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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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FUTURE PLANT DESIGNS SUBCOMMITTEE

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FRIDAY

AUGUST 23, 2019

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B10, 11545 Rockville Pike, at 8:30 a.m., Dennis C. Bley, Chair, presiding.

COMMITTEE MEMBERS:

DENNIS BLEY, Chair

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR. Member

MICHAEL L. CORRADINI, Member*

VESNA B. DIMITRIJEVIC, Member

WALTER L. KIRCHNER, Member

COMMITTEE MEMBERS (cont.):

JOSE MARCH-LEUBA, Member

DAVID PETTI, Member*

HAROLD B. RAY, Member*

JOY L. REMPE, Member

PETER RICCARDELLA, Member

DESIGNATED FEDERAL OFFICIAL:

WEIDONG WANG

DEREK WIDMAYER*

ALSO PRESENT:

RANDY BELLES, Oak Ridge National Laboratory*

AMY CUBBAGE, NRO

EDWIN LYMAN, Public Participant*

STEVEN LYNCH, NRO

QUYNH NGUYEN, ACRS

BILL RECKLEY, NRO

JOHN SEGALA, NRO

BOYCE TRAVIS, NRO

*Present via telephone

T-A-B-L-E O-F C-O-N-T-E-N-T-S

P R O C E E D I N G S

8:43 a.m.

CHAIR BLEY: Good morning. The meeting will finally come to order. This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Future Plan Designs. I'm Dennis Bley, Chairman of the Future Plan Designs Subcommittee.

ACRS members in attendance are Joy Rempe, Charlie Brown, Walt Kirchner, Jose March-Leuba, and Ron Ballinger, and Vesna Dimitrijevic. She was here. She'll be right back. We also have Members Mike Corradini, Harold Ray, and Dave Petti connected via Skype. Weidong Wang of the ACRS staff is the designated federal official for this meeting.

The purpose of today's meeting is to review the draft SECY paper on population-related siting considerations for advanced reactors. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate. This matter is scheduled to be addressed at the September full Committee meeting.

The Subcommittee will also take some time at the end of the meeting to discuss some issues on micro reactor policies as requested by the staff. These issues will be addressed formally later at a

future Subcommittee meeting.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act. The NRC implements in accordance with its regulations found in Title 10 of the federal code, Part 7.

The Committee can only speak through its published letters. We hold meetings to gather information and perform preparatory work that will support our deliberations at full Committee meetings.

The rules for participation at all ACRS meetings, including today's, were announced in the Federal Register on June 13 of 2019.

The ACRS section of the U.S. NRC public website provides our charter, bylaws, agendas, letter reports, and full transcripts of all full and subcommittee meetings, including the slides presented. The meeting notice and agenda for this meeting were posted there.

As stated in the Federal Register and in the public meeting notice posted to our website, members of the public who desire to provide written or oral input to the Subcommittee may do so and should contact the designated federal official five days prior to the meeting as practicable.

Today's meeting is open to public

attendance and we have received no written statements or those formal requests to make an oral statement. We have also set aside 10 minutes in the agenda for spontaneous comments from members of the public attending or listening to our meetings.

Today's meeting is being held with a telephone bridge line, allowing participation of the public. As mentioned, a separate telephone bridge line allowing participation by some members of the Committee, as well as the technical staff and contractors is also established.

A transcript of today's meeting is being kept. Therefore, we request that the meeting participants on the bridge lines identify themselves when they speak, and to speak with sufficient clarity and volume so that they can be readily heard and recorded.

Participants in the meeting room should use the microphones located throughout the meeting room when addressing the Subcommittee.

At this time, I ask that attendees in the room please silence all cell phones and other devices that make noise.

I remind speakers at the front table to turn on the microphone indicated by the illuminated

green light when they're speaking, and to likewise turn it off when they're not speaking. Otherwise, we have a lot of noise on the phone lines.

We will now proceed with the meeting and I call on John Segala, Chief of the Advanced Reactor and Policy Branch Office of New Reactors, to make some remarks. John?

MR. SEGALA: Thank you, Dr. Bley, and the other Subcommittee Members for allowing us the opportunity today to discuss an important topic on population-related siting considerations for advanced reactors.

This, as you well know, is a topic that has a long history. Bill Reckley, as Senior Project Manager in my branch, will be leading the presentation this morning.

We also have Randy Bells and Mike Pour from Oak Ridge National Labs on the line, who have supported us in this effort, so they are there to help answer questions as well.

Since we're going to be sending this as a paper up to the Commission for their vote, we will be requesting after the full Committee meeting a letter from the ACRS.

So with that, I will turn it over to Bill.

MR. RECKLEY: Okay, so, good morning. The way I'm going to kind of pursue this today is to go through the draft paper that we provided to the ACRS that has several options.

The purpose of the paper is to propose to the Commission an alternative to the current guidance that's been in effect actually for more than 50 years related to population-related siting considerations for nuclear power plants.

So I'll go through a little bit of the background. As John said, it's a long history. I don't plan to go through all of the various things, but focus really on the options that we included in the paper and then specifically the recommendation that we're providing to the Commission. Next slide.

So I've used this slide before for the ACRS, and basically as we're looking at advanced reactors, it tries to reinforce that we need and we're trying to take an integrated approach, because as you look at things like emergency planning, siting, and some other things that have been implemented as mitigation measures for the operating fleet, and you try to consider the overall goal of the Agency to focus on preventive measures and improving plant designs to minimize the reliance on mitigation

measures, you need to look at both the design and those mitigation measures at the same time.

This is a little different than what was done of the operating fleet, which was largely built and designed, and then assessed, and mitigation measures were put in place.

We're kind of approaching this from the other end saying, and this was also the case for the emergency planning zone paper, we're trying to define criteria for the designers to use from the very beginning to say if I can design a plant to retain the radionuclides and minimize public releases, then I can take alternatives to what mitigation measures have been put in place for the current fleet.

So this paper takes a similar approach for population-related siting considerations in that it's trying to define some performance measures that we would define, and then designers, if they could meet those performance measures, could apply an alternative to the current siting guidance.

So within this bow-tie diagram, again, that I've used before, you can see how our efforts to integrate these various things have been put in place, the licensing modernization project, or the draft guide 1353 that we presented to the Committee on

events, the identification of licensing basis events, safety classification, and defense-in-depth, and then how that process feeds into others such as the use of functional containment, which, again, we provided to the ACRS in SECY 1896 and the Commission has accepted, the emergency planning proposed rule, and the siting that we'll be talking about today.

So hopefully you can see how we're trying to make sure that when we're done, we have considered all of the various features on the plant design side, usually expressed as the prevention measures, and then also how we're trying to set up performance measures for mitigation actions.

CHAIR BLEY: Bill, can I ask you two --

MR. RECKLEY: Sure.

CHAIR BLEY: -- two general questions? One is you mentioned that the guidance has been around for more than 50 years, which I agree with, but I notice that -- and in the document, I think we talked about Reg Guide 4.7 and the fact that, you know, its basis included that we didn't have much experience at the time.

I see that the current version of the Reg Guide was published in March of 2014, and I don't remember, were there substantive changes as that's

been upgraded or what?

MR. RECKLEY: No.

CHAIR BLEY: Okay, so it's essentially the same --

MR. RECKLEY: Essentially the same.

CHAIR BLEY: -- criteria that we've always had?

MR. RECKLEY: Yes.

CHAIR BLEY: The other question is usually when we have a short paper like this one, you have an attachment that goes into great technical detail. Does the Oak Ridge report provide that kind of thing? Are you going to have an attachment or does it just stand on its own?

MR. RECKLEY: The intent is that this stands on its own. We refer --

CHAIR BLEY: With references.

MR. RECKLEY: With references, and the references go all the way back to TID 14.8.44 to some degree. One of the things about this paper, and I might as well say it up front, is we didn't calculate anything in this paper. I mean, what we're proposing did not result directly from calculations.

We're -- this is a largely judgment-based paper. We think if you look at the background

documents, you'll see general support and consistency, but you won't find, and we don't have, any calculations where you'll see a basis for either the one REM, or in option three, the doubling of that radius. So we'll talk about it as we go through the options, but this is largely based on judgment, on historical practice and insights.

One of the things we can talk about today is if you want to see more numbers, all of the studies are out there. We can try to get more data if it would help put things in context, but as we go through it today, that will be one of the things maybe we can get an insight from.

CHAIR BLEY: Okay, thanks, and I read your paper. I've read a lot of the old SECYs, and Reg Guide, and other previous documents, as well as the Oak Ridge ones, so I might lose track of what was where.

I don't think you talked about research reactors at all, but the research, I mean, the Oak Ridge report does get into a little of that history and why it's different from commercial reactors. Is that in your thinking? Does that come up somewhere or are you going to talk about it today?

MR. RECKLEY: We can. We can go there.

As a general matter, as we're looking, and we'll get into this a little bit more maybe if we talk about the micro reactors later --

CHAIR BLEY: Yeah.

MR. RECKLEY: -- that there starts to be some parallels in size and consequence to the non-power research and test reactor arena, and maybe we can look there for some guidance and consistency, keeping in mind one is commercial and one is a research grant.

CHAIR BLEY: Go ahead.

MR. RECKLEY: Go to the slide four.

PARTICIPANT: I think Dr. Corradini has a question. I have unmuted him. Dr. Corradini, you are unmuted. He's been texting me. Dr. Corradini, you're unmuted.

MEMBER CORRADINI: Can you guys hear me?

MR. NGUYEN: Yeah.

MEMBER CORRADINI: Okay, so, Bill, let me ask the question a little bit differently than Dennis, because I think Dennis did a really good job of kind of getting a background. I read the same Oak Ridge report. Is there a technical basis for the current Reg Guide 4.7 or is that a judgment hosted, you know, current operating reactors?

MR. RECKLEY: If you're asking can you find an equation that 500 people per square mile popped out of, the answer is no. There has been a lot of work done to show maybe the adequacy or the merits of that guidance, but that was based on engineering judgment largely in 1962 and we've pretty much stuck to that to current day. As I get into the --

MEMBER CORRADINI: I guess my --

MR. RECKLEY: Go ahead, Mike. I'm sorry.

MEMBER CORRADINI: I'm sorry. No, no, I don't want to get you ahead of your talk, so you can postpone my question.

The second part of my question is does this Reg Guide, since all of your options somehow focus on the Reg Guide and not on the regulations, does the Reg Guide, is the Reg Guide guidance limiting for any current light water reactors or any new builds?

In other words, my impression is the regulations are really limiting and the Reg Guide is guidance that doesn't seem to affect any current sitings, and so my question is --

MR. RECKLEY: Well, and that's a little bit of speculation because when an applicant picks a site and comes in, then they will have already looked

to try to assess whether it meets the guidance.

In terms of the most -- in licensing under Part 52, Turkey Point has a bit of a challenge because they exceeded the 500. It was able to be addressed, but it was a factor and an issue within that proceeding, so.

CHAIR BLEY: And Ravenswood actually disappeared.

MR. RECKLEY: I mean, that was in the early '60s --

CHAIR BLEY: Yeah, right.

MR. RECKLEY: -- or '70s, but, yes.

CHAIR BLEY: They were going to build that right near --

MR. RECKLEY: Right.

CHAIR BLEY: -- in New York.

MR. RECKLEY: Right, and that goes to John's history. That, and other similar proposals, ultimately led the Commission to do the policy that we wouldn't site them in metropolitan areas, but we would set up guidance to keep them away from densely populated centers. I'll talk about that under the current regulations, so.

MEMBER CORRADINI: Okay, and then my last question is, and then I'll be quiet for a while, is it

the intent, since you're going to present option three, to develop a technical basis for what you judgmentally have written in the SECY or is it just to stay with the judgmental estimate that we've read?

MR. RECKLEY: Currently, the plan is to keep with the judgmental development of that proposal.

MEMBER CORRADINI: Thank you.

MR. RECKLEY: So we've started to broach in on this already. The background is that the regulations for this are in 10 CFR 100.21, non-seismic site criteria. There are a number of factors within that regulation.

One is that a plant must have an exclusionary in the low population zone. The other is that the population center distance, which is the distance to a center of about 25,000 people, is one and a third the radius of the low population zone.

It refers to radiological effluence and radiological consequences. Those values are actually in 50.34 and 52.79. I'll talk about them in the next slide.

And then 21(h) is that a plant will be located away from a very densely populated center, again roughly 25,000, and that low population density is preferred.

The way that regulation has been met is through the guidance in Reg Guide 4.7, that the radial distance out to 20 miles does not exceed a population density of 500 persons per square mile. So if you go to the next one -- go ahead.

MEMBER BROWN: Relative to the 500 persons per square mile, have any plants that were built years ago, now as populations have encroached, have they now exceeded that 500?

MR. RECKLEY: Yes.

MEMBER BROWN: Like Surry, for instance?

MR. RECKLEY: I don't know the specific answer whether they did --

(Simultaneous speaking.)

MR. RECKLEY: -- but the answer is yes. This is a siting --

MEMBER BALLINGER: Initial siting.

MR. RECKLEY: Initial siting evaluation. Populations can grow around plants, and this is not one that is maintained as a requirement that you need to keep population densities below 500.

MEMBER MARCH-LEUBA: Only for five years, right?

MR. RECKLEY: Well, in doing the assessment, they project out five years using census

data.

MEMBER BROWN: But from that logic, if we already exceed based on population growth, why do we worry about a metric of 500 when you build it? It's kind of a hypothetical question, but.

MEMBER MARCH-LEUBA: Well, that's the way that the rule is written.

MEMBER BROWN: I understand that, but I'm just saying in terms of our downstream thinking, why wouldn't that thought process be taken into consideration?

CHAIR BLEY: It is a matter of choice for those who move next to a plant, or when you build a plant, they were already there.

MEMBER BROWN: Well, they can move also. Don't take that the wrong way. I understand that point, so, but it just seems to me, from a safety standpoint or however you want to talk about it, we already move ourselves into that range just based on population growth, and therefore --

MR. RECKLEY: Right. On the siting --

CHAIR BLEY: Excuse me. Somebody on the phone line is not muted and I'm hearing papers moving around and noises. Please mute.

MR. RECKLEY: Yeah, the other -- one thing

in terms of maintaining the ability to mitigate a reactor accident after operation begins, you can drift over into the emergency planning arena. That is kept up. They all need to do evacuation time estimates and redo them.

They'll need to consider how the area changes in order to maintain emergency planning, so it's not as if it's all, that we forget about the changing environment once the plant is sited, but this particular rule is just for the initial siting.

MS. CUBBAGE: This is Amy Cubbage, NRC staff. I'd also like to point out that this is in addition to other safety requirements with regard to exclusion area and population doses. This is a separate requirement.

MEMBER BROWN: No, I understand that. I read the same paper.

MS. CUBBAGE: No, I know. I just want to make sure for anyone else listening.

MEMBER BROWN: I got your point. Thank you.

MEMBER MARCH-LEUBA: When you are summarizing all of the zones, can you give us a little bit of background on the EPZ, the emergency planing zone? Where does it fit in all of these regulations?

Because I'm always confused about so many PZs.

MR. RECKLEY: Yeah, if you go to the slide five -- so let me talk about the siting and then we'll overlay the emergency planning.

So within the current siting 121, and when you combine it with the requirements in 50.34 and 52.79 on the dose, the areas or the distances that are defined is the exclusion area, and that is established as less than 25 REM for the worst two hours, the low population zone, which is identified as 25 REM for the duration of the accident, less than, then the population center distance, which I mentioned, one and a third times the LPZ distance that the reactor needs to be away from a population center of greater than 25,000, and then the purple line down at the bottom is out to 20 miles, the low population density is assessed of 500 people per square mile.

In the current regime, you could draw another circle at roughly 10 miles for the emergency planning zone. In the proposed rule, you could put in a circle at one REM over 96 hours for a consequence-based emergency planning zone. That was the general proposal in the proposed rule that's with the Commission.

The relationship between siting and

emergency planning is part of that history. I mean, one of the reasons to look at population density is to ensure that emergency planning can be put in place. That, in my view, this is a personal view, that was more so early on.

Then the other aspect of the 20 miles and overall siting, including keeping it away from a population center, was an early kind of implementation of a societal measure. As I think most people are aware, most of the NRC criteria are based on estimates to individuals, right, when you do an accident analysis. Then you assess what would be the dose to an individual?

So this siting guidance was a way to introduce a bit more of a societal measure to limit the impact not only to an individual where you're calculating the dose, but to the broader society, and again, this is my personal view because the history has evolved and everybody can have one, I suppose.

Early on, I think the siting criteria, and the 500 people, and the distance to the population center was more directly tied to our emergency planning, and you can look at the basis and there are those discussions.

As emergency planning improved over the

years, I think there was less reliance on the siting criteria and the population density because the emergency planning provisions became much stronger, and to me, it kind of just changed the balance, and that little societal measure factor became a bit more important for why we wanted to maintain this, but again, that's a personal view. You won't find it written anywhere, but there is a relationship between the siting criteria, the population density, and emergency planning.

CHAIR BLEY: This is kind of outside of NRC's domain, but communities develop the emergency plans and implement them. Do you know, do any communities restrict populations near plants as part of their emergency planning? I don't recall ever hearing of that.

MR. RECKLEY: You know, I don't think so, and if they were to actually try to do that, I think it would be a legal issue, but.

MEMBER BROWN: What about evaluation routes? If developers come in and they start building within that EPZ, do they consider that then in the layout of roads? Is that required or is that just --

MR. RECKLEY: That would become part of the assessment and the evacuation time estimates.

MEMBER BROWN: But that would have to be evaluated. There is some -- at least plant people would be aware of that, and that would have to be taken into account.

MR. RECKLEY: Plant people and local emergency planning people.

MEMBER BROWN: So road improvements and -- okay, just wondering of the communication existence.

MR. RECKLEY: So if we go to slide six? So why look into doing a change to something that's been in place since 1962? And that is that the siting, current siting guidance and siting practices have been identified early on as a potential policy issue for advanced reactors, and in particular, small modular reactors. The staff identified that in our implementation actions plans, which we've talked to the Committee about.

More recently, in SECY-1612, we talked about the use of mechanistic source terms and the possible implications of smaller reactors and mechanistic source terms, and possible arguments for siting of small modular reactors.

In that paper, we said if we came up with changes to guidance, we would prepare it for the Commission, and that's basically what this paper is

fulfilling, is what we had said in that paper.

In terms of why, if you look at the DOE website, and this has been true, again, ever since the beginning of the discussions with small modular reactors some 10 or 15 years ago, part of the potential uses of that technology was to replace retiring fossil stations and otherwise trying to do, have more flexibility in the siting where our guidance would be constraining for large reactors.

And so there were various studies done at Oak Ridge using Sage, a computer code, looking at populations and various factors for siting reactors, and it's referred, some of that work is referred to in the Oak Ridge report that we reference in the paper.

But in a minute, I'll get into -- it's a little easier with a figure in the table to show kind of how that, how the current guidance comes into play, so I'll get to that in a slide or two.

MEMBER CORRADINI: Bill?

MR. RECKLEY: Yes?

MEMBER CORRADINI: So let me ask a question here. Has research done any sort of analysis in terms of a range of accidents and a particular site that actually would give some sort of calculational basis for doses beyond the LPZ or the 1.33 times the

LPZ or is it all relative towards the planning? I'm looking for some sort of analysis that could be used as a technical basis for some of the quantitative values which your approach is suggesting.

MR. RECKLEY: Part of the issue is we're kind of, as I mentioned earlier, we're trying to define a performance metric that its designer would need to meet to justify using the alternative guidance.

So if you ask what analyses have been done, many analyses have been done for various plant designs, all right. Part of the issue, and we can look up and get back both studies for large light water reactors, SOARCA kind of work.

We can look up analyses that were done for small reactors, be it NGNP or NUSCALE, or even IRIS, some of the earlier designs, so there are a number of studies that we could go to. If you look -- but again, that's going to be specific to that reactor.

What we're trying to define is coming at it from the other side. If a reactor meets this performance metric, then you could use the alternative criteria.

If you want a rough feel for how dose falls off with distance, the backup slide, which I

took out of NUREG-0396, shows basically the rough, so it's a rough estimate that they used at that time frame for how dose falls off with distance.

MEMBER MARCH-LEUBA: That's slide 22?

MR. RECKLEY: Slide 22.

MEMBER CORRADINI: Okay, but where I guess I'm going, and I'm kind of repeating my earlier question again, which is going to keep on coming up, which is personally, your option three, as you're eventually going to get to and tell us about, makes sense qualitatively.

Quantitatively, I'm struggling to understand a performance metric that doesn't have some analysis behind it to provide a technical basis, but I appreciate the background with the specific studies, so I'm good for now. Thank you.

MR. RECKLEY: Okay, go to slide seven. So keeping in the background, again, as been recognized, the advanced reactor policy statement talks about attributes of advanced reactor designs, and as we've cited many times in trying to develop various performance measures.

Although we are not in a position to say any particular design has any particular attribute or can meet the performance measure, the general

assumption in order to allow us to go forward and even entertain defining performance measures is that advanced reactors have attributes that can result in smaller, slower release of radionuclides.

MEMBER MARCH-LEUBA: While we're talking the whole background, risk always has frequency and consequences.

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: And all of these lines you show us in line five were consequences. At which point, I mean, do we have to -- we always, we don't consider the two-mile radius as a meteorite hitting the planet for the source term. Can you in a way tell a little bit about where we're going, or where we have been and then where we're going?

MR. RECKLEY: Okay, yeah, as we get into the options. Let me hold that, and as we talk about the options, because the options --

MEMBER MARCH-LEUBA: I'll remind you.

MR. RECKLEY: Yes.

MEMBER MARCH-LEUBA: But where have we been in the past? Where are we today on frequencies?

MR. RECKLEY: You can see a discussion of frequencies in NUREG-396 where some of this was laid out, again, for the emergency planning aspect in

defining the exclusionary boundary and the low population zones. For current reactors, that's done looking at the design basis accident, which is a conservative, stylized, meant to be kind of a bounding accident.

As we get into the options, they differ. Option two is more straightforward consequence based. Option three --

MEMBER MARCH-LEUBA: I'm willing to wait.

MR. RECKLEY: Okay.

MEMBER MARCH-LEUBA: So basically where we are now is a postulated accident --

MR. RECKLEY: Yes.

MEMBER MARCH-LEUBA: -- in terms of what your source term is?

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: And we may be modifying that?

MR. RECKLEY: Right. Then the last time that the siting was revisited in a major way was the rulemaking in 1996, and even in the statement of considerations for that rulemaking, the Commission laid out the observation that the consequences from advanced reactors would be expected to be less and that you could see exclusionary boundaries and low

population zones approaching the site boundary.

The Commission then laid out, however, in that rulemaking the bottom bullet. Nevertheless, the Commission concludes that its defense-in-depth measure, the Agency would continue to site reactors away from densely populated centers, so we think our options meet that broad policy.

So if you go to slide eight? If you look at the planned uses of small modular reactors and advanced reactors in general, we identified two potential issues that would face the deployment of those reactors against our guidance.

One would be the 500 people per square mile out to a distance of 20 miles. As I mentioned, there would have been some discussion of using these to replace retiring fossil stations. Some of those are going to be closer to metropolitan cities, and that 20 miles is a factor.

On the other spectrum, some uses of advanced reactors, and again, micro reactors in particular, we'll talk about a little later, would be for remote communities, and in that particular case, the restriction is on the other end. The close in population would be limited based on the 500 people per square mile. I'll show it on the next slide.

CHAIR BLEY: Same issue though.

MR. RECKLEY: Well, it's the same guidance, but one is restrictive because of cities closer than closer miles. The others are closer, that when you look at the population density of 500 people per square mile --

CHAIR BLEY: That's right where you want to put the machine.

MR. RECKLEY: That might be -- right, the remote community might have more than 500 people per square mile in a tight circle, so we'll go through the options, and this is, what I just mentioned is kind of easier on slide nine to see in the table.

CHAIR BLEY: But before you go into the details of the options, over this long history, one issue keeps coming back. Why do we have these restrictions on population density? And more and more, it's been flagged as a defense-in-depth issue.

As you go through your options, and I think I know on option three, that it's covered, can you talk about how the defense-in-depth issue affects each of the options as you go through them and how it would be handled under the options?

MR. RECKLEY: Okay.

CHAIR BLEY: If it would be handled.

MR. RECKLEY: Okay, again, we think we maintain that overall Commission policy of remaining away from densely population centers as a defense-in-depth measure, but I'll try to make a specific --

MEMBER KIRCHNER: Bill, I would also observe to that in 0396, it's interesting to read that because the word "prudent" comes up, and prudency has meaning, like in financial management, and one can make the analogy, "What would a reasonable person do in this situation given a choice? Would you site close or would you not?"

So this idea, it's related to defense-in-depth and the idea of prudency, and so that always struck me when I reread 0396 that you had a consensus of people who are knowledgeable of the issues looking at way to try and bound an approach for public policy and that word creeps up, so that always sticks in the back of my mind. It's a different take on defense-in-depth.

MEMBER REMPE: And you might add that the prudency was invoked because there was uncertainty at the time that these measures were instituted because there wasn't a lot known about certain aspects of the designs.

MEMBER KIRCHNER: And there is a lot of

uncertainty now.

MEMBER REMPE: I wasn't going to say that. I'm glad you did.

MR. RECKLEY: Good point, total agreement.

MS. CUBBAGE: I just wanted to point out one thing that we didn't get to previously and that's in the 1996 rulemaking on this matter. The statements of consideration said that a means of locating reactors away from population centers, depending on their size, it would result in limiting societal consequences significantly in the event of a severe accident.

So I think that really speaks to what the basis was, was the consideration of a severe accident, and with these types of facilities with the potential for reactors that are not subject to having significant core damage with dispersion, that's where you need to think about the types of accidents that could happen and the types of societal consequences that could occur in the event of a postulated accident.

MR. RECKLEY: So I'm going to use option one, which is the status quo, for two reasons. One, just to reinforce what I was just saying about the limitations, you can see the current guidance would

limit out 20 miles the total population to 628,000 people.

And so some of the reports I mentioned that Oak Ridge performed for the Department of Energy looked at a city like Kansas City and retiring fossil stations, and which fossil stations could be replaced with a small modular reactor and varying the guidance.

And when you keep the 20 miles, it excluded a large number of those. As you generally collapsed the distance, more and more of those retiring fossil units became candidates for replacement with small modular reactors.

And they did specific studies of specific locations, which can kind of give you an idea of the desire from the implementation or deployment side. Again, this isn't us as the NRC's business. This is really kind of the business case for the SMRs, but that's what's in part driving the desire for us to look at it from a safety or policy viewpoint.

MEMBER BROWN: Yeah, when I saw that thing on the Kansas City layout, I didn't read -- or maybe I've forgotten when I read this. I didn't see any assessment. You talk about a small modular reactor replacing an existing fossil fuel plant or whatever it is, you know, but fossil fuel plants can be up in the

thousand megawatt electrical or more also, whereas all of the small modular reactors are 60, 100, 300, 500, 600. So how do you get the electrical pass out being factored into this? And it didn't seem to be addressed at all in their analysis.

MR. RECKLEY: If you look -- and it was summarized. If you look at some of the previous site -- and again, this is more on the business side versus the NRC side, but if you -- some of the earlier studies that they did, the number of parameters that they look at is way more than just population in terms of the potential siting.

So, but in particular, one of the reasons for looking at small modular reactors is a lot of those retiring fossil stations are on the order of hundreds of megawatts, not thousands, and if you were going to put one in one of those stations, then the electrical connections were already there for a reactor or any unit on that scale of hundreds of megawatts, not thousands like the large lights.

MEMBER BROWN: So that has been addressed --

MR. RECKLEY: Right.

MEMBER BROWN: -- in some way, shape, or form then.

MR. RECKLEY: Yes.

MEMBER MARCH-LEUBA: Existing exclusionary activity, if you call it exclusionary, it already exists. You already exist. You already have fans and --

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: -- you have the space.

MR. RECKLEY: Yeah, the cooling infrastructure, the electrical infrastructure, and to some degree, even the siting infrastructure.

MEMBER MARCH-LEUBA: The square feet that you need to put the plant.

MR. RECKLEY: Right, right. On the other side, the example I was given was remote communities. You can see 500 people per square mile limits you to 1,500 people within a mile, and so if you're trying to use a micro reactor, for example, for a remote community, that becomes constraining.

So in option one, we would just maintain the existing guidance, and you can see this is the curve of population versus distance. One number that comes up fairly often is the equivalency, if you will, of the 25,000. How close can a city of 25,000 be based on 500 people per square mile? It couldn't be

any closer than four miles because at that point, you would exceed 500 people per square mile even if no one lived --

MEMBER MARCH-LEUBA: The 500 people is up to 20.

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: So if you have one population of 25 on 20 miles, then it would be perfectly okay.

MR. RECKLEY: Right, we enforce the 500 people per square mile over the whole distance, so at 20 miles --

MEMBER MARCH-LEUBA: This is over any radius?

MR. RECKLEY: Over any radius, yes, yeah, within that 20 miles.

MEMBER MARCH-LEUBA: I saw this at Turkey Point. We mentioned it before. When we did Turkey Point, we took the whole population and divided it by 20 miles because everybody was in that little sector up northeast.

MR. RECKLEY: As we do specific assessments, we might look at things a little differently, but the general guidance is this is looked at --

MEMBER MARCH-LEUBA: Uniformly distributed --

MR. RECKLEY: Yes.

MEMBER MARCH-LEUBA: -- over 20 miles, not --

MR. RECKLEY: Yeah, we look at it -- the current guidance restricts the population to the first mile to 1,500 people, to the second mile, to 6,000 people, to the third mile --

MEMBER MARCH-LEUBA: Oh, so this is --

MR. RECKLEY: Yes.

MEMBER MARCH-LEUBA: Oh, okay.

MR. RECKLEY: And the -- so, yeah, it's looked at over the whole radius.

MEMBER MARCH-LEUBA: And your vision if the Commission would accept option one would be to handle new reactors on an exception basis?

MR. RECKLEY: Right, on a case-by-case basis. They could always ask for an exception or try to justify it taking a different approach than what's in our guidance, but again --

MEMBER MARCH-LEUBA: So it clearly is the minimum you work out from to let them work out to --

(Simultaneous speaking.)

MR. RECKLEY: Right, on a case-by-case.

And the other problem you get into is we're trying to define things for the designer to shoot for so that they know that if they meet that performance metric, then their design can be used in various places. If you go to a case-by-case, you let that uncertainty drift all the way through the licensing process.

CHAIR BLEY: There is another part of that, I think, and it's probably driving while you're doing this. If you come in with an exception to not a regulation, but guidance that's been in place for 50 years and used for every plant that's been built, you have a pretty good hill to climb, and if it's worth climbing that, if the staff can do it once for everybody, it probably makes a lot of sense.

MR. RECKLEY: And then we say in the paper if somebody were to propose that, we would probably go to the Commission and say, "This is a policy issue because this guidance has been in place since, for 50 years."

Go to slide 10. We'll get into the second option. So again, this second option maintains the rules. All along, all of our options are not proposing rule changes, and so the first two bullets are those that are derived right from the rules.

Maintain exclusionary boundary in low

population zones as they're defined now for 25 REMs over either two hours or the course of the event respectively for the two distances.

CHAIR BLEY: Can I go back and ask for a clarification? The only thing I remember in the rules, and you cited this, I think, is that the rule itself says, I think, lower population densities should be preferred.

MR. RECKLEY: Is preferred.

CHAIR BLEY: That's about all that it says.

MR. RECKLEY: Right.

MR. RECKLEY: That's what I thought.

MR. RECKLEY: Then we maintain the distance from a densely populated center of more than 25,000, and we would propose to change under option two the guidance in Reg Guide 4.7 to say an alternative acceptable approach for assessing population density is to maintain a rough equivalency using societal risk, and I'll talk about this over the next couple of slides, using a source term factor that's associated with the radionuclide inventories and potential releases.

In the paper, we point out we think power level could be used as a surrogate for this, and

assume that the potentially contaminated area is proportional to the source term factor. This is, these are rough equivalences, and the proportional to the source term factor is an assumption.

If you go back and look again at studies, you go back and look at the TID 14.8.44 and some of those other things, you'll see that that is generally true, but it's not a one-to-one. You won't see the calculations come out one-to-one, but it's roughly proportional.

MEMBER MARCH-LEUBA: Let me go back to my earlier question. For the source term factor, option two still has a deterministic bounding event or is it probabilistic?

MR. RECKLEY: The --

MEMBER MARCH-LEUBA: For your --

(Simultaneous speaking.)

MR. RECKLEY: The -- for option two, the analysis is, since it's kind of derived from the NUREG-396 and some of that work, has a deterministic root to it.

MEMBER MARCH-LEUBA: So you basically take numbers that exist now for a typical PWR and it's scaling with power?

MR. RECKLEY: Because you're scaling with

power.

MEMBER MARCH-LEUBA: So you're essentially keeping --

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: -- a bounding deterministic postulated accident?

MR. RECKLEY: Right.

MEMBER KIRCHNER: That effectively is what we saw with that early site permit that we --

MEMBER MARCH-LEUBA: I think that we're using published numbers by the SMR vendors. Wouldn't they say --

(Simultaneous speaking.)

MEMBER KIRCHNER: Yes, they had the numbers, but basically what they did is what Bill just described.

MEMBER MARCH-LEUBA: So they --

MEMBER KIRCHNER: They had a design basis accident and it's scaled with power to first order.

MEMBER MARCH-LEUBA: Okay.

MEMBER REMPE: Is that written anywhere in your SECY paper that you're going to have this bounding event rather than something like more consistent with the LMP where you, I mean --

MR. RECKLEY: It's probably not as clear

as it should be. The -- again, it stems from the fact that you're starting with what you have now and scaling it down as a function of power level.

MEMBER MARCH-LEUBA: But you're keeping your objective calculated EAV and LPC of 25 REM.

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: Now the question is how do you calculate that REM? If you just want to scale it with respect to an analysis or --

MS. CUBBAGE: In this case, you're not calculating a dose.

MEMBER MARCH-LEUBA: -- that would be 2a and 2b.

MS. CUBBAGE: Excuse me, this is Amy Cubbage. In this case, you're not calculating a dose. You're just saying it's a smaller reactor. Therefore, you can scale this criteria.

MEMBER MARCH-LEUBA: So option two is --

MS. CUBBAGE: Option two, this --

MEMBER MARCH-LEUBA: It does not maintain the 25 REM --

MS. CUBBAGE: It does separately.

MR. RECKLEY: Yeah.

MS. CUBBAGE: Separately.

MR. RECKLEY: The exclusionary boundary

and the low population zone would still need to be shown to be less than 25.

MEMBER MARCH-LEUBA: So you first scale it with respect to existing PWR.

MR. RECKLEY: Again, this is --

MEMBER MARCH-LEUBA: And then confirm that it's okay.

MR. RECKLEY: Right, well, again, this acceptable guidance is only an alternative to 500 people per square mile out to 20 miles. The regulations that define the low population zone and exclusionary boundary remain the same.

MEMBER REMPE: So I'm an applicant with an advanced reactor design, and let's say you went with option two. In order to say the site was appropriate for my certified design, I would use something that was in a 10 to the minus four frequency with the LMP and I would have a best estimate, but I'd have, with the safety-related things only working or something like that. Isn't that the way this would be applied?

MR. RECKLEY: If you -- and we're trying to make this not totally dependent on how you do it. So if you use the licensing modernization, you'd be looking at both design basis events and beyond design basis events, so you're going all the way down to five

times 10 to the minus seven to look at the consequences. If you're using a more traditional approach, you'd be using design basis accidents, which are intended to be conservative, and you're not analyzing to the same degree the beyond design basis events that are included in DG-1353.

MEMBER REMPE: So I think that's something that should be expanded upon in your SECY paper.

MR. RECKLEY: Okay, it's a footnote, so maybe it's obscure.

MEMBER MARCH-LEUBA: I think we're getting a consensus --

MR. RECKLEY: Okay.

MEMBER MARCH-LEUBA: -- that there is going to be some recommendations in the letter about having a table --

MR. RECKLEY: Okay.

MEMBER MARCH-LEUBA: -- on how you do the things.

MR. RECKLEY: Okay, so --

MEMBER CORRADINI: So can I ask a question here, Bill?

MR. RECKLEY: Yes, please, Mike.

MEMBER CORRADINI: So can Amy repeat what she said? Because the way I read this table is

strictly sourced from independent, but essentially power dependent. Am I understanding this table right? Because otherwise, I don't think this is very useful.

The assumption here is I don't know what the source term is, but because the size of the reactor decreases, I can decrease the size of the zone. Am I understanding this correctly?

MR. RECKLEY: Well, again, yes, and the example is -- I think when I get to the example on the next page, it will be more clear, but what Amy was trying to say is this is only for the guidance of 500 people per square mile out to 20 miles, which is the guidance.

To meet the rule on exclusionary boundary and low population zone, you're still going to be assessing the offsite consequences and making sure that it's at a certain level in order to justify those zones or areas.

So the rule stays in place. What we're proposing is just the alternative to 500 people per square mile out to 20 miles. What you see in the table and the figure on slide 11 is the proposed alternative, based on power level as you say, that would be the alternative to 500 people per square mile out to 20 miles, and so if we go to slide 12, the

example, I'll just run through what is the last column in the table.

PARTICIPANT: You skipped 11.

MR. NGUYEN: He said 12. Do you want 11?

MR. RECKLEY: Yeah, we've been talking about 11. I'm sorry. Yeah, let me go through 11 quickly. So again, this table would be the -- and I know it's hard to read.

It's more clear in the paper and in the Oak Ridge report, but the equivalency is estimated by saying that the societal risk of the current guidance is the area times a dose factor times the people per square mile.

And currently, R goes out to 20 miles, people per square mile is 500 people per square mile, and the dose factor is that dose factor associated with a large light water reactor. That's what we've licensed over the past 40 or 50 years.

MEMBER MARCH-LEUBA: Shouldn't the capital D be a function of R in there is more societal risk one mile away than 20 miles away?

MR. RECKLEY: You could make this as complicated as you would want. We kept it simple with just a factor that would associate the dose with something relatively simple to use like power level.

MEMBER KIRCHNER: I think, Jose, you still have to meet the requirements of 10 CFR 50.34, which is the dose at the AD and the LPZ.

MR. RECKLEY: Right.

MEMBER KIRCHNER: So you get that aspect because that's still a requirement.

MR. RECKLEY: Right.

MEMBER REMPE: So I went back to the SECY to check, and in option three, you do say beyond design basis events, but I guess I didn't see it anywhere for option two.

MR. RECKLEY: Right.

MEMBER REMPE: You had beyond in design basis as well as design basis, but my question was was this going to be for the plant or an individual unit?

MR. RECKLEY: This would be for a site plant.

MEMBER REMPE: So it is for the whole plant, and that's clearly --

MEMBER MARCH-LEUBA: Twelve modules?

MEMBER REMPE: Or four or whatever, and so if they come in or if you have a small micro reactor and they put 20 of them, you've got to consider all 20, okay.

PARTICIPANT: And that's clearly in the

SECY also?

MR. RECKLEY: Well --

MEMBER CORRADINI: I don't think that one -- I don't think -- I want to break in. I don't think what Joy just said is assumed here. I think it's on a module basis. It's on an individual reactor basis.

MR. RECKLEY: Let me go back and say good question. Let us --

MEMBER KIRCHNER: Well, I can say what we reviewed for the early site permit for Clinch River was the applicant selecting the largest anticipated module, and so they did their analysis based on that, which I believe was 800 megawatts thermal.

MEMBER REMPE: But again, this is a SECY --

MEMBER KIRCHNER: But it was a single unit. It wasn't multiple units combined.

MEMBER REMPE: But we need to understand what you're going to do, whether it's a unit or a plant here.

MR. RECKLEY: And I'll add clarity when we come back. The --

CHAIR BLEY: I thought your SECY started with that, that it was for a module.

MR. RECKLEY: Part of the difficulty in doing the

assessment is, as you use different approaches, that particular, how you address that particular issue changes. Under licensing modernization and DG-1353, it's a plan, multiple units. Under the current guidance and the approach, it's been more a unit. And so I'll clarify that and have a better answer when we come back on how this would be used for those two approaches, keeping in mind, because this is being laid out generically and, although we cite 1353 and would expect most advanced reactors to be used in that approach, it's not limited to that, and so we'll need to address if you came in with a more traditional approach. But just like current practice, that might introduce a bit of a discrepancy on how we handle things like multi-unit.

CHAIR BLEY: This committee has a long history of suggesting that one should be considering a site and not just a single unit.

MR. RECKLEY: So now we go to 12. I'll run through the example. So, again, this is basically running the last column in the table. In some ways it's a good example. In some ways it's probably not the best example. But we'll run through. If you get down to very small reactors, like a dose factor of five percent, which would be, roughly a 50 megawatt

plant, the assumption is, again, the contaminated area is proportional to the dose factor or power level, which you can find some basis for, again, not one-to-one, not exact calculations, but, roughly, proportional. That will take the affected area from 1200 square miles down to 63 square miles or a radius of four and a half miles.

MEMBER MARCH-LEUBA: Will you go back to slide 11, please. So I see that, I can read from my screen, 20 miles with 500 people per mile, you have 628,000 people. And if I look in the last column, it's only a thousand. It's likely the same number, but we're supposed to go five-mile radius.

MR. RECKLEY: Yes.

MEMBER MARCH-LEUBA: So that's how you do it. You find the number of people --

MR. RECKLEY: Right. So within the example, you're saying what's the affected area. It's proportional to the dose factor, so it goes from 1200 square miles or a radius of 20 miles down to 63 or a radius of four and a half. For conservatism, a margin is added, 25-percent margin is added to the area, which gives you a five-mile radius. Then you come back, under the current guidance, under the societal risk consideration, what was the affected population?

628,000 people. So keeping that the same and putting them in a smaller area, you get an adjusted allowable population density of 8,000 people per square miles.

MEMBER MARCH-LEUBA: So, basically, your option to say is my reactor is exactly the same as before, has the same primary, the same containment, the same release, the same source term, but this one is five percent radionuclides.

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: So, therefore, I think people only within five miles instead of twenty.

MR. RECKLEY: Right.

MEMBER PETTI: Bill? This is Dave Petti. Can you hear me?

MR. RECKLEY: Yes.

MEMBER PETTI: Let me make sure I understand. In this Option 2, you're scaling on power and underneath all of this is an assumption of an LWR source term just scaled by power while these advanced reactors have, let's call them a different releasibility of fission products, so you're conservative because probably the greater source term we think of is light water reactors and that many of these advanced systems would have, on an equal power, a light water reactor and even lower source term, per

se.

MR. RECKLEY: Yes, with lower driving pressures, different retentions, yes, that's true. Keeping in mind again, roughly, that the 500 people per square mile up to 20 miles was not based on a dose calculation either. It was just kind of put in place as a measure, a judgment, prudent, as Walter said. But if you're going to compare light waters to advanced reactors, you're exactly right, Dave. We would expect the doses to be smaller.

Now, given that this one comes up with such a big number, 8,000 people per square miles, that's actually a very, a fairly dense area. You would likely also need to look at the Part 100 requirements in terms of do you have an EAB and LPC and are you within an city of 25,000 people? Because at 8,000 people per square mile, you might find yourself within a population center, in which case you would need to look for an alternate site.

MEMBER MARCH-LEUBA: Well, okay. You will have three criteria: the 8,000 people per square mile, the 25 rem if it's two hours and 25 rem formulation.

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: And whichever is limiting is the one that --

MR. RECKLEY: Plus the third one that you can't be inside 25,000. So under Option 2, the advantages, it gives the designer something predictable to use. We think it maintains the overall policy of siting away from population centers. The disadvantages are we would have to go ahead and revise Reg Guide 4.7 so that it will be resources. We say throughout that that's remedied because Congress is currently giving us specific money for advanced reactor infrastructure, so, although that would be work, it's currently work Congress is funding. And there is, again, this possible negative perception of changing something that's been in place for so long.

So that's the discussion of Option 2. If we can --

MEMBER REMPE: So just to make sure I understand, because I saw this bullet last night and, to me, you have that remedied somewhat by budget appropriations, but you said verbally, oh, we got the money from Congress. Is that true? All of this work is off fee base, correct?

MR. RECKLEY: Yes, yes.

MEMBER REMPE: Okay. It's somewhat --

MR. RECKLEY: If you go to 13, 14. Sorry. We'll start talking about Option 3 in the paper. By

the way, we kind of had to limit ourselves. You could come up with an infinite number of ways to address this particular thing, especially, as Mike is saying, since it's largely judgment-based. We picked four options to present and made some judgments and assumptions within each of those as to how to address it. But I don't want to leave the impression these are the only four ways to do this. There have been multiple ways we could have done it.

CHAIR BLEY: Were these all dreamed up by the staff, or did these come out of meetings with others?

MR. RECKLEY: Option 2 was largely considered and developed by Oak Ridge in their report, and Option 3 was largely developed by the staff in-house.

CHAIR BLEY: Okay. Which follows the modernization plan or whatever we're calling that now.

MR. SEGALA: But we have discussed these with stakeholders at several public meetings that we've had with the community.

CHAIR BLEY: Strong feedback?

MR. RECKLEY: I wouldn't say strong feedback. The industry-related stakeholders, generally, they preferred Option 3, although they saw

merit in Option 2 as a possible approach. Union of Concerned Scientists was at the meeting. They preferred Option 4, develop a societal measure, that we'll talk about in a minute. And there are also stakeholders that would prefer us just not to do anything so Option 1.

So under Option 3, again, the rule stays the exclusionary boundary low-population zone would continued to be based on the calculation of dose, 25 rem over two hours over the course of the event. And we would maintain the requirement to be some distance from a densely-populated center more than 25,000 people.

But then the criteria that we defined is that for plants with event sequences of over one rem over a month from the event that the population density would be, the criteria we would use would be 500 people per square mile and we would look at the distance, which would be equal to twice the distance at which one rem for the month was calculated.

MEMBER MARCH-LEUBA: And you will be using --

MEMBER CORRADINI: Can I ask a question for Bill?

MEMBER MARCH-LEUBA: Go ahead, Mike.

MEMBER CORRADINI: So, Bill, is the one rem essentially derived from a PAG with no evacuation?

MR. RECKLEY: There would be no evacuation assumed, but it's a little different than the PAG because it's one rem over the month, not over some shorter time period on which you're making a determination on whether you should evacuate people. So it's similar but a little different in its derivation. Jose?

MEMBER CORRADINI: So one last question and then I'll let Jose. I apologize. So the only reason I'm asking these questions is it strikes me that the concept of 3 makes sense. The quantitative values used in the example need some sort of technical basis. I'm kind of back to that because I think I know where you're going by using DG-1353, and I think, I personally think it's a good way to do it. I just thinking picking the values and then doubling it, doubling the size, seems to me arbitrary without some sort of analysis behind it. So I'll stop.

MR. RECKLEY: Okay.

MEMBER MARCH-LEUBA: Option 3 now, was it administered accidental with beyond design basis at 5 times 10 to the minus 7?

MR. RECKLEY: If an advanced reactor was

using the methodology in 1353, they would be looking at the events in the design basis event and beyond design basis event categories. If they were using a more traditional approach, they would be looking at a DBA, however that was defined for them, and that we would have to work out with them like we've been working out with NuScale as to whether it's kind of a mechanistic source term approach or whether it is a more traditional approach of a source term out of the staff-defined guidance, the alternate source term guidance kind of approach where you put an inventory of radionuclides into a structure and then assume a leak rate.

So it would somewhat depend on how they were approaching it. We're trying to say, in terms of the siting guidance, it could accommodate either of those approaches.

MEMBER MARCH-LEUBA: If I was writing the guide, I would say for an approved DBA, to be determined either by the Commission approach or this. So that's basically what you're saying. During the design certification, there would be an agreement this is your worst case, that's the one you analyze.

MR. RECKLEY: Yes, yes.

MR. SEGALA: And I'd just like to add it's

down to 5 times 10 to the minus 7, but when they look at what BDBEs you consider, you also consider the uncertainty. So you could have event sequences that are lower than 5 times 10 to the minus 7; but, if the uncertainty goes above that band, then they will be included in LMP as a beyond design basis --

MEMBER MARCH-LEUBA: Yes. And as we know from new reactors, maybe the one that has higher frequencies, not the one that has the highest release. If you have events with the bypass containment, then you have a lot to release, even though it has more frequency. So you have to really do a risk-informed. You have to do both things, frequency and consequence, even if you have an event that doesn't release nothing.

MEMBER REMPE: So, again, with your footnote, you do have for Option 3 about the beyond design basis events are, generally, those sequences between 1 times 10 to the minus 4 and 5 to the minus 7 per plant year, but I didn't see the uncertainty worry and that might be a good place to also add that.

MR. RECKLEY: I can add that. Well, again, and that is emphasized over and over again in DG-1353, but it doesn't hurt to emphasize it again here.

MEMBER PETTI: So, Bill, just a question, a clarification. I guess I'm a little confused as I read through it with the one rem. I thought you guys had tied yourself to the PAG, so now you're acquiring kind of, it's, again, a different rule set. The PAGs are all done under best estimate. Is this done under a best estimate or a conservative?

MR. RECKLEY: Okay. Again, it will depend on the approach that the applicant is taking. If the applicant is coming under DG-1353, the design basis events and beyond design basis events are best estimate with measures to address the uncertainties, looking at the uncertainty bans and how you treat them and how you categorize them. But the actual calculations themselves are best estimate calculations. But there may be applicants that want to take a more traditional approach, in which case they would be looking at design basis accidents more like what we do now for large light waters.

CHAIR BLEY: I'm a little confused about that because in this approach and Reg Guide 1353, licensing modernization plan, we are looking at beyond design basis events, too, and that would kind of drop them off the picture if they used traditional design basis accident approach.

MR. RECKLEY: The logic of the traditional approach is --

CHAIR BLEY: The conservatism covers that.

MR. RECKLEY: -- the conservatism covers that.

CHAIR BLEY: Yes, yes, but we've run into the fact that that doesn't work.

MR. RECKLEY: Everything has limitations. But the DBA approach and in the conservative way it's addressed, and, if you look at exactly the light-water source term, there's been years and years of discussion as to whether that's a DBA source term or a really beyond design basis event source term. But the way it's handled, it's the DBA source term. But, again, this gets all into trying to maintain this. If you want to maintain the current approach, our expectation is that most, at least on the non-light water reactor side, high confidence that they would be using the DG-1353 approach.

CHAIR BLEY: I need to ask this because, although I read it, it might be the way I was coloring reading Option 3, which was DG-1353. Does it say in there you can use the traditional design basis accident?

MR. RECKLEY: That's a footnote.

MEMBER REMPE: Yes, there's a footnote but --

CHAIR BLEY: I read it, but I forgot it. I'm not finished yet. The other thing, kind of following Joy's, 1353 has a major emphasis on systematic review of defense-in-depth and saying something about that here might be worthwhile. I mean, you can go read 1353, but, for those who might not think it's included, it might be a good thing. Joy, go ahead.

MEMBER REMPE: Footnote five does say that an applicant using a licensing approach different from that discussed at 1315, could propose to use Option 3 by evaluating the potential off-site consequences for a wide range of transients and accidents, including beyond design basis events. If you add uncertainties for footnote six, please also say you need to either do it conservative if you use a traditional approach or you definitely need to consider uncertainties because I think we are going to get a lot of applicants who may not pick up on that and read our transcript.

MR. RECKLEY: Okay.

MEMBER CORRADINI: Bill, I want to make sure that Dennis's question is clear. So it's not

required in DG-1353, it's allowed. And one can take a conservative traditional light-water approach with just DBAs in a conservative manner.

MR. RECKLEY: Yes. Going to Joy's question, and I'll reword the footnote to be more clear, to me, when you do the conservative DBA, you are covering in a conservative manner the beyond the design basis events. I know what it says --

MEMBER KIRCHNER: Get the source term without having a severe accident, so that's presumed in generating the --

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: But from a practical point of view, what will happen is during the design certification the applicant will propose a DBA either using 1353 or using, pick out of here, and the staff will review and agree that that is a conservative --

MR. RECKLEY: That's right. And that it's applicable to use for the siting calculations.

MEMBER MARCH-LEUBA: I'm just confused, and I assume everybody else, too, I would simplify the second to say an agreed upon DBA, which you can use 1353 or you can use the --

MR. RECKLEY: All right. That will be clarified. So the way we described Option 3 in the

paper, and I tried to do it graphically here on the next couple of slides, is to go over three cases and how the rule and the population density would come into play. So if you go to 15. In 15, the hypothetical is that you have event sequences with off-site doses of around 25 rem. So you're going to have a low-population zone outside the site boundary associated with that.

If you have a low-population zone outside of the site boundary, then the one and a third times that distance comes into play in that a population center has to be at least that far away. Then if you have doses exceeding 25, you're also going to have doses exceeding one, and so you would calculate the distance at which you exceed one and that is doubled and, within that area, we would look at a population density of 500 people per square mile. So the decision was to keep the current population density and focus on the radial distance at which you're assessing that population density.

MEMBER CORRADINI: Bill, may I ask a question here?

MR. RECKLEY: Sure.

MEMBER CORRADINI: So I like your figure because the graphics can easily more answer the

question. What if the gray region starts impeding on the one and a third LPZ? Is it the boundary of the population center that then is violating the regulation, not the guideline, the regulation; or is it the center of the population center?

MR. RECKLEY: It's the boundary.

MEMBER CORRADINI: Okay. So the moment the gray strays into the one and a third LPZ, you're in violation of the regulation?

MR. RECKLEY: Well, we would be questioning their decision to site it that close to a population center.

MEMBER CORRADINI: Okay, all right. And then -- I'm sorry. Just one last thing. And then the one rem times two radius, you guys came up with a factor of two because of uncertainty or because of why?

MR. RECKLEY: It addresses a number of things. Uncertainty is the largest. It also addresses that if you look, if you look at this population density as largely being societal measures at this point, then it just defines a little larger area under which you're saying the potential impact of this reactor on an area is looked at a little further away than one R because one rem is not, again, that

number is not derived, we didn't back that off of some health effect or anything. We just picked one R because it's a traditional number that's been used for other purposes; and, in particular, it's the number that's assessed under DG-1353 or NEI-1804. But, again, it wasn't looked at as, it wasn't a derived number backing away from some probability of latent cancer fatalities or something like that. I mean, it's a number.

MEMBER CORRADINI: But it's in the PAG, right?

MR. RECKLEY: It ends, it's a different time line than the PAG. It's the same one rem, the one rem number is the same. It's one rem over a month versus one rem over 96 hours. Why do people pick numbers like one and two? You know, it's largely a matter of judgment.

MEMBER CORRADINI: But I think, Bill, I mean, so here's my problem. My problem is, without analysis, I see conservatism stacked upon conservatism that gives me a result that I don't understand other than it seems arbitrary because if the one is essentially a conservative measure of two and two is not a health effect until I get to five and then I multiply by two times the radius, I seem to have a

number of conservatisms laid on top of each other without any analysis that speaks to how much I essentially put defense-in-depth in a number of locations.

MR. RECKLEY: Yes. Okay. But, again, you're looking at both societal measures and societal acceptance, and you're not going to find, to my knowledge, you're not going to find numbers and ways to derive those.

MEMBER MARCH-LEUBA: No, those exist. I mean, you have the 5 rem limit for personal monitor and then 100 millirem for unmonitored people.

MR. RECKLEY: Again, we could convert this and you would be right that, if you looked at this in terms of the safety goals, we'd be well below the safety goals using these kind of numbers and these kind of transients. But --

MEMBER MARCH-LEUBA: My view is if I was designing a TV commercial for the general population, I would write how 100 millirem at two or one because we went into the dose for background sources. That's a very, very defensible number on a TV commercial. If you have an accident, you will not get more dose than you're getting now.

MS. CUBBAGE: This is May Cubbage. I

think we need to just really keep in mind that this requirement is not related to protecting any individual from health effects. This is a separate issue from the societal -- if there were an accident in the area, you could even consider the economic issues of people having to be permanently relocated. So, I mean, there are separate regulations that are protective of public health and safety. We need to keep that in mind.

MR. RECKLEY: Yes, I sort of mentioned that when we were looking at the bow tie. These are all, again, tied to unplanned events, the overlay, and we made this emphasis and probably should emphasize it here, as well. In terms of routine effluence and normal operations, all of those other regulations come in to play. So this is only an overlay looking at unplanned events and limiting the doses to individuals, as Amy said, and, in this particular case, also trying to limit the broader societal impacts of an unplanned event.

So going on to case two --

CHAIR BLEY: Let me interrupt you for just a second. We're not going to finish your 22, well, 20 slides by 10:30, so we're going to cut into the other discussion on micro-reactors a bit, which is probably

okay. But where would you like to take a break? Because we're going to take one soon. We can let him go through all the slides, but I'll start losing people momentarily. Go ahead.

MR. RECKLEY: I'll try to get through the cases and maybe we can do the discussion after the break with questions. So the case two is simply that you don't have sequences over 25, and so the LPZ collapses to the site boundary. But in this particular, again, example or hypothetical, you would have event sequences over one rem, and so the thing that becomes assessed is the population density out to two times the distance at which one rem. That, in effect, does control how close a population center can be. As I mentioned before, for 25,000, it couldn't be closer than four miles using this.

MEMBER MARCH-LEUBA: Say again. I thought, in this case, we can find it in the LPC.

MR. RECKLEY: Again, if you go back to the current situation, 500 people per square mile limits a population to less than 25,000 out to four miles. And so you couldn't --

MEMBER MARCH-LEUBA: That's still applicable?

MR. RECKLEY: Well, since 500 people per

square mile is the criteria, it becomes the same as the current guidance. It's just the radius that's being changed. We're not looking out to 20 miles. We're only looking out to twice the distance at which one R is calculated.

MEMBER MARCH-LEUBA: So you enforce 500 people per square mile to two or one?

MR. RECKLEY: Right.

MEMBER MARCH-LEUBA: Within two or one.

MR. RECKLEY: Right. So in this particular example, assuming that R was a couple of miles, then you couldn't have a population center within four miles.

The last example is where most advanced reactors want to be, which is --

CHAIR BLEY: Of course, you would -- well, yes, the population center only applies if it's more than 25,000 people. So if it's 20,000, it doesn't matter.

MR. RECKLEY: We'll get to that in the next example. In the third case, you have no events that exceed one rem over the month at the site boundary, so the LPZ, the EAB collapsed to the site boundary, and there's no population density factor that's looked at.

The only thing that remains in play is the regulation and policy to keep a reactor away from a population center of greater than about 25,000, which means, if you have a population center of greater than 25,000, you could be on the outskirts of it. If you have a, to Dennis's point, if you have a population center less than about 25,000, you could be within it.

CHAIR BLEY: So your remote community could, the remote community, you could put it right downtown if you wanted.

MR. RECKLEY: Right, yes, right. Or Air Force base or whatever is being considered.

MEMBER MARCH-LEUBA: And by population center, you mean the city limits? Because some cities are very --

MR. RECKLEY: These are population centers, not political boundaries. Now, this is a matter of judgment that will always be coming up as to how you define it. If a population, if a city limit -- and we talked about this internally, and it's just impossible to talk about all the variations. If a city is shaped like a doughnut with a bit empty spot in the middle, the population center maybe could be considered to be within that low population area in the center. But we're trying not to go there.

If we need, when we develop, once the Commission makes the decision and we undertake, if we're told to, changes to the guidance in 4.7, if we need to start to address these possible scenarios, we can try to go there. But I would prefer that we not do too specific extremes here.

MEMBER MARCH-LEUBA: You think this is an implementation issue?

MR. RECKLEY: Yes.

MEMBER MARCH-LEUBA: It's not a policy issue?

MR. RECKLEY: I think it's an implementation. Then going on to the last -- oh, okay. I'm sorry. Thank you. The advantages, similar to the advantage for Option 2, this lays out something for a developer to use and shoot for, give them some confidence that, if they've done the dose calculations, they can now go out and look at sites that would fall within this guidance. The same disadvantages as Option 2. We'd have to do the work, although, again, we're budgeted for it. And there's the possible negative perceptions of reducing this long-term practice.

Option 4 is to develop broader societal risk measures. And this would look at not only

specific health effects but also impacts on economies, land availability, displacement, decontamination costs. These kind of approaches have been talked about in various papers, and we talked about it in the post-Fukushima environment whether we should have such more specific measures of societal consequences.

The advantages, in terms of assessing the actual risks to an area based on the area and a particular reactor design, one can argue that this is the best assessment. It does kind of abandon the notion of design and site being considered as separate kind of defense-in-depth measures because now you're looking at the combined impact of a design on a site. It would take significant resources. I've heard people say this is basically equivalent to coming up with another safety goal policy statement. It's going to be a significant effort to try to define a societal measure.

CHAIR BLEY: Well, people have already done this sort of thing for other industries, and you either, the ones I'm familiar with, you either come up with a scheme for monetizing, which isn't very convincing to many of us, or you do a utility function, and if you do a utility function that may not be understandable to a number of people, and whose

utility function does one use? But people have done that for communities. Doing it for the whole country is kind of tough.

MEMBER REMPE: But this came up, as you mentioned, after Fukushima, and I thought that we did a little bit of digging into this area and we decided that there have been public judgments that said the NRC is not supposed to get into economics, that they're supposed to focus on public health and safety. Am I remembering correctly?

MR. RECKLEY: There was a paper, and I'm going to forget the number, in the 2012 time frame, and the Commission came back and said don't make equivalent the societal impacts and the health impacts. And, basically, that resulted in us maintaining the status quo in which, when we look at a regulatory analysis for changing a rule, we do look at some of these impacts in terms of effects on economies and so forth. But specifically within the back-fit assessments, again, looking at operating reactors, we don't look at them.

CHAIR BLEY: We had a subcommittee meeting at the request of several members of the public, including one former member of this committee, and the big thing that had come up after Fukushima was the

population displacement issue and the damage that does to people. There was a lot of discussion, but I agree with what you said, Bill, about where the Commission stood in these areas.

MR. RECKLEY: Right. And then the last bullet, and we talk about it a little bit in the paper, there's one thing doing the assessment, which is probably that methodology is well established, how to actually look at these things. How to use it in the decision-making process is the challenge, and what do you compare it to, what's an acceptable societal risk. Do you compare it to all societal risks, including natural hazards? Do you look at manmade hazards? Do you look at energy supplies? There would be a lot of sub-policy questions that would have to get resolved in order to develop this. And so, basically, that is largely the reason we wouldn't be recommending that approach.

CHAIR BLEY: I'd like to come back to that a little bit. Although people have done utility measures to do this kind of thing, one thing that, in a practical case, is often the result is that for a particular site and a particular facility, be it nuclear or something else, only one or two of these things really crop up as being the most important, the

driving factors, which simplifies the problem a great deal. I don't know how you deal with that ahead of time. But without that, there are serious complications. Go ahead.

MEMBER BALLINGER: But isn't Option 4 de facto happening every time anyway? You got an environmental impact statement, you've got public meetings, you've got all this stuff, so when you go to site a plant, irrespective of what we're doing here, Option 4 happens.

MR. RECKLEY: To some degree, it's brought into the consideration, sometimes by us, sometimes by others, I'll agree. But for us to come up with a specific measure in terms of siting -- I'll give you one particular question we would have to answer. If you're looking at, as Dennis mentioned, you'd probably characterize this in terms of dollars. That's a way to do it. That might drive you to site reactors based on that factor. On the other side, you have environmental justice that says don't look at areas where you minimize economic.

So all of these things would come into play. And if we were trying to do this, we would have to come up with some way to balance all of those competing societal --

MEMBER BALLINGER: What I'm saying is you don't have to. You don't have to. Option 4 happens.

MR. RECKLEY: Well, parts of it happen.

MEMBER BALLINGER: Parts of it happen. Sure. And maybe different parts at different sites, but, in fact, we don't have to deal with Option 4 because it happens.

CHAIR BLEY: But this Option 4 is saying systematically define all these parts --

MR. RECKLEY: And maybe that's then the challenge is if you try to actually come down and come up with a criteria where you would actually have a decision-making based on this, it would be difficult.

MEMBER BALLINGER: What I'm saying is you don't need to.

MR. RECKLEY: So that's the four options. The recommendation of the staff is to proceed with Option 3, and that puts us at 10:30. If you want --

CHAIR BLEY: Well, then that result of Option 3 would be a revision to Reg Guide 4.7.

MR. RECKLEY: Reg Guide 4.7.

CHAIR BLEY: That would be at 4.7, yes. Okay. Let's --

MEMBER MARCH-LEUBA: Can I ask a short question? One minute --

CHAIR BLEY: If they have a short answer. Go ahead.

MEMBER MARCH-LEUBA: You want to have a full committee meeting with a letter. What do you want the letter to say? We agree with you totally or we think that one through four are acceptable? Write the letter for us.

CHAIR BLEY: No.

MEMBER REMPE: He's not allowed.

MEMBER MARCH-LEUBA: What do you want in the letter? What are you expecting from us?

MR. RECKLEY: Given the discussions we've had, in fact, that these aren't derivations, these are judgment calls, we would look to something like it's reasonable.

MEMBER MARCH-LEUBA: What is reasonable?

MR. RECKLEY: Option, the use of Option 3 as a siting criteria is reasonable. Now, again, that's assuming that's what we would like to see. If the Committee wants to say it's reasonable if --

CHAIR BLEY: You will not write our letter.

MR. RECKLEY: It would be the shortest letter on record.

CHAIR BLEY: We are recessed until --

MEMBER REMPE: Well, hold on just one second.

CHAIR BLEY: No, I'm going to recess. What do you want?

MEMBER REMPE: Because different people may be up afterwards, and I have a question that follows what he's saying --

CHAIR BLEY: Same people.

MEMBER REMPE: You're going to continue this discussion and not go into the next topic? Because I do have a question about changes that you offered up. Are you planning to give us an updated version before full Committee meeting?

MR. RECKLEY: Address it in slides. I don't think we'll give you an actual --

CHAIR BLEY: We'll recess until a quarter til.

(Whereupon, the above-entitled matter went off the record at 10:27 a.m. and resumed at 10:46 a.m.)

CHAIR BLEY: We are back in session. Does anybody have any questions on what we've been going over this morning? Anything more to raise? Okay.

MR. NGUYEN: So I got Harold on Skype. Do you want me to unmute him?

CHAIR BLEY: Does he want to talk?

MR. NGUYEN: I don't know.

MEMBER REMPE: Why don't you do that and see if he has any questions.

CHAIR BLEY: He said he didn't want to talk.

MEMBER REMPE: Well, let's just see and make sure it works, too.

MR. NGUYEN: Member Ray, do you have any comments?

CHAIR BLEY: He's on break. Okay. Bill, John, whoever is -- yes, sir. Harold?

MEMBER CORRADINI: So are we going to move on to micro-reactors or do you want some comments on this?

CHAIR BLEY: Well, we're going to go around the table on everything later in the day. If you have something that requires a response from the staff, this would be a good time.

MEMBER CORRADINI: Okay. So just ask Bill again. I think a Member Petti asked the question, but I'm not sure if you answered it, Bill. Why not simply use the EPA PAG as the basis or at least be consistent with the EPA PAGs, rather than inventing another what appears to be different basis?

MR. RECKLEY: The primary reason is the decision that you're making out of the two things are different. Keep in mind that for the emergency planning zone discussions, the confidence that you're trying to get is that the design is such that you would not need to preplan moving people out of the way. And so one rem is used because it's the lower level of the PAG and 96 hours is used because it's the time frame which you would be evaluating a dose to see if you needed to evacuate people.

In this particular case that we're looking at, again, I'm looking at siting and the 500 people per square mile and the guidance more in the context of a general desire to limit broader societal impacts. So we use the one rem over a month not because it came out of a calculation but because we thought most applicants going forward would be using the guidance out of the licensing modernization project, and that's a parameter that's already being calculated in that methodology. So we're already, again, kind of looking at the integrated approach to this, trying to use calculations that are being done on the design side to also assess the mitigation side.

The factor of two was just a judgment that, again, the desire is to make sure that, in

siting a reactor, if it's going to have off-site consequences, that the impact on society is reduced. For example, there's a footnote in the paper that said the staff considered the relocation PAG, which is 2 rem first year, 500 millirem per year thereafter, as the longer-term guidance on whether populations would actually be relocated, not evacuated but relocated. That, you know, that has some merit to use as a performance measure to limit the societal risk, going back to the Option 4 discussion and trying to minimize the impact of relocating people. But, again, the judgment was we would try to use the number that was already being calculated within the methodology, which is the dose over a month, and --

MEMBER CORRADINI: So, Bill, just to stop you there for a minute. Where is that being calculated? I guess I've forgotten that.

MR. RECKLEY: Well, if you're using the guidance associated with DG-1353, you're calculating the consequence or showing it has no consequence for every licencing basis event, and the licensing basis events go all the way down into the beyond design basis event category, as John mentioned earlier, down to 5 times 10 to the minus 7, with an accounting for uncertainties and an accounting for cliff edge effects

and other matters.

MEMBER CORRADINI: So that's where the calculation of dose in one rem over a month is required by using the LMP?

MR. RECKLEY: Yes.

MEMBER CORRADINI: Okay. I guess I forgot that. Okay. Thank you.

MEMBER REMPE: So if you're going to make this for the site and not a unit, what keeps something like Monticello from trying to say, well, I'm less than the total megawatts electric for an advanced reactor site, can I do this? I mean, they're already sited, but something like a Monticello.

MR. RECKLEY: Well, the primary one is to set the scope, so we had gone forward with, say, this is applicable to advanced reactors, which we would define as being small modular reactors and non-light water reactors.

MEMBER REMPE: So less than 300 megawatts electric total is the key? I mean, we hear one advanced reactor is going to try to bump up with its 12 units to 60 megawatts per unit electric. I just am kind of wondering are you going to have a megawatt electric limit on it or what keeps you from having a larger bunch of units at the site, a larger number of

units? Is it going to be 800 megawatts electric, or what's the upper cap on it, I guess, is where I'm kind of going.

MR. RECKLEY: Again, and this is one of the things I'll have a slide for the full committee because it will need clarification in the paper and we won't have time to revise the paper, but, depending on the approach that you take, the regulatory approach to multiple units differs between where we see ourselves going forward under licensing modernization and the traditional approach that we've taken. So an applicant, if they're using licensing modernization, will address multi-unit risks. The more traditional approach, I'll have to go back and do a little more research, but, in general, you are looking at single unit risk.

MEMBER REMPE: Okay. When you do your more research, have something to talk about an upper cap because if you have a large number of these, well, again, you said a general multiple, but maybe there's some that are larger in power and there are multiple units and they don't want to use LMP and how do you keep somebody from squeezing in or something that way is where I'm kind of wondering on this.

MR. RECKLEY: Okay. I mean, we do have

guidance in place currently for looking at it. It's just not a regulatory requirement, so we've had to come up with a softer way to consider it, largely within the risk assessments that are done versus within the consequence calculations. But we'll prepare something and then describe how we will incorporate that into the paper by the full committee meeting.

MEMBER REMPE: Thanks.

CHAIR BLEY: Are you closely in contact with the Level 3 PRA folks? Because they've been wrestling with parts of that and have some ideas. You mentioned consequence, so if you try to cover it, if you cover it, in general, and, say, like the PRA has to consider it is one thing. Then it's their problem to consider it, and we got to say, yes, you did that well or not. But given an event that can affect multiple units, then they have to say can they all go to a bad state? If it's something like electric power, there's a lot of reasons why maybe they don't. And if it's something like a really big earthquake, then it's a little different story. So we'd like to hear whatever you've thought about by the time you come back and if you think you'll have anything in the paper about it.

MR. RECKLEY: Yes, we'll add some things in the paper. But, again, I'm not sure it will satisfy you because where we end up is what we can do regulatorily and what we can do if --

CHAIR BLEY: Well, a clear statement of that would be helpful.

MR. RECKLEY: Right. Okay.

MEMBER CORRADINI: So I have one last question, Bill, that was brought up at the beginning that we never circled back to it. Some of these smaller designs essentially seem to be more connected to what I see in a non-power reactor set of criteria. So let me take a specific example and just play it out.

So we've got this reactor at 20 megawatts power, and let's just say for the moment it turns into a power reactor that makes electricity from the 20 megawatts thermal. It is in violation of the 25,000 population center, is it not?

MR. RECKLEY: That would be an example I was talking about earlier. If you look at the whole NIST campus, whether you would say it's in a population center of 25,000 or the NIST campus itself is big enough to give you distance to a population, I'm not going to answer the question, I'm just going

to say that is the question that would be brought up and we would have to answer in that particular case.

MEMBER CORRADINI: But I think you and I are saying the same thing. Case three is if I put the NIST reactor, Case 3 would not be satisfied for the NIST reactor because the NIST sits inside of the gray area and, therefore --

MS. CUBBAGE: This is Amy Cubbage. Mike, what we're saying is you could argue that the population center in the Gaithersburg area is like a doughnut and that the NIST campus is large enough and doesn't have population that it could be considered that it's separate from the Gaithersburg population center. But these aren't things we've ever contemplated before. They're just things we're thinking about different areas, and we're not, obviously, siting a reactor.

MEMBER CORRADINI: All right. I understand. That helps me, though. The reason I'm bringing this up is for the next set of presentations you're going to have a lot of examples in theory that are going to essentially challenge the policy concept. So I want to make sure that at least they're brought up, but the whole idea of, essentially, non-power reactors and how they're used, to me, is the size of

these things get smaller and become more relevant.

MR. RECKLEY: And we are looking at that context of what insights you can get out of the RTR non-power realm to look at smaller reactors. So we are looking at that.

MEMBER CORRADINI: Okay.

MR. LYNCH: If I may add in, this is Steve Lynch, currently the Acting Chief of the Advanced Reactor Licensing Branch but also in my permanent role a project manager with the Research and Test Reactors Licensing Branch. Just to add a little bit of context on how we look at siting for research reactors, typically, Part 100 doesn't apply with the population centers with research reactors. NRC staff do look at population centers of interest surrounding a university reactor or other research reactor within about an eight kilometer radius or five miles. This could include location of campuses, cities. But what's important to keep in mind when looking at siting for these research reactors is, typically, as part of the accident dose evaluation, their research reactors are designed such that if a site boundary for the duration of an accident, a member of the public would receive no more than 100 millirem, which is at the Part 20 limits for normal releases and doses to a

member of the public during regular operation of a reactor facility. So I think that also influences how we look at siting for some of these currently-licensed research reactors is based on what are the accident dose consequences at the site boundary.

For the example of a NIST reactor, while it is a testing facility that does follow Part 100, if I am remembering correctly, and at safety evaluation that reactor is also designed to only have consequences of 100 millirem at the site boundary should there be an accident. So while power level is important and looking at these facilities, we should also consider the accident consequences in their designs.

MEMBER CORRADINI: I agree. I think that was Mr. Lynch, I agree. I am bringing it up as an example that some of these advanced designs are going to get of that size such that this could -- you could be in be theory, not in accordance with regulation and still be safe.

MD. CUBBAGE: Yeah, Mike, this is Amy. And I think we're nodding in agreement here. And I think Steve's major point that he wanted to make is to keep in mind that the design goals or acceptance criteria for some of the research facilities is much

lower than what we've been contemplating in these discussions, so 100 millirem rather than one rem.

MEMBER REMPE: And they're usually maximum credible accidents. They're not even realistic. They're very conservative calculations too.

CHAIR BLEY: Thank you. Boyce, are we up to you now?

(Off the record comments.)

CHAIR BLEY: Okay. Please go ahead, John.

MR. SEGALA: So thank you, Dr. Bley, and subcommittee members. Boyce Travis is a technical reviewer in the Advanced Reactor Technical Branch in the Office of New Reactors. And he'll be leading up the presentation.

I wanted to take a couple of minutes and kind of provide some overview of where we've been overall with advanced reactors and then sort of set the stage for why we're here on micro-reactors. I'll try to get through this quick, because I think we're running low on time.

So today we'd like to have some initial discussions, high level discussions. We're just kind of teeing off this issue of micro-reactors. So we're going to be going over micro-reactors, some of the potential licensing and policy challenges. And then

we're going to talk about current and planned activities.

And then since we're at the early stages and don't have firm positions yet on any of these topics, we wanted to get initial feedback from you. And that's going to help us.

As we move forward over the next couple of months, we're going to be interacting with stakeholders, and so we can take your input as we engage with them. So at this stage, we're not looking for a letter from the ACRS.

CHAIR BLEY: But you'll be coming back with a SECY. When do you expect that to happen?

MR. SEGALA: That's going to be early next calendar year.

CHAIR BLEY: Okay. So we'll have a subcommittee then when we get the SECY.

MR. SEGALA: We have a slide on that to kind of talk about --

CHAIR BLEY: Oh, on the brand. Okay, perfect.

MEMBER REMPE: So I'm sorry to interrupt. But Harold Ray sent me an email saying he tried to respond.

PARTICIPANT: Mic?

MEMBER REMPE: I'm sorry to interrupt. But Harold Ray sent me an email. He's tried to respond, and he's still muted. Could we do a test case just to make sure he has access?

MR. NGUYEN: I will unmute Harold right now. Member Ray is unmuted.

MEMBER REMPE: Okay, Harold, can you try again? Say it again?

MEMBER RAY: I'm told I'm no longer muted.

MEMBER REMPE: We can hear you.

MEMBER RAY: I was just trying to respond to Dennis. Can you hear me?

MEMBER REMPE: Yes.

MEMBER RAY: Okay. I was trying to respond to the question earlier and say I still have the concern about uncertainty. But I don't think it's worth discussing it here. I don't think it's (telephonic interference.) Thank you.

CHAIR BLEY: Thanks, Harold. Yeah, the idea of the uncertainty issue has come up several times. So that's on their menu.

MR. SEGALA: Okay. So this slide should look familiar to you. This is our implementation action plans for advanced reactors. We briefed you on this back in 2017, but this lays out our six

strategies.

I'm not going to go into detail, but back at that time, you gave us a recommendation that we should focus on Strategies 3 and 5 in the near term. And we've been doing that.

We also said that, as new information came around, or as we interfaced with pre-applicants, that we would adjust our priorities. And because of the increased interest in the development of micro-reactors over the last year, we've decided to prioritize micro-reactors in Strategy 5.

Let's see, so the other thing -- stay on that slide -- the other thing to mention is we had always had plans in the mid and long-term implementation action plans to look at a possibility of a new regulation for advanced reactors with the Nuclear Energy Innovation and Modernization Act that was passed in January of this year.

We're now required to complete a rule-making to develop a technology, inclusive risk-informed, performance-based, regulatory framework for advanced reactors by the end of 2027.

I want to focus a little bit on consequence-based security. We talked about siting, and that touches on the micros. We talked about EP

which is touched on by micros. But security is another one of those areas that I'm not sure that you're all that familiar with.

We received an SRM in November of 2018 where the Commission approved the staff's recommendation in SECY-18-0076 to pursue a limited scope rulemaking to provide alternatives to the current physical security requirements for advanced reactors.

Based on inputs from stakeholders, this limited scope is focused on the number of armed responders, which is currently required to be ten, as well as a secondary alarm station.

The proposal is to keep all other Part 73 requirements the same and look at developing performance-based criteria for determining, you know, how many armed responders are needed and whether or not you need the secondary alarm station.

So we issued a regulatory basis document in July of this year. It just recently closed for the public comment period. We're just starting to get the public comments and take a look at them. And so we're going start developing a proposed rule and associated guidance and reach out to stakeholders.

(Off the record comments.)

CHAIR BLEY: 18-076?

MR. SEGALA: Yes. Next slide, yeah, I'm not really going to talk too much with the time here. I think, you know, Bill already presented this slide for siting. And we've been embracing, you know, risk-informed performance-based approaches on all these topics.

Because of the enhanced safety characteristics that are anticipated for micro-reactors, which Boyce is going to talk about, they may warrant going further than where we're proposing to go generically for some of these topics for advanced reactors.

The next slide, so we've been engaging with stakeholders as we prepare for, I mean, we're engaging with advanced reactor developers as we've been preparing for potential applications over the next several years.

And so this illustrates the wide variety of designs that we're considering. On the right are the three technology working groups, but recently industry formed a Micro-Reactor Task Force. It has several different designers on it, but we're signaling that in the red box with the Micro-Reactor Task Force.

And so with that, I will turn it over to

Boyce.

MR. TRAVIS: Sure, thanks, John. And you know the next slide.

So depending on who you talk to, you'll get a different sort of set of definitions for what constitutes a micro-reactor. In the Defense Authorization Act for this past year, DoD was tasked with developing a micro-reactor that stated in the definition is less than 50 megawatts electric.

On DOE's website, they list three main features for a micro-reactor, that being factory fabricated, transportable, and self-regulated using passive safety systems.

In this context, self-regulating means something to the effect of capable of reactivity and heat removal regulation without active systems, not self-regulating in the sense that the NRC's regulations would not apply --

(Laughter.)

MR. TRAVIS: And so for the purposes of what we'll be talking about here, micro-reactors that we, the staff, are envisioning coming in are anticipated to be small, both in thermal power level and site size, non-LWRs with a reduced reliance on complex safety systems, and using more passive and

inherent safety features and, most importantly, focused, from the staff's perspective, as having low potential consequences as a result of an accident.

We recognize that micro-reactors are in varying states of development. And the exact nature of how they meet some of these points that I just discussed will differ between designs an the stages of the design.

Obviously, the designers are going to have the burden of proof to demonstrate how they meet all of these aspects. And these are anticipated characteristics at this stage.

And so although many of the discussions related to micro-reactors are going to focus on thermal power level, it's important to distinguish that from being a pure proxy for consequences in radionuclide inventory.

Because a lot of the micro-reactor designs have long core lives or don't plan to refuel for an extended period of time. And so that changes the calculus of calculating consequences.

CHAIR BLEY: Are they all heat pipes so far? Or are there other designs?

MR. TRAVIS: So the two that we've had official interactions with are both heat pipe-based

designs. I think we're aware of other designs that would call themselves micro-reactors that might not use heat pipes, but those are still in very early stages of development. So I couldn't give you the necessary information and say no.

MR. SEGALA: Yeah. I think in general we have very little information on the wide variety of micro-reactors being developed at this point.

CHAIR BLEY: Do you anticipate, I've gotten this far, that the SECY will focus on the heat pipe designs or somehow be very general?

MR. TRAVIS: So the goal of SECY is to be more general. I think that we'd prefer to have a more inclusive framework that applies, with a risk and consequence-based focus instead of being focused on design specific aspects.

CHAIR BLEY: I guess why I bring it up is I have -- it doesn't matter if I have trouble dreaming up a design, but I do, that would be as simple to consider as the heat pipe kind of design.

I'd worry if the SECY got so general that it didn't allow taking advantage of some of the characteristics of the heat pipe designs.

MR. TRAVIS: Yeah. I think that that's a fair assessment. I think that, again, we're focused

on end-state consequences and reliance on effectively passive and inherent safety features. And if it was possible to do that without heat pipes, we'd certainly be considering that design in a micro-reactor space.

Can we move on to the next slide?

And so for some more background, both DoD and DOE have micro-reactor efforts in progress. DoD, through what was at the time the Strategic Capabilities Office, has a request for solutions. And some of the aspects that they're requesting a micro-reactor have is a one to ten megawatt electric design, transportable by a C-17, that's inherently safe and uses TRISO fuel.

Separately, DOE has provided funding opportunities to some micro-reactors developers and has been tasked with Congress with providing and preparing a report on a pilot program to use a micro-reactor to enhance energy resiliency at certain federal facilities such as military installations.

NRC has been involved at a high level on both of these efforts as requested by Congress, DOE, and the DoD.

MEMBER CORRADINI: Boyce?

MR. TRAVIS: Yeah.

MEMBER CORRADINI: Boyce, yeah, Dennis

asked a question, and maybe this is the right time to bring it up. There was a meeting at Idaho National Laboratories in June that had a workshop on micro-reactors.

And there was a whole range of possible designs, I will just say possible designs. So the members may want to get -- I can try to get a website for you to look at and see the presentations. Was the NRC at that? I assume that they were?

MR. TRAVIS: Yeah. I personally was not, but we sent at least three staff to that meeting. So I know that we had multiple staff members at that workshop.

CHAIR BLEY: Hey, Mike, if you can get that to Derek, we would appreciate it, so we can all see it.

MEMBER CORRADINI: Yeah, I'm pretty sure, Dennis, that there was a website where all the presentations, and the agenda, and the members, people present were there. So I'll find it.

MEMBER REMPE: So I'm very interested in how the NRC plans to regulate the transportation of these critters, and where their scope would and wouldn't be.

If it's on an Air Force aircraft carrier

as this -- but it's going to be sited on a defense site, a military base, and produce power, does NRC still have oversight? And where does the boundary start and stop for the NRC scope?

MR. TRAVIS: That's a complex question. I think, in terms of, for instance, it would be possible to have NRC oversight and regulation on a stationary military installation for a reactor. But for something that was transported, again, via C-17, DoD has the ability to authorize at a reactor independent of the NRC for something like that.

I think the transportation question is one of the most complex questions that we have to address regarding this. And that's something we're considering.

And I think that the specifics, to get to your question, how much would we be involved in an aircraft transportable design that was used by the military, I think would depend on what DoD's intended use was and what authorization process they were going to follow for that.

My personal -- I don't envision us, for a purely military use, transported by the military reactor design, I don't think the NRC will probably have a role in that. I think that'll be DoD

authorized and licensed. But it's possible to envision a design that is, you know, does involve NRC oversight in some sense.

MEMBER REMPE: So the Navy interactions I understand, with their transport of their little aircraft carriers that have reactors on them. I don't understand how the Air Force and the Army would interact, if at all, with NRC. I suppose they don't have to at all unless there's some sort of -- pardon?

MEMBER KIRCHNER: There is precedent for that.

MEMBER REMPE: There is a requirement to interact with them?

MEMBER KIRCHNER: And they have dealt with the transportation issues before.

MEMBER REMPE: In the sky?

MEMBER KIRCHNER: Both. The Army had deployed modular reactors in the 60s timeframe. And I do believe that the old former AAC was involved. And then we had space reactors. And the space reactors have even more --

MEMBER REMPE: That's true.

MEMBER KIRCHNER: -- challenging, shall I say, requirements. And so there is a precedent. I'm not saying the issues are solved. But there is a past

precedent for interagency collaboration on these issues.

CHAIR BLEY: But as far as NRC or ACRS involvement, the reason we look at nuclear ship, nuclear power plant reactors is, one, because Admiral Rickover wanted it but, two, because that led to a presidential order that we would review those designs. And that's really the only clear link for NRC to --

MEMBER REMPE: And I understand that relationship. I'm not sure I understand the other as well, because it's prior to my time.

CHAIR BLEY: And that's just a shipboard propulsion reactor. If they put these things on a ship, that may not apply.

MR. TRAVIS: So we do have --

MEMBER CORRADINI: So, I was going to say, Dennis, I think Boyce said something that we might want to get a copy of. When is that report to Congress due out? Because I think that addresses some of the questions that Dennis and Joy were asking.

MR. TRAVIS: So I don't know the exact date that our report is due. I know we have provided comments to DOE on it. And I think we can -- we can get back to you with what the timeline for issuing that report is.

CHAIR BLEY: Thank you.

MEMBER CORRADINI: But I think that would help at least illuminate what has already been considered. Because that was part of the requirement with the Defense Appropriations Act that required the report.

MR. TRAVIS: Yeah, we'll take that as follow-up action. Because I'm almost 100 percent sure that it has not been officially issued yet. But it will be in the near-term, I think. And so we'll take that as a follow-up item to order that on as part of any future meeting requests from them.

MR. LYNCH: And to clarify, this is Steve Lynch, as far as authorities go for licensing facilities, there is Section 91 of the Atomic Energy Act that does give the Department of Defense authority to license facilities that are used for defense or military purposes.

And I think where some of the questions come on licensing authority, especially at facilities that could be located at Department of Energy or Department of Defense locations, is what would the ultimate use of the facility be.

So where the NRC may come in and have jurisdiction would be if a site, just use Department

of Defense an example, but a facility is located out at the Department of Defense site but is used for commercial power generation, that's where the NRC may come into play. But if used for military purposes or defense purposes, then the Department of Defense could have the jurisdiction under the Atomic Energy Act.

MEMBER REMPE: So if it's for military purposes for power production, where they previously had purchased the power from an offsite entity, that seems a little muddy to me.

MR. LYNCH: Yeah. You're talking about purchasing from a facility located offsite of a military base?

MEMBER REMPE: Previously they purchased it offsite. Now they want to purchase it from an onsite facility. Is that really defense purposes only, I mean, they're competing with offsite --

MR. LYNCH: So again, with --

MEMBER REMPE: -- sources.

MR. LYNCH: -- in addition to considering what the facility is used for, we also would consider who owns the facility. Is the facility owned by the Department of Defense? Is it owned by an independent vendor that happens to be located on a site? And that's where we'd have to, again, have additional

discussions. But we have had preliminary talks with the Department of Defense on what looks like.

So yes, it is speculative and murky. But we can come to conclusions based on knowing where the facility is located, who is the owner and operator of the facility, and what it's being used for. So all of those -- answering all those questions can lead, one way or another, who would be the licensing authority.

That being said, even in situations where another government agency, such as Department of Defense, would be the licensing authority, they could still consult with the NRC and request assistance in doing licensing reviews, as we do for the Department of Defense in the Navy reviews.

CHAIR BLEY: If the consequences can be shown to be very low, and maybe you get to this later, would you be considering a once and for all license that wouldn't need site-specific analysis? Because some of these are really independent of anything that's site related.

MR. TRAVIS: No. I mean, I think at this stage that's not something we're considering. But it would have to be. I mean, nothing's truly off the table at this point, but there are siting regulations that require us to site a nuclear power plant. And in

this case, they'd be producing power.

And I would expect that what applies in scope might be reduced, but the regulations themselves are still going to apply for siting a micro-reactor at this stage. But we're still in the preliminary phase of, you know, trying to figure out what that looks like.

CHAIR BLEY: Given the population center one, not considering that one, because some of these are --

MR. TRAVIS: I think you're going to --

CHAIR BLEY: If these turn out to have the kind of very low consequence and release capability that some are planning and hoping, that would seem that the 25,000 population center might not have a reason to exist.

MR. RECKLEY: And what the industry has said is that although they, at this point, are in favor of Option 3, they may ask us, when we look into the Part 53 rulemaking or some longer term activity, to revisit the 25,000.

CHAIR BLEY: Thanks.

MR. TRAVIS: So I think we'll move on to the next slide.

So industry, in the form of NEI, has

recently established the Micro-Reactor Task Force to evaluate potential issues related to micro-reactors. And they came up with, internally, came up with a list and prioritized the issues they saw most important are micro-reactor-specific considerations.

And there are some bullets here below. The ones I'll highlight are aircraft impact, operations and staffing, resident inspectors, security and emergency preparedness. We, as the staff, have come to some of the same conclusions on those issues.

And the eventual paper that is presented on this topic is going go consider issues and how the micro-reactor designs, how we will regulate them commensurate with their consequences and risk on some of those considerations listed in the bullets there.

MEMBER MARCH-LEUBA: And this will be only for civilian applications?

MR. TRAVIS: That's correct.

MEMBER MARCH-LEUBA: If you put it in a forward looking, really tight plan, it is under this area.

MR. TRAVIS: Right. The policy considerations and the licensing considerations we're discussing here are purely the ones that would be for an NRC regulated facility in the continental United

States.

And I'll note that the NEI activity is currently in process. We wanted staff, as far as the developing of the paper, we wanted to ensure that all the stakeholder views are appropriately considered and represented. And even the NEI, I think, plans to develop white papers on many or all of these issues. And it's something that we'll want to have considered in the SECY paper.

So on the next slide, and before I say anything about it, I'll emphasize that this is presented as an example for illustration only. We are just attempting to use the best publicly available information for kind of giving you a flavor for what a micro-reactor looks like.

This currently is the best example we have access to that's publicly available. Westinghouse, as part of a Licensing Modernization Pilot Project, submitted a -- or they submitted the results of their LMP pilot to the staff.

The science preliminary and the scope of the pilot was limited. Currently, the vision for the reactor is one to 14 megawatts thermal using a sort of steady state fission product barrier design with a solid monolithic block that encapsulates the fuel

channels and then heat pipes to remove heat from the reactor and provide -- move heat to the secondary site for power conversion.

Westinghouse has further designed a, quote, secure vault to protect it from external events. And the design uses inherent safety with reactivity control via control drums and an emergency shutdown system to separate independent systems, and then heat removal, again, via heat pipes. And then in the accident condition, conduction and convection to their cannister continued system.

They have no active components in the sense, on the primary site, as we would think of from a traditional facility today.

But again, this is an example only, and its design is still early in the process -- it's early in the process from the perspective of they would have to demonstrate all of these features work the way they say they do before we'd consider moving forward with that.

Move on to the next slide. So for context on the SECY paper, small modular reactors had similar licensing and policy considerations as part of their development. In 2010, staff submitted a SECY paper regarding those issues that might require Commission

consideration to support future design and license re-applications.

The current envisioned structure for this paper is something similar but with issues that are more specifically tailored to micro-reactors. And the motivation for this is both for near-term applications, in the sense that we expect micro-reactor applications in the very term, and then for our longer term solutions in rulemaking space to make sure that micro-reactors are classified and reviewed commensurate with their risk and consequence impact.

And so the current vision for the paper is to present solutions for those near-term applicants that rulemaking might not serve and then also for a more holistic solution in the long-term.

So on the next slide, for context the micro-reactors that we anticipate seeing are going to be sited for things like military defense sites, very remote areas for micro-grids, and then some economic considerations that have been proposed for backup generation for facilities, things like desalination or process heating.

All the initially proposed designs share the small size, low potential consequences, and generally simpler design features as compared to the

traditional reactors that are even advanced on auto reactors.

And the motivation behind the paper we're looking to submit to the Commission is that many regulations that were constructed with large LWRs in mind may not make sense to a apply to micro-reactors in light of the operational model and anticipated safety characteristics. Again, we'd like to regulate these commensurate with their consequence and risk impacts.

Next slide. So in some cases, the review or purchase associated non-powered production of utilization facilities may be more appropriate. And we have a review infrastructure for those in place, in that micro-reactors and these non-powered production utilization facilities have similar size and consequences. So that gives us a framework to begin looking at the situation from. Again, that's not something we're necessarily proposing at this stage.

What we are evaluating is proposing a performance-based, consequence informed criteria, augmented by size as necessary, in that we would propose to classify micro-reactors by demonstrating a dose level at the site boundary that does not exceed some threshold that we haven't decided on yet, and

then potentially augmenting that with a size criterion because, for micro-reactors, we expect them to be much smaller in size than those proposed for --

What we don't want is for large non-LWRs that could potentially meet the dose criterion to come in with the same criteria as micro-reactors, in that some of the considerations that Bill's talked about was size, site sizing and population density considerations. As I have mentioned --

MEMBER CORRADINI: Boyce, may I ask --

MR. TRAVIS: Go ahead, Mike.

MEMBER CORRADINI: I just wanted to make sure I understood that second bullet. So I didn't completely understand what you're saying. Are you saying that at some size and below you're going to have a dose criteria at the site boundary, and therefore it would be a third pathway other than just being a small modular reactor?

Can you kind of re-explain the second bullet. You went a bit fast for me.

MR. TRAVIS: Yeah, sorry. Sure. So the current thinking for the paper is to potentially have a size consideration in terms of either power level, well, I'll just say power level for now, and have a dose threshold for which, if you met both of those

criteria, you would be classified as a micro-reactor. And then you could take advantage of some of the proposed approaches that will explore the specific issues that we'll talk about on the following slide.

MEMBER CORRADINI: So let me use the examples just so that I've got it straight.

MR. TRAVIS: Sure.

MEMBER CORRADINI: So it wouldn't be 50 megawatts electric, it might be something -- so 300, just for the sake of arbitrariness, 300 and below is defined as small modular reactor. Ten megawatts electric and below might be defined as a micro-reactor?

MR. TRAVIS: So I think that what we'd be saying is that, I'll use ten as an example, not that we're considering that number, but ten megawatts electric and below, and having a dose at the site boundary of less than some threshold would qualify you as a micro-reactor.

MEMBER CORRADINI: Okay. But then I want to link that back to what I thought you said, or maybe John, somebody said that if that's the case they may then get themselves in some sort of bind relative to the current siting regulations. And there would have to be a relaxation of the 25,000 person population

center also.

MR. TRAVIS: So I think the thinking right now is that, siting for future reactors, the hope would be that that criterion would not be something that they would get themselves in a bind with. But if they did that we would have, I mean, in a sense we'd still have the ability to evaluate issues like that on a case by case basis with exemptions.

And so for the operational cases that we've currently seen proposed, I don't think that that would be an issue for micro-reactors. But I wouldn't rule anything out at this point.

MEMBER CORRADINI: Okay. All right, but your point is that you guys are at least aware and thinking of that?

MR. TRAVIS: That's correct, yes.

MR. SEGALA: And this is John Segala.

MEMBER CORRADINI: The only reason that I bring this up is Bill Reckley's Case 3 is the one that I keep on narrowing down into trying to understand how we would approach it. So thank you.

MEMBER REMPE: So if you did that, let's talk about how you would side with the dose -- how the doses would be evaluated. Are you thinking you're going to make them do a maximum credible accident like

we do with the research reactors? Are you going to have them do a conservative? Are they going to have to do a systematic assessment of possible hazards associated with their widget?

MR. TRAVIS: So I think all three of those considerations are on the table. I think internally we, as a staff, are still discussing that. I think that we could see potentially a combination of a couple of those proposed approaches being how dose is calculated, given that part of our motivation is that we'd want to consider -- we want to make sure that we aren't excluding anyone purely on the basis of the methodology for calculating the dose.

MEMBER REMPE: As long as you're thinking about it.

MR. TRAVIS: Yeah. No, I think that's the largest consideration internally for how we're developing this paper, is we know that if we go through this approach, that threshold is going to be one of the larger sticking points for this. And so we want to make sure it's well founded.

CHAIR BLEY: Okay. One of the things I would hang up on is you don't have a set of initiating events for these. You don't have a set of design basis accidents. It's going to be probably pretty

tricky to come up with the accidents that need to be considered.

MR. TRAVIS: Right. And so I think the current thing for that dose threshold is that, no matter what is used to choose the initiating events, it would be the limiting, either limiting in a sense from a maximum hypothetical case, or limiting in a sense from the maximum consequence case for which all of the licensing basis events that are considered. And so --

CHAIR BLEY: The thing I'm kind of thinking about, if you use these for the sort of things I've heard about, you use them as a power source in some industrial application, if you're going to have this thing sitting close to other equipment, that isn't usually the thing we worry about for large power reactors. Maybe the accidents that could release the most would be something, you know, breaking one of these open, or something like that, from related equipment that's nearby.

MR. TRAVIS: Yeah.

CHAIR BLEY: And maybe that's not even a big deal.

MR. TRAVIS: And that might be true. I think that any consideration for the classification of

a micro-reactor would take into account external events and events around the site of facility. I'd say external events, traditionally that's seismic and things like that.

But external events in this case would also include industrial processes that are close by. And those evaluations are currently part of all reactor applications in that they look at nearby industrial facilities.

But in this case, if it's co-located with an industrial facility, those considerations would be amplified. It's something that would certainly have to be considered in that dose calculation.

And so, if we go on the next slide, so currently, the staff's thinking on the paper is to explore, and this is probably not an exhaustive list, issues related to micro-reactors where existing guidance and regulations may not be fully applicable.

And so using physical security and emergency preparedness as an example, existing rulemakings on these topics, which we have for both physical security and emergency preparedness, are well received by industry and viewed as something that will be utilized for micro-reactors.

However, specifically for micro-reactors,

the NEI working group and other industry stakeholders have stated they plan to seek or may plan to seek further steps with regards to those prescriptive requirements, both in Part 73 and for onsite emergency preparedness requirements.

In the case of aircraft impact, 50.150 requires that power reactors perform an assessment of the effects on the facility of a large commercial aircraft.

In the rulemaking, at the time the rule was promulgated, the Commission recognized that non-LWR functions may or may not be the same as those required for LWRs. And industry, specifically for micro-reactors, believes the size and location could play a role in the justification for taking exemptions from some of the requirements associated with aircraft impact.

Further and separately, existing guidance for aircraft impact precludes some considerations for assessing aircraft impact on below grade SFCs. And so that's something that could be a consideration for micro-reactors going forward.

One of the more interesting pieces for micro-reactors related to staffing and requirements for remode operation, so recently there have been

efforts on SMRs to provide a framework for reduced control room staffing that could be used similarly to reduce control room staffing specifically for micro-reactors.

But the control room staffing requirements represent only one part of the staffing, the total required staffing for the designs. And from what we understand from NSG, they've expressed interest in having very, very few operators on site for some of these micro-reactors and, in some cases, having autonomous operation which would be a pronounced departure from existing practice.

And because currently, we require an operator at the controls at all times, and only licensed operators are required or allowed to manipulate reactivity. And so this is an area where we would expect more design details and proposed staffing requirements, or proposals for staffing to fully assess those impacts.

CHAIR BLEY: We have regulations in these areas.

MR. TRAVIS: That's correct.

CHAIR BLEY: When I think about these things, I'm thinking most of our problems are with pumps, and pipes, and valves. We probably don't have

any pumps and valves, might have a valve of some sort. Don't have pipes in the traditional sense, or you might not.

When you think about aircraft impact, the first place my mind jumps to is thinking in terms of missile impact. And we allow a probability of the fifth calculation to suffice for dealing with the whole issue. And hitting one of these things with a hard part of an airplane's going to be pretty tough even if you set it up and try to do it yourself.

I think we've got to be thinking, well, you've got to meet the regulation or come up with some way to say that, you know, it really doesn't apply to this situation.

MR. TRAVIS: Oh, right. And that's, I mean, that's exactly the impetus behind the paper, is that we recognize that the regulations for these areas and others potentially were constructed with larger facilities in mind.

And we'd like to figure out a way to introduce a framework to either have a specific micro-reactor classification for these requirements or to have a framework in place to allow for, you know, exemptions that make sense or a classification structure that makes sense for micro-reactors where,

again, as you said, it's a very small site. The reliance on active components is substantially reduced.

And so these are the areas that we've identified that the current regulations have prescriptive requirements that may be associated with large facilities. But in cases for micro-reactors, it may not be practical or even applicable in some cases potentially.

But to go through the process of exemptions for every single micro-reactor design that came in is something that would be a substantial effort. And so this paper's trying to address that in a more holistic fashion.

CHAIR BLEY: I really look forward to seeing the paper. I look forward to seeing the stuff Mike talked about too. Because depending on what these things might look like, the whole class of accidents that can occur can be completely different.

MR. TRAVIS: Yeah, even on designs --

CHAIR BLEY: Two LOCAs make sense too. A loss of heat removal's probably always going to make sense. Some of the other kinds of accidents wouldn't make sense. It might vary greatly from one design to another. Sorry, Amy.

MS. CUBBAGE: Oh, no. I just wanted to offer, this is Amy Cubbage, NRC staff, that the diagram that Boyce referred to earlier with eVinci. They have submitted a pilot study on the licensing modernization focusing on internal events. But it may be interesting for you to take a look at it. It's posted on our public website.

MR. TRAVIS: The other number's on the slides.

MS. CUBBAGE: Yes, and --

CHAIR BLEY: Oh, okay. Good.

MS. CUBBAGE: -- everything's on our website. So it gives one developer's preliminary view of the types of initiators --

CHAIR BLEY: That they want to consider, okay.

MR. TRAVIS: Right. And so the one more I will hit on before we leave this slide is that we touched on earlier, between manufacturing, license, and transportable reactors, because the reactor is so small, integral manufacture of the nuclear portion of the reactor is a feasible approach. And some stakeholders have expressed interest in that.

And so that could be covered under our manufacturing license or a similar process. However,

there's also an interest in potentially pursuing a transportable design based on, as you noted, the DoD and DOE report and requirements.

And so that's something that we have only initially begun to consider what the potential impacts for that are. And that, again, is one of the largest issues probably facing this design.

The stationary micro-reactor is something that, again, we've touched on some prescripted requirements for large facilities. A transportable design is another thing entirely and something we're wrestling with to figure out how to address that and what the path forward's going to be.

MEMBER CORRADINI: So can I ask a question now, Boyce?

MR. TRAVIS: Sure, Dr. Corradini.

MEMBER CORRADINI: Since you've been at a lot of these meetings, is it at all conceivable that a commercial entity would want a transportable one? My impression was there's kind of a bifurcation that the military, and probably under 91b of the Atomic Energy Act, would worry about transportable. And fixed sites are more attuned to what you guys are going to have to deal with.

MR. TRAVIS: I think that, right now, the

thinking is along the lines of what you just said. But again, we don't want to preclude that from happening. And there's been some inkling from industry for something like disaster relief, like Puerto Rico, for example, to have the ability to have a reactor that you could -- it wasn't necessarily transportable in power, but you start it up somewhere, shut it down, move it, start it up again somewhere else. That is something that has been tentatively discussed by stakeholders.

MEMBER MARCH-LEUBA: Since this is going to be factory made, you have to transport it at least once. And most likely on decommissioning. So it can get realized.

MR. TRAVIS: Right. The potential for that, factory fueling, and testing, and shutdown, and then transporting it, it's something that --

MEMBER MARCH-LEUBA: Initial transport will be with a clean core which probably the licensee will be commissioning. But the decommissioning will be the worst condition.

MR. TRAVIS: Right.

MEMBER REMPE: From my understanding, other countries are offering this for sale to some countries that sell it --

MEMBER MARCH-LEUBA: They're moving it in boats.

MEMBER REMPE: Yeah.

MEMBER MARCH-LEUBA: And I don't think -- you're doing a high level licensing requirement. Are you giving any thought to licensing the fuel?

MR. TRAVIS: So right now the thinking is that fuel qualification would be done under a similar process than what exists now. But fuel qualification for advanced online water reactor designs in general is something we're looking at in more detail. Because there is a large spectrum of different fuel designs that will or could be used.

MEMBER MARCH-LEUBA: I'm very leary of --

MR. TRAVIS: That's correct, yes

MEMBER MARCH-LEUBA: It's really to uncertainty which is conservatisms.

MR. TRAVIS: That's exactly right. I mean, fuel qualification is another topic entirely. But we are looking at it in detail for all advanced online water reactor designs.

And I think the micro-reactor designs are somewhere where, as you said, there's not a lot of experience. There may not be a test base. And we're trying to figure out what the best path forward for

looking at that is.

MS. CUBBAGE: This is Amy Cubbage. I'd also like to offer that any micro-reactor design using TRISO particles, which could be many of them, can leverage the work the Department of Energy's done on the AGR test program.

MR. TRAVIS: Yeah, and along those lines, we have a topical report in-house for initial review of the TRISO fuel. We're putting a foundational test basis in place for review.

MEMBER MARCH-LEUBA: Can you just give me a sense if there's more than five people in the bridge.

MR. TRAVIS: I think it would be fair to say most of them plan to use high assay, low enriched uranium between five and 20 percent.

MEMBER MARCH-LEUBA: Last time we speak, the enriching facilities are unable to transport anything over five. I mean, there is no DoD-approved method of transport other than the 1-S, which is about like this size.

MR. TRAVIS: Yeah. That is one of the things being considered both for transportation and security requirements. There are additional security requirements associated with high assay limits.

MEMBER MARCH-LEUBA: The DoD --

MR. TRAVIS: Right.

MEMBER MARCH-LEUBA: -- doesn't allow it on the road.

MR. TRAVIS: The transportation package is a separate issue, yeah. We agree.

MS. CUBBAGE: At this time, we don't see those a policy issues. We see those as infrastructure issues.

MEMBER MARCH-LEUBA: I would expect, if private companies is putting money on this or at least charging DoD for doing this, they would like to implement it soon. They're not going to wait 15 years to present it. So the implementation, well, I guess it's their job to think about it.

MEMBER REMPE: So as part of your effort, are you considering facilities that might be needed to get required data? Or that's really someone else's problem?

MR. TRAVIS: I think it depends. I think, for the most part, the qualification in the fuel is the responsibility of the manufacturer or vendor. It's really the licensee.

MEMBER REMPE: Can you point and say you need to have some data to justify this as part of this

effort? I was just kind of wondering.

MR. TRAVIS: I think that's definitely -- speaking personally, I expect that data will be required for fuel qualification, for instance.

MEMBER REMPE: You think they don't, yeah.

MR. TRAVIS: Yeah.

MEMBER REMPE: I agree.

MS. CUBBAGE: These aren't unique to micro-reactors.

MR. TRAVIS: Right.

MEMBER REMPE: No, but with this --

MS. CUBBAGE: So this is why he's not really focused on it.

MEMBER REMPE: But when you talk about leveraging the DOE effort, some of this with the high assay, some of the non-TRISO ones also will need a lot of data to justify --

MS. CUBBAGE: Absolutely.

(Simultaneous speaking.)

MEMBER REMPE: -- a new manufacturer.

MS. CUBBAGE: It's an all non-LWR problem, not a micro issue.

MEMBER REMPE: You bet.

MR. TRAVIS: And then the last thing I'll mention on this slide is for siting environments, all

the staff is in the process of preparing an ISG for micro-reactor environmental reviews because of the substantially smaller size and site scope.

And I think that's the end of the presentation. No, excuse me, the most important slide, next steps. So currently staff plans to interact with stakeholders during the fall.

As I said, NEI is developing white papers and will be interacting at periodic stakeholder meetings on this topic to ensure that the views of all stakeholders are appropriately considered and dispositioned in the paper.

That's part of the reason we've come to the ACRS, is to again get your initial views on the topic. And we'll plan to come back at least once, if not twice, in preparation for the eventual SECY paper.

The plan is currently to develop a white paper, solicit comments via the similar process that was used for the siting paper. We'll put out a white paper at a stakeholder meeting, solicit comments. We'll come to the ACRS with the paper.

Then we'll get on with the SECY paper, a draft SECY paper, and work with the ACRS to schedule a subcommittee meeting sometime early next year and a full committee meeting on the draft SECY, probably in

the late winter, early spring timeframe.

CHAIR BLEY: Thank you. Anything from members?

(No audible response.)

CHAIR BLEY: Pretty interesting if we think about potential consequences is it a driver for our effort and yours? Somehow it seems we're going to spend more time on this issue than maybe we ought to. But it is new and requires some thinking.

At this time, I'm going to have the public phone line open. And then we'll look for comments there. Is there anyone in the room who would like to make a comment? If so, please come to the microphone and identify yourself.

When we open the public phone line, I'd like to start with Ed Lyman if he's there. He was -- you talked to our folks yesterday or day before and would like to make a comment. Then we'll go for other people.

The line's supposed to be open. Ed, are you on the phone?

MR. LYMAN: Yes, I am. Can you hear me well?

CHAIR BLEY: Very well, please go ahead.

MR. LYMAN: Okay, great. Thank you. I

appreciate the opportunity to make a few comments on the issue of siting near potentially populated urban areas. I just want to make a few points.

The first is there was a discussion with a long history of this issue. And of course, the ACRS itself, who was intimately involved in the original development of the siting criteria going back to your predecessor on the Reactor Safeguard Committee which if you've read Edward Teller's memoirs, was originally called the Committee for Reactor Protection by the Atomic Energy Commission because of its insistence on looking at the details and the actual safety characteristics of reactors in relation to where they should be sited.

So along with that history, I think it's critical when you look at that long history and the precedents in evaluating this issue. And I think it's really one of the most important things the ACRS can do.

I'll get to the point. And the reason why is because I'm very concerned about the direction the Commission is going in with regard to the defense reactor licensing.

The issue of defense in depth came up. Well, the current approach, I think, is violating

defense in depth in the context of all the cumulative changes that are being proposed to licensing for defense reactors, or non-light water reactors.

And these include not just the essential elimination of the promulgation urban siting, but also the reduction of the ETZ size, the reduction in security requirements, the reduction of operator/staffing requirements, the reduction in safety-related equipment requirements, the reduction in contaminant performance requirements.

And when you look at the cross-cutting justification for the reductions, it goes back to the PRA. So I would say this is a like a potential common cause failure, because the applicants to the NRC would like to propose a process in which the same tool can be used to, across the board, achieve reductions in these previous safety and security requirements.

And my concern is the cumulative impact of all those changes upon actual public health and safety, again going back to the PRA for paper reactors that will not have had any operating experience or validation.

And the Committee certainly knows the complexities of the consequence of PRA in consequence analysis either for operating reactors for which there

are decades of operating experience. The source terms are still mysterious associated within the Fukushima accident consequences, is still not fully explained in terms of the progression of the accident.

So to base all these -- the weakening of all those requirements across the board, based on these paper studies, is a violation of the PRA policy statement that strays far from the intent of the PRA policy statement to reflect a state of the art, that the use of PRA should be commensurate with the state of the art.

So it's really up to the ACRS, I think, to hold the line on what the Commission is doing. What are the issues with regard to sabotage? The issue came up of whether you should consider the single units or multiple-unit failures in developing any of these test-based approaches.

If you look at the issue of sabotage, given that reduction in security is one thing that is now being considered with the draft rulemaking process, a sabotage attack to defeat reactor cooling systems is probably not in a less than one year amount of time associated with disrupting one cooling system.

So if you look at the threat of sabotage that could lead to multiple reactor failures, that may

be a real probability if you just look at the accidents or frequency. So again, that's something that you should factor in.

And finally, the issue of societal safety goals and climate contamination while, again, because the Commission has refused to go in the direction of developing a prior contamination-based or a societal safety goal, that is allowing these kinds of approaches to go forward without due consideration of the societal impact.

So obviously, even if the dose at the site boundary is low toward these reactors, if you have them in the middle of a densely populated urban area, the ground contamination and the economic consequences could be quite severe.

And the current approach of the interface with societal components to take into account that long term rate of contamination, it's not going to appropriately value those effects.

So I don't think any of these approaches should go forward unless there's an associated ground contamination standard which is tied to the safety goals and to whatever other backfit analysis needs to be done for checking the adequate protection in these cases. And that's my statement. Thank you.

CHAIR BLEY: Thank you very much, Dr. Lyman. Anybody else on the phone line who would like to make a comment, please identify yourself.

(No audible response.)

CHAIR BLEY: I think that's all then. Thank you, we can close the --

MR. NGUYEN: Oh, yes. I --

CHAIR BLEY: Yeah, we can close the public line now, please. And now we'll go to the members on the phone. Mike --

MR. NGUYEN: Turn off your mic.

CHAIR BLEY: I did. Why don't we start with you, Mike?

MEMBER CORRADINI: Okay, thank you. Thank you, Dennis. First, let me thank the staff. I think this is an interesting discussion in both topics.

I guess I'd like to hear more about this when we move to the full committee, but my feeling is that the Option 3 approach is a reasonable approach as long as there is a defined technical basis as to why we would pick some of the numbers.

That's the reason I asked most of the questions. It's not that the qualitative approach is something that I would disagree with, rather I think it's an actually logical approach to doing things.

It's just the picking of the numbers. You've got to have some sort of basis. So that's why I was asking the questions of Bill and of the other staff.

As for the second topical area of micro-reactors, I think we're kind of too early in the game. And I guess I look forward to the topics that the staff is planning to assemble and put in their SECY when we see that in subsequent months. That's it.

CHAIR BLEY: Thank you, Mike. Harold?

MEMBER RAY: I agree with Mike, all that he said. I couldn't add anything more to it. Thank you.

CHAIR BLEY: Thanks, Harold. Dave Petti?

(No audible response.)

CHAIR BLEY: Are you still there, Dave?

MR. NGUYEN: He's here.

PARTICIPANT: Is he muted?

MR. NGUYEN: No, he's not muted.

CHAIR BLEY: Oh. Dave, we're hearing nothing. Unmute your mic if you're trying to talk.

MR. NGUYEN: He's done it himself before.

CHAIR BLEY: Okay.

MR. NGUYEN: And then I think we have Randy from Oak Ridge.

CHAIR BLEY: Yeah. Well, he's not --

(Off the record comments.)

MR. NGUYEN: Okay.

CHAIR BLEY: He's not one of ours. That's all on the line. Ron?

MEMBER BALLINGER: I think Mike has said exactly what my comments would be.

CHAIR BLEY: Okay. Thank you. Joy?

MEMBER REMPE: I also appreciated the discussion. I am very interested in the topic in both of the discussions.

With respect to the siting paper from the staff, I think that our letter will be very much dependent on a few of the details, questions, and promises from the staff on how they're going to flesh things out. And so I hope that those details are given to us in a way that we agree with. And so I, again, Option 3 seems reasonable, but I think more details are needed regarding how it's going to be approached and implemented.

With respect to the micro-reactors, there were a lot of papers that are coming up, the white papers by industry as well as the white paper that you're doing.

The website, I guess, Derek sent us a link to it, so we can look at that soon. But I think you

are touching on the appropriate topics but it's, you know, preliminary. But I appreciate you coming and talking to us early.

As those papers get developed, even before the SECY is developed, if you would be sure and contact Derek and let us see them, that would be good. You might even want to consider coming and talking to us before you have the final SECY with your white paper, if you feel that's not an imposition. I'd be interested in hearing about it sooner. So anyway, that's all my comments.

CHAIR BLEY: Thank you. How about Charles, you're up.

MEMBER BROWN: Yeah, just -- oh, thank you. Just my general conclusion from looking at it, I didn't disagree with the Option 3 approach for the most part.

But when people talk about performance-based, I automatically start thinking what's the performance basis against which I do a performance-based. And most of everything I read is pretty much judgmental and subjective which I don't object to either.

So I'm not really sure I would call this approach a performance-based technology inclusive type

thing. This is just a matter of re-examining the basis to see if a different set of metrics, judgement-wise, apply. But I guess we'll see where it goes.

There is no quantification that I can see that you can come up with, or at least I couldn't think of any in the process of reviewing all the stuff. So anyway, I appreciated the presentation.

CHAIR BLEY: Thanks, Charlie. Jose?

MEMBER MARCH-LEUBA: Okay. I want to repeat what everybody else says. As I physicist as well as an engineer, I like Option 3 because it has, quote/unquote, calculable boundaries based on objective criteria.

The problems I had is, as usual, with the implementation details. For you to be able to calculate those dose rates, you need to define the source term.

And one comment we're going to have, if you make it frequency-based, while there was the idea that any of these new reactors are going to have a core damage frequency lower than your boundary, or at least they're going to claim to. And they're going to say my dose rate is zero.

And therefore, we need to define something like the worst credible event if you were wrong or

something like this. I mean, we cannot allow a zero dose to be calculated. So write up for the SECY, option three is perfect.

Implementation details, we're going to have to work on the source term. Because that's where everything comes down to. What if you were wrong in that calculation, and you really did release some iodine?

On the details also, I like the one rem criteria, because it's very defensible. But as I said earlier, if I was writing a commercial for CNN, I would make it 100 millirem, because that is the background dose that you're getting every day. So if you put that plant in my backyard, and the worst thing happens to it, I would still not have all of my dose this year.

And this provenance, I want to be so safe that 100 millirem is the same thing in the water. And it's a few more feet for the boundary. So just think about it, that 100 millirem is more defensible.

Thank you for a great presentation.

CHAIR BLEY: Thank you. Vesna?

MEMBER DIMITRIJEVIC: Well, thanks for your presentation. For me that was very informative about the location. And I didn't really prepare well

for this meeting. So I have to think --

CHAIR BLEY: Okay.

MEMBER DIMITRIJEVIC: -- when I go back. The one thing which I want to say, what Mike said, that he would like to see technical basis for numbers. I don't think that he will be able to see that based on what you presented. Because there is no technical basis for the numbers, and this is not -- it is judgmental call.

So if you're writing the round numbers, then why don't you put 1,000 instead of 5,000. You know, it makes this a more relevant number. That's only basis, as you say, why people choose the one or two.

But this is definitely not a risk approach. And so maybe it's not even performance-based approach. I mean, it's basically more so in the context. So I do really have to think about what I would do in the case of this, so much uncertainty. I will think I will choose the simplest, keep it simple, it was our knowledge in doing it that way, how to calculate it.

CHAIR BLEY: Thank you, Vesna.

Is Harold back, I mean, Dave?

MR. NGUYEN: Yes. I had a message from

Member Petti. Quote, just tell the Committee I agree with Mike C's comments, end quote.

(Laughter.)

CHAIR BLEY: Okay. I too want to thank you all for good presentations and good discussions. I'd emphasize a few things that came up from my colleagues around the table.

But maybe the biggest one, and I noticed in the Oak Ridge report, because they went through looking at our great improvements in our ability to calculate source terms or calculate consequences, he said but then we get surprises.

And they brought up Fukushima and how you got more out than you would have thought about if you didn't think about the particular sequence of events that happened there.

And I think that's the thing with some of these new ones. We really have to be sure we're creative in thinking about the things and combinations of things that could go wrong. And I don't know a better way to do that than to try to do a good PRA. But it requires some real creative thinking.

I think that applies maybe. I won't say even more, but certainly it applies to the micro-reactors as well, because here's a place where our

history of what we look may not be the right thing to help us decide what to look at for these.

Joy mentioned the hope of another subcommittee meeting before we get to the full committee on this.

MEMBER REMPE: That's on the micro-reactors. It's not on the --

CHAIR BLEY: Oh, on the micro, sure. Okay.

MEMBER REMPE: -- siting.

CHAIR BLEY: Good, I wanted to make sure that was straight.

MEMBER REMPE: Yeah. I just think there's a lot of work that's going to have to be done. So I emphasized that.

CHAIR BLEY: The one thing I'm a little worried about, and Derek, you're on the line, we only have a couple of weeks before the full committee meeting. And getting a chance to look through this transcript, I think, will be pretty important before we actually write a letter. So this is one, based on the timing to the letter, that I think I'd like to push our organization to try to get it as fast as possible so we can include that.

On that other line, I think Ed Lyman brought up a lot of interesting things, some of which

we've talked about and some of which maybe we didn't, that, you know, point to the same things. When we have paper studies of paper designs, the real work's going surprise us. And we have to allow something for that and figure out the best way to do that.

I don't have anything more. Again, thanks to everyone. Thanks to all the members for a good meeting, and at this point we'll adjourn.

(Whereupon, the above-entitled matter went off the record at 12:08 p.m.)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

ACRS Future Plant Designs Subcommittee

Draft Commission Paper

"Population-Related Siting Considerations for Advanced Reactors"

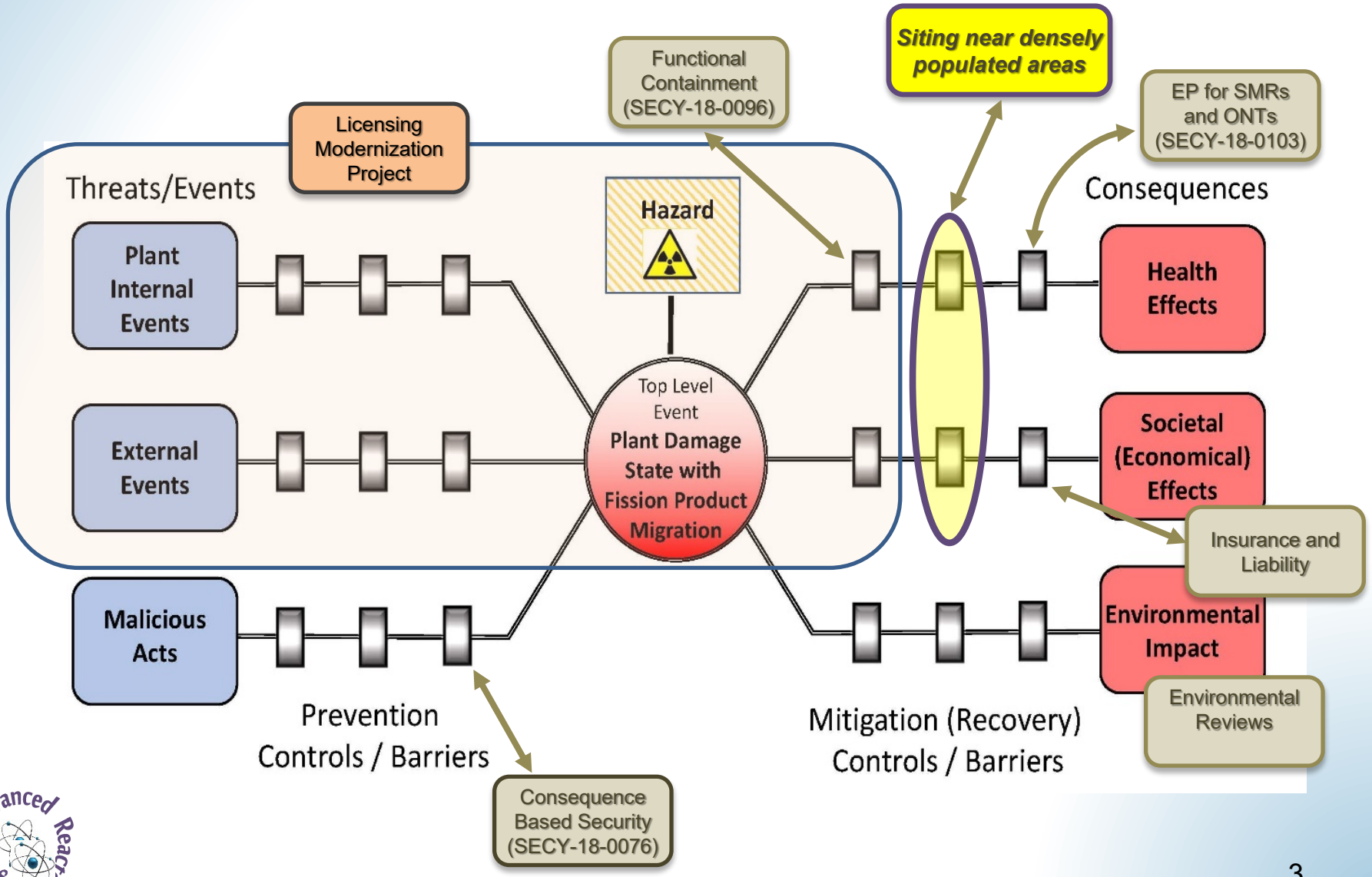
August 23, 2019

Draft SECY Paper

(ADAMS Accession No. ML19203A219)

- Purpose
  - The purpose of this paper is to provide options and a recommendation to the Commission on possible changes to guidance documents associated with population-related siting considerations for advanced reactors. The staff's recommendation is to pursue a revision to the population-related guidance to provide technology-inclusive, risk-informed, and performance-based criteria to assess population related issues in siting advanced reactors.
- Background (Regulations & Guidance)
- Discussion (Options)
- Recommendation

Background - Integrated Approach

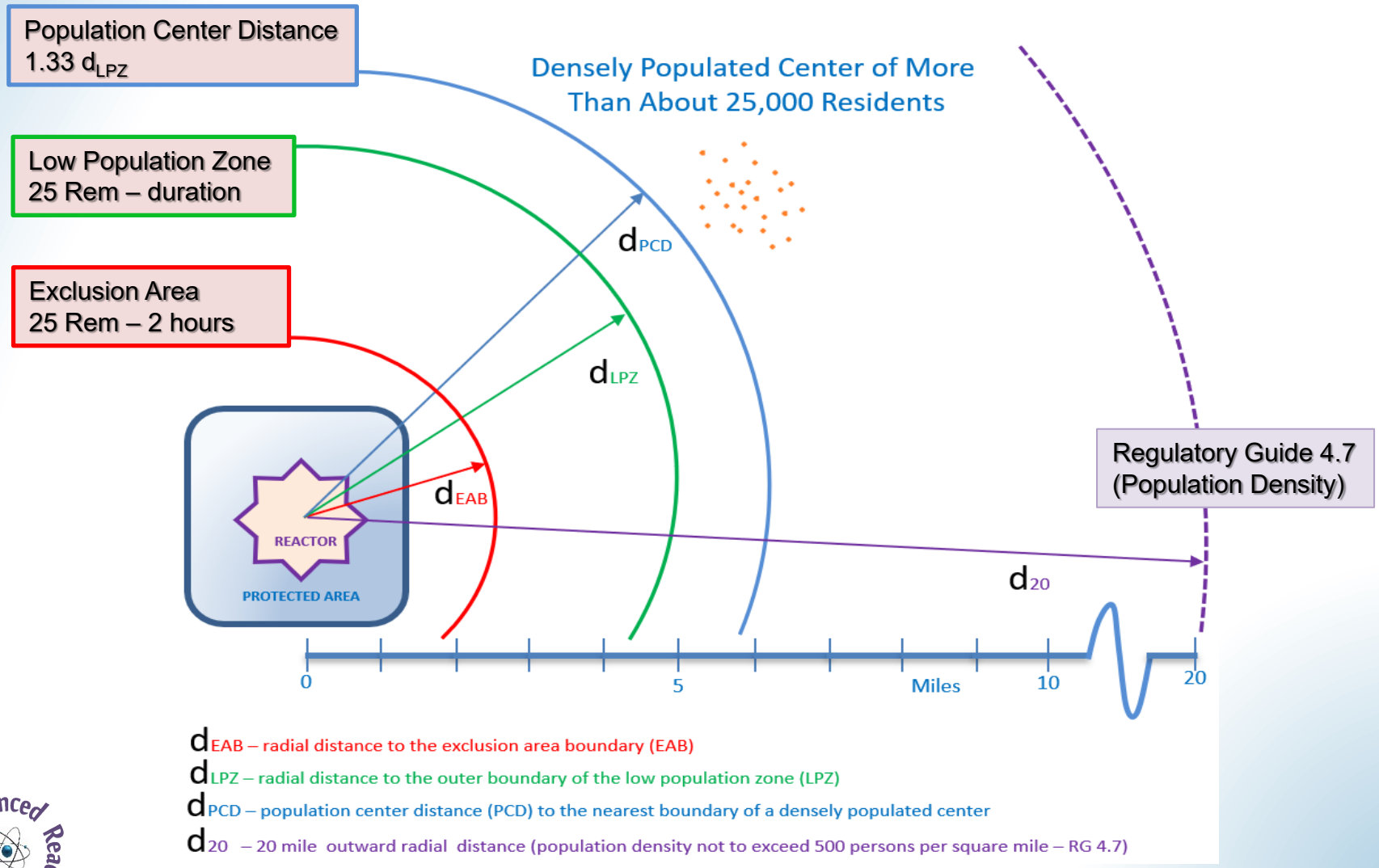


Background – Requirements/Guidance

- Regulations
  - 10 CFR 100.21, "Non-Seismic Site Criteria"
    - (a) Must have exclusion area and low population zone (LPZ)
    - (b) Population center distance (1.33 LPZ)
    - (c) Radiological effluents, Radiological consequences
    - (h) Located away from very densely populated centers (25,000 residents) and low population density preferred
  - 10 CFR 50.34 (52.79), Content of Applications
- Regulatory Guide (RG) 4.7, "General Site Suitability Criteria for Nuclear Power Stations"

> *A reactor should be located so that, at the time of initial plant approval within about 5 years thereafter, the population density, including weighted transient population, averaged over any radial distance out to 20 mi (cumulative population at a distance divided by the circular area at that distance), does not exceed 500 persons per square mile. A reactor should not be located at a site where the population density is well in excess of this value.*

Background – Requirements/Guidance



Background - Policy Issue

- NRC Non-Light Water Reactor Near-Term Implementation Action Plans (July 2017, ML17165A069; Strategy 5 – Policy Issues)
- SECY-16-0012, “Accident Source Terms and Siting for Small Modular Reactors and Non-Light Water Reactors” (February 7, 2016; ML15309A319)

- DOE website describes advanced reactors (in particular SMRs) as having greater scalability and siting flexibility for locations that are unable to accommodate more traditional larger reactors. This would include providing an energy source that does not emit greenhouse gases for smaller electrical markets, isolated areas, smaller grids, sites with limited water and acreage, or unique industrial applications.

Background – Advanced Reactors

- Advanced Reactor Policy Statement
  - … attributes that designers of advanced reactors should consider, including highly reliable and less-complex heat removal systems, longer time constants before safety system challenges occur, the reduced potential for severe accidents and their consequences, and the use of the defense-in-depth philosophy to maintain multiple barriers against radiation release.
- 10 CFR Part 100 Rulemaking (1996)
  - … The consequences of design basis accidents, analyzed using revised source terms and with a realistic evaluation of engineered safety features, are likely to be found acceptable at distances of 0.25 miles or less. With regard to population density beyond the exclusion area, siting a reactor closer to a densely populated city than is current NRC practice would pose a very low risk to the populace.
  - Nevertheless, the Commission concludes that defense in depth considerations and the additional enhancement in safety to be gained by siting reactors away from densely populated centers should be maintained.

Discussion - Options

- Two potential issues identified:
  1) 500 people per square mile (ppsm) out to a distance of 20 miles
  2) 500 ppsm close to reactor site used for small communities

  – Background and references in ORNL/TM-2019/1197
  (ADAMS Accession No. ML19192A102)

- Staff developed several options for consideration:
  – Option 1 – Status Quo
  – Option 2 – Source Term Factor
  – Option 3 – Offsite Dose Calculation
  – Option 4 – Develop Societal Risk Measures

Option 1 (Status Quo)

Advantages

- Save resources by deferring case-by-case assessments until there is increased certainty of applications

Disadvantages

- Case-by-case assessments do not reduce regulatory uncertainties
- Funding for advanced reactor activities available now

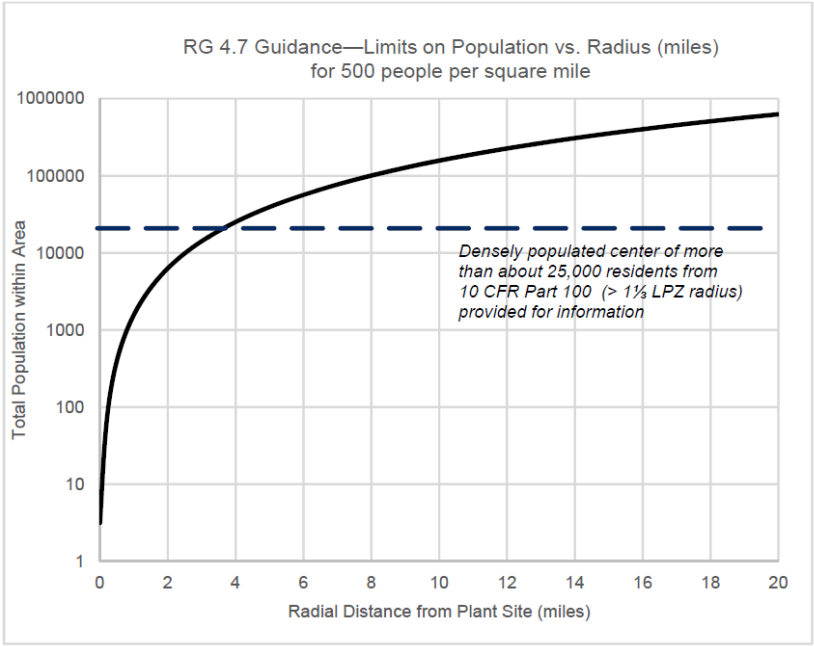


Figure 2 RG 4.7 limits on total population versus radius

Distance (m)	Total Population
1	1,571
2	6,283
4	25,132
5	39,270
10	157,078
15	353,426
20	628,312

Option 2 (Source Term Factor)

Description

- Maintain EAB and LPZ for event sequence doses of 25 rem over 2 hours and course of event respectively
- Maintain distance from densely populated center of more than about 25,000 residents
- An acceptable approach for assessing population density and associated areas is to maintain a roughly equivalent societal risk (SR) using a source term factor associated with radionuclide inventories and potential releases (e.g., power level) and assuming that the potentially contaminated area is proportional to the source term factor

Option 2 (Source Term Factor)

$SR = \pi r^2 \times D \times ppsm$

where:

SR represents societal risk

r is the radial distance from a reactor site

D is a factor representing the source term or radioactive material released from a facility

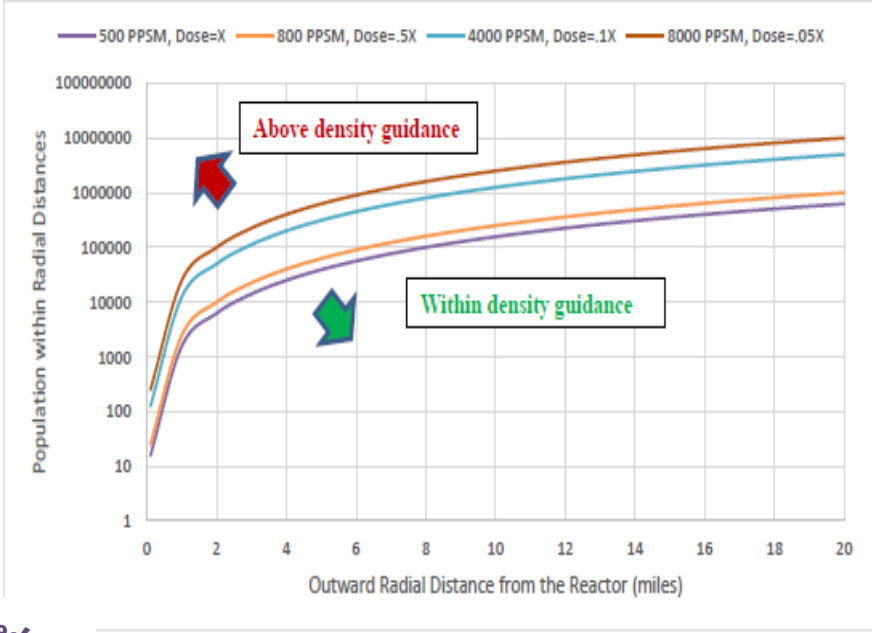


Figure 5. Population density comparison.

Table 1. Population density calculation results

Source term		×	0.5×	0.1×	0.05×
Radius (miles)		20	14.1	6.3	4.5
25% margin (miles)			15.8	7.1	5
	Pop. density:	500	800	4,000	8,000
Miles	Area	Population			
0.1	0.03	16	25	126	251
1	3.1	1,571	2,513	12,566	25,133
2	12.6	6,283	10,053	50,265	100,531
3	28.3	14,137	22,619	113,097	226,195
4	50.3	25,133	40,212	201,062	402,124
5	78.5	39,270	62,832	314,159	628,319
6	113.1	56,549	90,478	452,389	904,779
7	153.9	76,969	123,150	615,752	1,231,504
8	201.1	100,531	160,850	804,248	1,608,495
9	254.5	127,235	203,575	1,017,876	2,035,752
10	314.2	157,080	251,327	1,256,637	2,513,274
11	380.1	190,066	304,106	1,520,531	3,041,062
12	452.4	226,195	361,911	1,809,557	3,619,115
13	530.9	265,465	424,743	2,123,717	4,247,433
14	615.7	307,876	492,602	2,463,009	4,926,017
15	706.9	353,429	565,487	2,827,433	5,654,867
16	804.2	402,124	643,398	3,216,991	6,433,982
17	907.9	453,960	726,336	3,631,681	7,263,362
18	1,017.9	508,938	814,301	4,071,504	8,143,008
19	1,134.1	567,057	907,292	4,536,460	9,072,920
20	1,256.6	628,319	1,005,310	5,026,548	10,053,096

Option 2 (Source Term Factor)

Example

- Source Term Factor of 5% (e.g., 50 Mwe)
- Affected area proportional – 63 square miles vs. 1,256 square miles
- Corresponding radius 4.5 miles (5 miles with margin)
- Population density of 8000 ppsm
  - $(628{,}000/ \pi 5^{2})$
- Consider 10 CFR Part 100 Requirements

Option 2 (Source Term Factor)

Advantages

- Supports the policy on siting plants away from population centers and introduces a variable criterion based on source term or power level
- Variable criterion is based on a general relationship between possible radiological releases and the inventory of radionuclides (e.g., power level) while otherwise maintaining the independence between siting and design
- Promotes regulatory stability and predictability by replacing single prescriptive criterion with technology-inclusive guidance based on general, high-level relationships

Disadvantages

- Requires expending resources (remedied somewhat by budget appropriations)
- Possible negative perceptions of reducing practice of site approvals being independent of reactor designs

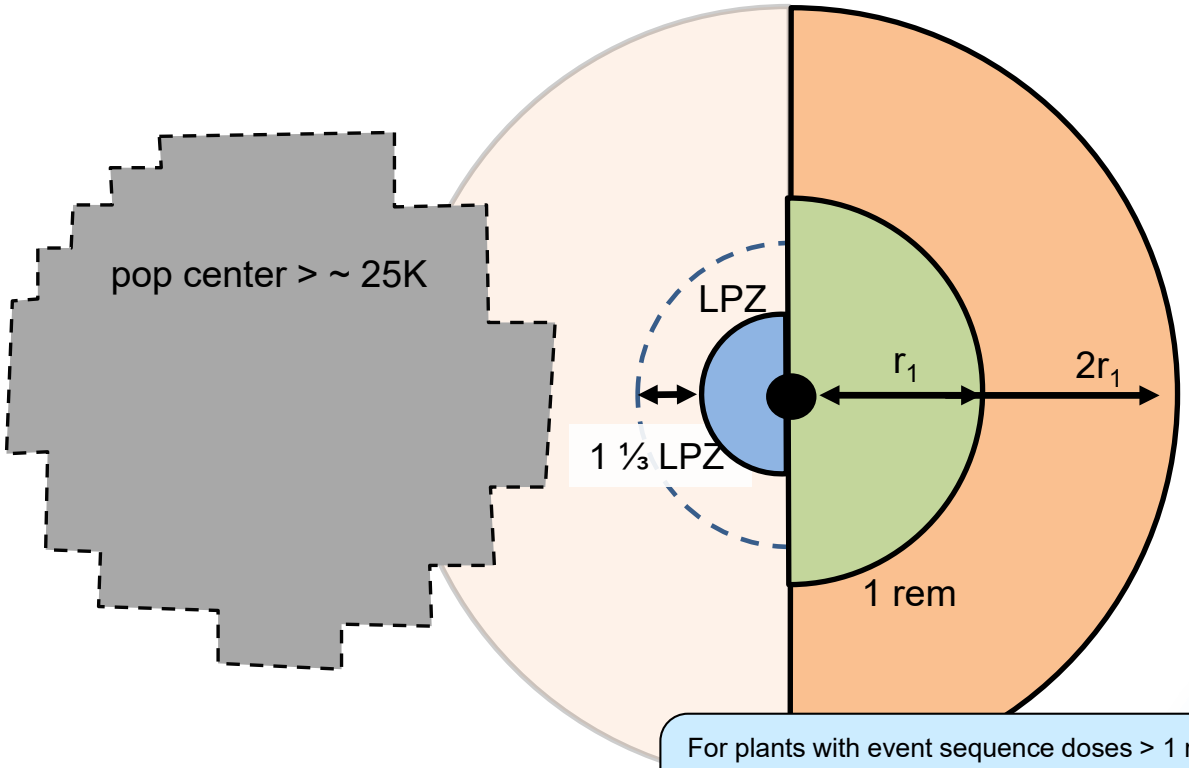
Option 3 (Offsite Dose Calculation)

Description

- Maintain EAB and LPZ for event sequence doses of 25 rem over 2 hours and course of event respectively
- Maintain distance from densely populated center of more than about 25,000 residents
- For plants with event sequence doses > 1 rem over a month beyond the site boundary (DBEs and BDBEs as defined in DG-1353), population density < 500 ppsm over the radial distance equal to twice the radius at which 1 rem over a month is estimated

Option 3 – Case 1

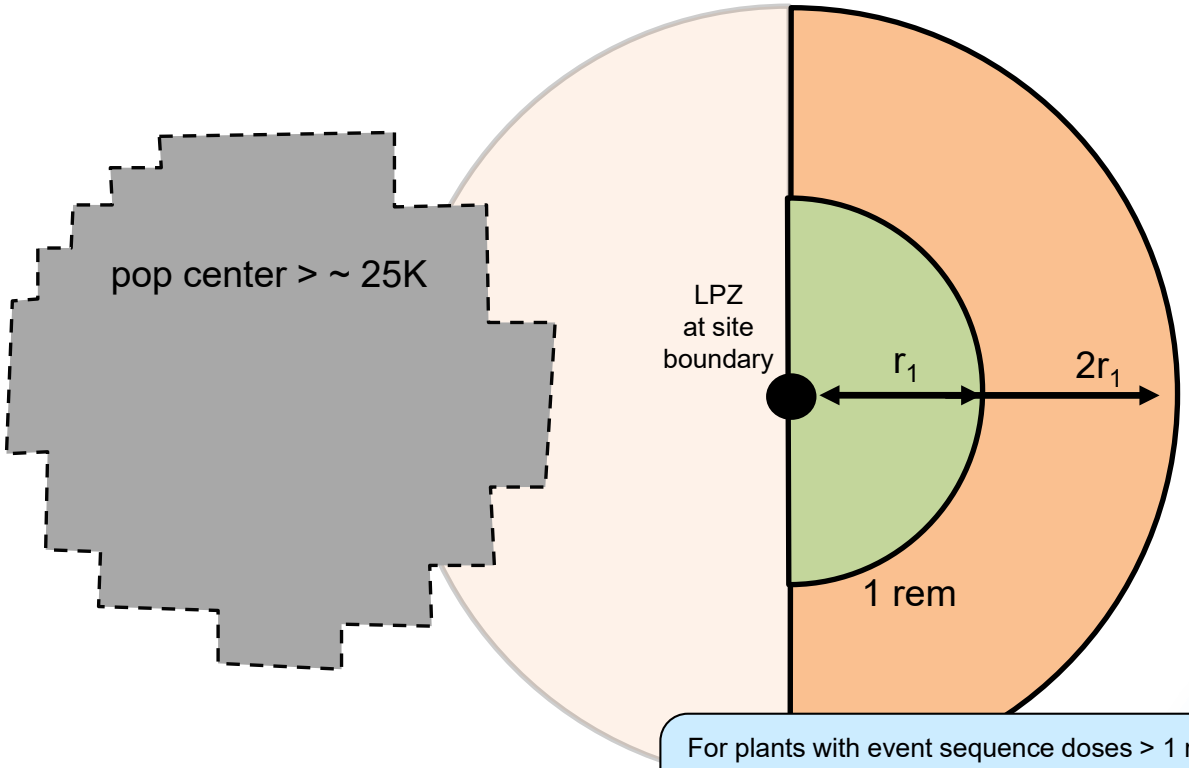
Case 1:
Event Sequences with Offsite Doses > 25 rem over course of event
Event Sequences with Offsite Doses > 1 rem over the month following event



For plants with event sequence doses > 1 rem over a month beyond the site boundary (DBEs and BDBEs as defined in DG-1353), population density < 500 ppsm over the radial distance equal to twice the radius at which 1 rem over a month is estimated

Option 3 – Case 2

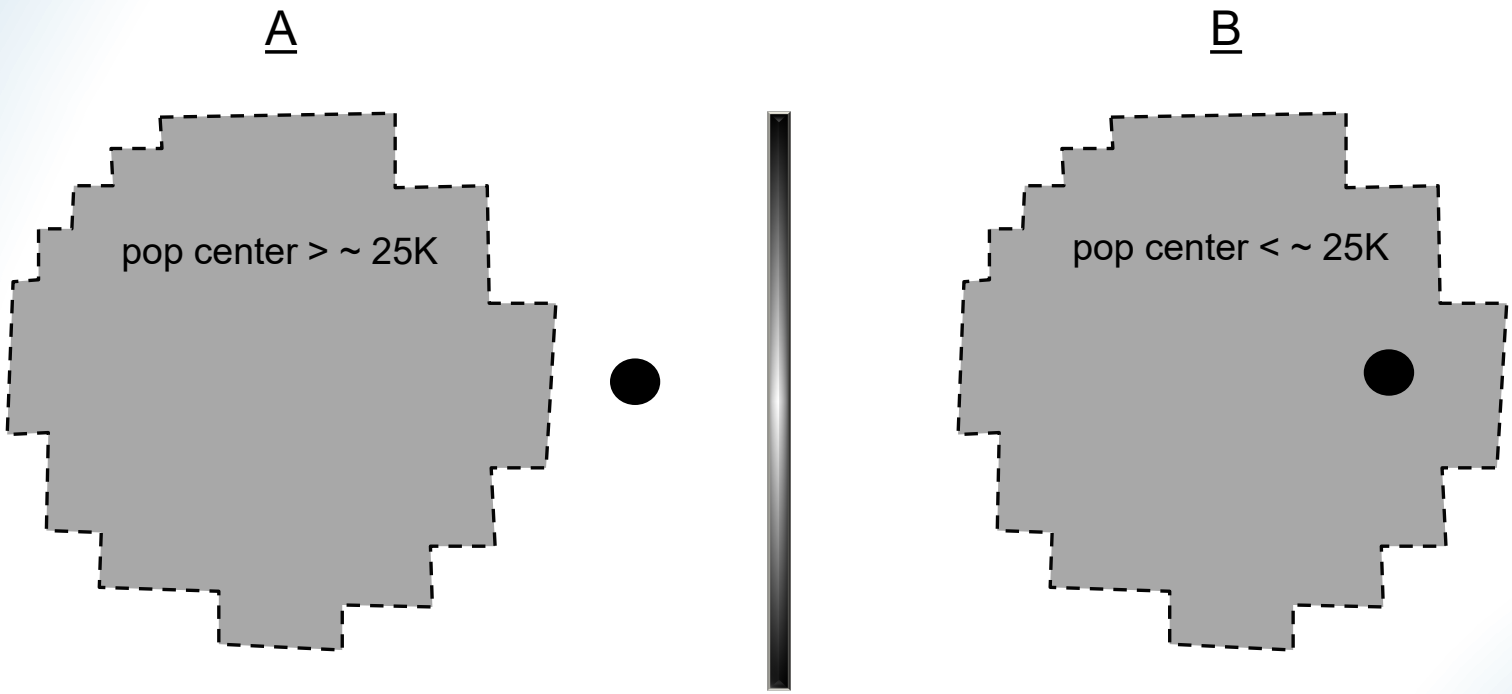
Case 2:
No Event Sequences with Offsite Doses > 25 rem over course of event
Event Sequences with Offsite Doses > 1 rem over the month following event



For plants with event sequence doses > 1 rem over a month beyond the site boundary (DBEs and BDBEs as defined in DG-1353), population density < 500 ppsm over the radial distance equal to twice the radius at which 1 rem over a month is estimated

Option 3 – Case 3

Case 3:
No Event Sequences with Offsite Doses > 25 rem over course of event (LPZ at site boundary)
No Event Sequences with Offsite Doses > 1 rem over the month following event



Population center distance means the distance from the reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents

Option 3 (Offsite Dose Calculation)

Advantages

- Allows consideration of the design- and site-specific accident consequences and specific features of an advanced reactor design that may limit the release of radionuclides beyond the likely lesser power levels
- Promotes regulatory stability and predictability by replacing single prescriptive criterion with technology-inclusive, performance-based approach

Disadvantages

- Requires expending resources (remedied somewhat by budget appropriations)
- Possible negative perceptions of reducing practice of site approvals being independent of reactor designs

Option 4 (Societal Risk Measures)

- Develop societal risk measures for assessing specific advanced reactor designs at specific sites
- Consider factors beyond the potential dose to individuals and populations, including matters such as adverse effects on economies, land availability, population displacement, and decontamination costs

Advantages

- Provides assessment of the societal risks associated with a specific reactor design located on a specific site for comparison to other societal risks or performance measures

Disadvantages

- Significant resources and time to develop
- Significant change from considering siting as an independent element of defense in depth
- May require the NRC to characterize nonnuclear risks (e.g., natural disasters and other energy supplies)

Recommendation

- The staff recommends that the Commission approve Option 3, which consists of revising guidance to provide technology-inclusive, risk-informed, and performance-based criteria to assess population-related issues in siting advanced reactors.

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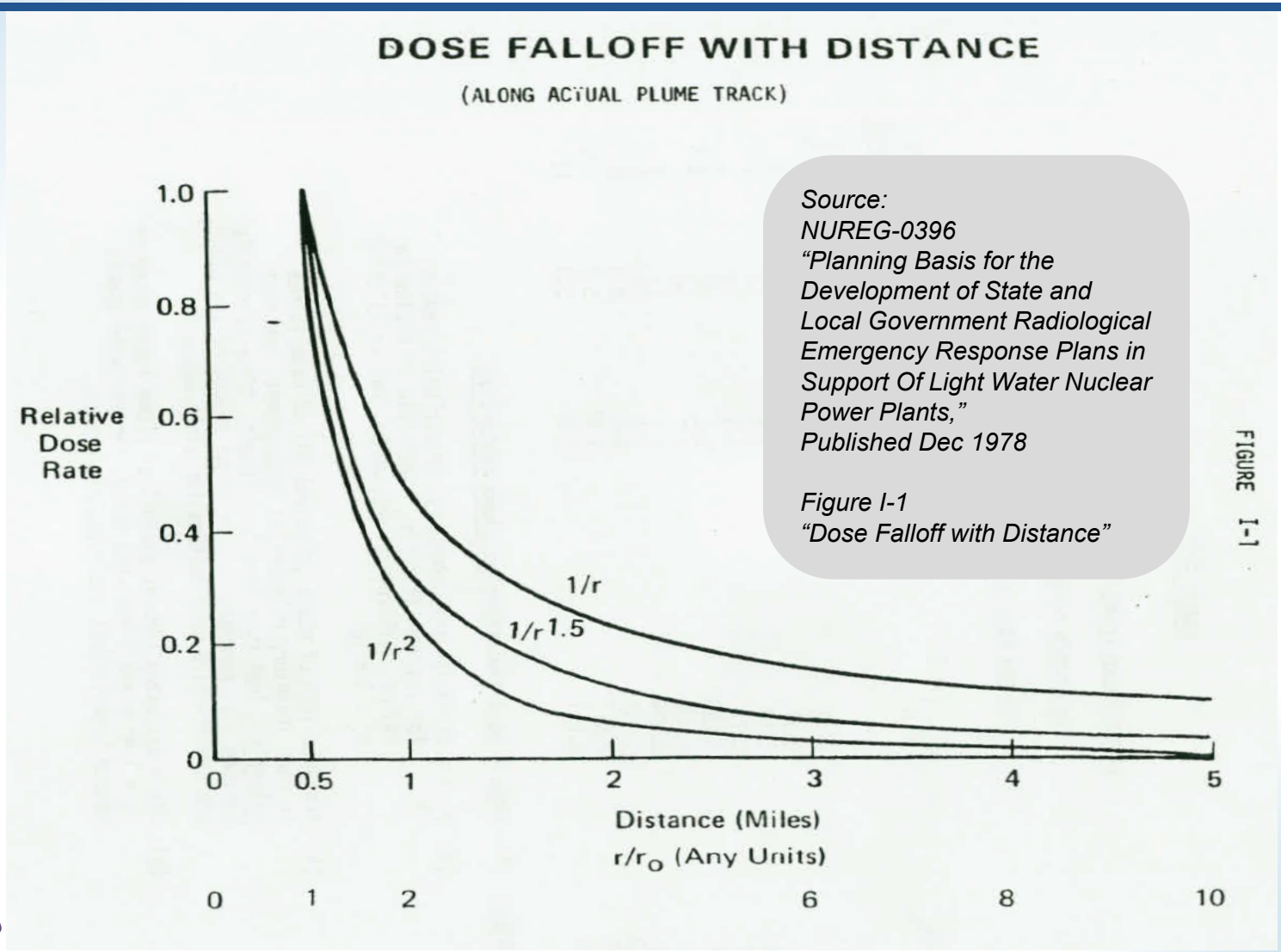
Population-Related Siting Considerations Discussions

Advanced Reactor Program

Backup Slide



Source:
NUREG-0396
"Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support Of Light Water Nuclear Power Plants,"
Published Dec 1978

Figure I-1
"Dose Falloff with Distance"

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ACRS Future Plant Designs Subcommittee

Micro-Reactor Licensing and Policy Considerations

August 23, 2019

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Purpose

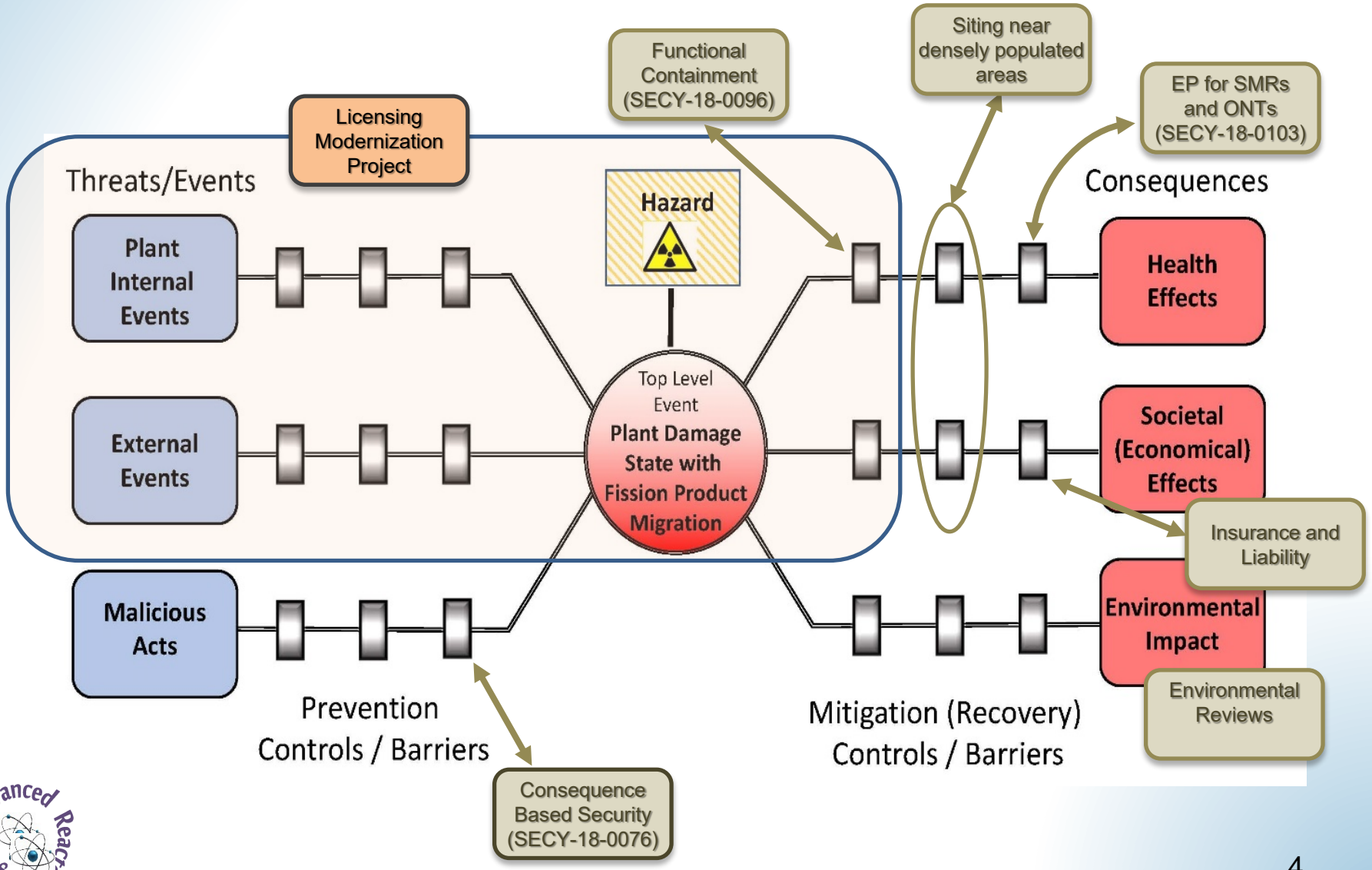
- Introduce some potential issues related to micro-reactors
- Discuss current and planned activities on micro-reactors
- Solicit preliminary ACRS thoughts on the topics presented

Advanced Reactor Program

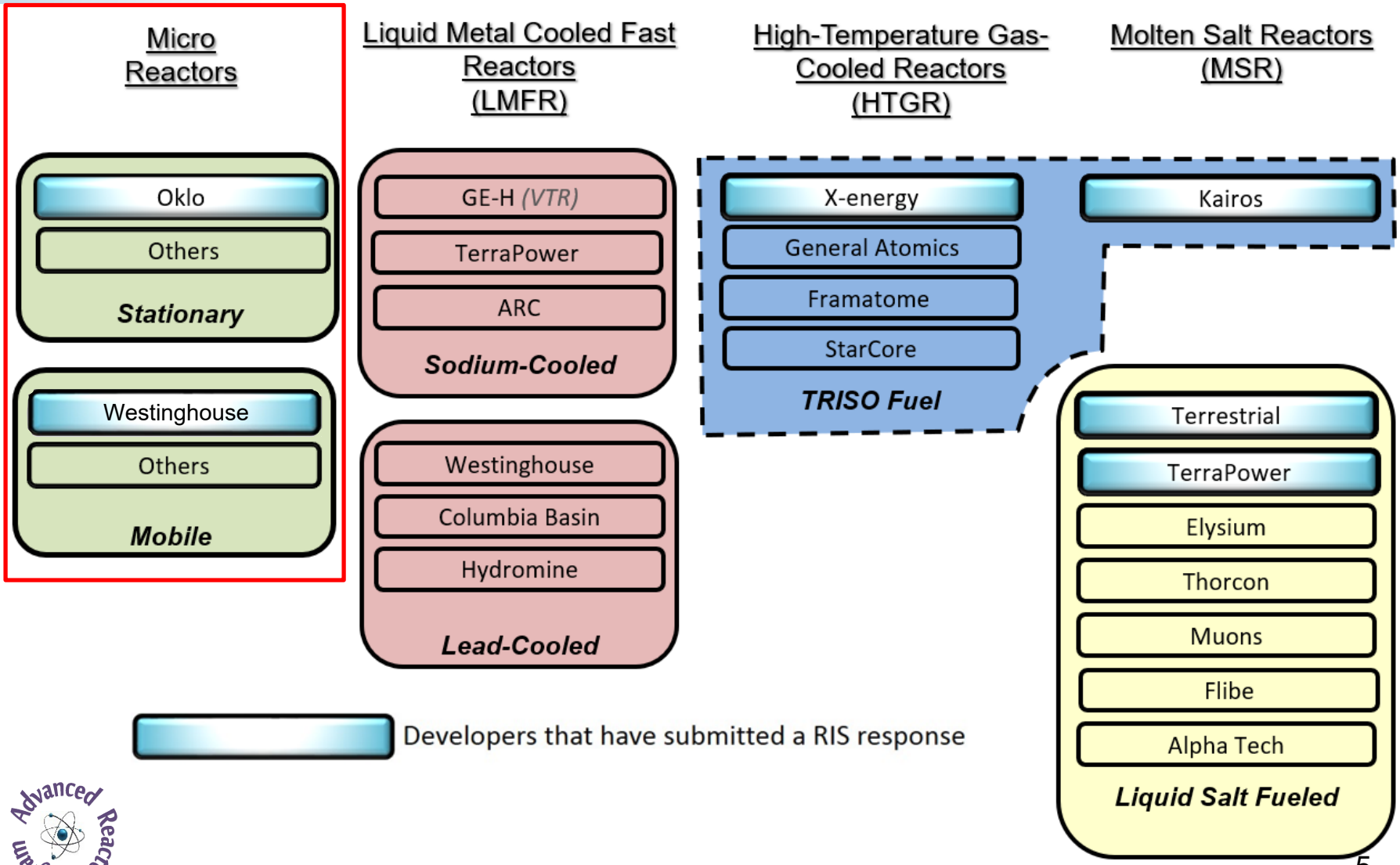
Background – Implementation Action Plan

Strategy 1 Knowledge, Skills and Capability	Strategy 2 Computer Codes & Review Tools	Strategy 3 Flexible Review Processes	Strategy 4 Consensus Codes and Standards	Strategy 5 Policy and Key Technical Issues	Strategy 6 Communication
ONRL Molten Salt Reactor Training	Identification & Assessment of Available Codes ✓	Regulatory Roadmap	ASME BPVC Section III Division 5	Siting near densely populated areas ✓	NRC DOE Workshops
Knowledge Management		Prototype Guidance	ANS Standards 20.1, 20.2 30.2, 54.1	Insurance and Liability	Periodic Stakeholder Meetings
Competency Modeling		Non-LWR Design Criteria ✓	Non-LWR PRA Standard	Consequence Based Security (SECY-18-0076)	NRC DOE GAIN, NEICA & VTR MOUs
Fast Reactor Training		Environmental Reviews		EP for SMRs and ONTs (SECY-18-0103) ✓	NRC DOE DOD Micro Reactor MOU
HTGR Training		Licensing Modernization Project ✓		Functional Containment (SECY-18-0096) ✓	International Coordination
				Micro Reactor Issues	

Background - Integrated View of Safety



Background – Prospective Applicant Landscape



What are micro-reactors?

- No single agreed upon definition
  - 2019 Defense Authorization Act uses less than 50 MWe
  - DOE lists three main features: “factory fabricated, transportable, and self-regulating utilizing passive safety systems”

- For the purposes of discussion here, micro-reactors are anticipated to have the following attributes:
  - Small, both in thermal power level and site size
  - Non-LWRs
  - Reduced reliance on complex safety systems, coupled with more inherent safety features
  - Have low potential consequences as a result of an accident

DOD/DOE Micro-reactor efforts

- DOD (through Strategic Capabilities Office) has a Request for Solutions for a micro-reactor that is 1-10 MWe, transportable by a C-17, inherently safe TRISO fueled design

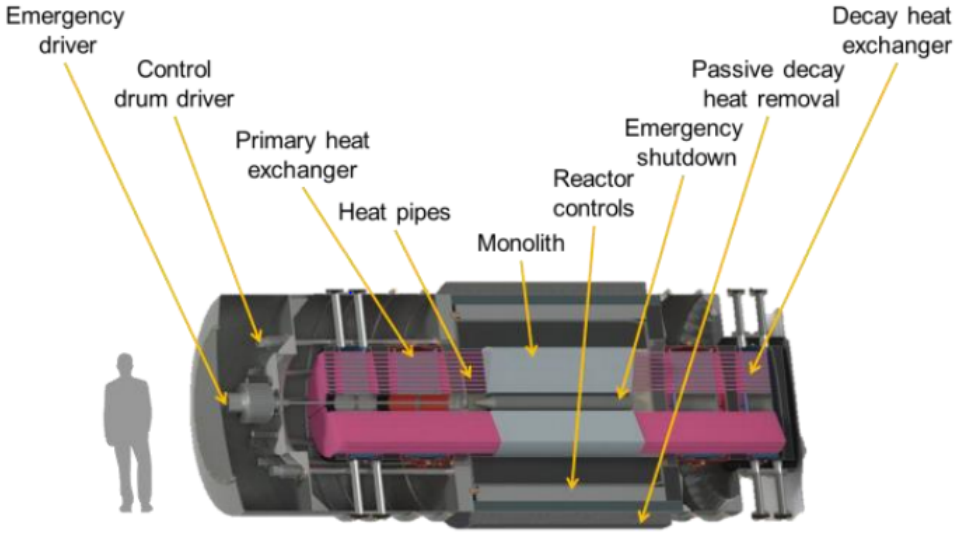
- Separately, DOE has provided funding opportunities to some developers and has been tasked by Congress with preparing a report on a pilot program to utilize nuclear micro-reactors to enhance energy resiliency at certain Federal facilities

NEI Micro-reactor task force

- NEI recently established a micro-reactor task force to evaluate potential issues related to micro-reactors

- They plan to draft white paper(s) on some or all of the following topics viewed as high priority issues:
  - Scope and level of effort of micro-reactor review in relation to the safety case
  - Aircraft Impact
  - Operations and staffing requirements
  - Resident inspectors
  - Physical security
  - Emergency preparedness

Example – Westinghouse eVinci micro-reactor



- Recent eVinci LMP pilot demo (ML19227A322)
- Preliminary design, limited scope
- 1 to 14 MWt
- Fission Product Barriers
  - Solid monolithic block encapsulates fuel channels
  - Surrounding monolith block
  - Canister Containment System
- Further “Secure Vault” protects from external events
- Inherent Safety
  - Reactivity control via control drums and emergency shutdown system
  - Heat removal by heat pipes (normal) and conduction and convection to canister containment system
- No mechanical pumps, valves, or large primary loop piping

Potential Policy Issues

- In 2010, staff submitted a SECY information paper (SECY-10-0034) regarding potential policy, licensing, and key technical issues that could require Commission consideration to support future design and license review applications for small modular reactors (SMRs)
- Staff plans a proposed paper that reviews issues in a similar fashion for micro-reactors
- Staff considering both near-term (e.g. exemptions) solutions to address early movers and longer-term resolutions (changes to framework or rulemaking) for the potential issues

Micro-reactors - Context

- Substantial recent interest in micro-reactor designs from private industry, DOE, and DOD for variety of traditionally non-nuclear applications:
  - military defense sites,
  - remotely sited areas (micro-grid)
  - utilization as back-up generation
  - process heating

- Initially proposed micro-reactors anticipated to share small size, low potential consequences, and generally simpler designs

- Many regulations that were constructed with large LWRs in mind may not make sense to apply micro-reactors in light of their operational model and anticipated safety characteristics

Micro-reactors – Exploring Different Approaches

- In some cases, review approaches associated with non-power production or utilization facilities may be more appropriate, due to the potential reduced size and consequences of a micro-reactor

- Staff is evaluating options proposing a performance based, consequence informed criteria, augmented (e.g. by size) as necessary
  - Provided a micro-reactor can demonstrate the dose at the site boundary does not exceed some threshold, staff would propose classifying and reviewing micro-reactors using a modified approach

- In the short-term, this approach would involve exemptions or other licensing vehicles for individual applicants, as needed; in the long term, staff could propose a rulemaking to classify micro-reactors and establish requirements

Micro-reactors – Policy and Licensing Considerations

In an upcoming white paper, staff plans to explore the following issues related to micro-reactors where existing guidance and regulations for power reactors may not be fully applicable:

- Security Requirements
- Emergency Preparedness
- Staffing Requirements
- Remote Operation
- Aircraft Impact
- Oversight, Annual Fee Structure
- Manufacturing licenses and Transportable Reactors
- Siting and Environmental

Next Steps

- Staff plans to interact with stakeholders during the fall to ensure views are appropriately considered and dispositioned in white paper
- Complete white paper and solicit comment
- Staff will then develop a SECY paper
- Staff will then work with ACRS to schedule a subcommittee and full committee meeting on the draft SECY early next year

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Discussion