE

+ + + + +

THURSDAY

AUGUST 24, 2023

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The Subcommittee met via hybrid in-person and Video Teleconference, at 1:00 p.m. EDT, Vicki Bier, Chair, presiding.

COMMITTEE MEMBERS:

VICKI BIER, Chair

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR., Member

VESNA DIMITRIJEVIC, Member

GREGORY HALNON, Member

WALT KIRCHNER, Member

JOSE MARCH-LEUBA, Member

ROBERT MARTIN, Member

DAVID PETTI, Member

JOY L. REMPE, Member

THOMAS ROBERTS, Member

MATTHEW SUNSERI, Member

ACRS CONSULTANT:

DENNIS BLEY

STEVE SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

HOSSEIN NOURBAKHSH

ALSO PRESENT:

GEORGE APOSTOLAKIS, Invited Expert

WILLIAM RECKLEY, NRR

ADAM STEIN, Public Participant

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

1:00 p.m.

CHAIR BIER: Well, it is now 1:00, so this meeting will now come to order. This is a meeting of the Regulatory Policies and Practices Subcommittee of the ACRS in support of ongoing ACRS efforts exploring the NRC's safety goal policy.

My name is Vicki Bier. I'm the Chair of today's subcommittee meeting. Members in attendance today are Charles Brown, Greg Halnon, Tom Roberts, Robert Martin, Joy Rempe, Dave Petti, Matt Sunseri, Jose March-Leuba, Ron Ballinger. We have consultant Steve Schultz in the room. I do not know for sure if Walt Kirchner or Vesna Dimitrijevic are online --

MEMBER KIRCHNER: Vicki, I'm here. Hi, George.

MEMBER DIMITRIJEVIC: I'm here, too.

CHAIR BIER: Perfect. And I know our consultant Dennis Bley was planning to join. I do not know whether he is on yet. Okay. There we go. So that is the attendance for today, plus a number of other interested parties online.

We are holding this open meeting to gather information to support an ACRS working group exploring the quantitative health objectives in this safety goal

policy. I want to emphasize right now that we are in the very preliminary stages of that work and the effort right now is focused exclusively on just gathering information, of which today's presentation is part of that.

So we have invited former NRC Commissioner George Apostolakis to provide his thoughts on the safety goal policy. I want to note that Dr. Apostolakis was also a member and former chair of the ACRS and is well known for a lot of his research contributions on the development and application of PRA methods, as well, so I'm very glad that we have him here to talk to us today.

For background, the ACRS section of the U.S. Nuclear Regulatory Commission public website provides our charter, bylaws, agendas, letter reports, and full transcripts of all full and subcommittee meetings, including the slides. The meeting notice and agenda for today's meeting were also posted on that website.

The subcommittee is going to gather information, analyze relevant issues and facts, and may choose to formulate proposed positions or actions, as appropriate, for deliberation by the full Committee. A transcript of this meeting is being kept

and will be made available.

Today's meeting is being held hybrid with both in person and remote Microsoft Teams capability. There is also a bridge line number allowing participation over the phone. There will be an opportunity for public comments at the end of today's meeting, maybe in a couple of hours from now or thereabouts. When addressing the subcommittee, participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard. And when not speaking, please do mute your computer microphone or phone to reduce any interference.

We can now go ahead with the meeting, and I will call upon Dr. George Apostolakis, our invited expert, to begin today's presentation. George, you can go ahead.

MR. APOSTOLAKIS: Thank you, Vicki. I guess you can hear me now okay?

CHAIR BIER: Yes, we hear you fine. Thank you.

MR. APOSTOLAKIS: Good, good. Thanks. Well, when you asked me to prepare this presentation, I thought, I said, gladly, yes because I thought it was going to be very easy for me to put together a few

slides. But it turns out it was not very easy. I've been away for a number of years now from the NRC and, especially when I started looking at Part 53, I really had to spend a lot of time trying to understand the staff's position and the NEI's position. But, anyway, I think I did at the end, so I'll tell you today what I learned.

Next slide, please. Good. Okay. Some comments on the safety goals, who have been now in effect for many years. There have been changes, okay, so -- no, the previous slide. Originally, the safety goals were intended to be applied generically -- no, next slide. Slide number two. Jose.

PARTICIPANT: Commissioner Apostolakis, we're working it out here now.

MR. APOSTOLAKIS: Okay.

CHAIR BIER: Minor technical difficulties.

MR. APOSTOLAKIS: Yes, yes. You think it will be easier if I handle them?

CHAIR BIER: Probably not. I would suggest people who are following along on Teams can see the slides. I don't know why they are not showing up on the overhead, so maybe you can just go ahead and talk to slide two, and we will get back to it.

MEMBER REMPE: George, can you see Jose's

slides? They're coming now. Okay.

CHAIR BIER: Now we have to go back to the correct slide.

MR. APOSTOLAKIS: Yes, this is it.

MR. MOORE: Okay. So now Mike has control, Member Bier, but I would suggest not doing anything up there, and Mike can --

CHAIR BIER: Okay. Any minute now, we will be back to being ready.

MR. APOSTOLAKIS: So you still cannot see the slides?

CHAIR BIER: Well, I see them on my computer, but we don't see them on the overhead for some reason.

MR. APOSTOLAKIS: I see, I see.

CHAIR BIER: So it will be just a moment.

MEMBER KIRCHNER: Vicki, we see them -- this is Walt, Vicki. We see them on Teams.

CHAIR BIER: Good to know.

MEMBER REMPE: I think if Mike re-shares, we'll be fine. We're trying to get it so we can see George and the screen.

PARTICIPANT: Let Mike just control the slides and not do anything at all up there.

CHAIR BIER: That sounds better. Mike, if

you can re-share. Sorry for the complications.

MR. APOSTOLAKIS: No problem.

CHAIR BIER: Okay. Yes, full screen, Mike, and then we can go ahead. Perfect. Thank you. Sorry for the interruption.

MR. APOSTOLAKIS: So everybody sees them now?

MEMBER REMPE: Yes.

MR. APOSTOLAKIS: Good. So the original intent was that the safety goals would be applied in a generic sense and not in specific applications, but, over the years, these things have changed, they have evolved, so, routinely, I remember we have been comparing individual plant CDF and LERF to the goals and, in fact, Part 52 demands this. And also you had a presentation by David Johnson some time ago, and he talked about the proposal by the ACRS before the Commission issued its safety goal policy, and that proposal included goals plus upper limits, and the existing goals do not include the upper limits, but, informally, I think there are upper limits. And I remember years ago some engineer in one plant made a mistake, and he issued core damage frequency higher than 10 to the minus 3 due to fires, internal fires, and I was a member of the ACRS then and I remember

that, immediately, the staff put together a team of experts and dispatched them to the utilities' offices to go over the calculations and confirm perhaps the number was valid. It turned out it was not; there was a mistake in the calculations. But the important point here is that the number of more than 10 to the minus 3 prompted immediate action from the NRC staff. So there are informal upper limits, too.

Next slide, please. By the way, if you want to interrupt me, that will be fine. It makes it for a more interesting presentation.

MEMBER KIRCHNER: Okay. George, this is Walt. Yes, I want to interrupt you. So in your previous slide, you said that the CDF and LERF were compared to the goals routinely. Could you just give your perspective on that because that wasn't a full Level 3 PRA, that was just those Level 1 numbers. What was the interpretation between those numbers and the safety goals?

MR. APOSTOLAKIS: Yes. There was a study, I think it was right after the goals were published, a study done by the staff and also by the ACRS staff independently where they showed that, if you met the subsidiary goals for CDF and LERF, then you have met also the health effects goals. It was a very

interesting calculation going back. In fact, the CDF goal assures that the latent cancer goal was met, and the LERF goal made sure that the acute fatalities goal was met. The calculation made some assumptions that were pretty conservative, as I recall. And the reason, of course, was that the uncertainties in the calculation of health effects were so large that making any regulatory decisions using Level 3 results would have been very, very difficult. The uncertainties in LERF and CDF are still there, but they're more manageable. So the whole system evolved around CDF and LERF goals.

MR. BLEY: George, it's Dennis Bley. Do you remember, did the staff write a paper on that? We haven't run across that in the things we've been digging up lately.

MR. APOSTOLAKIS: Yes. I remember reading it, and I will have to look for it again, but there is, yes.

MR. BLEY: Okay. If you can find it, I think it would be interesting.

MR. APOSTOLAKIS: Yes, I'll try to find it and send it. I think it's called Appendix C to something, but I don't remember. I'll track it down, yes. Anything else on this?

MEMBER KIRCHNER: Yes, George. Walt again. You made a very important point that I think you're going to address later in your presentation, but the uncertainties in the human effects are, like you said, you can bound the CDF and LERF probably better than you can bound the uncertainty in latent cancers and so on and so forth, and so it kind of suggests that regulating, quote-unquote, to an actual quantitative goal might be a questionable direction to take.

MR. APOSTOLAKIS: So what is the question? I'm sorry.

MEMBER KIRCHNER: So was your position with the ACRS and then later with the Commission that you regulate to the quantitative safety goals?

MR. APOSTOLAKIS: I don't know what you mean by regulate, but definitely, if the calculation for CDF, for example, show that you were above the goal, something happened, and I gave you an example of when the deviation was an order of magnitude where the NRC staff reacted immediately. I don't know if you call that regulation; I don't know. But the point is that these were goals. They were not criteria. I mean, the NRC staff and the Commission issued statements that there is a huge difference between a

goal and a criterion, a regulatory criterion, because the regulatory criterion has to be met. And if it is not met, then you're in violation. For a goal, you may be, say, a few above 10 to the minus 4 for CDF, like two 10 to the minus 4, but then that is not a violation, but then that is not a violation. You exceeded the goal. It would be nice to do something to go below the goal, but, if there is compelling evidence that you cannot, we can live with it. On the other hand, as the example showed, if you are above a goal by an order of magnitude, I think the message was we cannot live with it.

So it was a very subjective decision what to do if you were above or below. If you're below it's fine. So in that sense, they were truly goals, not criteria.

MEMBER KIRCHNER: Thank you. That answers my question. Thank you.

MR. APOSTOLAKIS: Yes. Thanks. Okay. So the next slide then. We had again, over the years, especially after Fukushima, the issue of doing PRAs for multi-unit sites came up. And in the United States, we had, at most, three units in some sites, plant Vogtle will make them four at that site. But another interesting thing is that there are some

geographically adjacent sites that we are not doing any PRAs for. We have enough difficulty doing the multi-unit sites, so to move on to adjacent sites is probably asking for too much. But I just wanted to point that out.

But, of course, in other countries, like in Canada, Bruce Power has eight units and, in Japan, Kashiwazaki-Kariwa has seven units. So for them, doing PRAs for multi-unit sites is much more important than in the United States at that time.

But on the next slide, it's interesting that the NRC staff proposed to the Commission that the safety goals be applied on a per-site basis. As you know, right now we say such and such per reactor year, and the proposal was to say such and such per site year. The Commission opposed this recommendation, and they said somewhere in there that they did not want to impose a bias against multi-unit sites. I don't know what the bias would be, but that's what the Commission said. And in the United States, the QHOs are still now, are being interpreted on a per reactor basis.

Next slide, please. Now, should we modify the goals as new evidence is accumulated? I view the QHOs as a commitment of the nuclear community, including the NRC and the industry, as a commitment to

society, as sort of a contract that we will never, we will do our best not to exceed the goals. So they should be revised only when there is compelling evidence that they should be, and, again, in my view, if they are to be revised, they should be revised in a conservative way.

Now, I have heard the argument many times that the Fukushima accident did not violate the NRC QHOs because there were no significant early deaths and all calculations show that the latent deaths will be minimal. And I was perplexed by this argument, and so the question in my mind was whether this was a valid comparison. In other words, can you take an inherently probabilistic result, like the expected number of acute fatalities and then have a specific accident that does not violate that result, that goal, and argue that the goal is incomplete. They are two different things.

So if you look back at the history of the accident, in fact, there were messages to the regulator of that time in Japan, NISA, that the seawall at Fukushima was much lower than the expected height of a tsunami. The seawall was of the order of about 5 meters, and the expected worst tsunami was more than 15 meters, a significant difference. The

Society of Japanese Civil Engineers formally issued a statement, as I recall, in 2009, two years before the accident, that this was the case, that the seawall was very inadequate, and Tepco, the owner of the plant, at the beginning, fought this argument but then, at the end, they had their own experts looking at the calculations, and they were also persuaded that the seawall was indeed very low, of a very low height. And they agreed to raise the seawall or to do something about it at the opportune moment. And, of course, much to their disappointment, to say the least, the tsunami occurred before they took action and overwhelmed the site.

So the question in my mind is if, now in 2009 - 2010, somebody had done a Level 3 PRA in Japan, I am convinced that all the goals would have been found to have been violated because of the height of the seawall. So the fact that they didn't, the accident didn't have any significant acute fatalities, for example, that does not mean that the goals were not violated because it's not a valid comparison. The comparison should have been do a Level 3 PRA using the existing height of the goal of the seawall, and then, as I say, I'm convinced that they would have found that the CDF goal was violated and the acute and

latent fatalities goal were violated, too. Unfortunately, that was a time when PRAs were not taken very seriously in Japan. Nobody had done anything, so this is purely a thought experiment.

CHAIR BIER: George?

MR. APOSTOLAKIS: Yes.

CHAIR BIER: If I can interrupt very briefly, do you envision that that comparison would have assumed evacuation similar to what took place or would have assumed the population in place with no evacuation?

MR. APOSTOLAKIS: No, I think the Level 3 PRA considers possibility for evacuation, yes. It turned out that they evacuated a lot of people. In fact, most people passed away during the evacuation. But the Level 3 PRA does allow for that. There's a probability that certain people will be evacuated and so on. That's the beauty of PRA, that it considers all the possibilities.

CHAIR BIER: Okay. Thank you.

MR. APOSTOLAKIS: Okay. So as I said, PRAs were not taken seriously at that time in Japan. Next slide, please. So the literature has some proposals for complementing the existing QHOs as a result of the Fukushima accident and our chairman,

Vicki Bier, is, of course, in one of the papers, that at least I found, and there is a key sentence there that says our results suggest that the number of people relocated is a good proxy for societal disruption and relatively straightforward to calculate. So they're proposing to use the number of people who relocated.

There's another paper by -- I don't know how to pronounce this -- Mubayi and Youngblood of Idaho National Laboratory that they propose a qualitative goal that should be of no significant likelihood that a large-scale long-term evacuation will be needed as a result of a nuclear power plant accident and then they go ahead to propose a quantitative health objective would satisfy this qualitative goal.

So there have been proposals. People have thought about it and so on. But the Commission has not taken any action.

Next slide shows proposals from the Canadian Nuclear Safety Commission. I don't think they have been adopted yet. My information is a little old, but a couple of years ago I checked with some friends up in Canada and they told me the commission had not adopted the goals. I don't know

whether they have at this point. Frankly, I doubt it.

So they have qualitative goals for new plants in Canada. The likelihood of accidents with serious radiological consequences should be extremely low, and potential radiological consequences from severe accidents should be limited to as far as practicable. And then they go ahead to propose quantitative goals in the next slide. So they still talk about core damage, so they don't anticipate, of these goals, they didn't anticipate that in Canada there would be any designs where the notion of core damage did make sense, so they still talk about core damage.

So the frequency of severe core degradation should be less than 10 to the minus 5 per reactor year. That's very interesting. Per reactor year. And then you go to the notes and you see some very interesting statements. The first note says that the effects of adjacent units. In other words, they acknowledge that you have many units at the particular site. The effects of adjacent units at multi-unit stations are considered and accounted for when calculating the safety goals for internal event sequences at the representative unit.

So, basically, they're saying you're still

doing the calculation for one of the units at the site, but, when you calculate the CDF for that unit, you have to take into account the fact that there are other units at the same site that may be undergoing some accident at the same time.

MR. BLEY: Hey, George, this is Dennis again. This is very particular to internal events where there's not nearly as much interaction in the risk from unit to unit and not for external events where that's more significant. Can you say anything about that?

MR. APOSTOLAKIS: To tell the truth, I don't recall anything on external events. But you're right, you're right. I mean, it's the external events that really emphasize the multi-unit nature. So they say explicitly internal events. I don't recall anything on external events.

Then they have two goals for acute fatalities, I guess, and latent fatalities in terms of the kind of radionuclide that has been released. So the frequency of release of 10 to the 15 becquerel of iodine-131, that's for early deaths, triggering evacuation should be less than 10 to the minus 5 per reactor year, and the frequency of release of 10 to the 14th becquerel of cesium, which, of course, would

be responsible for latent deaths, triggering long-term evacuation should be less than 10 to the minus 6 per reactor year again. Very interesting proposal in terms of releases again, but the most interesting thing is this per reactor year basis.

In 2004 -- next slide -- the ACRS, for some reason, considered the issue of goals and what to do with the multi-unit sites and came up with the first recommendation that the QHOs apply to the site as a whole. The sum of the contributions from each reactor on the site to acute and latent fatalities should be bounded by the QHOs, which comes back to my sort of earlier statement that the safety goals, the quantitative health objectives, are sort of a contract, a commitment between the nuclear establishment and society as a whole. So you can't really say, look, I have seven units at the site, but I will do it on a per reactor year basis. Society doesn't care about that. They care about the risk, and that's why the ACRS says that the QHOs apply to the site.

But then there was one rare instance where the committee was split almost in half regarding the core damage frequency goals. So we reported to the Commission that the committee had not reached

consensus on the approach that should be taken to determine the core damage frequency goal. There were two views. By the way, it was not exactly half, but I think the minority that supported one of the views was something like five or six members and the majority obviously was one or two more than that. But the committee felt that they should not be reporting the use of the majority only because the minority was significant, five or so members.

So the next slide shows disagreement. One view was that, if you have, say, four reactors at the site, you take the CDF goal of 10 to the minus 4 per reactor year and you divide it by four or five number of units and then you have a new goal for each unit. The opposing view, the majority view, was that the CDF is an accident prevention goal and we should not divide it by anything, requiring each module to have CDF value given by the overall CDF goal divided by the number of mergers would introduce a new safety goal concept, a site CDF, and then the committee speculated, actually, that that was never the intent of the Commission. Nobody knows what the intent was when they issued it, but, anyway, you know, when you propose something, you are trying to support it as much as you can. As I remember with option two that

we should have a universal goal for CDF applying to all reactors independently of how many of those you would have on a site. Anyway, that was an interesting disagreement.

So these slides so far have dealt with the existing safety goals and the various proposals people have made and so on. And now we come to Part 53. So the original LMP, Licensing Modernization Project, on which the NEI proposal 18-04 is based, lists three metrics. The total frequency of exceeding a site boundary dose of 100 millirem from all licensing basis events shall not exceed one per plant year, so you see we're already in a per plant year basis. This metric basically covers the relatively frequent events that have very low consequences. And for the infrequent events that have severe consequences, there are two goals that, again, having to do with individual risk of early fatalities within one mile and so on should be less than 10 to the minus 7 per plant year. And then the corresponding goal for latent cancer fatalities should be less than 10 to the minus 6 per plant year.

So, again, we have two goals that are health related, health effects related, because so many different designs that people are considering.

And for some of them, as I said earlier, the concept of core damage does not apply. So you have to go to a higher level of risk in order to find the common metric.

Now, there was an interesting letter from NEI -- next slide, please -- at the end of 2021 where they really objected to the use of the QHOs in the rule. So they say somewhere -- I didn't put quotation marks here, but all of these are direct copies from sentences in the letter. It is unclear why the NRC believes the QHOs must be in the rule at all rather than relying on the longstanding implementation of QHOs through the NRC's safety goal policy. This means that you are required to meet the QHOs in the guidance document, the regulatory guide. In fact, 1.233, Regulatory Guide 1.233, approved the NEI proposal 18-04. Well, they also list the QHOs.

And Part 52, by the way, if you go back to Part 52, requires that the applicant submit a summary of the PRA and its insights, not the full PRA. And the second bullet here shows what really the objection is all about. If the QHOs are in the rule, they must be met for legal compliance. And since the PRA is the basis for meeting the QHOs, more, if not all, of the PRA will need to be submitted on the docket and would

be subject to contention. This is an argument that came up even when I was a commissioner. I think it was in the context of Part 52. The industry always opposed having the PRA part of the docket because people or interveners can object to parts of the PRA, and you'd have endless debates and arguments about specific points of the PRA.

And then the NEI letter goes on to say, look, whether the QHOs are in Part 53 itself or in guidance document, in the regulatory guide for example, the design analysis and licensing approach that will be taken by an applicant and the NRC scope of review would be the same, but we would avoid having the QHOs in the rule with all the legal implications and the possibility of having the whole PRA submitted and subject to contention perhaps.

Now, the letter goes on to say -- the next slide -- that, in spite of this strong opposition, there is at least one member of industry that believes the QHOs must be in the rule to provide regulatory predictability by avoiding the need to develop surrogate metrics for the QHOs. And the letter concludes that more discussion on the benefits and disadvantages of the options of how to address QHOs in a way that includes both predictability and

flexibility would be beneficial, which I thought it was a great statement that, basically, they said, look, we really object to what you're proposing right now, but let's talk about it more, let's think about it a little more.

Now, regarding the PRA -- next slide -- the NRC staff has made it clear that the PRA should include event sequences involving two or more reactor modules, as well as two or more sources of radioactive material which would include waste processing and storage systems. That's really a tall order for a PRA, given the state of the art now.

The Joint Committee on Nuclear Risk Management of the ASME and ANS issued in 2021 the final version of the standard probabilistic risk assessment standard for advanced known light water reactor nuclear power plants. And this was a result of about ten years of trial use of this standard proposed. This was a major step forward. I read the standard, or most if it anyway, and, indeed, it would be very, very helpful to an applicant that would have to satisfy the NRC staff's requirement in the first bullet. But it is not the solution to the problem. There are still many, many issues that a multi-unit PRA and multi-source PRA has. The IAEA, International

Atomic Energy Agency, had a major project a few years back that developed an approach to multi-unit site PRAs. And if you look at the demonstration, there were many assumptions that the analysts had to make. I don't think they had the benefit of the ASME/ANS standard, but, even so, they really had to make a lot of assumptions in order to be able to reach a conclusion or some kind of result. So in my mind, this is really a major requirement, and I will come back to it in my conclusions.

Now, the NRC staff -- next slide -- responded to the NEI document of 2021, and, of course, they argued that the QHOs should be in the rule itself and not in guidance documents. And the first bullet here, I think, is very good that risk-informed performance standards, including the QHOs, provide a fixed cumulative risk standard for licensing events ranging from anticipated transients to very unlikely event sequences. In other words, you have the new proposed regulatory system that is very risk informed, performance based, and so on. You have to have at the end a standard against which you can compare your calculations, and that standard, according to the staff, is the QHOs. Otherwise, it's open field and you don't know why something should be approved or

not.

And then they go on to say that, without these cumulative risk standards in Framework A, which is the risk-informed framework, including the QHOs, there would be no equivalent to the collective effects of the prescriptive requirements in Part 50 and 52 that provide reasonable assurance of adequate protection. This is a statement that I really had to think very hard about to understand it, and I think what the staff means here -- you see, I'm not a commissioner, so I cannot pass it down to my office to explain it. I think what they mean is that, in LWRs, we meet the safety goals, although some people have doubts about that, but, anyway, we meet the safety goals, so plants that have been licensed under Part 50 and 52 meet the safety goals, so we have achieved adequate protection because we meet the safety goals. So in the new plants now, if we meet the safety goals, we will also have adequate protection. I don't know. It's a little bit stretch in the argument, but that's the best interpretation I could figure out, that meeting the safety goals assures that you have adequate protection of public health and safety.

MEMBER PETTI: George?

MR. APOSTOLAKIS: Yes.

MEMBER PETTI: This is Dave. Just a question on that. I tend to think of it the opposite, which is how would Framework A show without the QHOs that, in fact, you have equivalent levels of safety as 50 and 52? That's the struggle that, I think, the staff had, and they felt that the QHOs being a collective risk method would be a way to do that. Otherwise, how do you know? Because -- yes, yes.

MR. APOSTOLAKIS: Yes, this is the right interpretation.

MEMBER PETTI: Okay.

MR. APOSTOLAKIS: Okay. The next slide. I think, essentially, the staff is repeating here their earlier argument. Compliance with the existing totality of NRC prescriptive regulations provides reasonable assurance -- this is now for the existing LWRs -- reasonable assurance that adequate protection is maintained. And Framework A proposed to support the adequate protection finding with a collective set of functional and performance-based requirements, which are intended to ensure that the proposed new regulations provide a level of safety comparable to that required by the existing regulations. It's different words for the same argument.

But then, in February of 2022, NEI issued

another letter and an attached document, 21-07, Rev. 1, that was also based on some work that the team that developed the Licensing Modernization Project had done. So they go back to the same approach that applies to the existing Part 52 regarding the PRA because that was the main argument of the NEI original letter, that if you have the PRA in the application then also some legal consequences will result.

So the PRA information included in Chapter 2 of the Safety Analysis Report should be at a summary level only as described below. It should address the requirement in 10 CFR Part 52 that the SAR include a description of the PRA and its results. As I just said, Part 52 requires a summary of the PRA and risk insights derived from it, but not the PRA itself. However, the PRA details should be maintained at the utilities' headquarters or offices, and the staff, of course, will be free to visit and review the detailed PRA whenever they like. So the supporting methods and detailed information used in the PRA will not be included in the SAR but will be available to the NRC staff, which is exactly what Part 52 also requires.

So my conclusions from all this. Next slide. As people have recognized already, the result or the main consequence of the Fukushima accident was

a major societal disruption. Several thousands of people had to be relocated, and they will stay away from their homes for decades. So the issue of major societal disruption, it seems to me, should be investigated further for possible inclusion in the safety goals. However, the comparisons with the Fukushima accident should be re-evaluated. As I said at the beginning, I don't think it's correct to say that Fukushima did not kill anybody; therefore, there is something wrong with the goals. That's not a valid comparison.

But still, you know, I mentioned the two papers, one by Vicki and her collaborators and the other by Youngblood and his collaborator. So some more work, I think, will be needed on that front.

In my view, the QHOs should be included in Part 53, and doing a credible PRA for all sources should be included in Part 53. But let's acknowledge also that NEI had some good points. Doing a credible PRA for all sources of radioactivity at the site will be very challenging in my view, even with the existence of the ANSA as a new standard that I mentioned earlier.

Now, the NRC staff will probably have to provide additional help, additional to the standard,

perhaps using insights from the PRA Level 3 project that they have been working on now for I think more than ten years. So maybe they can provide some practical advice to the industry as to how to achieve a credible PRA for a multi-unit, multi-source site. And I -- yes?

CHAIR BIER: Quick question, George. When you say the QHOs should be included in Part 53, do you mean by that that a PRA result in excess of the safety goals would violate licensing conditions or only that they should be included kind of as a reference point?

MR. APOSTOLAKIS: Well, they should be included in the sense that I described earlier, that they are goals. And, again, they are not criteria. If you are a little bit above the goal and you provide convincing argument why you cannot reduce your result any further, I guess the staff would be willing to go along with it. But if you are, say, an order of magnitude higher than the goal, then you would have a problem.

So that's how the concept of a goal has always been treated by the NRC staff. And I mentioned the example of the fire PRA calculation that was more than an order of magnitude higher than 10 to the minus 4, and immediately the staff dispatched the group of

experts to the utilities' headquarters.

So it's a little fuzzy, but it's not a criterion. They should be included in Part 53 as a goal, not as criteria.

CHAIR BIER: Thank you.

MR. APOSTOLAKIS: Okay, yes. And, finally, the last bullet, the license application should include a PRA summary and insights only and the details should be available to the NRC staff or the utilities' offices.

And that concludes my presentation, and I took exactly one hour. Thank you.

CHAIR BIER: Thank you. Please.

MEMBER MARCH-LEUBA: Do you see any difference between multi-unit and multi-module? Like, for example --

MR. APOSTOLAKIS: No.

MEMBER MARCH-LEUBA: -- when you have Milestone and Fitzpatrick geographically located a mile from each other, that's a completely different situation than when you have a NuScale 12 module in the same pool.

MR. APOSTOLAKIS: I think people use the terms multi-unit and multi-module almost interchangeably. Even if the modules are separated by

one mile, as Dennis mentioned earlier, you still have the issue of external events, an earthquake, for example, or an external flood or anything.

So, no, I don't think people make the distinction. Maybe they do in some places but --

MEMBER MARCH-LEUBA: My point, in multi-module when you're sharing a lot of internal, it makes the need for conceding together more desirable or necessary than when you have two miles apart and you only have external --

MR. APOSTOLAKIS: You're right, and the PRA will reflect this, will definitely reflect the short distance. You are referring to the NuScale pool, right?

MEMBER MARCH-LEUBA: Something like that. They share a lot of pumps and valves and --

MR. APOSTOLAKIS: Sure, sure.

MEMBER MARCH-LEUBA: -- ultimate heat sink and the same spent fuel pool.

MR. APOSTOLAKIS: Yes, yes, yes.

MEMBER MARCH-LEUBA: And the same operators, the same control room, same I&C.

MR. APOSTOLAKIS: No, you're right, you're right.

MR. BLEY: George, from Dennis. You said

you think that the QHOs ought to be in Part 53. Have you thought much about some alternative cumulative risk approach? 1860, the technology neutral framework, had a nice appendix. It might have been two appendices, one that showed why QHOs are a representative way to look at integrated risk, but they also talked about the possibility of developing some standard risk curve that your CDF should not exceed anywhere along that curve. It might be a fair amount of work, but, at least for me, that's more intellectually satisfying than the QHOs are.

MR. APOSTOLAKIS: Well, yes. I had read NUREG-1860 years ago, and I remember there was some discussion but I don't remember the details. But that may very well be an option. The QHOs, in terms of an integrated contribution, is appealing, it seems to me.

Now, there is a possibility that, for some designs, you can develop subsidiary goals, and the rule, I think, does not exclude that. Just as we did with light water reactors, we developed CDF and LERF, it's possible that, for some new designs, you could have a subsidiary goal with reduced uncertainties that could be used in decision making. I don't know; nobody knows. But this can be done.

MR. BLEY: Yes, and that's actually more

satisfying. Part 53 doesn't actually acknowledge quite that the QHOs are subsidiary goals and for specific technologies, and it might be wise to develop others. But I saw it from a legal point of view, if they could get by with that. But I don't remember it in there. It might be. I've read it a lot, but there's a lot of stuff there.

MR. APOSTOLAKIS: There is a lot of stuff, and I cannot point you to where they're actually saying that. But, you know, they have also issued, the staff issued documents countering the arguments that the NEI letter raised, so maybe I saw it there. But I am convinced, I don't know why but I am, that the staff allows for the development of subsidiary goals whenever it is possible. Maybe I'm wrong, I don't know. But I thought it was something that it did allow.

MR. BLEY: I hope so. I don't remember it. Maybe --

MR. APOSTOLAKIS: Yes, I don't either, I don't either. Anything else?

MEMBER DIMITRIJEVIC: Hi, George. This is Vesna.

MR. APOSTOLAKIS: Hey, Vesna, how are you?

MEMBER DIMITRIJEVIC: Good. How you

doing? Well, I have a lot of thoughts about that, and I already brought one of my separate opinion about this, you know, to our letter on the 53.

Well, my main concern is that, first, in the history of, you know, that PRA and safety goals, first was a CDF and LERF. QHOs come later. The staff, you know, qualitative goal, which was very sort of like great statement of they should not be significant in addition to other societal risks, so those are sort of qualitative goals. And nobody can argue with them; they're perfectly fine and they're really respectable.

And then it comes the quantitative health objective, which actually introduced two assumptions from this qualitative goals. One assumption is that what is significant is less important than is not significant. That's totally fine, reasonable assumption. And then the next assumption is the societal risk, so now they interpret societal risk to be cancer and prompt fatalities. That assumption is already not great because, as we saw in the history of the nuclear accidents, you know, starting at Three Mile Island through the Chernobyl and then, you know, Fukushima, that actually risk from the nuclear industry was not in really prompt fatalities and it

was not really in the -- I mean, I don't know too much about statistics from cancer, but, you know, that I would not think that is a representative risk from the nuclear power.

So we are making steps from qualitative goals to quantitative health objectives, and then, in this NUREG, okay, so we have already learned from CDF, we started with 1400 much earlier, and now we have these two qualitative goals and quantitative health objective, and so they're meant to check what CDF and LERF satisfy those two, you know, cancer and prompt. Now, they make a billion totally unjustified assumptions and introduce so much uncertainties. But they sort of connected in the CDF and LERF and, actually, as we say, CDF of 10 to minus 4 and LERF for 10 to minus 5 through the industry.

But assumptions they make, they're starting from one mile around the plant from the, you know, that prompt to that 10 miles for the cancer, for 50-year period for cancer, to that, which I saw one of the greatest factor is, if you have learned what is probability, then you will die with prompt fatality, which that was like 2,000. So now this is where sort of this connection lost credibility to me and introduce so much uncertainties that actually, you

know, we show that we are meeting, we are guarantee meeting the QHOs with CDF and LERF, but, in this connection, there was just too much uncertainties.

So when you said about Fukushima, what you said about Fukushima is we calculate the LERF, it probably didn't meet the goal, but that's based on the latest results which we will be discussing in a month or something, that's entering QHOs by huge margins because, in the Level 3, we saw it didn't meet the subsidiary goals. And we also see actually the industry, if we look in the number of the melts (phonetic), the industry doesn't meet the subsidiary goals because that CDF is larger than 10 to the minus 4 if we count Fukushima as multiple melts and things like that. But definitely industry meet the health goal. They didn't introduce the huge number of the prompt fatalities and the huge -- I don't know about cancer, so I'm staying out of that.

So my main point in this debate is let's go back to qualitative goals and say let's make sure we don't introduce high risk to society, but then let industry come in with all these new designs, find a way to measure this from that and proving that they don't introduce high additional risk. So, therefore, let's don't introduce cancer and prompt, as it is in

QHOs, but just talk about societal risk, and then we can -- I totally agree with your conclusions. I think they're wonderful. You know, we can sort of, like, consider add a societal risk, we can look at the Level 3 results, and we will see that this connection between our subsidiary goals and now, you know, the QHOs was not really, we should actually break it and, you know, just go and talk about the general qualitative safety goals.

MR. APOSTOLAKIS: Well, good luck with that. You are asking the Commission to go back and revise the policy that has been in effect for what? Thirty or forty years.

MEMBER DIMITRIJEVIC: This is all applied to the 52 --

MR. APOSTOLAKIS: Oh.

MEMBER DIMITRIJEVIC: -- and CDF and LERF represent, as well. I don't really know do they really correspond well to the cancer and prompt fatality, but they represent industry well and I totally agree with them as a goal. And, actually, CDF, less than 2 minus 40; it doesn't say cancer risk less than that, you know. So I just want to say the subsidiary goals, you know, they represent us well, but let's go and find something new for the new

industry. It could be, as the Canadians proposed, some level of releases of the, you know --

MR. APOSTOLAKIS: Yes, yes.

MEMBER DIMITRIJEVIC: -- something like that. Let's leave the door wide open instead --

MR. APOSTOLAKIS: No, I think that's fine, yes, yes.

MEMBER DIMITRIJEVIC: -- and 5 minus 7, you know, based on some statistics of the, you know --

MR. APOSTOLAKIS: Well, one argument that staff used many years ago against adding high level goals in addition to acute and latent fatalities was that the goal in CDF is good enough because, if you have a goal for CDF, then everything else that you can think of, large-scale relocation of people and so on, that's covered because you are preventing a core damage. And I think that's going to come up again for light water reactors.

So it's not clear to me what your objection is, Vesna. You're objecting to the subsidiary goals?

MEMBER DIMITRIJEVIC: No, no, subsidiary goals I don't object. I'm objecting to this, you know, 3 minus 6 on the prompt and --

MR. APOSTOLAKIS: I see, I see.

MEMBER DIMITRIJEVIC: I'm objecting to these numbers on the prompt and cancer risk fatalities.

MR. APOSTOLAKIS: Yes. And don't forget that these are policy statements. What does that mean? You're not going to find a scientific explanation why you have to do it this way. That's why it's policy. It's the judgment of the Commission. So you may disagree with the judgment, but that's their judgment at the time. So it's not something that is calculable quantity, you know. They just said, look, we think we should be at 10 percent of 0.1 or 10 percent of whatever of cancer risks. Why? There is no way; that's what we think. I'm sorry. Okay.

So you have to be very careful how you express your disagreement. Again, this is not a technical issue. It's just the judgment of five wise people, although, if you go back through the record, there were some objections by Commissioner Asselstine and Commissioner Bernthal.

So, anyway, I can't add anything to that.

CHAIR BIER: If I can interject briefly, it was mentioned that, if Bill Reckley is available, he might be able to comment on the staff views about

subsidiary safety goals.

MR. RECKLEY: Bill Reckley, NRC staff. We mentioned in the preamble that an applicant choosing to use another goal, either a surrogate, that's what we called it, a surrogate goal, to do that, and it's mentioned in the preamble as a way to not compare directly to the latent cancer and prompt fatality numbers.

MR. APOSTOLAKIS: So the staff does allow the possibility of subsidiary goals, correct?

MR. RECKLEY: Correct.

MR. APOSTOLAKIS: Okay. I thought I saw it someplace, but I didn't remember where. Very good. Thank you, Bill. I understand you are leading that effort on Part 53 Framework A; is that correct?

MR. RECKLEY: I was part of the team.

MR. APOSTOLAKIS: That's nonsense. You were more than part of the team. And I think I should congratulate you. You did a hell of a job.

MR. BLEY: Bill, it's Dennis. That's up in the preamble, and I had forgotten that. Preamble is a little better, in a way, than the old statements of consideration, but those things used to get disconnected. Is the preamble going to stay connected to the rule all the way through? Do we know about

that yet?

MR. RECKLEY: It is the same as the statements of consideration.

MR. BLEY: So ten years from now, we might have trouble reconstructing this conversation, just like we've had with statements of consideration in the past. Finding the old ones can be very difficult at times.

MR. BLEY: Thank you for the observation, Dennis. So while we have George with us, are there further questions or comments or discussion that people want to share?

MEMBER ROBERTS: Yes, this is Tom Roberts. A relatively straightforward question. The Fukushima scenario, I'm trying to understand why you think a Level 3 PRA would have predicted consequences that exceeded the QHOs when the actual consequences appear to have not. I think what you're saying is that what actually transpired at Fukushima from the tsunami was not the worst that could have happened or even some of the probable cases that would have come out from the event trees, given that the tsunami had happened. Is that what you're saying, or is it something else that leads you to believe that the results would have failed the QHOs?

MR. APOSTOLAKIS: The PRA is a probabilistic methodology. It considers all conceivable possibilities, assigns probabilities to them, and comes up with distribution or a mean value and so on. So to take an actual incident and say, oh, look, they didn't kill anybody here; therefore, there is something wrong with the goals, that's not valid in my opinion because you have to compare probabilistic results with the goals. And what I'm saying is they had done a Level 3 PRA including the major design deficiency of the height of the seawall, they would have found a high core damage frequency, violating the goal for CDF and then, of course, higher expected numbers of death, acute and latent. And that's the proper comparison, not the outcome of one experiment, if you will, because, I don't know, the evacuation worked very well, they killed more than a thousand people, I think, during the evacuation, but that was not due to radiation. And in my view, the comparison is not valid.

CHAIR BIER: So, Tom, that raises a really interesting point. One thing I remember from looking at the plumes for Fukushima is that it so happened that the wind direction was blowing out over the water during virtually the entire time, and it's hard to get

our mind away from that reality today and say, well, you know, it turned out not that bad. But you're right, I think, that if you did a probabilistic analysis and looked at what's the chance of a worse wind direction that was blowing inland, it might have been very different consequences predicted. We would have to go back and think about that.

MR. APOSTOLAKIS: Exactly.

MEMBER REMPE: This is Joy, and I agree with what you're saying about the wind direction. We were lucky. But on the other hand, I am familiar with information that Tepco has published publicly about the likelihood of the tsunami peak waves exceeding the seawall, and it is not consistent. I haven't read the document you're talking about from the civil engineers, but I think there was some uncertainty with, you know, the way the land formation was up north and the fact that the tsunamis were so high was not a clear-cut case in their opinion and what I have read. But I am not an expert on it, and I don't think that's the main focus of this meeting. But, anyway, I feel obligated to speak up and mention that.

MR. APOSTOLAKIS: As I said, at the beginning, Tepco objected to the arguments that the tsunami would be so high. But, again, based on what

I read, eventually, they agreed. They formed their own group of experts. They reviewed the arguments that the other side was making, and, eventually, they agreed and said that we will take care of the height at the opportune moment.

MR. BLEY: Hey, George. I remember you talking about this a long time ago and I read about it elsewhere. But following the tsunami, when they looked around, I recall that pretty far inland they found a stone tablet with a message from the emperor don't get any closer to the ocean because the tidal wave came in this far like 800 years ago.

MEMBER REMPE: So, Dennis, that's what I'm aware of, and that was after the tsunami. But Tepco published something, and I could provide it if folks are interested, that indicates that that land formation up north was different. And so they weren't apologizing for what happened, but they just pointed out that there were differences in there. But I don't think that's the main point of this discussion, but I --

MR. APOSTOLAKIS: No, it is not. It is not.

MEMBER DIMITRIJEVIC: Okay. But that gets us back to some point. You know, George just said

that this is true that there is a frequency first of the seismic event and there is a conditional probability of tsunami given seismic event, and maybe this frequency, because it's very difficult to get this data on that, and I tried to look at the tsunami frequencies data.

But what is actually here is one part of my objection. So let's say that we even have a CDF higher than 10 to minus 4, because that wall definitely wasn't adequate, and that tsunami automatically leads to core damage. Now, even if you have a CDF, now comes this conditional probability, and let's discuss the cancer instead or prompt fatalities because that equation was performed.

So this conditional probability, which they used to form this QHO, the subsidiary connection, was based on some old data from the Surry (phonetic) station from 1990. But in the new LERF, Level 3, it's even smaller, so it's 40,000. Given that you have a CDF, it is 40,000 chances that you will get the cancer. So, therefore, let's say that you have a CDF of 10 to minus 3, the 40 minus 3, now we are talking the 40 minus 6 probability of getting the cancer as a result of that.

Now, the new Level 3 results show that

that number is actually much smaller, even in order of 10 to the minus 6. Given that you have a CDF and that you didn't have a large release, so you succeeded the relocation, that probability of getting cancer is still very small. So that's why I said they've definitely satisfied the QHOs as they are now, even if they didn't satisfy subsidiary goals.

Given that you have a core damage frequency now, what is conditional probability that will result in the cancer within 10 miles and within 50 years. We don't know that for Fukushima, but that's what the actually the health objective is.

MR. APOSTOLAKIS: Well, Vesna, I must say I don't quite follow your argument. But if you have written it someplace, I'll be glad to read it. You are giving too much information and just an oral briefing is not good enough in my opinion, so I'm not really following your argument.

MEMBER DIMITRIJEVIC: I was thinking about writing that, but I'm retired and lazy. I don't really know where to find a platform for this. If the United States doesn't want to listen, then that is a problem.

CHAIR BIER: Well, I do think, Vesna, that's something that we can follow up on either

internally in the working group or with George directly to discuss further.

Additional questions or comments?

MEMBER KIRCHNER: Yes, Vicki. This is Walt. Thank you.

CHAIR BIER: Great.

MEMBER KIRCHNER: George raised some interesting points that we, as a committee, debated during the intervals of updates and briefings on 53. Going back to one, starting with a more legal set of concerns, so the PRA being on the docket, subject to contention, one of the things I was asking myself is why is the PRA not subject to something equivalent to NQA-1 or Appendix B, which is what's required in 50 and 52 of the deterministic analyses. I mean, there, the PRA supplements the application, almost validates it so to speak. And then if there are problems, like George pointed out, well, then you should go back and identify design changes and/or mitigating factors.

But for something that's based on the PRA, George, then doesn't it -- do you think the new PRA standard is strong enough that you, you know, with things like peer review, you know, you're building the whole case on the PRA essentially and then elaborating from there. Is that standard rigorous enough in your

opinion?

MR. APOSTOLAKIS: No. It gives high-level advice. It has what they call supporting requirements. But how you meet those requirements, the standard is not helping you with that. And that's what I meant that the applicant who wants to do the PRA will face tremendous difficulties, in my view, and the standard helps a lot, but it doesn't really solve the issue. And that's why I said maybe the staff can provide additional guidance as to what's important, what you have to worry about, as a result of their experience with a Level 3 PRA for multi-unit sites.

But the standard is a very good step forward but not the end result in my view. I mean, other people may disagree. Because I remember the application of the IAEA approach to an actual site, and they had to make a lot of assumptions. They were reasonable assumptions, but somebody else might make a different assumption. And they did come up with earthquakes dominating the risk. So I can see now that that result opening up a whole host of debates and arguments, did you do it right, did you include this and that.

So that's a big challenge in my opinion exactly. Because the PRA plays such a crucial role,

we need more help.

MEMBER KIRCHNER: Thank you.

CHAIR BIER: Yes. I completely agree, by the way, with the concern about litigating every line item in the PRA in the docket. I'm old enough to remember a time when the Atomic Industrial Forum was proposing that, oh, relying on PRA will reduce litigiousness or whatever, and I remember thinking, boy, you now have, you know, nine million numerical estimates that you can argue with.

MR. APOSTOLAKIS: Yes, yes.

MEMBER MARTIN: Vicki, Bob Martin. So for George's sake, I'm one of the new members, Bob Martin, and most of my career was commercial and worked with Vesna for a period of time. But I also have worked a lot with licensing managers, you know --

MR. APOSTOLAKIS: I can't hear you.

MEMBER MARTIN: Sorry. I've also worked a lot with licensing managers, and there is, you know, when maybe in an informal setting, it can be rather cynical and, you know, even with Part 52 they'll say it took us -- well, ten years ago, they said, well, no one has used Part 52 and been successful. Now, of course, they can't quite say that. But now with Part 53, their visceral response to an incorporation of

QHOs, they're saying, well, we're just not going to use Part 53. And I think so much of that comes to, you know, the ultimate goal that they need certainty, and deterministic prescribed methods, for better or for worse, provide a degree of certainty. I think the PRA has a lot of promise, but I don't think they can be completely separated from, you know, more deterministic approaches.

So I think the pathway that would actually get someone to use Part 53 is almost offers, you know, multi-options there and allows really PRA to be used to arbitrate technical questions. But, you know, one of the big questions, of course, you mentioned with the NQA story and that's just a huge challenge, you know, because interpretation of NQA can go many directions. But, you know, if you fall to the most conservative opinion, you'll quickly find that the uncertainties of PRA would lead you basically to a deterministic result and you'd be back where you started again.

But, anyway, I just wanted to throw that out there.

MR. APOSTOLAKIS: I think Framework B of Part 53 is more along the lines of what you just said. Framework A takes an entirely different approach.

It's true risk informed and performance based. And the issue of, you said certainty, I would say predictability, that's an argument why the QHO has to be in the rule because it defines the standard against which everything else is compared to. In other words, you're making all these assumptions, you're deriving the licensing basis events, and then you do the DBA analysis and all that. At the end, you do the QHO and you bring everything together, and that is the predictability part that you have a standard against which you can measure how well you develop your licensing application.

If you don't have that standard at the end, you don't know. You don't know. Okay. I did my DBA analysis and I managed to stay below the line and all that, but now what? Okay.

In the Part 50 and 52 approaches, there is a presumption that if you meet the regulations, the deterministic requirements, you have met the adequate protection standard, but that's a presumption. Now it's quantitative, but, because it's quantitative, you pay a price: you have huge uncertainties. It's always a balance, you know.

But you said a lot of these licensing managers are a little bit cynical. Well, a lot of the

NRC staff are cynical, too. So, you know, I've been there, and, you know, they can make snide remarks about the staff and vice versa.

MR. BLEY: This is Dennis. If you remember, yesterday, not that far back, an applicant was in who was using the LMP, very much in the spirit of the first part of Part 53. And although they said they had to do a lot of work, they found it very helpful, and the committee will be seeing details of that when they get beyond the current phase and we start looking at some of the detail.

MEMBER REMPE: And I'd even add further, Dennis, that they said they like Part 53 because it would provide certainty in some aspects, like classification of SSCs, et cetera, right?

MR. APOSTOLAKIS: So why are you keeping their name secret?

MR. BLEY: We usually don't talk about other meetings in one meeting, but it was TerraPower.

MR. APOSTOLAKIS: Yes, okay.

PARTICIPANT: The difference is that they haven't been all the way through, right? Everyone is happy in the beginning. We all hug, and it's wonderful. And later, later, it all changes.

MR. BLEY: They've been further through

than we've seen, and I think Dave can tell you some of the other new designs that have gone pretty far through that process, as well, for DOE.

MEMBER PETTI: I think those that have the most mature designs and are furthest in recognize the value of 53 in establishing the licensing bases for technologies that we don't have a licensing basis. That's really the strength, in my opinion, is that there's a rationale, a technical basis, for how you pick your events and how you classify your components. That's the strength.

MR. APOSTOLAKIS: But let's not forget Part 53 is one part. If they hate probabilities, if they don't like all that stuff, you can go with Part 50 and 52 or Part 53 Framework B. It's not something that you must do. That's very important, in my opinion. It's an option.

MEMBER KIRCHNER: Yes, that's a good point, George. This is Walt again. I wanted to draw you out a little more. Okay. Let's just take it as it is. We've got Part 53 Framework A. You believe, you made the statement in conclusion that the QHOs should be in the rule, but you also underscored how this is policy and that they are goals, not criteria.

So from your own experience, and you've

been through reviewing a lot of these applications, how would you see the staff implementing this? In other words, you know, we've got the frequency consequence there and its anchor points. I always looked at it, as long as you're within the bounds of that with a reasonable treatment of uncertainty, then that would give it some equivalency in terms of adequate protection vis-à-vis the current regulations in 50 and 52.

But could you elaborate what you're thinking when you say it's a goal, not a criteria, but put it in the rule? How do you see the staff using it?

MR. APOSTOLAKIS: The way you just described it is one way. The staff is very experienced with the goals, in my view. They understand very well the difference between a goal and a criterion, and I think it will be fine. I mean, it will be a learning period for them, too, just as there will be one for the designer in the industry. But I have confidence that everything will be okay. I mean, that's not a problem. The problem is doing a good PRA in my view.

CHAIR BIER: One comment that I've heard or seen in some previous discussions is that the

safety goals actually influence decision making much more than what we see officially in the dockets because some plants may do a PRA and get a high number and they go back and revise some things before they even submit and say, oh, we should fix these things so that we can justify a lower number, and I think staff, I've heard, has used it in kind of the same way, not as a result but as, like, how seriously should we take this or that issue, is it a nitpick or is it something that really rises to the level of a major public safety concern. So, hopefully, that will continue to be the case under Part 53 also.

MR. APOSTOLAKIS: Yes, I agree.

MEMBER BROWN: Hi, George. This is Charlie Brown, if you vaguely remember me from 14 years ago or 15 years ago.

MR. APOSTOLAKIS: I remember you very well, Charlie.

MEMBER BROWN: Uh-oh.

CHAIR BIER: And he looks the same.

MEMBER BROWN: I still have no hair; that's the good news. I guess since I'm the resident skeptic on non-deterministic design efforts, I think I'm the resident skeptic anyway, after 35 years designing stuff or looking at designs for the Navy, my

basic concern with what we've done over the years is the argument of where the NRC or the staff steps in. There are some systems, for parts of them, you look at them, there should be, and you know what the hazards are just from a thought process, deterministic pronouncements or requirements in your rule are very valuable. If everything is up in the air as a total I'm going to do a statistical evaluation of whether I would do it one way or another, there's some things that ought to be designed deterministically and then there's a place for the PRA to come in and certify whether you really missed anything or not. So a starting point is very important in my mind, and I don't see that in the Commission. The staff is very reluctant these days, when we review a design, to say, hey, look, licensee, this has got to be done this way, even though we don't say it explicitly in the rule, but we discuss it in reg guides or standards.

So I think there needs to be more of a balance as opposed to a total, total picture look at PRAs. They're valuable, but they shouldn't be looked at as the best of the best. So that's just a skeptic's view.

MR. APOSTOLAKIS: I think you're right. And PRA never claimed to replace everything. But

let's take this Part 53 Framework A. You do the PRA with a design basis accident. You assume or you determine what the performance of the safety systems, the safety-related systems will be and all that. But then the time will come when you have to use deterministic criteria to make sure that that performance will, in fact, be achieved. So it's not that everything is just probabilities without any mechanistic criteria.

But I do agree with you that -- I don't think we have gone too far with the PRA; I disagree there. I mean, the first serious PRA was done in 1974, and we're still arguing, you know, whether to use it or not. But, again, Part 53 is an option. Framework A is an option. You don't have to do that. You can go back to Part 50 or Part 52. So that removes a lot of the burden that you have to respect everything that PRA does. But a combination of deterministic requirements and PRA, in principle, is what we should do and what we're doing. There's no question about it. At some point, you have to do a thermal hydraulic analysis.

MR. BLEY: I guess you just hit the point, George. I'm a little surprised hearing PRA as a statistical analysis. It's an engineering analysis

that includes a lot of calculations very similar to the deterministic calculations. Often, they're not done with the same bounding rules. They're done to try to represent the full uncertainty that's involved, but there's a great deal, a great deal of engineering analysis in one, and the idea that it's just a statistical analysis is just not true.

MR. APOSTOLAKIS: That's correct. Charlie is very skeptical because he comes from the world of instrumentation and control, I think.

MEMBER BROWN: That is correct.

MR. APOSTOLAKIS: So probabilistic analysis doesn't really play a major role there.

MEMBER BROWN: But in our discussions on the design of some of these systems, in the I&C world, there are some parts of those designs where a prescriptive approach solves a known problem. A typical example is software corrupting and locking up. And if you vote with software processes and a line of data comes through from one division and goes to all four and it locks them up, there's only a few ways to do that in order to be able to tell each processor when do I lock up, and there's a way to do it that works. Some people want to use hardware, somebody actually proposed using a software watchdog timer.

That was nuts.

So it's a balance, like everything else. But you're right, I come from that world, and there are certain ways of designing hardware that's got to work in the environment that you just need to use your head. And when we try to suggest that to folks, oh, no, no, no, no, no, we can't tell anybody that. But, yet, this organization is responsible for the safety of the population in the building of these plants.

You're right. I do come from a different venue.

MR. APOSTOLAKIS: You know, I remember when we were colleagues on the ACRS, it was very clear where you were coming from. But maybe that world, deterministic analysis, should play a more significant role. I don't know. But, yes, I remember that. You always had something bad to say about PRA. I remember that, too.

(Laughter.)

MEMBER KIRCHNER: Hasn't changed, hasn't changed.

MR. APOSTOLAKIS: Some things stick to your mind, you know.

MEMBER PETTI: All I have to say is let's wait and see the first application that takes LMP all

the way through to an OL.

MR. APOSTOLAKIS: Okay.

MEMBER PETTI: Even a CP is not good enough, as we all know, as there's not enough detail, and then come back and talk because I think it's being over-characterized. I think that, in the end, you're going to see as mix of deterministic and probabilistic because they each have their pluses and they each have their minuses. And design teams are not stupid. They're going to optimize in a way that makes sense for their technology.

MR. APOSTOLAKIS: Yes. As I said, I mean, you know, the PRA will give you the performance requirements for the safety related systems. Then you have to make sure that these performance requirements are met. How do you do that? You have to go back to actual engineering calculations.

But if you want to talk about the first time that it's applied and the difficulties, well, go back to the 60s. The first time they approved the license, the reactors, what kind of regulations did they have and how many regulations did they have to issue in the following ten years because the original regulations were not good enough? You always learn the first time you do something. Always. Even the

LOCA regulations were not in the books, as I remember it.

MR. SCHULTZ: They were not there. This is Steve Schultz. They were not there.

MR. APOSTOLAKIS: Thank you.

MR. SCHULTZ: And both the development of the regulation and then the implementation of the regulation by the licensee was very, very difficult.

MR. APOSTOLAKIS: Exactly.

MR. SCHULTZ: The process took a long time; it was very difficult.

MR. APOSTOLAKIS: I hope that, with Part 53, we're not going to repeat that history in the sense that ten years from now we will still be revising the regulations, but, you know, every time you have a first application, there is always issues, there are issues.

CHAIR BIER: Okay. Further questions or comments from committee and consultants? This has been a very good discussion, I think. If not, we can now go out for public comment. I know there's a number of people in the audience who may want to have comments. I suppose, if people are on Teams, you can raise your hand and I will try to call on you. But if people are on the phone line, you can also just unmute

and --

MR. APOSTOLAKIS: Okay. So let me recall something from the experience. ACRS subcommittee meetings always take a break at some point, Madam Chairman.

(Laughter.)

CHAIR BIER: Oh, we can certainly take a break.

MR. APOSTOLAKIS: I'm sure we can. Are we going to do it?

CHAIR BIER: Well, I was thinking we could be finished, but you never know. So I am happy to take a ten-minute break and come back at 3:05 or thereabouts.

MR. APOSTOLAKIS: Yes. Thank you very much.

CHAIR BIER: Thank you for the reminder.

MR. APOSTOLAKIS: Thank you.

(Whereupon, the above-entitled matter went off the record at 2:54 p.m. and resumed at 3:05 p.m.)

CHAIR BIER: Okay. It looks like we are now at 3:05, and I guess, with that, we can open it up to public comments. First, just for clarity, we do not take question and answer from the public, so you may have a question, you can let us know, but don't

expect an answer during this session. And with that, again, if there are people online on Teams, you can raise your hand. If there is anybody on the phone, feel free to unmute yourself and make your comment. So far, it is looking remarkably quiet, but I want to give it another minute or --

MR. APOSTOLAKIS: It's like a license application. Nobody wants to be first.

(Laughter.)

CHAIR BIER: Everybody wants to hear what somebody else has to say first. Okay. We have a hand raised from Adam, so go ahead, please. Thank you.

MR. STEIN: Hi, this is Adam Stein from the Breakthrough Institute. I appreciate the opportunity to make a comment. I really enjoyed the discussion today and appreciate the time that everybody has taken to put this meeting together. I think it's definitely an important area that has had a lot of discussion in various formats on the rulemaking side for Part 53 recently.

I find it interesting that the recommendation was to include the QHOs in the rule but as goals, not criteria. It's not clear to me what the value of including it directly in the rule as a goal when it is already a policy goal, what the benefit of

being directly in the regulation is, other than potentially making it more cumbersome later on if the Commission decides to ever revise the goals. I'm not saying whether the Commission should or should not.

As it's currently designed, it is a strict criteria in the rule, and I have concerns about it being a criteria in the rule, in part, because of the legal concerns that NEI pointed out but also for the reasons that you couldn't observe whether they were in compliance or not. You could not show whether that level of consequence to the public from an event was statistically present or not, which can be attributed to the corollary as was discussed with Fukushima. You can't say whether it actually violated the QHOs on a data point. You'd be almost imposing that sort of one plant's data point on comparison to the QHOs for each plant, which I think is inappropriate and not statistically viable.

CHAIR BIER: Okay. Thank you. Go ahead. Do you have further points, Adam? Sorry.

MR. APOSTOLAKIS: Can I respond to that?

CHAIR BIER: Well, we don't ordinarily respond to individual comments. I suppose we --

MR. APOSTOLAKIS: I'm not part of the we.

CHAIR BIER: That's a good point. You can

speak for yourself, not for the ACRS.

MR. APOSTOLAKIS: Well, hell, no. Well, I think I don't read Part 53 as treating the QHOs as criterion. I mean, if that's your interpretation, then I think you're right to object. But even the name, quantitative health objectives, objectives are the same as goals, so I think that would take care of your concern, in my view anyway.

Any other comments, questions?

CHAIR BIER: Further hands from people on Teams or, again, anybody on the phone line is welcome to just unmute and make a comment. Give it one more minute maybe to see if we have any further comments raised.

If not, first of all, I want to thank you, George, for just the time and effort you put into this. It's obvious you put some time in and did a lot of preparation and made a very thoughtful presentation. You see you stimulated a lot of discussion among the committee members, which is all good. And if you want to make one or two sentences of closing remarks, I think we can allow that also.

MR. APOSTOLAKIS: Well, thank you again for inviting me. Some of it brought back memories from an earlier life as a member of the committee. As

I said at the beginning, I really had to spend a lot of time on Part 53 in trying to understand it and the arguments from the earlier NEI letter, but then the latest letter was really a major thing in the sense that it repeats the Part 52 requirements for the PRA in terms of submitting a summary and insights and having the details at the offices of the licensee for the staff to review. So that really, at the end, convinced me that, among other things, that QHOs should be part of the rule.

So other than that, thank you again and good luck with your deliberations.

CHAIR BIER: Thank you. And we're very glad you took the opportunity to do this. So I think, with that, we are adjourned for the afternoon, and many of us will see each other tomorrow morning.

(Whereupon, the above-entitled matter went off the record at 3:12 p.m.)

Some Thoughts on Safety Goals

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http://criepi.denken.or.jp/en/nrrc/index.html

Presented at the
ACRS Subcommittee Meeting on
Perspectives on Safety Goal Policy
August 24, 2023

Changes over the years

"safety goals are intended to be applied generically and are not for plant specific applications."
(Commission's Policy Statement, 1995)

- **Individual plant CDF and LERF are compared to the goals routinely.**

- **Informal upper limits are implemented.**

  - **CDFs greater than 10^{-3} per ry prompt immediate action.**

Multi-Unit and Adjacent Sites

- **U.S.A.**
  - Currently at most 3 units
  - Plant Vogtle will have 4
  - Geographically adjacent sites: Salem 1&2 (PWRs) and Hope Creek (BWRs 3 total, PSEG); Nine Mile Point 1&2 (BWRs Constellation Energy) and FitzPatrick (BWRs Entergy 3 total)
- **Canada**
  - Bruce Power: 8 units
- **Japan**
  - Kashiwazaki-Kariwa: 7 units

Whole-Site Risk: Early Consideration

- In the early 1980s, the NRC staff proposed that Safety Goals be applied on a per-site basis
- Commission decided not to impose a "bias" against multi-unit sites
- Quantitative Health Objectives (NRC) are now interpreted on a per-reactor basis

How stable should the QHOs be?

- The QHOs are a commitment to society.
- As such, they should be revised only when there is compelling evidence that they should be.
- One could argue that the Fukushima accident did not violate the NRC's QHOs.
- Is this a valid comparison?
- A Level 3 PRA prior to the accident would probably have shown that the goals were not met.
- There had been serious warnings that the tsunami height had been underestimated.

Some Proposals

- **"Our results suggest that the number of people relocated is a good proxy for societal disruption, and relatively straightforward to calculate**. " (Bier et al, PSAM 12, 2014)

- **"There should be no significant likelihood that a largescale, long-term evacuation will be needed as a result of a nuclear power plant accident**." (Mubayi Youngblood, Nuclear Technology, 2021)

CNSC Technical Safety Objectives for New Plants

- **Likelihood of accidents with serious radiological consequences should be extremely low.**
- **Potential radiological consequences from severe accidents limited to as far as practicable.**

Greg Rzentkowski, Presentation at 34th Annual Conference of Canadian Nuclear Society, Toronto, June 9-12, 2013

CNSC Proposed Quantitative Safety Metrics for New Plants

- **Frequency of severe core degradation (SCDF) < 10^{-5} per reactor year**
- **Frequency of release of 10^{15} Bq of I-131 triggering evacuation < 10^{-5} per reactor year**
- **Frequency of release of 10^{14} Bq of Cs-137 triggering long-term relocation < 10^{-6} per reactor year**

SCDF **"… the effects of adjacent units at multi-unit stations are considered and accounted for when calculating the Safety Goals for internal events sequences at the representative unit (generally, the lead unit)."**

LRF **"The assessment is done per reactor year with due account of the effects of adjacent units at multi-unit stations"**

G. Rzentkowski, Y. Akl, and S. Yalaoui, Application of Probabilistic Safety Goals to Regulation of Nuclear Power Plants in Canada.

ACRS Letter, April 2004 (1)

- The Quantitative Health Objectives (QHOs) apply to the site as a whole. The sum of the contributions from each reactor on the site to acute and latent fatalities should be bounded by the QHOs.

- The Committee has not reached consensus on the approach that should be taken to determine the core damage frequency (CDF) goal. Two views are presented in the discussion below.

ACRS Letter, April 2004 (2)

- **Option 1**
  - The site goal (e.g., 10^{-4} per ry) is divided by the number of units at the site.
  - The risk from and the likelihood of a core damage accident at all sites cannot be precisely equal. However, there is the expectation that they be comparable.
- **Option 2**
  - CDF is an accident prevention goal and its value should be the same for each reactor at every site.
  - Requiring each module to have a CDF value given by the overall CDF goal divided by the number of modules introduces a new Safety Goal concept, a site CDF. Such a concept was never intended to be part of the Safety Goals.

Part 53 Metrics

- **The total frequency of exceeding a site boundary dose of 100 millirem (mrem) from all LBEs shall not exceed 1/plant-year.**

- **The average individual risk of early fatality within 1 mile of the exclusion area boundary from all LBEs shall not exceed 5×10^{-7}/plant-year.**

- **The average individual risk of latent cancer fatalities within 10 miles of the exclusion area boundary from all LBEs shall not exceed 2×10^{-6}/plant-year.**

NEI (Nov. 5, 2021)

- it is unclear why the NRC believes the QHOs must be in the rule at all, rather than relying on the long-standing implementation of QHOs through the NRC's Safety Goal Policy.
- If the QHOs are in the rule, they must be met for legal compliance, and since the PRA is the basis for meeting the QHOs, more, if not all, of the PRA will need to be submitted on the docket and would be subject to contention.
- It is recognized that regardless of whether the QHOs are in the Safety Goal Policy or Rule Language, the design, analysis, and licensing approach that would be taken by an applicant, and the NRC scope of review would be the same.

NEI (Nov. 5, 2021)

- **There is at least one member of industry that believes QHOs must be in the rule to provide regulatory predictability by avoiding the need to develop surrogate metrics for the QHOs.**

- **Therefore, more discussion on the benefits and disadvantages of the options of how to address QHOs in a way that achieves both predictability and flexibility would be beneficial.**

PRA

- **If applicable, the PRA should include event sequences involving two or more reactor modules as well as two or more sources of radioactive material, which could include waste processing and storage systems.** (NRC staff)

- **A standard exists: ASME/ANS RA-S-1.4-2021, Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants**

NRC Staff (1)

- **Risk-informed performance standards, including the QHOs, provide a fixed cumulative risk standard for licensing events ranging from anticipated event sequences to very unlikely event sequences.**

- **Without these cumulative risk standards in Framework A, including the QHOs, there would be no equivalent to the collective effects of the prescriptive requirements in Parts 50 and 52 that provide reasonable assurance of adequate protection of public health and safety.**

NRC Staff (2)

- compliance with the existing totality of NRC (prescriptive) regulations provides reasonable assurance that adequate protection is maintained.

- Framework A proposes to support the adequate protection finding with a collective set of function-oriented and performance-based requirements. These requirements are intended to ensure that the proposed new regulations provide a level of safety comparable to that required by the existing regulations in Parts 50 and 52.

NEI 21-07, Rev. 1, February 2022

- **The PRA information included in Chapter 2 of the SAR should be at a summary level only as described below. It should address the requirement in 10 CFR Part 52 that the SAR includes a description of the PRA and its results.**

- **The applicant maintains complete PRA documentation in its plant records.**

- **The supporting methods, data, and detailed information used in the PRA will not be included in the SAR but will be available for NRC audit.**

Conclusions

- The issue of major societal disruption should be investigated further for possible inclusion in the safety goals. Comparisons with Fukushima should be reevaluated.
- The QHOs should be included in Part 53.
- Doing a credible PRA for all sources of radioactivity at the site will be challenging, even with the existence of the JCNRM Standard.
- The NRC staff should provide additional help perhaps using insights from the PRA Level 3 project.
- The license application should include a PRA summary and insights only. PRA details should be available to the NRC staff,