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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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DESIGN CENTERED LICENSING: TERRAPOWER SUBCOMMITTEE

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WEDNESDAY

AUGUST 23, 2023

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The Subcommittee met via hybrid in-person and Video Teleconference, at 8:30 a.m. EDT, Thomas Roberts, Chairman, presiding.

COMMITTEE MEMBERS:

THOMAS ROBERTS, Chair

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR., Member

VICKI BIER, Member

VESNA DIMITRIJEVIC, Member

GREGORY HALNON, Member

WALT KIRCHNER, Member

JOSE MARCH-LEUBA, Member

ROBERT MARTIN, Member

DAVID PETTI, Member
JOY L. REMPE, Member

ACRS CONSULTANT:
DENNIS BLEY
STEVE SCHULTZ

DESIGNATED FEDERAL OFFICIAL:
KENT HOWARD

ALSO PRESENT:
REED ANZALONE, NRR
BRIAN JOHNSON, TerraPower
NICK KELLENBERGER, TerraPower
ED LYMAN, Public Participant
CANDACE DE MESSIERES, NRR
SCOTT MOORE, ACRS
GEORGE PICCARD, TerraPower
JESSE SEYMOUR, NRR
MALLECIA SUTTON, NRR
ERIC WILLIAMS, TerraPower
GEORGE WILSON, TerraPower
EMILY YOUNG, TerraPower

C-O-N-T-E-N-T-S

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

8:30 a.m.

CHAIR ROBERTS: This meeting will now come to order. This is a meeting of the ACRS Subcommittee for the TerraPower NATRIUM Design Reactor. I'm Tom Roberts, Chair of the Subcommittee.

ACRS members in attendance are Ron Ballinger, Juan, or Jose March-Leuba, Matt Sunseri, Dave Petti, Joy Rempe, Bob Martin, Vicki Bier, Greg Halnon, and Charlie Brown. Members online are Walt Kirchner and Vesna Dimitrijevic. Can you please confirm you're online?

MEMBER DIMITRIJEVIC: Yes, we are here. Good morning.

CHAIR ROBERTS: Good morning, Vesna. And Walt?

MEMBER KIRCHNER: Yes, Tom. Good morning.

CHAIR ROBERTS: Yes, good morning. And consultants, we have Steve Schultz in the room, and Dennis Bley online. Dennis, can you confirm you're there?

MR. BLEY: I'm here.

CHAIR ROBERTS: Thank you. Now, Kent Howard of the ACRS staff is the designated federal official for the meeting, over there.

Today the Subcommittee will discuss a topical report submitted by TerraPower, and reviewed by the NRC staff on the subject of independence between the nuclear island and the energy island of the NATRIUM design.

The topical report sets out to make the case that all structured systems and components, or SSCs, relied upon for reactor safety are on the nuclear island. And events on the energy island are sufficiently decoupled from the nuclear reactor that the energy island can be considered to be non-safety, and not require use of reactor safety standards in design and construction.

These are more detail on this from the applicant, as well as the contents of the direct safety evaluation from the NRC staff.

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

We hold Subcommittee meetings to gather information and perform preparatory work that will square deliberation at a full Committee meeting if necessary.

The Committee can only speak to its published letter reports. As with any ACRS meeting, attendees should consider any remarks by ACRS members are their personal comments and not Committee positions.

The rule for participation in all ACRS meetings, including today's were announced previously in the Federal Register, and included on the ACRS section of the USNRC's public website.

This website provides our charter, by-laws, agendas, letter reports, and transcripts of all full and Subcommittee meetings, including presented material.

As stated on the 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 officer five days prior to the meeting as practicable.

We did not receive any written comments or requests to make oral statements from members of the public regarding today's session.

Today's meeting is open to public attendance. And there will be time set aside during the meeting for comments from members of the public attending or listening to our meetings.

Today's meeting is a hybrid meeting, meaning there is both in person attendance and remote capability via a Microsoft Teams link.

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

At this time, I ask all the attendees to put their devices on mute, both the Teams computers and cell phones, to minimize disruptions, and unmute only when speaking.

We'll now proceed with the meeting. And I'll call upon Mr. Nick Kellenberger from TerraPower to make introductory remarks.

MR. KELLENBERGER: Good morning and thank you, ACRS Subcommittee. We are excited for our first Subcommittee meeting. We had a presentation earlier this year on the overview of our plant, but this will be the first, this is the first meeting on our, one of our topical reports.

As the Chair said, I'm Nick Kellenberger. I'm a licensing manager at Terra Power, and joined by, to my left Eric Williams. He's the Senior Vice President and design authority for the NATRIUM reactor; George Wilson, who's our Vice President of Reg Affairs and Licensing.

Also in the room, Emily Young, our manager of deterministic safety analysis, and George Piccard, who's our Site Director for Unit 1, first NATRIUM plant. With that I'm going to turn it over to Eric to walk us through the beginning. And then George will take over near the end.

MEMBER MARCH-LEUBA: Sorry. These microphones are very, very directional. All of the people in the --

MR. WILLIAMS: Okay. I'm going to go ahead and talk. If there's any problems with the audio, just stop me and let me know. So, my name is Eric Williams. Thank you for the introduction. And I'm happy to be here to talk about this topical report today.

We've lined up a presentation that goes through the topics here. We're going to go back and look at the reactor overview of the design. But since we were here recently and explained the reactor overview recently to the ACRS I'm going to more focus on what's important for the topical report discussion today. So, going through and pointing out the key features of the energy island and nuclear island interfaces, and things like that.

Then we're going to talk about operation flexibility, and how the energy island is designed to operate and take care of transients. We're going to talk about what we mean by transient separation, so that will get into some of the structure that we're using to look at licensing basis events, and all of the licensing modernization project approach.

And then we're going to end with regulatory impacts. And George is going to take that portion at the end. And so, really all of the discussion is really designed to set up that discussion on regulatory impact. So, we'll jump right in.

All right. So here's the look that we usually portray if we're talking about the NATRIUM safety features. Some of the main differences to other technologies are kind of tabulated there on the left.

It is a pool type metal field sodium fast reactor. A lot of the experience in the United States has been with loop reactors. There's been a lot of international experience on pool reactors.

So, that's one of the key aspects here that's important to talking about the thermal inertia that exists in the primary heat transport system. Having the pool reactor in the large volume coolant in the vessel is an important feature for that.

Metal fuel, and the specific design for the NATRIUM reactor lead to a lot of the safety features that we portray on this slide. The fact that it's metal fuel, and it's metal coolant makes the two very compatible with one another, which adds another aspect to the safety case.

And the molten salt energy island is another change that we've introduced into the design, that we think adds a lot to the safety case. And we're going to be talking a lot about that part today.

Other sodium fast reactors have had steam gener -- had sodium steam generators, sodium water steam generators. So that is one of the aspects that we've eliminated by design. Because the sodium water reaction is highly energetic.

What we now have are sodium salt heat exchangers. So, we'll be introducing a lot about those today in the discussion. And there is also an exothermic reaction between sodium and salt that we've mentioned before, much more benign reaction than sodium and water. But still something that is addressed in the design.

And the large thermal inertia is something that's going to come up a lot, not just in the primary heat transport system, but the intermediate heat transport system, and the salt system as well. There's a lot of volume of coolant in those systems that can absorb heat. So, those are kind of the key aspects for setting up today's discussion. We've got a --

MR. BLEY: Eric?

MR. WILLIAMS: -- fundamental safety -- Oh, yes.

MR. BLEY: This is Dennis Bley online. I don't know that we talked about it last time. But looking at this picture there's a lot of stuff inside your pool. Can you say anything, just briefly, about how you've set this up to be able to do maintenance with such a compact design?

MR. WILLIAMS: Yes, sure. So, all of the main components are designed to be removed and replaced, or go through operation and maintenance. So, even the kidney shaped intermediate heat exchangers are designed to come out. The mechanical primary sodium pumps can be removed.

There's a maintenance port as well in the reactor vessel head that I don't think can be seen on the diagram, that can be used to go in and hook up different machines to perform maintenance.

And then of course you've got the refueling equipment that mates up with the reactor vessel head to maintain the fuel assemblies. So, we are designing that for maintenance.

I think the picture gives the impression of more congestion than there actually is. Certainly in the center of the reactor vessel head, where the control rods come in. That is a highly congested part right there just due to the control rods, the refueling. That's the rotating plug that handles the refueling equipment as well.

So there's some congestion in that area. But it's still a very large vessel. And we have the equipment, you know. I think it looks a lot more congested on the picture than it actually is. But --

MR. BLEY: Okay.

MR. WILLIAMS: -- the cool pools reopen, yes.

MR. BLEY: Thank you. And at some point in the future, if you guys have movies about this operation will work it would be real helpful to see that.

MR. WILLIAMS: Yes, definitely. Yes. We

can pull up the 3D model even, and rotate it around and take a look inside.

MEMBER REMPE: Is the 3D model sufficient? Or are you planning to do some sort of non-nuclear prototype with all the widgets in there, and practice maintenance as part of your development?

MR. WILLIAMS: We will be practicing some maintenance in our test and fill facility. That's designed to go on site in Wyoming as a way of combining both some full scale testing of equipment, as well as the facility needed to fill the actual reactor with cilium eventually.

So, in that facility we'll be testing some full scale prototypes. And some aspects of that will be for maintenance operations as well, refueling, and things like that.

MEMBER REMPE: Thank you.

MEMBER MARCH-LEUBA: While you were discussing the figure, that bright red square on the button, what is it?

MR. WILLIAMS: Yes. That's the heated length of the fuel. So, you can kind of sense how small that is compared to the amount of coolant that you have.

(Off microphone comment)

MR. WILLIAMS: Yes.

MEMBER MARCH-LEUBA: -- capacity.

MR. WILLIAMS: Right.

MEMBER MARCH-LEUBA: And the vessel is low pressure obviously. And is on air. It's not in a large cooling pool like --

MR. WILLIAMS: Right. You're actually looking at two vessels. And hard to see. But you've got a reactor vessel. And then surrounding that reactor vessel is a guard vessel, and in between that space is interim space using argon gas, so you actually have two vessels there, and outside of that guard vessel is air, and that is what cools the reactor in emergencies, takes care of the decay heat removal.

MEMBER MARCH-LEUBA: People contribute sodium and moisture.

MR. WILLIAMS: Right.

MR. BLEY: Jose, if you can stay on the mic it would help us out here.

MEMBER MARCH-LEUBA: I was talking into the mic. So --

MR. BLEY: It's clear now. It wasn't then.

MEMBER MARCH-LEUBA: After seven years

here I thought you would understand me. I mentioned that there is no, I don't see any credible path mixture between the sodium and water. Because there is no water.

MR. WILLIAMS: Right.

MR. BLEY: Yes. Thanks.

MR. WILLIAMS: So, on the right of the slide we've got our fundamental safety functions. I'll just touch upon some of the differences here.

So, in control I think it's important to point out the motor driven control rod run back. That's something that comes up a lot in discussion energy island transients that we don't need to scram the reactor on. We just need to do a power run back.

The control rods are designed to handle those run backs, to avoid the scram. So, that takes into account the transients, the time constants that exist throughout the integrated plans, to be able to run back the power and avoid the scram. So, that's something that we'll be discussing today.

There's also of course the gravity driven control rod scram. And then we talked about the inherent reactivity feedback. That's also a form of reactivity control that comes from the design of the core restraint system and the fuel itself.

When we look at cooling, of course we call this an in vessel primary sodium heat transport, or an integrated reactor vessel. Meaning the entire primary heat transport system is contained within the vessel.

That means the only primary fluid that leaves this vessel is the cleanup systems, which are small bore pipes that clean up the liquid sodium and the cover gas inside the reactor vessel. All the penetrations go through the reactor vessel head as well.

There's also an intermediate sodium system, because the primary coolant isn't leaving the vessel. The intermediate heat exchangers give up heat to an intermediate sodium system that carry the heat out of the vessel and to the sodium salt heat exchangers.

And within that system is also another sodium to air heat exchanger that can run in both an active mode and a passive mode.

And so, the active mode is what is going to be used when we talk about a lot of the transients today that run back the power down to five percent, isolate from the energy island, and then remove heat with these sodium air heat exchangers, using forced flow mode.

So, that's going to be the typical thing that we'll come back to and refer to as the intermediate air cooling system. It will also work in natural draft flow as well.

So, there's some dampers that can open, and just allowing natural draft you can get heat removal there as well. And then the -- Yes.

MEMBER MARCH-LEUBA: Let me talk into the microphone. You don't remember a part of your life where you were not working on this design. But to us it's new?

MR. WILLIAMS: Yes.

MEMBER MARCH-LEUBA: So, please try to explain to us. So, those green heat exchangers I see there are sodium to sodium?

MR. WILLIAMS: Yes.

MEMBER MARCH-LEUBA: And then the sodium goes outside the vessel?

MR. WILLIAMS: The intermediate sodium.

MEMBER MARCH-LEUBA: The intermediate sodium --

MR. WILLIAMS: Right.

MEMBER MARCH-LEUBA: -- goes outside the vessel and heats up the salt?

MR. WILLIAMS: That's right.

MEMBER MARCH-LEUBA: And that intermediate sodium can also transfer heat to air in the environment. Is that in site containment or is it outside containment?

MR. WILLIAMS: Those exchangers are outside.

MEMBER MARCH-LEUBA: Oh. So, it transfers the heat to the environment?

MR. WILLIAMS: Yes. It does.

MEMBER MARCH-LEUBA: Try to --

MR. WILLIAMS: Okay.

MEMBER MARCH-LEUBA: You see here to --

MR. WILLIAMS: I will.

MEMBER MARCH-LEUBA: We don't know this.

MR. WILLIAMS: Okay.

MEMBER MARTIN: Yes. And I have a question as well. Bob Martin, member. Regarding the air cooling natural draft flow, that is strictly a safety system, right?

MR. WILLIAMS: Yes.

MEMBER MARTIN: And during normal operations you would isolate that? No. So, you get parasitic heat losses?

MR. WILLIAMS: Yes. And that's okay. That's okay. Yes. Yes. One of the key aspects to the reactor air cooling system, that's the third bullet under cooling.

That's a system that's cooling the outside of this guard vessel using air. Is that it's primarily radiation heat transfer limited. So, it runs on temperature to the fourth power. And so, it takes the primary coolant heating up in order to kick it into operation.

So, during normal operation you can accept the parasitic heat loss. Of course, we'd like to sell more electricity with that. But it's okay for the benefit of having it always on, and nothing having to move position or anything to kick it in other than the fluid heats up. So, yes, that's the RAC erector cooling system.

MEMBER PETTI: Just a question on the height of the vessel.

MR. WILLIAMS: Let me think of the actual number here. I think it's about, yes, between 50 and 60 feet tall, yes.

MEMBER BALLINGER: This is Ron Ballinger. You're going to get beat up on the prototype versus non prototype issue as we go along.

I seem to recall a very long time ago when the French folks discovered that they couldn't find the fuel after the irradiation, because of the distortion. And with a constrained core you can limit that I'm assuming.

But how do you deal, that's one case where without a test it's going to be tough. Is it going to be tough, do you think, to justify not making a prototype?

Because without the irradiation damage on the fuel you won't get the distortion, limited as it might be because of the core restraint system, to verify that the darn control rods will go in when they're supposed to?

MR. WILLIAMS: Yes, so a lot of, I mean, our fuel, we're relying on the database provided by the Fastbucks test facility for our fuel, and we've set the design of the Type 1 fuel to be very close to what was used at FFTF for that reason.

And then, we're supplementing that with quite a lot of four mechanical tests. We have a lot of full scale tests that look at distortion. We distort assemblies in our facility in Bellview, and look at withdrawal and insertion forces on those.

We also do multi assembly core mechanical tests to get additional data on anything that is different with the NATRIUM fuel. And so, I think we're relying on the database from FFTF as well as the attesting that we've done got in our plan to make the argument that that prototype isn't needed.

And then, to go to our advanced fuel then we need years of operation with a lead test assembly program in NATRIUM to build it back. So, we're starting with the bootstrap method using a fuel design that's very, very close to FFTF.

MEMBER BALLINGER: You're satisfied you can make that case?

MR. WILLIAMS: Yes.

MEMBER KIRCHNER: Eric, this is Walt Kirchner. Just clarification. My memory for FFTF is oxide fuel. Did you have, did they, did Argon send metal fuel for irradiation --

MR. WILLIAMS: Yes.

MEMBER KIRCHNER: -- experiments or data in FFTF?

MR. WILLIAMS: Yes, they did. They did. They were in the process of testing metal fuel. So, they hadn't converted over to metal fuel or anything. So it was an oxide fuel reactor with metal fuel assemblies within it. So, we do have data on that. And we've acquired those assemblies to do PIE on.

MEMBER REMPE: Now much fluence did they

get in FFTF?

MR. WILLIAMS: I don't know off the top of my head. You could maybe contact somebody back --

MEMBER REMPE: Well, again, this, the purpose of the meeting isn't on that. But that's something to think about.

MR. WILLIAMS: Okay. We do have a, George, remind us. We have a fuel qualification topical report right now. Yes.

MR. PICCARD: Yes. We have several reports, we just got back the draft form that will talk about the new qualifications methodology and how we're going to go through that, so it will be covered. And it's on future topical reports in more detail.

MR. WILLIAMS: Okay. The last fundamental safety function is contain. I don't think we're talking too much about that today, because we're not talking about releases.

But we have low pressure systems in the plant. I think we mentioned that already. Low pressure in the primary system that you see here. Low pressure in the intermediate feed transport system, and even in the salt system.

So, none of those systems are highly pressurized. You won't get high pressure until you all the way out to the steam generating system. So, that helps quite a bit with the containment strategy.

We know that sodium has affinity for radionuclides. So, we'll be factoring that into the mechanistic source term analysis. And there's multiple boundaries, you know.

There's an intact primary system like you see here. And then there's, you know, a head access area above the reactor vessel head. That's also another layer of protection.

CHAIR ROBERTS: Eric, are we looking at the containment right now, this thing, picture beside --

MR. WILLIAMS: Essentially those are the guard vessel surrounding the reactor vessel is part of that.

CHAIR ROBERTS: What do you --

MR. WILLIAMS: And the seals --

CHAIR ROBERTS: -- as containment?

MR. WILLIAMS: Yes. So, that's a, it's a series of SSCs that are credited. The guard vessel is part of that. The reactor vessel head is part of that. And the isolation valves on those two systems that come out of the primary system for the cleanup, I think those are also part of that.

MR. WILSON: We'll have a functional, this is George Wilson, TerraPower. We have a functional containment design that will go from some of the EPZ methodologies that we take credit for different portions based on where we're at. So --

MR. WILLIAMS: Yes.

MR. WILSON: It would follow the SECY paper if that was approved, that SRM that was approved by the Commission on how to describe and go through the functional containment. So, that will be further discussed later.

MR. WILLIAMS: So, taking all that into account you have a pretty simplified response to abnormal events. And that group of bullets you see there is really what we would be crediting in say a design basis accident scenario with reliable reactor shut down.

Then you transition to natural circulation cooling. You use the reactor air cooling system, or indefinite asset emergency heat removal. You've got the low pressure functional containment. Then there'll be no reliance on the energy island for any safety functions.

No safety related operator actions for AC power as well. And we've kind of already discussed our basis in the legacy US SFR experience. All right. Go to the next one, Nick.

So, this just shows a bird's eye view of the site that's laid out. I think last time we were here we didn't have quite the topology, the way it really looks in Wyoming. So, that's kind of a nice feature that's been added.

I don't think anything is significantly moved around though, since we last discussed with you. We're mainly talking about here the, well, if we talk about the nuclear island first, you can see Buildings 1, 2, 3, and 4 in the center of the slide.

1 is the control building, 2 is the fuel handling building, 3 is the reactor building where the vessel that we saw on the prior side is in the reactor building below grade. And then the reactor ox building, which is Building number 4.

We're going to be talking a lot about the equipment in that building today, because we're talking about these energy island transients. And I wanted to point out the question that often comes up is the nuclear island salt system isolation valves, and where they're located.

They're actually located at, just outside of Building number 4, in the salt piping that is going out to the salt storage tanks. And that's identified with Label 5. 5 shows you the piping train that comes out of the sodium salt heat exchanger, and goes out to the storage tanks that you see on the energy island.

So, those isolation valves, there'll be one on the hot side and one on the cold side, those exist just outside of Building number 4, as close as practical to it. So, that's where the break is where we talked about the interface between the nuclear island and the energy island where that break occurs physically.

MEMBER HALNON: So, Eric, intermediate cooling, forced cooling, is that the two structures just to the left of the Number 5 circle there?

MR. WILLIAMS: No. Those would be close to Building 4. I think it's that grey --

MEMBER HALNON: So, it's inside those --

MR. WILLIAMS: Yes.

MEMBER HALNON: Inside the nuclear island?

MR. WILLIAMS: It is in the nuclear island yes.

MEMBER HALNON: We just don't see it.

MR. WILLIAMS: Yes. You'll see it a little bit better on the next slide.

MR. KELLENBERGER: Yes. It's these two

tan towers to the left of 4. Those are the --

MEMBER HALNON: Okay. So, that's the separation you have?

MR. WILLIAMS: Right.

MEMBER HALNON: Okay. Thanks.

CHAIR ROBERTS: This is Tom Roberts. Can you talk some more about those valves? Are they, you know, giant valves that shuts, isolates the flow on that sub pipe? How big a pipe is that?

MR. WILLIAMS: It's about a 36 inch pipe. So, it is designed to isolate the salt system, isolate the nuclear island from the energy island. So, when we do our power run back we'll reduce power to about five percent. And then we'll isolate from the energy island. And we'll take care of all the decay heat removal.

Say if you're in a, even during an outage for refueling, or something like that. We'll come down and take care of all the heat removal using the intermediate air cooling system, those sodium to air heat exchangers.

MEMBER MARTIN: A clarification. Bob Martin. To the right of seven is that like a air cooling ultimate heat sink?

MR. WILLIAMS: Yes. That's the forced

cooling, cooling down --

MR. WILSON: It is not an ultimate heat sink. That is just a cooling tower for the turbine, for the condenser.

MR. WILLIAMS: Yes.

MR. WILSON: That has nothing to do with safety. So --

MEMBER MARTIN: I wasn't using the ultimate heat sink as a safety term. Because obviously --

MR. WILSON: It just --

MEMBER MARTIN: -- heat loss --

MR. WILSON: It's condenser cooling for --

MR. WILLIAMS: Right.

MEMBER MARTIN: I'd like to -- And this is your design? Not just a artist rendering, or anything for --

MR. WILLIAMS: Right, yes.

MEMBER MARTIN: -- Linkedin, or something?

MR. WILLIAMS: Right.

MEMBER MARTIN: Last month we were at Comanche Peak. And one of the things that impressed me was just really how compact everything was. And here I see a control room over here on the left in a very linear layout.

And now, part of the, you know, part of the point is all this independence, you know, by seeking. So, it's very obvious where you need to draw a line.

But I have to wonder, when it comes to, you know, a big part of your safety case is built on the hazards of, so you're going to have PRA, what have you. You're going to have maybe a fair amount of cabling, electrical.

And I wonder whether your, you know, total length of these activities, and just maybe just a thermal inertia that you have there. Plus your pool, your intermittent loop, your salt, and then the steam.

And in, so I'm wondering about the responsiveness of the plant overall. Again, an independent, you know, if you're trying to get a dependence you're going to be a lot decoupled.

But even, you know, there's a trade off, right, with the responsiveness of the plant. You're going to have something as simple as load follow, which makes your, you know, of course operators impatient. The answer is an automatic control.

But all these sort of thing is going to factor into I would say your PRA. And have you considered how the physical layout like this, you know, like the linear feet of your cabling and stuff play into that? Is that on your mind?

MR. WILLIAMS: It's definitely on our mind. I mean, we have built quite the integrated real F5 model of this plant that takes into account all of these interfacing systems.

We're also using that for the engineering simulator, which is starting to come online. So, we'll be running a lot of these transients to see those different time constants and, you know, system interaction type facts that come into play with these things.

And right now it's actually looking very beneficial from the standpoint of plant control. And we'll get into a little bit of that when we get to a slide coming up, about the difference between the nuclear island operator and the energy island operator.

But I think that that buffer of having the salt tanks in the middle, in between these systems does provide this very good divisional between the two. So, it's not all so tightly coupled, because those tanks kind of buffer things.

MR. WILSON: And this is George Wilson. And we also have a human factor's evaluation topical report coming in that you guys will get a look at potentially later on, to address some of the comments that you brought up.

MEMBER BIER: Yes. That was going to be my follow up. This is Vicki Bier. Which is, so Bob kind of mentioned just the linear feet of cable and your piping, or whatever that may make it vulnerable. But also, are there actions that are going to require people going back and forth between the different locations? Or --

MR. WILSON: Right now we're doing -- This is George Wilson. We don't have any safety. We're not taking credit for any operator actions. And we do not have any safety related AC at all on the plant.

So the design itself addresses some of your guys' questions, but will also address the human factors. Like I said, there's topical reports that are still being written, that's going to the NRC, that you'll have, and so you will get a chance to have additional questions to that.

MEMBER HALNON: Yes. And we went through this in your last presentation about the location of the control room, and whatnot. And you might think, I understand that the picture itself, it's not a quarter mile.

MR. WILLIAMS: Right.

MEMBER HALNON: It's a pretty compact plant. So, moving it 100 feet to the right is not going to increase the responsiveness all that much, if any. Because you may have to be walking around buildings or through buildings at that point. So, we did discuss some of this earlier on. So, really good to see how responsive other topicals.

MR. WILLIAMS: Yes.

MEMBER REMPE: So, I have a different question. I'm not sure if this is the place, or later. But you always emphasize you're building upon U.S. experience. And I'm thinking of the Japanese experience in Monju.

And if your, some of this requires instrumentation. And of course the leakage was from somebody putting in a thermal couple that was not, was susceptible to corrosion and leakage.

And are you going to have, and I looked through the materials we were given at a different level. But are you going to have some sort of limitations to consider that you aren't going to have some problems in the energy island that, and I'm thinking co-located hazards, that if something were to degrade, and that salt happens to have a problem, and people are responding to it, that it might adversely affect the nuclear island.

MR. WILLIAMS: Well, I don't, I think, you know, most of the problems that would be initiated in the energy island, you know, would simply result in a power run back.

Because you want to, if it's a big enough problem you'd want to shut down the energy island, and go do the repair. I think the good thing about this plant is that you don't have to scram the reactor to do that. You can take a power run back, put the system through a much milder transient, much safer transient to go down in power on the nuclear island.

There's also quite a bit of time before you have to do that. We'll talk about it in a minute, which is a big improvement I think.

So, I don't, I can't see right now why a maintenance issue or a failing piece of equipment on the energy island would ever impact the safety of the nuclear island.

From a reliability standpoint it is very important though. And we are trying to design a very reliable energy island, probably more reliable than what concentrated solar plants would want, or need.

So, you know, we want the high capacity

factors that nuclear plants expect, and so our energy island will be designed with a high level of reliability, so that will definitely be true now.

MEMBER PETTI: I understand that the concentrated solar guys, the reliability is not very good. What are you guys --

MR. WILLIAMS: Yes. We're looking at the OE from the concentrated solar industry.

MEMBER PETTI: I mean --

MR. WILLIAMS: We're looking at the codes.

MEMBER PETTI: -- sold by them. It's advisory.

MR. WILLIAMS: Yes. The codes that they've applied to their systems, and different types of failures that they've seen in the field. So, we're in tune with all of that very closely. So, we're taking that into account in our design.

And the interesting thing though is just that that, with their low capacity factors they don't really necessarily need the same reliability that we do. So, that is something that we're paying attention to.

MEMBER BROWN: Question. You mentioned there's no safety related electrical systems at all. And yet, the reactor protection system is scram supplant as part of the nuclear island. And it's got four divisions. And how do you maintain --

MR. WILSON: I meant that --

MEMBER BROWN: -- power --

MR. WILSON: -- there's no backup. We don't have any safety related diesel generators, or anything like that. We don't have any --

(Simultaneous speaking)

MR. WILSON: That's right. You'll have RPS. And you also have all the PAMs instruments.

MEMBER BROWN: Is there one system set up to have redundant run back capability? In other words, redundant systems to drive those? That seems to be --

MR. WILSON: There's logic --

MEMBER BROWN: -- the primary thing. So, that's what I'm talking about.

MR. WILSON: Yes. There's logic.

MEMBER BROWN: Like the SS4 division. And just so the run back obviously is there to bring the power down during operations if you have difficulties, so you don't have to scram.

And I was curious. They didn't talk about having any redundant channels or divisions for that. It sounded like a one division, one off sort of.

MR. WILSON: It may be later --

(Simultaneous speaking)

MR. WILSON: We have a topic report to talk about the nuclear island control system. We've had interactions. And the RPS system will go through the design review guide. But there's multiple channels. And we have logic --

MEMBER BROWN: Okay. All right.

(Simultaneous speaking)

MEMBER BROWN: Thank you.

MEMBER MARTIN: There's a question. You've, of course already, George, mentioned, you know, safety related components, what have you. We're safety related this, that at this stage, at least of your interaction with ACRS.

As far as I know, not seeing any kind of safety classification methodology. I see, you know, you go through a hazard, a PRA, what have you. There's a methodology to making those claims.

All I hear is claims, arguments. But as far as I know have you sent something to the staff that explains the classification methodology?

MR. WILLIAMS: Yes. We've had interactions with the staff, and how we've utilized an AI 1804, and how we're doing our SSE classification, how we're doing our design base and licensing basis events. We've had all those interactions. And we've written topical reports and white papers to the staff.

MEMBER MARTIN: Okay.

MR. WILLIAMS: So, there's a series of topical reports that we still have to submit to the staff. And the staff has received several topical reports already.

MEMBER MARTIN: Okay. Maybe I'll save my question for the staff.

CHAIR ROBERTS: Yes, this is Tom Roberts. One more question. And I hope we can get it off the slide. Part of what Joy was asking. Did you look at potentially catastrophic events happening in the energy island, like something, you know, something blows up due to a chemical reaction? Or, you know, a exothermic reaction of the salt with something?

I don't know. But, it's I don't really see in the topical reports talk about how that would not affect operations on the nuclear island.

MR. WILLIAMS: Well, our licensing basis events are, and our initiating events that we're screening are all driven by failure modes and effects analyses on the equipment.

So, we are looking at from a fundamental standpoint how each piece of equipment can fail. We're not seeing anything like an explosive reaction in the salt tanks, or anything like that. Because salt isn't interacting with air.

You know, if you get a salt leak from a tank it freezes in the air. It solidifies and comes as this white powdery stuff that you clean up with a shovel.

We are addressing the potential for flooding from, you know, a catastrophic failure of the tanks using berms that you don't actually see in this diagram. But they would direct the flooding away from the nuclear island.

And then it's about, you know, impact of failures, you know, that have to go all the way through the energy island salt piping, through the nuclear island salt piping, and to the sodium heat exchangers, sodium air heat, sodium salt heat exchangers. Through those to the intermediate heat transport system and through the IHX to the primary pool.

So, it's all about kind of impact from the energy island and make it through all of that to any, you know, adverse any fundamental safety function, which we're saying it cannot based on our simulations that we've done.

So, we are looking at things like, you know, salt hammer type events. If those isolation valves close quickly, you know. Things like energy island salt pump trips, and things like that.

So, all of those things that can happen on the energy island are being studied. They're part of the design. And we have a design requirement that they shall not impact the nuclear island.

So we'll be continuing to, you know, if anything changes we'll be continuing to look at that, but we're not seeing anything like an explosion in the tanks or anything of that nature, because we don't see a precursor for that.

CHAIR ROBERTS: Okay. Thank you. Yes, in theory an explosion in the energy island could affect habitability in the control room, or any of a number of direct mechanical effects on the nuclear island. So, I'm glad to hear you're looking at that.

MR. WILLIAMS: Yes.

MEMBER MARCH-LEUBA: And, Tom, this time I wanted to answer the previous question. Is it okay?

MR. ANZALONE: Yes, thanks. Is there a microphone up here? Okay.

MEMBER REMPE: I think it's the top one.

MR. ANZALONE: Okay. Thanks. Yes. I just wanted to clarify that we're going to be talking about the safety. Oh, sorry. Reed Anzalone from the staff. We're going to be talking about the safety classification process in our presentation. So, happy to address the question then.

MEMBER MARCH-LEUBA: Thank you.

MR. WILLIAMS: Thank you. So, just to get off this slide, you know, Building 6 is where the steam generator equipment is. And Building 7 is where the turbine haul is. So, we'll go to the next slide.

And this one is looking at the three central nuclear island buildings, as if we're standing at the energy island looking back towards the nuclear island.

So, if you're looking, if you ever go back and flip back and forth between the two slides, you're looking backwards to the nuclear island here.

So, in the middle you see the reactor building. You can see the reactor vessel, guard vessel. Below grade there, you can see the pipes for the intermediate heat transport system that come out of the reactor vessel head. And they make their way over to the reactor auxiliary building, above grade.

And that is where the sodium salt heat

exchangers live. They're above grade in that building. There's two of them per train. And there's two trains.

And so, that's where the intermediate heat transport system interfaces with the nuclear island salt system, and transfers heat from the sodium to the salt.

There is also some discussion in the topical report about drainage. You know, in cases where you need to go into a long term outage you would drain. You could drain both the sodium and the salt system from, sodium from that heat exchanger. So, there's drain tanks for both of those.

If there was a leak in the sodium salt heat exchanger you would also initiate a drain, so that you could, you know, terminate that interaction between sodium and salt, and go in and take care of the leak.

So, the sodium and salt drain tanks are both below grade in the reactor ops building. So, that's where those will be physically located.

You can see the salt piping going out to the thermal storage system over there on the left. That is where those NSS isolation valves will be located.

And you can see the intermediate air cooling heat exchanger up at the top there, above the reactor ops building. That's what we call the air heat exchangers of the intermediate air cooling system.

It's connected to, there's one of those connected to each of the intermediate heat transport loops. So, there's two of those in the design. And like I said earlier, they can run in forced flow cooling mode, where there is actually blowers blowing air across the coils of the heat exchanger.

It can also run in natural draft mode, where the dampers open and just allow natural draft air flow over the coils. And that's the system that's used in a lot of these run backs, and certainly in refueling mode. Yes, question.

MEMBER KIRCHNER: Eric, this is Walt Kirchner. A couple of questions. The sodium salt heat exchangers, you mentioned earlier that sodium salt mixtures are exothermic.

Since these are solid systems, in terms of solid liquid during normal operation, is there the potential for propagating a, energy back into the primary vessel?

MR. WILLIAMS: They're actually not solid.

There is a drain tank in the intermediate heat transport system. So, there's a cover gas on that drain tank.

MEMBER KIRCHNER: Yes. I see you have an argon, a pre surface argon cover gas.

MR. WILLIAMS: Right. Right. And we can detect the leak in a number of ways. And either initiate a run back, or if it propagates to, you know, a loss of heat transfer at the IHX, then it would be picked up by one of the scram set points in the nuclear island, if that were to happen.

MEMBER KIRCHNER: I'm not so much worried about it leaking into one of your compartments. Although that would be a concern from a fire consideration.

But my concern would be, any energy transfer due to an exothermic reaction between the salt and the sodium. That could pressurize the system.

MR. WILLIAMS: Yes. That is something we are looking at though. That will be looked at in our models for any sort of pressure wave that could make its way back to the IHX. So, that would be something that we would definitely look at.

MEMBER KIRCHNER: Yes. I think that would be important. The other Achilles heel these systems in the past has been the air cooling system for decay heat removal.

So, can you tell us a little bit more about this? This intermediate air cooling, is that sodium to air?

MR. WILLIAMS: That's right. Sodium to air. So, you have your intermediate heat transport loop. And you have a leg that comes off of the main pipe. And it goes out to this sodium air heat exchanger. Like I said, there's one in each loop.

And it's always running through there. And so, what needs to happen is, for natural draft air cooling the dampers would open to allow more air to flow. If it's going into forced cooling mode then the dampers open and the blowers turn on to remove heat from that heat exchangers.

So, it's one of the workhorse components that we have. Because it's always used in a run back. It's always used as the main go to system for taking care of decay heat when you're not in a, you know, emergency situation.

MEMBER KIRCHNER: Right. So, this system would have isolation valves on it should you get a air a leak to air. I mean, the concern would be a fire or other energetic events that could result from leaks in the system.

MR. WILLIAMS: Yes, yes. If there were to be a leak in the system that would probably be a drain dilute kind of situation.

MEMBER KIRCHNER: Okay. Thank you.

MEMBER MARCH-LEUBA: You mentioned the intermediate air cooling has AC power blowers? But they're not required for decay heat.

MR. WILLIAMS: Right.

MEMBER MARCH-LEUBA: Only during --

MR. WILLIAMS: Right.

MEMBER MARCH-LEUBA: -- the low power.

MR. WILLIAMS: Right, yes. Only during low power --

MEMBER MARCH-LEUBA: The decay heat safety removal is the air ducts?

MR. WILLIAMS: Yes. It's the air ducts. So, that would be reactor air cooling ducts. You're seeing two of them there in the reactor building.

MEMBER MARCH-LEUBA: So, I'm going back to my, everything above grade is susceptible to missiles that can impact. You can live without that? Can you live without the air cooling ducts?

MR. WILLIAMS: We can live without a

certain, we can take a certain amount of degraded performance in the reactor air cooling system. It's actually very robust in fact to say pressure drops and things like that.

As long as you have that radiation heat transfer going between the guard vessel and the reactor vessel, then the system performs very well. We will, I mean, obviously be quantifying how much degradation we can handle.

And, you know, in the PRA, you know, looking at, it's part of the aircraft impact analysis that we have to do, so there's a lot. At some point, you can, you know, block up all the air ducts, and then, you know, you'll probably bring in some equipment from off site to unblock the duct or something, you know, in that beyond design basis regime, but we're still working through all that.

MEMBER MARCH-LEUBA: You mentioned time constant will play a significant factor; you're talking --

MR. WILLIAMS: No, yes. Right.

MEMBER HALNON: Eric, one last question. Since the fuel is in sodium, the spent fuel's in water, can you just talk to me about how that transition is done, so that you don't get a problem --

MR. WILLIAMS: Oh, yes.

MEMBER HALNON: -- when you insert it in water?

MR. WILLIAMS: Storage, yes. That's very carefully. So, fuel comes out. Obviously, I should have mentioned this. But the fuel actually goes into an in vessel storage location outside of the reactor core barrel when it is done in the core.

And it cools off there for a cycle, inside the vessel, before it even comes out. So that's a, you know, a unique feature I think of a lot of sodium bass reactors, pool reactors especially I think.

So, it cools off a little there, comes out of the vessel. And then it gets transferred to an X vessel storage tank, which is filled with sodium. And it goes there during the outage. And you collect all of your assemblies there.

And then after the outage you go in and process them. And what you would do to put them into the spent fuel pool is, you would take them out, and they would go through a pool immersion cell, PIC, which is a pit. It's probably one of those that you see below grade over in the field handling building.

And it goes into that container. And what we do is we blow initially dry nitrogen over that, to just blow off any sodium that is remaining, and gradually turn up the humidity on the nitrogen very slowly and carefully until any water in the nitrogen is able to react with the sodium in any crevices or things like that, until it's all removed.

And then finally when that is performed it gets moved over to the spent fuel pool. So, and during that whole migration, you know, it is handled very carefully, taken through systems that have barriers between it and air through inerted environments, so that there's no chance of contact with, the sodium on the fuel assembly with the air in the reactor.

So yes, sometime I'm sure we'll go through that whole process in detail. Yes. All right. I think that --

CHAIR ROBERTS: This is Tom Roberts. I was going to point out that we're about 40 minutes into, essentially into the presentation with five slides done. So, just --

MR. WILLIAMS: Okay.

CHAIR ROBERTS: -- keep that in mind and try to maybe pick up the pace a little bit, and hold the questions if possible. Thank you.

MR. WILLIAMS: Yes.

MEMBER REMPE: We always blame the Subcommittee.

MR. WILLIAMS: Okay. So now we're looking back towards the energy island. You can see in the picture to the right the energy island salt piping that's coming back.

You've got pipes going from the cold salt tank that go back to the nuclear island. And pipe that goes from the sodium salt heat exchanger to the hot salt tank. So, they're all contained within that.

One thing I wanted to point is, you see several of the green lines that are coming, going into the steam generator building. That's because we have five steam generator trains, and the hot salt tank has five pumps that go into, one per steam generator train.

Off the cold salt tank, you also see quite a few pumps and lines there. That's the attemperation pumps that come off of the cold salt tank and go over and mix into the salt coming out of the hot salt tank.

And then you can see a process flow diagram down there at the bottom left. A lot of the typical equipment that you see in a steam generator is contained on this.

There are again five of these steam

generator system trains. So, if we just take from the left to the right, you can see hot salt coming out of the tank there.

It goes into both the super heater and a reheater. The reheater takes some cold reheat from the turbine extraction, and sends it back as hot reheat.

The evaporator starts to bring the feedwater up to saturation in the steam drum. And then that goes over to the super heater to super heat the steam, and send that off to the turbine.

We also use some of the salt to preheat the feedwater over there on the right. And so that essentially completes that circuit.

We have looked at, you know, transients where you lose that cold salt, that salt return to the cold salt tank. And we can go quite a bit of time without that cold salt return before we have to do anything on the nuclear island to adjust power, or take the plant down, rather.

So, that is something that we've looked at with our transient analysis. And we'll continue to be, you know, checking that as we go through the rest of the design.

MEMBER HALNON: Are the two tanks, hot and cold, are they identical?

MR. WILLIAMS: Yes.

MEMBER HALNON: And so the same?

MR. WILLIAMS: Yes.

MR. SCHULTZ: Eric, the transient analysis that you did associated with the Energy Island, those calculations are done with what methodology? Staff had some comments during their audit associated with the pedigree of the evaluation.

MR. WILLIAMS: Yes. Those were done as part of our integrated plant analysis work, specifically looking at all of the ASME design transients, level A, B, C, D. And some of those then get run over in the SAS code as part of looking at these transients from a DBA perspective.

So we kind of used the best estimate methodology to look at the ASME design transients and then those factor in. If something like that were to make its way into a DBA, then we would look at a different methodology for safety analysis.

The transients that were looked at by the staff, I think we had one calculation that used SAS, but most of them were using 3D.

MR. SCHULTZ: Okay. The staff just mentioned that they hadn't taken a look at those in terms of code review and so forth.

MR. WILLIAMS: Okay.

MR. SCHULTZ: That could be something that is done in the future?

MR. WILLIAMS: Yes.

MR. SCHULTZ: Thank you.

MR. WILLIAMS: Yes. Those were preliminary. This topical report, which was submitted in October of '22, was based on a conceptual design of the plant.

So I think it did a really good job of showing us these various time constants that exist in the system and how robust the design is to have this sort of independence between Energy Island and Nuclear Island. We know that we will be repeating these analyses as we proceed through the design.

MR. SCHULTZ: The staff mentioned all that in their audit report and also came to the same conclusions regarding the results. Thank you.

MR. WILLIAMS: All right. Let's go to the next slide. We'll talk a little bit now about operational flexibility. These are really the talking points for the next slide, so why don't I just speak to this as we look at the picture on the next slide.

We're kind of seeing two sides of the view here. The side on the left is the view from the Nuclear Island operator and the side on the right is from the view of the Energy Island operator.

On the Nuclear Island side, we're going to have licensed reactor operators controlling reactor power. This allows the Nuclear Island operator to really focus on the safety of the plant.

As long as the cold salt tank is flowing appropriately into the sodium-salt heat exchangers, we're not going to be affecting any of what we call the interface parameters between the Energy Island and the Nuclear Island that would cause a scram or anything like that. So that's kind of the view from the Nuclear Island standpoint.

From the Energy Island standpoint, the grid operator is able to then control the turbine to meet the electricity demand of the grid. As long as the Energy Island operator is managing the inventory between the hot and cold salt tanks, they won't be triggering a runback.

They can manage that any way they want. They can turn back electricity production. They can increase electricity production. Whatever is required to maintain a certain minimum cold salt tank level, they can do that without recourse through the Nuclear

Island.

And so one of the things we look at is what does that cold salt tank minimum level need to be. For example, you would take the height of salt required to provide net positive suction head to the cold salt pumps.

Add to that the amount of salt that you need to do a runback, to consume the runback, and add to that the amount of salt you need to consume to isolate the two systems from one another. And then say to the Energy Island, don't go below that.

That would be a way of giving that Energy Island operator flexibility to meet the grid demand without impacting the Nuclear Island at all, and always maintaining the reserve that you need to do a proper runback without having to scram the plant.

MEMBER HALNON: Eric?

MR. WILLIAMS: Yes.

MEMBER HALNON: When everything is working right, that sounds great. What happens when, say, the dispatch calls for more power than what the Energy Island can produce?

Are those controls and limits things that cause some kind of action? You can control your operators on-site and you can train them, but you're not going to train the dispatcher.

MR. WILLIAMS: Yes. That all has to be -- control bands, alert levels, response times, all of that has to be factored into what the grid operator is doing. I don't know if we want to say any more about how the grid operator would react to those things.

At some point they hit a limit and they can't provide any more electricity. Or if they're up at the maximum electrical output of 500 megawatts electric and the grid still demands more but they've depleted the hot salt tank, then they would have to dial that back.

MEMBER HALNON: I guess I was more thinking of low-power operation where you're a little overambitious in saying, you've got a big hot salt tank there. I can grab more than what you're producing right now and hopefully meet the curve somewhere in the middle before you run out of hot salt.

We can talk later, but it would be interesting to talk through those types of scenarios to see how the systems would react. It's probably controls on the Energy Island to find the dispatch, but that interface was a big deal in commercial reactors between the grid operator and the control room.

MR. WILSON: This is George Wilson. We have monthly meetings with PacifiCorp to go over this. We talk with their compliance people and their grid people. We're coordinating all this now and looking at it.

We haven't finalized the procedures, but we're starting to talk about compliance because it's also new for them to get a nuclear plant on their grid. There's additional standards that are going to apply to them now. So we're still working with them, doing the coordination. George's group is leading.

MEMBER HALNON: I guess my point is if there's some things beyond your control that you need to look at from the Energy Island and how that might affect the Nuclear Island.

MR. WILLIAMS: That's a good point.

MEMBER KIRCHNER: This is Walt. Just to kind of add onto your line of questioning, Eric or George, could you give us a feeling of what's the net output from the reactor versus the net output from the steam plant, from the Energy Island?

And what's the time constant between the two? Where I'm going with this is, what's the steady state, and then what would be the peaking factor? How would that feed back on the reactor system?

Or Greg went through a scenario where you're dumping, you're reducing power. You mentioned 500 megawatts of electric for the Energy Island. What's the equivalent from the reactor? How much can you store?

How are you sizing that hot tank such that when you look at that operational interface, you're going to have a time constant that will run the reactor itself up and down in terms of thermal transients?

MR. WILLIAMS: So the design is for the reactor to run a steady-state, full-thermal power. We're not cycling back to any sort of load following. We're doing the load following purely on the Energy Island side.

MEMBER KIRCHNER: Yes.

MR. WILLIAMS: So in thermal equilibrium, the reactor is putting out the equivalent of 345 megawatts electric. And the Energy Island is providing 345 megawatts electric to the grid for a period of time, between four or five hours let's say, you can go up to 500 megawatts electric or you can go down to 100 megawatts electric.

If you're in a daytime scenario and all of the renewables are online and you want to dial back the system, you can dial it back as low as 100 megawatts electric. That's just a limitation of your turbine design.

You can change that, if you want, with a different design. All of the equipment beyond those tanks are designed in size for 500 megawatts electric, whereas all of the equipment on the Nuclear Island side before the tanks is all designed for 345 megawatts electric.

MEMBER KIRCHNER: Okay. Thank you.

MEMBER MARCH-LEUBA: From the top of your head, in units of power for 500 megawatts electric operation, how big is the hot tank? Four hours, 12 hours, 48 hours?

MR. WILLIAMS: Yes. It's between four and five hours.

MEMBER MARCH-LEUBA: Only four to five hours?

MR. WILLIAMS: Yes.

MEMBER MARCH-LEUBA: For the renewable it's 12, right? The nighttime is 12?

MR. WILLIAMS: Right, but the peaks really only last for that period of time. The peak in the evening and then the peak in the morning, we have people that are waking up. Yes.

MEMBER MARCH-LEUBA: Obviously, it doesn't compromise the tanks?

MR. WILLIAMS: Right, no. That's optimized for Wyoming. If you went to somewhere else, you might have a different --

MEMBER MARCH-LEUBA: And you would just have to change the size of the tanks?

MR. WILLIAMS: You can change the size of the tanks. You can have additional pairs of tanks if you need more storage. You can have additional turbines if you want lower turndown.

There's a lot of optionality on the Energy Island and a lot of flexibility. It's the Nuclear Island we want to standardize and run full-power all the time. So yes, very flexible.

MEMBER MARCH-LEUBA: Do you envision having to sell megawatts electric at a loss? There's sometimes in which nobody wants your power.

MR. WILLIAMS: Right, yes. We're not designing for that.

CHAIR ROBERTS: Following up on Greg's and Jose's questions, it looks like from the reactor safety perspective, your biggest concern would be a low demand, which is going to basically drain the cold tank and fill the hot tank. Is there some minimal level that is essentially a tech spec that if you go below that, you do have a reactor safety concern?

MR. WILLIAMS: I think the power runback, what happened before that. I'm sure there are even lower limits that would be tech specs on the tanks perhaps.

CHAIR ROBERTS: Tech spec would seem to imply safety-grade instrumentation and that kind of thing to measure it. I was trying to understand how you can maintain the separation when the cold tank level really is a factor in reactor safety.

MR. WILLIAMS: Yes. I guess in a future slide here we're going to talk about the interface parameters a bit. And actually, on this next slide is where we have them listed. These are the things that we would be looking at from a safety perspective.

If you go to the next one here, this is where we start talking about separation. These are the parameters that we really think of in terms of something that would start to have an effect, would start to propagate through the IHD and then to the PHD.

We've looked at all the failures that could occur out there in the Energy Island, all the way to complete loss of salt flow, which is probably the most bounding of all of them. Just have all of the salt tanks stop running. That would be even worse probably than hitting a low level in the tank or something like that.

And so they all come down to either a loss of or reduced heat removal from the intermediate heat transport system because of something that happened out in the Nuclear Island salt system or an increase in heat removal on the intermediate heat transport system.

And so these are the parameters that we would probably be looking at more, not so much the tank levels but things closer to the sodium and salt heat exchanger, such as a loss of salt flow that would be detected in the Nuclear Island salt system, a high salt temperature coming out of the sodium-salt heat exchanger, or low salt pressure that might indicate a leak.

On the increased heat removal side on the IHD, you can have increased salt flow from a pump over-speed condition or low salt temperature that might be introducing an overcooling transient on the primary system.

So these are actually the parameters that we would look at. They kind of decouple ourselves, if you will, from the Energy Island. Things that happen on the Energy Island can be taken care of by the Energy Island operator. They can be taken care of with power runbacks.

You would have to propagate out to these parameters to start impacting the primary system through all those time constants. And so when we ran our transients and showed those to the staff, we were looking at transients and examples of these different parameters that get triggered.

And then you have things even further out beyond the tanks like turbine trips, steam generator malfunctions, equipment like that that would be further away from the sodium-salt heat exchanger that would probably start to trip equipment on the Energy Island due to asset protection, and eventually would trigger one of the runbacks at points to go back and run the system back normally.

MEMBER PETTI: I don't think you answered the question. I understand these events, what they could do, and how they could challenge it, but I thought Tom's question was the case of low power and the salt level in the cold tank is also really low.

It's sort of an operational condition that you could somehow get into a different problem. I guess I didn't see how these transients capture that question.

MR. WILLIAMS: Yes. If we think about operating the plan and delivering electricity from the grid where you've depleted the cold salt tank level down to the lowest that you're allowed, you would still have, based on what I was talking about a few slides ago about sizing that minimum level, you would still have enough salt to do the runback and to isolate the system and still have enough for net positive suction ahead of the pumps.

So that level was designed to only allow the Energy Island to operate when it's reserving that amount of salt to go ahead and do a runback of the plant. It's not designed to go below that.

That kind of gets back to Greg's question over there. You would have to stop producing electricity if you got to that level. You'd have to manage that inventory within the limits provided to the Energy Island.

MR. WILSON: This is George Wilson. We haven't developed it but we'll develop system operating procedures, conditions, and limits. It'll be in those system operating conditions and limits that you'll have normal operating bands. We just have not done those.

So to address your question fully, all that stuff will be covered when we have our operating procedures when we've completed them.

MEMBER HALNON: And that comes back, George, to a fundamental question on the operator. Even though you say that there's no events that the operator has to respond to, is there a condition where the operator is required to maintain a certain operating envelope to maintain pre-existing conditions so that no response is such as required?

The fundamental question is if they're required to keep it within an operating band, is the operator not in essence responding to a license-based event by maintaining the operational boundaries, if you will, in place?

MR. WILLIAMS: This is George Wilson. If you do it by design, I can have design intake have the systems take action. I wouldn't have to rely on an operator. It would be a fall-back, but I could have the system take action. As Eric was saying, transient runbacks and you essentially get a scram.

George, did you want to add?

MR. PICCARD: Yes. George Piccard from

plant operations. I will just add to that there is little difference in how you would maintain with a design margin and then an operational margin and other types of operational primers of the amount of salt you want to reserve in the cold tank.

You have to have a certain amount of water in the tank. It would be the same type of procedural guidance. You would have a design basis and then an operational margin.

Some additional operational margins before you load the dispatcher to actually control anything, you would have even more margin to how much salt reserve you'd have in the cold tank. You wouldn't allow them to be able to control the turbine during start-up or shut-down or any type of other transient or any type of maintenance.

There would always be an override where the operators have to give control to the load dispatcher to be able to control the turbine. Any signal that comes from the plant would override anything that came from the load dispatcher. They're not going to be able to control the turbine any time that you don't want them to control the turbine.

MEMBER HALNON: Okay. Well, I think we'll explore it more but again, a combination of operating procedures, technical specifications, operator training, and system interactions with those operators pre-existing, pre-transient conditions. You have to set up those conditions. It would be an interesting period of discussion when we get into the operators.

MR. PICCARD: There would be a tech spec probably for the minimal amount of salt in the cold tank. Remember that's only there to allow the worst-case scenario runback to allow you get below five percent power. Not a whole lot of heat is required for that. It doesn't have anything to do with the safety case.

MEMBER HALNON: There's no effect from the Energy Island to the Nuclear Island, yet this is an effect. So we have to explore that connection and how that impacts the safety. Okay. I've got a clear picture of where we're going. Thanks.

MEMBER REMPE: Just a note of procedure. When you're not up front, you need to say your name every time you talk for the court reporter. And you probably should say it now. Thank you.

MR. PICCARD: That was George Piccard.

MR. WILLIAMS: Okay. I think we can move a little quicker. The next three slides are really background type of information just to show and talk a little bit about that we do have a robust procedure following NEI 18-04 to identify licensing basis events.

And so the events that we've talked about here would all be initiating events screening. That would be looked at as part of the PRA. We're really talking about those events in the green shaded region here mostly today. This is a nice slide that reminds us of all of the different families of events that are out there being considered.

So the next slide shows us the defense line scheme that we use on NATRiUM. I don't think defense lines come directly from NEI 18-04. They're more of a TerraPower methodology for being able to consider defense-in-depth adequacy in the earliest design phases.

So looking at defense lines, tracking them as design requirements in our configuration management of the design has really helped the safety analysts, PRA people, and the engineers on the design really being able to talk the same language.

When we look at these defense lines, we're going to see a lot of the Energy Island systems, the runback taking care of Defense Line 2 functions, but no Defense Line 3 or 4 functions on the Energy Island.

That's part of the independence that we have in the design. The Defense Line 3 is where the safety systems are. The Defense Line 4 is more of the mitigation systems.

And then the next slide kind of shows a little bit of what we were talking about there and a framework for thinking about Energy Island event responses versus Nuclear Island event responses and how we look at deterministic safety analysis.

A lot of the typical events that you would think of in an operating nuclear power plant that happen on the balance of the plant side, those same type of events on NATRiUM would really have no impact on the Nuclear Island. They can't really affect the Nuclear Island until an interface parameter like we were talking about on the prior side gets triggered.

And in all cases, if the defense line 2 function fails, like the runback is designed to happen but it doesn't happen fast enough, there's still the reactor protection system set points on the Nuclear Island to protect the reactor. So there's always that defense line 3 protection in the plant.

All right. This one really talks about the types of transients that we looked at. They all fall into that decrease or increase in heat removal from the Nuclear Island salt system.

And it's really the thermal inertia and the intermediate heat transport system and the primary heat transport system that provides the adequate time to respond to the event via signals monitored within the Nuclear Island.

So in fact, I think the deterministic safety analysis will look at a pretty extreme loss of heat transfer at the sodium-salt heat exchanger and really use that to bound any possible thing that could happen on the Energy Island, and show that the reactor is designed with adequate safety margin.

We looked at a couple of transients in detail here. The power runback, which is really something that we want to perform to avoid the scram, begins with reactor power being decreased by the insertion of control rods at a predetermined rate.

And being able to do that -- there's different timing that can happen with that. We're designing those control rods to be able to perform that runback in time to avoid the scram.

That involves looking at a lot of different transients. Depending on how the runback gets triggered, there's different time constants and different interactions between the systems. We're making sure that the control rods are designed in all cases to avoid that scram.

Then the IAC and RAC provide the system heat removal. These are what would normally happen in the plant. We're not talking about DBA-type assumptions here. We have both intermediate air cooling and reactor air cooling able to provide heat removal.

The primary sodium pump and the intermediate sodium pump get decreased through their targeted flow settings as part of the power runback. And then finally, when you get down to about five percent power, then you isolate from the Energy Island using the NSS isolation valves.

In the case of a scram, if one of the reactor protection set points gets triggered, then the reactor power gets decreased. The control rod is dropped by gravity, in this case, as opposed to running them in on the motors.

The IAC and RAC also provide heat removal here. The PSPOPs get ramped down. And then you isolate when you get down to five percent power.

If we were to look at this same transient from a DBA perspective, then you wouldn't take credit for the intermediate air cooling. You would only take credit for reactor air cooling. Instead of the PSPOPs ramped down, they would be coasting down. And we don't take credit for the NSSI isolation.

These are kind of the scenarios that were included in our transient analysis that we showed the staff and the different examples of each of these that were presented.

MEMBER MARCH-LEUBA: Is only the scram safety grade?

MR. WILLIAMS: Only scram is safety grade.

MEMBER MARCH-LEUBA: What are the implications with ATWS? We cannot get to the reactors by designing that scram very reliable. Is there more than one way of getting the rods in? Do you have a way to push the rods in if they don't go by gravity?

MR. WILLIAMS: Yes. We have a scram follow function. That is also motor-driven here.

MEMBER MARCH-LEUBA: Is it safety grade?

MR. WILLIAMS: I am not sure.

MS. YOUNG: This is Emily Young from TerraPower. The scram follow function is one of our DL4 functions for our defense-in-depth. If our gravity drop doesn't work for whatever reason, then we'd go into that feature.

So it's not necessarily going to be a

safety-related feature. It's just going to be a defense-in-depth adequacy feature for us.

MEMBER BROWN: I thought the topical report read that if you scrammed, you automatically initiated the drop-in. That's the way I read it. If I read it wrong, just tell me, but that's what I saw, that there wasn't a differentiation.

MS. YOUNG: This is Emily Young. I'll double check and get back.

MEMBER BROWN: Okay. That's the best way to do it. You don't want to wait until you don't have any rods.

MEMBER MARCH-LEUBA: The question I was going to mention is to eliminate errors from your analysis, you have to demonstrate that your scram is on the line of 5 or whatever number you choose. So I guess it's only if the components are safety grade.

MEMBER MARTIN: Real quick, what power level does the Energy Island generate power to the grid?

MR. WILLIAMS: You mean during start-up?

MEMBER MARTIN: Yes, during start-up. Obviously you would have a procedure unlike what it is for shutdown.

MR. WILLIAMS: George, our start-up

narrative?

MR. PICCARD: Yes. George Piccard, TerraPower. The way the start-up narrative currently reads is that we would actually put the steam generators into a hot standby mode.

You don't need to necessarily have the same type of -- get to a certain power and then roll the turbine. You would have a light-water reactor typically at maybe 25-30 percent power.

Depending on where the salt tanks were whether you had a long shutdown or a short shutdown, you could bring the reactor up to power, low power. You could stay on the intermediate air cooling system or you could put more heat into the salt tanks.

So there's a lot more flexibility in the start-up than you would have at the light-water reactor. I don't think right now we actually know when is the ideal time to start rolling the turbine at what power level, but I would imagine it would be similar, 20 percent to 50 percent power.

You'd want to start putting your heat somewhere. So it's just a matter of how much capacity you have for where your heat goes and when you want to start using it.

If you don't want to roll your turbine and you still want to bring the power up, we also have steam dump valves. So there's a tremendous amount of flexibility of when you actually want to start generating electricity. You just don't have to do it at a certain point during start-up.

MEMBER BROWN: Is this Nuclear Island a true nuclear island? You don't even need the Energy Island at all; it can support itself?

I thought all the electrical power that was generated in the Energy Island is not self-supporting. Is it independent?

You don't have to have the grid to run the plant, but you have to have the Energy Island to operate the plant without electricity, but you don't have any diesel generators.

So there's some point in here where you need other power for doing something, I would think. It sounds like if all the lights go out, you don't care anywhere in the entire, whole plant.

MR. WILSON: This is George Wilson. We have a diesel generator. It's not safety grade.

MEMBER BROWN: Okay.

MR. WILSON: I don't have any safety-related backup power.

MEMBER BROWN: That's fine. What I was

really getting to is you don't have to have the grid in order to operate via a stable, low-power conditioning. You're self-supporting?

MR. WILLIAMS: Yes. You can dump the steam, I think, which is what George was saying there.

MEMBER BROWN: As well as run your turbines, if you needed to. You could generate your own electrical power from the Energy Island; is that correct also?

MR. WILSON: This is George Wilson. We're going to re-validate it if we're going to backfeed from generator output back and give houseloads back into what you can.

That is something that's still being evaluated where we'll potentially backfeed in there. Right now our sodium pumps would be powered from the grid. So if you would lose the grid, you would lose your sodium pumps.

MEMBER BROWN: All right. Thank you.

MEMBER KIRCHNER: This is Walt Kirchner. Along those lines, you initially had indicated five steam generator trains. Have you decided on your turbine equipment yet?

If you had five turbines -- I'm not saying that's what you're doing -- you could do a cold blast start of the plant by yourself without off-site power.

MR. WILSON: This is George Wilson. That's something that we've talked with some people that are interested in our plant, actually doing a backfeed and doing a cold start off of our salt tanks. That's not something that we've put into the design yet, but that is something we're evaluating.

MR. WILLIAMS: Emily, you want to add something?

MS. YOUNG: Yes. Emily. Again, a point of clarification, you are correct. The scram follow would initiate immediately following a scram signal generation, correct. Scram follow, yes, for freezing.

And then also there was a question about unprotected events. I just want to make a point of clarification that we do have some unprotected events that we are looking at for the LMP process in terms of discussing the cliff edge effect, but those are currently screened out of our BDBE region.

Their frequency is what we're clarifying as an OQE, an other quantified event. So we will look at those.

But the scram follow events where we don't have gravity drop and motor drive-in, those events are categorized as a beyond-design-basis event per the LMP currently. So they will be on our list of assessed events in our LBE list.

MR. WILLIAMS: Thanks, Emily.

All right. I'll turn this over to you, George.

MR. WILSON: My name is George Wilson. I'm going to talk about what I call the interface or the separation between the Energy Island and Nuclear Island, the potential regulations that wouldn't fully apply to our design.

The first thing we have to look at is the NRC's definition in 10 CFR 50.2 of what safety-related means. And then we look at what the NEI 18-04 difference in safety-related, their definition.

The NEI's is actually based on function and frequency. The NRC's is to do with boundary and has three criteria. Right now we need to either show how we're going to meet the intent of 50.2 or take an exemption of 50.2 and use the classification and the definition and NEI 18-04 for our definition of safety-related.

I'll focus on the bottom two first. For 10 CFR 55, licensed operator reaction, if you look into the guidelines and the definitions in 10 CFR 55, this is one of the actions. We require an operator to have a license.

The scope of 55.2 says any individual who manipulates the controls of any utilization facility licensed under 50.52 and 54 of this chapter. The key word there is control

When you go into the definitions in 10 CFR 50.54, the definition is controls when used with respect to a nuclear reactor means an apparatus and mechanism, the manipulation of which directly affects the reactivity or power level of the reactor based on the fact of the inertia that you can operate the turban.

It has to go through the salt tanks and then it has to go through the intermediate heat transfer system. Finally, it gets to the primary heat transfer system. The time lapse that it takes, there is no direct reaction between operating the turbine and the impact of the reactor.

It can be minutes or even hours before you would see an impact back onto the reactor power based on where you were at. So with that, it is our intention to allow the turbine generator to be operated by the grid operator just like they would in a fossil fuel plant.

MEMBER MARCH-LEUBA: When you say grid

operator, do you mean somebody located in Atlanta?

MR. WILSON: Well, it would be someone located in the grid operations of --

MEMBER MARCH-LEUBA: Remotely?

MR. WILSON: Remotely, right. It would just be operated remotely. Our turbine will be designed with a different ramp rate. Our plant can truly load follow because there is no -- you operate the turbine and reactor at a different power level.

So it is our intentions with our design to allow our turbine to be operated remotely. There will be constant communication with our control room and our operators, but it would be the intention to allow our turbine to be operated.

MEMBER MARCH-LEUBA: And of course, this is a plant that will be doing the safety analysis because all you do is get bored of the computer with numbers. You could consider cybersecurity, attacks, and all this kind of stuff -- you have to make sure that the Energy Island truly does not feed back into the nuclear?

MR. WILSON: Right. We have to have air gaps. We will meet the NRC's requirement. NEI will be doing the cybersecurity. We'll also have to meet the requirements of the CIP standards because there is a bright line between when FERC standards roll over and it's the first isolation point after the turbine.

So we'll have to meet all the requirements for cybersecurity and physical security. We've had to look at allowing to reach out to the grid operator to do the turbine. It will be something new for the NRC. We've already bridged that with --

MEMBER MARCH-LEUBA: You're completely opening the firewall to the grid operator?

MR. WILSON: To a certain extent. I'm not going to go into that.

MEMBER BROWN: To a lesser extent unless you open the LAN.

MEMBER BALLINGER: This is Ron Ballinger. When you say control power remotely, will you be allowing people to remote control other characteristics like reactor power? Can you do that?

MR. WILSON: I just know right now we would allow the -- I don't know about decay bars. Is that what you're talking about, reactor power?

MEMBER BALLINGER: Yes.

MR. WILSON: We're still working with PacifiCorps on what we're going to do, but there would be no issue with them changing. You're just changing the output of your turbine that you're putting into the grid. If I'm putting a reactive load out, I would have to maintain reliability.

We're still working those details out with who would be our grid operator of PacifiCorp. That would be our intention to allow them to. There will be direct communications all the time, but that's something that the industry is actually very interested in.

MEMBER HALNON: So in the spirit of helping move along, this has been done for 50 years. The case is that they're saying it doesn't affect the reactor.

If it doesn't affect the reactor and it doesn't affect reactor safety, then what the grid operator does is independent of all that. The certain extent is within the limits we've already talked about.

MEMBER MARCH-LEUBA: The problem, Greg, is the US is a juicy target for the bad guys. If a hacker in North Korea gets control of your Energy Island, it's not a safety concern, but you'd make it to CNN. And you will have to go testify in front of Congress.

MEMBER HALNON: I think we can argue that point as well. I don't think it's that juicy of a target, but go on.

MR. SCHULTZ: Steve Schultz, just a question. I understand the turbine operation issue associated with operator licensing. The other elements associated with the Energy Island, are those functions for the tanks and so forth performed by a licensed operator?

MR. WILSON: Right now we're still developing our reactivity manipulations control program. If you look at the NRC's conditions, it said we didn't look at 54(j). We will have definitions. We'll have that just like any other reactor.

You have to have a reactivity manipulations control program and start looking at the indirect impacts and what would have to be controlled by a licensed operator or overseen by the operator. So we're still fully evaluating that.

But right now, if there would be, it would be some of the stuff with the salt tanks and nothing with the rest of the plant on the Energy Island side. We're still looking at that. We haven't fully developed that. That's one of the conditions the NRC has put in our top drawer.

MEMBER HALNON: Understood. Thank you.

MR. WILSON: When we looked at 10 CFR

Appendix B, Appendix B states that this appendix applies to all activities affecting the safety-related functions of those structure systems and components.

During our classifications of the way that we do the SSCs, based on when we do the licensing basis events, currently there is no safety-related or non-safety related with special treatment systems, structures, or components located on the Energy Island.

Therefore, on the classification -- you heard the NRC staff; they'll talk about it a little bit more -- their Appendix B would not apply to anything on the Energy Island. The other two regulations are kind of lumped together.

One of them would be a limited work authorization of 10 CFR 50.10 and 10 CFR 50.65. Requirements for monitoring effectiveness of the maintenance at power plants, known as the maintenance rule. 10 CFR 50.10 and 50.65 have the same language in there. So 50.10 actually borrows the maintenance rule language for some of the criteria.

When we looked at the maintenance rule language specifically, we focused on (b)(2). It says non-safety related structures, systems, or components. It you look at item number 3, it says whose failure could cause a reactor scram or actuation of a safety-related system.

To get additional clarification for that, the NRC's Reg Guide 1160, which actually references the NUMARC 93-01 standard -- and if you go into the NUMARC 93-01 standard, item number 3, which is more clarity to the regulations, states systems, structures, and components identified in the licensee's analysis whose failure would cause a reactor scram or actuation of a safety-related system. Based on that clarification, the salt system could cause a reactor scram if a runback did not happen.

So we said that it meets that criteria of the maintenance rule. It is our intention based on using the LMP process to go after an exemption of this based on our risk-informed performance-based approach because, as I stated earlier, there's no safety-related or non-safety related with special treatment systems in the Energy Island.

So really, the intent of the maintenance rule was to keep those systems robust so that you made sure you can do your safety system. So it is our intention to go after an exemption of 10 CFR 50.65 just for that criteria and have those systems, structures, and components in the Energy Island of the maintenance rule.

That's all I have. If there's no questions, thank you guys for your time. We greatly appreciate your time. We're here if you have any other questions.

MEMBER MARCH-LEUBA: Out of curiosity, could you tell us something of your schedule? What are your plans?

MR. WILSON: The plan is we'll be submitting our construction permit application in March of 2024 for the NRC to review.

MEMBER MARCH-LEUBA: Your vision is to be operating the plant when?

MR. WILSON: We'll start preconstruction activities the first quarter of '25. Full operations -- Nick, you can help me here -- I think it's 2030.

MEMBER MARCH-LEUBA: Thanks.

CHAIR ROBERTS: It's Tom Roberts. It's now 10:05. We're about 25 minutes behind schedule. To help that along, I figure we'd take about a ten-minute break. Looking around, I think there's agreement to do that.

I think we have enough time towards the end of the schedule here to make up the time. We'll reconvene at about 10:15 this morning. We'll go with the NRC staff and then proceed from there.

(Whereupon, the above-entitled matter went off the record at 10:06 a.m. and resumed at 10:16 a.m.)

CHAIR ROBERTS: It is now 10:15 and we're coming back into session. We now have the NRC staff presentation. Candace de Messieres will start the presentation for the staff.

MS. DE MESSIERES: Thank you, Chairman Rempe and Member Roberts, for the opportunity to present to the committee today. I am Candace de Messieres, Chief of Advanced Reactor Technical Branch 2 in the Division of Advanced Reactors and Non-Power Production and Utilization Facilities, or DANU, in the Office of Nuclear Reactor Regulation.

During this meeting, the NRC staff will provide you with a summary of our review of TerraPower's topical report titled Regulatory Management of NATRiUM Nuclear Island and Energy Island Design Interfaces.

As we've been discussing, this topical report pertains to the decoupling strategy to ensure independence of operation between nuclear and Energy Island systems for the NATRiUM design.

The topical report contains TerraPower's evaluation for regulations and requests NRC approval of the topical report such that the NATRiUM reactor licensees can utilize the regulatory evaluation via reference and licensing submittals.

I'll emphasize that this review is part of ongoing pre-application engagement with TerraPower. Our review conclusions rely on key preliminary design and analysis aspects and assumptions.

These aspects and assumptions, which include implementation of key design features and assignment of SSC safety classifications, will be confirmed as part of future licensing reviews and are reflected in our topical report safety evaluation in the form of limitations and conditions.

I will now turn it over to the NATRiUM Project Management and Technical Leads, Mallecia Sutton, Senior Project Manager, and Reed Anzalone, Senior Nuclear Engineer, as well as Jesse Seymour, Senior Reactor Engineer Examiner, to present details of our review.

Thank you again for the opportunity to present to the committee. We look forward to your observations and feedback.

MS. SUTTON: Good morning. I'm Mallecia Sutton. I'm glad to be here with you guys. Let me go to the next slide, please.

I'll provide a review of the time line of this topical report. We had a pre-engagement application public meeting on November 17th of 2021 to discuss the potential of submittal. The initial submittal was a white paper titled Energy Island Decoupling Strategy, which was submitted on February 4th.

At the staff review, we had another discussion with TerraPower where they voluntarily withdrew the submittal because we didn't have sufficient information to conduct a review.

After further discussion, TerraPower decided to submit its topical report, why we're here today, titled Regulatory Management at NATRiUM Nuclear Island on October 4th of 2022. Staff accepted the topical report on November 16th.

We conducted an audit to understand the transient analysis discussed in topical report to demonstrate compliance with 10 CFR 50.54(j). The staff will discuss more detail. The audit ran from January 23, 2023 to March 10, 2023. Then staff finalized the draft safety evaluation report, which was issued on August 10, 2023.

With that, I'll turn it over to Reed to go over the staff's evaluation of the topical report. Thank you.

MR. ANZALONE: Thanks, Mallecia. I think I can tell the microphone is working, which is always a concern for me.

I think TerraPower did a pretty good job of going over the purpose of the topical report. I'm not going to talk about that anymore. I'll just focus on our strategy for the review.

What we wanted to do in this review, given where we are in the design and licensing design process with TerraPower, what we wanted to focus on was those key aspects of the NATRiUM design and analysis presented in the topical report, and kind of use that as the context for the regulatory evaluations that they were doing. And then propose appropriate limitations and conditions that would be necessary for those evaluations to be acceptable.

And really, that's kind of the structure of this presentation too. We're going to talk about the key aspects of the design and analysis. We're going to look at the regulatory evaluations, and then we're going to talk about the limitations and conditions.

Next slide. I say basically the same

thing on this slide. Next slide, please.

So I also have a little design overview that I put together that I think goes along with what TerraPower did. We can walk through this pretty quickly.

These figures are taken from the topical report. There's the primary heat transport system. There's the intermediate loop going between the intermediate heat exchanger and the sodium-salt heat exchanger.

There's the thermal salt storage system with the hot and cold salt tanks. And the separation between the Nuclear Island and Energy Island is those isolation valves there on the thermal salt storage system.

Also on the Energy Island there's the steam generating system. Those are the same diagrams that TerraPower presented earlier.

Keep going.

So on the Nuclear Island, we've got these safety systems, the reactor air cooling system, and the intermediate air cooling system. The one thing I wanted to talk a little bit more about on this slide was the audit, which TerraPower touched on a little bit, what they shared with us. I wanted to just mention the key audit findings.

We looked at the analysis that they performed concerning the Energy Island/Nuclear Island interface and the ability of the Nuclear Island to respond to transients on its own. Those Energy Island events -- and TerraPower mentioned this -- that have the greatest possibility to affect the Nuclear Island are the ones that occur physically closest to the Nuclear Island.

Events that occur further out from that interface can really all still be boiled down to changes at the Nuclear Island/Energy Island interface. The question is just how long does it take for those changes to propagate through.

Even then, once you have those changes that you see at the Nuclear Island/Energy Island interface, how long does it take those to propagate through to where they have an effect on the core?

TerraPower talked a bit about the thermal inertia of the various systems. We see that those are really significant towards making the case for Energy Island/Nuclear Island independence.

The design of the primary heat transport system, the fact that they're using a pool-type SFR, the intermediate heat transport system and how big it is. And then the really big thing is the thermal salt storage system, which pretty much effectively insulates changes in turbine power from affecting reactor power, as we've discussed.

Next slide.

MR. SCHULTZ: Reed, before you go on, this is Steve Schultz.

MR. ANZALONE: Sure.

MR. SCHULTZ: I meant to ask TerraPower about this. You talked about the time frames that are available for the interaction between the Energy Island and the Nuclear Island qualitatively. Can you quantify that a bit, the power and so forth?

MR. ANZALONE: It really depends on the specific transient, what's going on, and what system you're talking about. But it is minutes to hours, not seconds. I think that's pretty much the only level I can -- it really depends on the particular --

MR. SCHULTZ: That's fine. I wanted to get the minutes and the powers on the record. Thank you.

MR. ANZALONE: Okay. I think George mentioned that during the last little bit of --

MR. SCHULTZ: Thank you.

MR. ANZALONE: So I'm going to touch on

the safety classification using NEI 18-04, which is the risk-informed, performance-based technology inclusive guidance for non-light-water reactor licensing basis development. That's a mouthful so I'm just going to say NEI 18-04 LMP from now on.

We endorsed that in Reg Guide 1.233. TerraPower is following those approaches as endorsed in the Reg Guide.

It's a risk-informed, performance-based safety classification approach that's laid out in NEI 18-04, which is highly integrated with other aspects of the process including the selection and analysis of licensing basis events and evaluation of adequacy. I think TerraPower later in the presentation showed some of those pieces all together.

It's a slightly different definition for safety-related SSCs than in 50.2, which George touched on. The 50.2 definition talks about safety-related SSCs should be those needed to ensure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, or the ability to prevent or mitigate the consequences of accidents which could result in off-site releases comparable to the 50.34 limits.

We think that conceivably you could use the LMP process to demonstrate compliance with that 50.2 definition of safety-related, but you may or may not. So you might need to take an exemption from 50.2. I think TerraPower is considering that as well.

Go to the next slide, please, Candace.

CHAIR ROBERTS: Reed, Tom Roberts. I'm just trying to understand some examples of what might not meet the definition of 50.2, if it were shown to be safety-related per LMP.

MR. ANZALONE: I think there's a question of whether what TerraPower has in their reactor design constitutes a reactor coolant pressure boundary, quote/unquote, because it's operating at atmospheric pressure.

They have made a distinction historically between reactor coolant boundary versus reactor coolant pressure boundary. Other more exotic designs might deviate a little bit even further away from those definitions in 50.2.

So NEI 18-04 and our Reg Guide kind of leaves open the possibility that you might need an exemption from 50.2. Does that answer the question?

CHAIR ROBERTS: I think so. Is that the case here? It seems like integrity of the coolant boundary is going to be required regardless of what you call it.

MR. ANZALONE: Yes. It's just a matter of wording. I think they would propose an alternate definition. I believe there was a public meeting we had with them some time last year where they talked about changing that to just say reactor coolant boundary or primary coolant boundary instead of reactor coolant pressure boundary.

CHAIR ROBERTS: It gets into more semantics than technical? That's what I'm trying to understand.

MR. ANZALONE: Yes. I would agree with that.

CHAIR ROBERTS: Okay. Thank you.

MR. ANZALONE: So the NEI 18-04 process uses this definition for the different safety classifications that are available. There's the safety-related SSCs and those are the SSCs selected for the required safety functions to mitigate design-basis events within the frequency consequence target curve. I have a slide coming up where I'm going to explain what that actually means.

And SSCs selected for required safety functions to prevent high consequence beyond design-basis events from entering the design-basis event region beyond the frequency consequence target. I'll talk about those more when we get to the next slide.

There's also this concept of non-safety related with special treatment, which is roughly analogous to Part 50. Those are the non-safety related SSCs that are performing risk significant functions or needed for defense-in-depth.

I think that conceptually you can think about you might have multiple SSCs that can do a safety function. You would have one you would designate as safety-related and then you would have another that you would designate potentially as non-safety related with special treatment.

And then the final category is non-safety related with no special treatment, which as TerraPower has discussed, they're trying to get all those Energy Island SSCs to be in that final category.

Next slide, please, Candace.

Here's the frequency consequence target curve from NEI 18-04. I'm just going to use this to try to help explain those safety-related SSCs.

If you can advance it a little bit, that's the design-basis event region, which is those events that have a frequency between 1E minus 4 and 1E minus

2. The high consequence beyond design-basis events are those in the beyond-design basis event region.

So that's between five times ten to the minus seventh and ten to the minus fourth. Those are beyond the 50.34 dose limit. The safety-related SSCs are used to keep the DBEs within the frequency consequence target. The high-consequence BDDE is within the frequency consequence target.

Also -- if you can advance it one more time, Candace -- only the safety-related SSCs are available to keep design-basis accidents below the 10 CFR 50.34 dose limit.

Those design-basis accidents are DBE events that have been stylized to use very conservative assumptions. There's a deterministic analysis that's done to show that they stay below the 50.34 limit using only safety-related SSCs.

MEMBER MARTIN: This is Bob Martin. Is their power showing preliminary results for dose consequences --

MR. ANZALONE: Yes.

MEMBER MARTIN: -- and their methodology? Is there a slide, maybe somewhere else because it's not here, of how they compare to the curve?

MR. ANZALONE: There are some results

from, I want to say, earlier this year. Those were at the time considered proprietary.

MEMBER MARTIN: We're okay seeing that, right?

MR. ANZALONE: Yes since this is a public meeting. Yes, everything was inside the target curve.

MEMBER MARTIN: They submitted a topical on those consequences and methodology?

MR. ANZALONE: They will be submitting a topical and on the deterministic safety analysis. The safety classification process was one of the key things that we were considering in our review of the topical report in addition to the design.

So now I'll talk a little bit about the regulations that were covered in the topical. I think George actually did a great job overviewing these during TerraPower's presentation.

They looked at 50.10 and 50.65, which are the LWA rule and the maintenance rule which, as he said, have identical requirements for some of them. They looked at Appendix B and Part 55.

Next slide.

The LWA rule provides a requirement that no person may begin the construction of a production or utilization facility on a site on which the facility is to be operated until they've been either issued a construction permit or a limited work authorization.

50.10(a)(1) provides the scoping criteria that defined what constitutes construction in the context of the rule. Those scoping criteria were chosen to encompass those SSCs that have a reasonable nexus to radiological health and safety or common defense and security.

If you go to the next slide, Candace.

Criteria 2, 3, and 4 were chosen based on the language in the maintenance rule, which had already been around for some time at this point. Basically, when the Commission was promulgating the LWA rule, there was a desire to try to use agreed-upon definitions for what had a reasonable nexus to health and safety.

They just basically lifted those criteria from the maintenance rule because there was guidance and they had been used for some time. Then also, criteria 1 is safety-related SSCs.

And then there are several additional criteria. Those necessary to comply with Part 73, which is the security regulations, those needed to comply with 50.48 and criteria 3 of the general design criteria, which are fire protection regulations and those needed for on-site emergency facilities.

If you could go to the next slide?

MR. MARCH-LEUBA: Not allowing testing? You have testing at the end of the first paragraph.

MR. ANZALONE: I have to say I don't actually know off the top of my head.

MR. MARCH-LEUBA: I think if they come and ask you that you would tell them, yes, go ahead and test all you want. Okay.

MR. ANZALONE: So I'm going to walk through all the criteria in 50.10(a)(1). First I'll talk about TerraPower's evaluation and then I'll talk about what we thought about that evaluation.

So criteria 1 they said wasn't applicable because those Energy Island SSCs are non-safety related with no special treatment. We said that was reasonable.

It's consistent with the NEI 18-04 safety classification definition, but we did have a limitation regarding the definition of safety-related. I've already talked about how there's a distinction between the 50.2 definition and the NEI 18-04 definition.

Criteria 1 here actually specifically

refers back to 50.2. Rather than saying safety-related, it says safety-related SSCs as defined in 10 CFR 50.2.

So if it just said safety-related, it wouldn't necessarily be an issue. But if they're getting an exemption from 50.2, they would also need to get an exemption here. And that's what the limitation tries to make clear.

Criteria 2 TerraPower determined wasn't applicable because Energy Island SSCs aren't used to mitigate accidents or transients or used in the EOPs, the emergency operating procedures. We thought that was consistent with the plant design.

We wouldn't expect non-safety related SSCs to participate in mitigation or prevention of accidents or transients, but we haven't reviewed TerraPower's emergency operating procedures. They're still under development. So we added a limitation and condition on the topical report to address that.

Criteria 3 isn't applicable because the NSD SSCs wouldn't be capable of preventing safety-related SSCs from fulfilling their safety functions. We thought this was consistent with the NEI 18-04 safety classification definition. And I'll also note I think I have a slide that talks a little bit more about this later.

There was a comment or a staff position in the Reg Guide endorsing NEI 18-04 that says basically, if an SSC provides a central support to a higher classified SSC, so if you had an SSC providing support to a safety-related or non-safety related with special treatment SSC, we would expect that support in SSC to be classified the same as the higher classification SSC.

And finally, on this slide criteria 4, and George talked about this, they determined that it was applicable because the failure of an Energy Island SSC could eventually cause a reactor trip and they planned to seek an exemption. And that they would use the same exemption basis for 50.10(a)(1)(4) and 50.65(b)(2)(3) because those are the same language.

We agreed with TerraPower's determination that the criteria was applicable. We thought it was reasonable to use the same exemption basis for the two regulations that have the same language, but we didn't take a position on the prospective exemption. We'll review that when we get it.

Next slide.

Criteria 5 TerraPower said wasn't applicable because there wouldn't be any physical security program SSCs on the Energy Island. And that if they had any SSCs that were identified as critical digital assets for the cybersecurity program, they wouldn't be installed on the Energy Island prior to the construction permit.

We felt like that was consistent with the design, but we kind of expect that that would be constrained in scope to the Nuclear Island. We didn't have a lot of detail on the security program. We're going to have to look at those further when we have those details.

Criteria 6 they judged to be non-applicable because fires on Energy Island would not prevent the ability to maintain and achieve shutdown, which is really the focus of 50.48. We thought that that was an adequate evaluation because those Energy Island SSCs are non-safety related with no special treatment, as TerraPower talked about quite a bit today, and can be achieved and maintained solely using Nuclear Island systems.

And then finally, criterion 8 they determined was not applicable because the on-site emergency facilities would not be located on the Energy Island. We felt like that was consistent with the plant design and could be a design goal, but we hadn't seen that flushed out yet to the point where we could say definitively yes. The on-site emergency facilities are not on the Energy Island. So we had a limitation condition there.

Next slide.

MEMBER HALNON: So the end result of all of this was this evaluation in combination with the limits and precautions, limits and conditions, and their exemptions? They can build Energy Island without a limited work authorization?

MR. ANZALONE: If it appears it's going in that direction.

MEMBER HALNON: Okay. So this is a hurdle that they jumped over, and it looks like there's a clear road ahead but there's still some --

MR. ANZALONE: Yes. I would agree with that.

So I'll talk a little bit about the maintenance rule but really, fundamentally the evaluation was basically the same as for 50.10. The maintenance rule requires licensees to have a program that monitors the performance or condition of certain SSCs or demonstrates that they'll be able to perform their intended functions through appropriate preventative maintenance.

The scope of the SSCs are basically the same as the several regulations that we already talked about in 50.10. 50.65(b)(1) is similar to but not identical to 50.10(a)(1)(i) in that it doesn't say safety-related SSCs as defined in 50.2. It says safety-related SSCs to include all of the stuff that's in the definition in 50.2, so it's a little bit different there, but then the other criteria in 50.65 are the same as the ones in 50.10.

Next slide.

So TerraPower didn't evaluate 50.65(b)(1), which is the note about safety-related, so we didn't disposition that in our safety evaluation. The other criteria we evaluated the same as in our evaluation under 50.10.

Next slide.

Appendix B provides quality assurance requirements for the design, manufacture, and construction of certain SCCs, and it applies to all activity is affecting the safety-related functions of SSCs that prevent or mitigate the consequences of postulated accidents that could cause undue risk for the health and safety of the public.

Next slide.

So TerraPower asserted that all the Energy

Island SSCs will be non-safety related with no special treatment, and that SSCs classified as non-safety related with no special treatment under that NEI 18-04 process wouldn't be capable of affecting the safety-related function of the SSCs used for prevention or mitigation.

We considered the role that we would expect non-safety related SSCs to play, and determined that the evaluation was acceptable. That's the staff position that I mentioned earlier, that support SSCs should be classified at the higher level of the SSCs that they support.

Now I'm going to turn it over to Jesse --

MEMBER MARCH-LEUBA: Hold on.

MR. ANZALONE: Sure.

MEMBER MARCH-LEUBA: Let me just make a comment. This is not a criticism. Appendix B is good. Appendix B is also painful and expensive to be brought in.

From a public presentation point of view, they don't need to do any QA on the Energy Island. I'm sure TerraPower is going to do some ISS standard or something like that.

So from a public presentation point of view, we should say that the QA that they're planning to do is sufficient and doesn't need to be expanded to the Appendix B's standards. I'm just suggesting that because I'm sure you're going to use QA. It's an expensive plant.

MR. ANZALONE: Point taken. Thank you.

MEMBER HALNON: The QA is going to be essentially -- it's required by the construction codes, right?

MR. ANZALONE: Which is not nothing.

MEMBER HALNON: No. You've got all kinds of steps on there.

MR. ANZALONE: All right. Now Jesse is going to talk a little bit about Part 55.

MR. SEYMOUR: Thank you, Reed.

My name is Jesse Seymour. I'm an operator licensing examiner and technical reviewer at NRR. I reviewed the Part 55 related portion of the topical report.

In the topical report, TerraPower describes that the NATRiUM design removes direct interaction between the reactor and the turbine generator, which results in operation of the turbine generator not constituting an apparatus or mechanism. This manipulation directly affects the reactivity or power level of the reactor.

TerraPower also states in the topical report that NATRiUM design would allow for a non-licensed operator based upon that to operate the turbine generator. From an operator licensing perspective, this is much different than the current large light-water reactor practice in which turbine generator operations have historically been considered to be control manipulations, and therefore restricted to being only performed by licensed operators.

In evaluating TerraPower's position, a key consideration is TerraPower's description of the NATRiUM thermal storage system as providing a significant thermal energy storage capacity that can be used to support electrical generation such that the reactor power wouldn't be directly correlated to turbine manipulations.

MEMBER HALNON: Jesse, did you look at this from just the turbine generator set or for the whole Energy Island perspective?

MR. SEYMOUR: I'll address the Energy Island aspect a little further into this. The primary consideration was who could operate the turbine. So again, when you're looking at the Energy Island, obviously there's other things that could potentially be seen coming off the system, drawing salt energy.

MR. HALNON: Levels of the salt tanks was what I was -- it seems like the closest connection to effects on the Nuclear Island. That's what I was curious about, whether or not we're talking about an exemption for the entire Energy Island or just what you have to run the turbine with.

MR. SEYMOUR: So the focus of topical evaluation is going to be on the turbine generator operation itself and whether the turbine constitutes a control. When we get to the broader discussion of the Energy Island, that's covered more so by the 50.54(j) discussion I'll be going through later on.

MR. HALNON: Okay.

MR. SEYMOUR: One thing I do want to throw in there is this is part of the reason that we wanted to judge the exemptions on their own merits when those come in. Those will more, we would expect, very clearly define the scope of what would be exempt and what wouldn't.

We evaluated these considerations within the context of the regulations of 10 CFR Parts 50 and 55, the associated regulatory history, and the relevant statutory requirements. As I'll discuss in detail in the next slide, the word direct is used in the definition of control is central to understanding the meaning of key regulations involved here and evaluating the assessment of the topical report.

Next slide, please.

The Atomic Energy Act defines operators under Section 11 as being individuals who manipulate the controls of utilization facilities. The Atomic Energy Act also mandates under Section 107 that individuals who operate utilization facility controls must be licensed by the NRC.

Thus, there is a statutory driver behind why only licensed operators will operate the controls of the facility. Very importantly, though, the Atomic Energy Act does not define what those controls actually consist of, which leaves that definition to instead be made by the NRC via regulation.

From the inception of operator licenses back in 1956, manipulation of the controls of the utilization facility has been restricted to licensed operators under the Regulation 50.54(i). That specific regulation is very closely linked to the Atomic Energy Act provisions that I discussed.

It's worth noting that the original 1956 definition of controls was much broader than the modern version and formally encompassed mechanisms which by manipulation or failure to manipulate singly or in combination could result in the release of atomic energy or reactor materials in amounts determined by the Commission to be sufficient to cause danger to the health and safety of the public. So again a very, very broad definition in its original form.

In 1963, the Atomic Energy Commission narrowed that definition significantly on the basis that a regularly narrow interpretation of what was truly controlled would be more consistent with the Commission's original intent.

An amended definition of controls remains unchanged in its present day and is limited to the scope of apparatus and mechanisms, the manipulation of which directly affects the reactivity or power level of the reactor.

Separately, 50.54(j) was also introduced in 1963, which also addresses the manipulation of apparatus and mechanisms other than the controls, the operation of which may affect the reactivity or power level of a reactor and states that those shall be manipulated only with the knowledge and consent of a licensed operator present at the controls.

Notably, those types of operations are permitted to be conducted by individuals other than licensed operators provided that the provisions or consent and oversight are still met.

The key takeaway here is that the regulations recognize the distinctions between an apparatus or mechanism, whose manipulation directly affects the reactivity or power level of the reactor, and those that are not direct in nature, with separate requirements governing each of those.

As mentioned earlier, the word direct and the definition of controls is the key here. The implication of the use of the word direct was that controls can be interpreted to mean apparatus and mechanisms that when manipulated affect reactor power level reactivity without also needing something intermediate to make that happen.

Manipulations of that type fall under the scope of 50.54(i) and their performance is going to be restricted to licensed operators and senior operators. Again, there's a very direct tie back to the Atomic Energy Act on that.

Thus the presence or absence of a significant intermediary between any given manipulation and the reactivity or power level effects on the reactor is the key factor that we as a staff in our judgement identified as being the essential determinant of whether given operations fall under the scope of 50.54(i).

Based upon that perspective, we evaluated the implications of NATRiUM's described design and determined that the thermal storage system would act as a significant intermediary between manipulations involving Energy Island steam loads and reactivity effects on the reactor.

This led to our conclusion in the safety evaluation. Manipulations of NATRiUM apparatus and mechanisms that affect Energy Island steam loads do not directly affect the reactivity or power level of the reactor, and therefore do not fall under the scope of 50.54(i).

The topical report does not address compliance with 50.54(j) though. This was incorporated into the limitations and conditions that will be discussed later in the presentation.

Unless there's questions, I'll go ahead and turn it back over to Reed.

MEMBER HALNON: So you're talking about the thermal storage system doesn't affect reactivity, but it sounds like it could cause a reactor scram or runback. How is that not affecting reactivity?

MR. SEYMOUR: The distinction made here is you have a category of things that directly are discussed to affect reactivity, and you have a category of things that the operation of which may affect reactivity.

The distinction is that one set of things falls under (i) in 50.54(i) and the other falls under (j). What we're saying here in the topical is that there is very well a subset of things that could fall under (j). We'll cover that in a limitation that we put on there.

MEMBER HALNON: So that's all being dumped into (j)?

MR. SEYMOUR: That's correct, yes. So it'll still be necessary for TerraPower to show how they're going to comply with (j) or to go through and seek some type of an exemption.

I would mention, and I'll build upon this, during the audit we did query TerraPower on how they want to pursue compliance with (j). Again, this was done in audit so it's not something that's necessarily reflected in safety evaluation.

They did provide us with a copy of their draft reactivity plan. At the point that we looked at it, it was still in a very rudimentary state, being flushed out. But that plan was intended to, I believe, eventually show how they're going to comply with 50.54(j) for Energy Island operations.

MEMBER HALNON: So you get another bite at the apple to discuss how the thermal systems could affect reactivity?

MR. SEYMOUR: That's right. Ultimately the applicability is still there for 50.54(j), which puts that into a regime where you either have to comply or seek an exemption from it.

MEMBER HALNON: Okay.

MR. SEYMOUR: Again, there's a significant difference between (i) and (j). With 50.54(i), as I talked about, there's almost a straight line going back to the Atomic Energy Act.

MEMBER HALNON: Yes. It seems like there's a success route there. It's just a matter of what the documentation is going to be?

MR. SEYMOUR: That's correct.

MEMBER HALNON: Okay.

MR. SEYMOUR: I'll turn it over to you, Reed.

MR. ANZALONE: I think that's one of the themes of what we're talking about here. There's a success path. We're kind of outlining what that success path looks like, but that path has to be walked.

Now I'm going to talk a little bit about the limitations and conditions, which kind of provide the contours of that path. The first limitation is about key aspects of the NATRiUM design.

That states that applicants referencing the topical would need to use a plant design that's substantially similar to what was discussed in the topical and that deviations that could affect the safety evaluation conclusions need to be justified when the topical report is referenced.

I think in general in the topical report process, this is one of these things that's kind of assumed would happen that you need to justify the applicability of the topical report to your plant when you reference it. But we wanted to put this in as limitations to underscore the importance of those design features that enable the independence of the Nuclear Island and Energy Island.

While those regulatory evaluations that we talked about were really relatively high level, we did make our determinations in the context of the NATRiUM design and its capabilities. Part of the reason we're doing this too and putting it specifically as a limitation in the condition is that there is interest in applying similar approaches to decouple the Nuclear Island and Energy Island that's been expressed to us by other industry organizations.

So we wanted to kind of outline, here are the things that you need to happen in the design to make something like this possible.

Next slide.

So limitation condition 2 talks about the safety classification process. This is sort of a similar theme to the first one. They use NEI 18-04 in the topical report to do the safety classification.

We relied on that to make our determinations, but also the design process is iterative. NEI 18-04 identifies that it would be intended to be applied iteratively as the design matures. Eric mentioned this in their presentation.

They've done these analyses. They are doing these analyses. They're going to continue to do these analyses and reconfirm as the design matures that the Energy Island SSCs continue to be non-safety related with no special treatment for the conclusions in our safety evaluation to remain applicable.

So limitation 3, this is the one talking about the difference in the definition between 50.2 and NEI 18-04 for safety-related. And I think I already covered that one. I'll move on.

Limitation 4, there are other definitions in the regulations of construction. Part 51, which is the environmental regulations, also has a definition of construction that's similar or possibly identical to Part 50. I'm in safety licensing, not environmental, so I'm not actually that familiar with the environmental regulations.

We just wanted to make it clear that the evaluation applies to the Part 50 definition of construction that TerraPower evaluated. It doesn't apply to any other places that construction might be defined.

Five, and I already talked about this. We haven't reviewed EOPs for NATRiUM and TerraPower didn't discuss them in sufficient detail to ensure they don't rely on Energy Island SSCs.

Six and 7, similar to 5. We're going to need more information on the physical and cybersecurity programs to ensure that the Energy Island doesn't include SSCs that fall under the scope of those programs. We think the design supports it, but we didn't have enough to be able to say definitively.

Now Jesse is going to talk about 8 and 9.

MR. SEYMOUR: Thanks, Reed.

As mentioned earlier, the topical report does not address the requirements of 50.54(j). Therefore, we did not provide any safety evaluation of the implications of NATRiUM's design as it relates to that specific regulation.

Again, 50.54(j) deals with apparatus and mechanisms, the operation of which may affect reactivity. It does not require a licensed operator to do those things, but a licensed operator at the controls has to provide knowledge and consent.

Thus, any NATRiUM facility licensee or applicant for an operating license or combined license that references this topical report, in the absence of receiving an exemption, must ensure that manipulation of any Energy Island apparatus or mechanism which may affect the reactivity or power level of the reactor is only permitted with the knowledge and consent of a licensed operator or senior operator.

Beyond that, 55.31(a)(5) requires that reactivity manipulations for operative licensed applicant experience requirements must involve operating the controls which, as discussed earlier, are associated with direct reactivity or power changes.

Therefore, any apparatus or mechanism determined to not be a control must logically also be excluded from being acceptable for applicant experience credit under 55.31(a)(5). Again, this was important to point out because historically we've accepted those loading changes as a reactivity manipulation for that type of credit.

So consistent with that, applicants for operator or senior operator licenses at a NATRiUM facility where the facility licensee references its topical will not be able to rely upon manipulation of apparatus and mechanisms that affect Energy Island steam loads, including the turbine generator, for the purposes of satisfying those operator license experience requirements.

I'm going to turn it back over to Reed again.

MR. ANZALONE: I'll just talk about this last limitation, which is pretty simple. The topical report discussed the basis for the proposed exemptions. We reviewed it for information, but we're not taking a perspective on the exemptions that we haven't received yet in the safety evaluation.

MR. BLEY: Excuse me. This is Dennis Bley. Could you back up one slide and go over that last point you made? It kind of slipped past me. I didn't fully understand it.

MR. SEYMOUR: Sure. This is Jesse. When a licensed operator applicant applies for a license, one of the requirements is that they have to show they conducted five significant reactivity manipulations. Those can either be done on an actual plant, or with a few more restrictions it can be done on a simulator.

One of the keys is that they have to utilize the controls of the facility. Historically, with the existing large light-water fleet, we have accepted credit for those occurring, moving the rods, berating, diluting, manipulating recirculation pumps on the reactor side. And then over on the secondary side changing turban loading has been something that we've accepted for credit before.

So based upon this topical report and our evaluation of it, again, it creates a little bit of a logical disconnect if you were going to say that the turbine and its manipulation does not constitute a control on the one hand, but then on the other hand allow that to still be credited for those types of applications.

Essentially, what that condition and limitation is saying there is that you can't have your cake and eat it too, for lack of a better way to put it.

MR. BLEY: Okay. I think I get it now. Thank you.

MR. SEYMOUR: If you could go to the next slide, please?

So the high-level conclusions. The topical report is acceptable for referencing future licensing submittals subject to our limitations and conditions, which we think delineate that path where it would be acceptable. The plant design and Energy Island's safety classification, they are integral part of our evaluation.

With that, I will open it up to any questions.

MEMBER HALNON: On the cybersecurity side when we drew the bright line back in 2010-ish time frame for operating plants, are you going to carry that same scope, I guess, for lack of better terms, for the NRC to be into the construction as well?

I assume that when Vogel was constructed, the NRC looked at the compliance with the New York side as well, like they do in the operating plants. Is that going to carry forward in these advanced reactors as well?

MR. SEYMOUR: I'm not a cybersecurity expert so I can only comment so much, but that is basically my understanding of where things are. We've talked with the cybersecurity people about this.

MEMBER HALNON: Okay. So obviously, there's no major change in how we're going to be looking at it in the future then?

MR. SEYMOUR: Not to my understanding, but I could be proven wrong.

MEMBER HALNON: Okay.

MR. MARCH-LEUBA: My concern with the cyber is this starts defining political components. Nothing in the NEI is a political component. Therefore, a cybersecurity plan is not required.

MEMBER HALNON: Well, by the NRC's standard. The NERC standard would put them into a more special category.

MR. MARCH-LEUBA: I've always said you guys have to be looked for aquariums. And the EI sounds to me like an aquarium. I will tell you the story after. Or just Google cybersecurity attack on a casino with an aquarium.

MS. de MESSIERES: This is Candace de Messieres of the NRC staff again. I just wanted to reiterate we did explicitly put that limitation and condition in the topical safety evaluation just because we do need more information in this area, so more to come.

MR. SCHULTZ: Reed and Jesse, this is Steve Schultz. Just to confirm in general, during the presentations today from TerraPower, your review of your overall evaluation, and the limitations and conditions, things are aligned between you and TerraPower, associated with their actions that they see they need to take in regard to the exemption requests?

MR. SEYMOUR: Yes, I would say so.

MR. SCHULTZ: And other follow-up actions associated with the limitations and conditions?

MR. SEYMOUR: Yes.

MR. SCHULTZ: And with regard to the exemptions, it doesn't seem as if they're high hurdles, the Part 50 exemptions that TerraPower is moving forward to obtain.

MR. SEYMOUR: I think I would agree with that. Like I said, they laid out a lot of the basis for the exemptions in the topical report, so we're kind of aware of where they're going to go.

MR. SCHULTZ: So your limitations and conditions are aligned with that as well?

MR. SEYMOUR: Yes.

MR. SCHULTZ: Thank you.

CHAIR ROBERTS: Are there any other questions from the members online?

MEMBER KIRCHNER: No, thank you, Tom.

CHAIR ROBERTS: Thanks, Walt.

Hearing none, I have one final question for the staff. Is there anything in this topical report you think was innovative or kind of ground-breaking or just kind of the normal process of doing business with the pre-application phase?

MR. SEYMOUR: I would say the whole concept is kind of innovative and ground-breaking, but I think that's mostly just because nobody has really had a technology that seemed to us to be capable of doing this previously.

I think for a lot of the reasons that Jesse and I have laid out, it's not something that you could do with a large light-water reactor with the current designs that are in the operating fleet. So it took somebody coming up with a design that was capable of doing this and then trying to put into practice.

I think there is some ongoing things that TerraPower is going to need to make sure of. I'm confident that they are going to do that because this is one of their key design principles, to maintain the separation between the Energy Island and the Nuclear Island.

But as they go through the process, they're going to have to continue to try to reinforce that separation to be able to make sure that these things can actually be followed through as they're described in the topical report. I'll leave it at that.

MR. BLEY: This is Dennis. Could I ask a question of TerraPower? Throughout this discussion, you talked a lot about using the LMP. We've heard some complaints from people about how arduous that is.

So I have two questions for you. One is, can you describe a little bit how you found the use of the LMP in your projects so far?

Two, do you have any comments on the limitations and conditions the staff has placed in their review? Were they surprises to you or are you pretty comfortable with them?

MR. JOHNSON: This is Brian Johnson on the line, Manager of Nuclear Safety Licensing leading up the risk reliability efforts and a lot of the LMP implementation.

I will agree. I think the LMP is somewhat arduous, but I think it's a worthwhile and good way to establish a positive safety case that's thorough early on.

I think it's also going to be something we want to leverage to defend things like our safety classifications so that they don't drag on, that we have an agreed-upon systematic basis for making those determinations, rather than ad hoc determinations based on whatever negotiation we can do, whatever precedent exists.

So that experience of developing the PRA and going through the LMP, I think, has been overall good and that we have gotten significant insight from that process.

I'm not going to speak directly to the limits and conditions of the topical here, but I did want to say that has been our overall experience with LMP. Yes, it's a lot of work, but it gives worthwhile insights.

MR. WILSON: This is George Wilson of TerraPower. We expected that we were going to get limitations and conditions on the topical report for where we were at.

We just wanted to make sure that the NRC was open, our logic was there, and the regulatories flow past so that we can continue through the process. So we expected the limitations and the conditions that we received.

MR. BLEY: Gentlemen, thanks.

CHAIR ROBERTS: Are there any other questions for the staff or the applicant? Now is the time on the agenda for comments from members of the public. If anybody online would like to make a comment, please go ahead and unmute yourself, state your name and organization, and make your comment.

Hearing none -- there is a hand, okay. What does the hand mean?

MR. LYMAN: Ed Lyman.

CHAIR ROBERTS: Yes, hello. Go ahead.

MR. LYMAN: This is Ed Lyman from the Union of Concerned Scientists. I'd just like to bring up one point. I've heard from a reliable source that the estimated capital cost of this project has doubled from original estimates.

I don't know if that means from the $4 billion that was originally stated, meaning you would be up to $8 billion. Clearly, the molten salt storage aspect is a substantial contributor to that capital cost.

I would anticipate there may be design changes along the way to try to address the capital cost increase that could impact the conclusions now that we've reached here. So I'm just raising that as an issue, perhaps for the committee to keep in mind, but some of these redundancies may go away. Thank you.

CHAIR ROBERTS: Thank you. Are there any other members of the public that would like to make a statement?

Hearing none and seeing no additional hands raised, now is time for the Committee discussion. I guess I'll start by suggesting from what we heard today, I would suggest that we would not need to write a letter because of various reasons.

One is the limitation condition number 2 in the topical report. Basically you can go through this whole line of reasoning on the actual design as it's produced.

There's nothing really that's being committed to at this point other than acknowledging that the process leads to the types of interaction that you've heard today. I'd be interested from the members if people see it that way or have different views.

MEMBER MARCH-LEUBA: I'm a proponent of not writing those when it's not needed. Whenever there is a new and novel concept in its first application, I think in years later will have value. The energy out from Nuclear Island is the first time I've seen it implemented. I think having a position for FCRS is okay.

MEMBER HALNON: I absolutely hate agreeing with Jose, but I think that it serves a couple of purposes. One is there's a couple of items that I think we still need to keep our eye on.

That is the requirement for the operators to maintain pre-existing conditions prior to a transient in order for that operating envelope to say within the bounds of where it needs to be so that they don't have to respond to an accident condition.

That's more on the nuclear side than Energy Island side, but I'm interested in the how tech specs would roll out, procedures, EOPs, and those types of things before we could say that we agree, there's a clear distinction here where there's no license operators on Energy Island.

Secondly, to Jose's point, it's a progressive aspect of our committee to give a green light, if that's what we're going to be, which I think we should be, to a novel concept to move forward with. I think we concluded, or at least I concluded in my mind, that both the staff and the applicants have done a good job to lay groundwork for future work that has a clear success path, but there's still some hurdles to get beyond.

Not just the exemptions, but some of the other analyses that have to be done. I think there's a good aspect to putting a green light on that, but also the cautionary aspect of some things that still need to be shaken out.

MEMBER REMPE: I agree with the members who have spoken, except that I have more problems with agreeing with Greg than Jose.

MEMBER PETTI: I'm just concerned with how we write such a letter. It's kind of like a green light but putting your foot on the break because there's these issues out there that you really can't evaluate until the design gets more mature.

So if we do it, it's going to have to be really carefully worded. Is it viewed as a full green light? The staff didn't give them the full green light. This is kind of a blinking yellow at best.

We don't usually write letters like that. I think we're going to see this is all going to come back again. It's sort of an issue of when is the optimal time.

MEMBER REMPE: There are some things that we will be evaluating as we go forward. It's not really cautions. It's just, hey, there's some outstanding.

I'm sorry I interrupted you, Vesna. Go ahead.

MEMBER DIMITRIJEVIC: That's okay because that's the limits of my ability to participate in this discussion. This is just conceptual, the approach.

So I don't really think that there is a reason for us to write the letter before the design is complete. They're still going to talk with us about human factors that we don't completely understand yet until the PRA is completed.

So basically, what they have been saying is technically that Energy Island can be separated from Nuclear Island. And therefore, the components there would not require the same certification, but this is just concept until these other things are complete.

MEMBER BROWN: This is Charlie. Are you finished, Vesna?

MEMBER DIMITRIJEVIC: Yes.

MEMBER BROWN: I guess I would agree with Tom and Vesna. They've just laid out a concept for how we would like to go. They've given us the plant concept for how to get separation, but there's a whole pile of additional items that need to be evaluated relative to exemptions and the limitations and conditions, which we don't have any closure on at all.

I would prefer to have some more detail of how they're actually going to finish rowing the boat through these rapids before we write a letter on it because right now, all we can say is maybe. So I would vote for no letter at this particular time. That would be my position.

MEMBER BALLINGER: This is Ron Ballinger. From the standpoint of the technical side, I agree with Tom. We don't need a letter. But what we're talking about here is something which has a much larger implication going forward.

What we're talking about here is basically spending reserve for these plants. In the future, it's like putting a battery on the grid in effect, and not having the transmission lines from a freaking -- excuse my French -- from a wind turbine somewhere.

So going forward, having the Energy Island separated from the Nuclear Island has implications which we may want to at least point out. I don't know whether we want to do that in a letter or not, but this concept has larger implications, although people say it's existed for a long time. What's the difference between that and pump storage, I guess.

MEMBER HALNON: If you go just a little bit further, Ron, it may not be an Energy Island. It may be a chemical plant. You don't want to put nuclear licensed operators at a chemical plant because they could indirectly affect reactivity by changing their chemical processing. So it's got further implications even broader than that.

It's also -- correct me if I'm wrong -- this is the first licensing action that TerraPower has asked for. Is that correct?

PARTICIPANT: This is the first time.

MEMBER HALNON: To show progress in the advanced reactor world, I think it's important that we show the committee is engaged and going forward. Yes, we don't give a complete green light, I agree, to the separation of Energy Island from Nuclear Island.

I think it's even beyond conceptually when we see a clear path. There's regulatory hurdles to get over, but they're regulatory hurdles, not necessarily physical. There might be one or two physical ones that we pointed out. I think it's important for us to endorse a potential path forward for not just energy islands but chemical process plants, hydrogen plants.

MEMBER BALLINGER: In theory, they could shut that down from the salt loop to the Nuclear Island, and just run the turbine and generate power until they ran out of heat.

MEMBER HALNON: Yes, until the tank is empty.

MEMBER REMPE: Okay. The letter would not occur until October Full Committee week if it were to occur. So I would recommend that you take a vote through the subcommittee and then during P&P September Full Committee, it will become an official committee decision on this.

So why don't you give a recommendation to go forward or not to go forward from the subcommittee. And then you'll have to present it at full committee in September.

If it does not go forward, you need to have a paragraph that could go into them needing summary notes. I don't think there's more than a subcommittee could do right now. You might want to take a vote and decide what the consensus or the majority is.

MEMBER MARCH-LEUBA: The subcommittee does both, right?

MEMBER REMPE: You can have a soft P&P and have a recommendation for the subcommittee. That's what I'm trying to say. I hear both sides of the aisle and I'm kind of stepping in to help you out here.

CHAIR ROBERTS: Okay. So our subcommittee vote would be to enter P&P with a recommendation to either write a letter or not write a letter for presentation at the October meeting?

MEMBER REMPE: If there is going to be a letter, then there would be a presentation in October. The one question I didn't hear asked is did the staff or the applicant request a letter from ACRS?

It does cost the applicant to take time to do a presentation. You can do it remotely. You don't have to fly in or anything.

MS. SUTTON: Neither the staff nor the applicant requested a letter. I know we do have a proposed date for October 4th if it was needed. So I guess we will know in September if we will support a full committee.

MEMBER REMPE: And there's nothing that

having to wait until that October -- are there decisions being made by the applicant or the staff other than you can't issue your SC without our letter if we're going to have a presentation? But there's nothing like a real operating plant. Sometimes we're delaying something but we're not really.

MS. SUTTON: There's no ground-breaking. There's no construction being done, no construction activities. So at this time we just have several topical reports. We have six in house that we're reviewing that will potentially come to the subcommittee.

MEMBER HALNON: Is it required that we have a full committee presentation? Since the subcommittee is the full committee, why can't we just say let's have a one-hour deliberation and then go into letter writing?

MEMBER REMPE: Are there any members not present today?

MEMBER HALNON: That is an option.

MEMBER MARCH-LEUBA: What we do in this case is we ask the staff to make a summary presentation of ten to 15 minutes, and have the applicant on the phone in case there's a question.

MEMBER HALNON: Just in case there's some lingering questions.

MEMBER MARCH-LEUBA: They don't have to travel.

MEMBER REMPE: Absolutely, yes. They don't have to. Anyway, I'd take some sort of vote on the recommendation.

CHAIR ROBERTS: Let's go ahead and take a vote. The vote would be on whether a P&P coming up in two weeks, whether it's the recommendation of the subcommittee that the full committee meet to deliberate a letter.

Does that make sense? A yes vote would be to proceed with a letter and a no vote would be to not proceed with a letter. How would you vote?

MEMBER KIRCHNER: I personally would make a summary and not do a letter. My reasons would be that I think we would find ourselves repeating all the limitations and conditions that the staff has discussed as parent of their deliberations in FC.

I'm not sure that this would really -- again, we're at a conceptual phase. There are lots of questions yet that will depend on the details that will be forthcoming for the applicant. So I guess at this point, I would not write a letter, just put a summary entry into our record.

CHAIR ROBERTS: Thanks, Walt.

Vesna?

MEMBER DIMITRIJEVIC: Same here. I already said that, a summary note.

CHAIR ROBERTS: Let's get a show of hands in the room of who would write a letter? And who would proceed with writing a summary and the P&P but not form a letter?

The vote is five plus two, so seven to four to proceed on the basis of not writing a letter. I'll draft a paragraph for the P&P coming up in two weeks, and then we'll have another discussion and another vote at that point.

MEMBER MARCH-LEUBA: Procedurally, you would present a recommendation of the subcommittee to the full committee. Hopefully, nobody will change their mind. The decision would be on the full committee.

CHAIR ROBERTS: Okay. Thanks, Jose.

MEMBER MARCH-LEUBA: The staff and applicant can probably assume that you won't write the letter, but you won't know until September.

MS. SUTTON: This is Mallecia. I just want to clarify. Is the vote to actually write a summary? And if no summary, then we'll have the October meeting? No letter but the summary of the meeting?

MEMBER REMPE: Just to clarify, this summary is just, hey, the subcommittee met. We discussed this. The general people were favorable. We supported the LNCs, the limitations and conditions, whatever comments. You're done.

CHAIR ROBERTS: This is our record that we made a decision not to do a letter.

MS. SUTTON: I just wanted to make sure we are on the same page. Thank you.

MEMBER BROWN: You're clean.

MR. MOORE: This is Scott Moore, the Executive Director. We prepare a summary for each full committee meeting. It would go into that. The summary is publicly available in ADAMS. It would describe whatever the full committee decides to do on this.

The full committee could still decide to write a letter, as Jose has pointed out, but it's unlikely given that you've got, I think, everybody here. You can see it in the summary and so can the public.

MEMBER REMPE: Sometimes an applicant or licensee likes that summary saying that even though they didn't write a letter, they supported it.

MEMBER BROWN: Our summary can have a

caveat that we reviewed all the stuff and it's not unreasonable, but no closure on things, however Tom can phrase it in a happy manner.

MR. KELLENBERGER: So we would know in September whether we need to come back for the full committee in October?

CHAIR ROBERTS: No surprises.

MEMBER REMPE: We'll make sure to let you know.

CHAIR ROBERTS: Are there any other comments that the members or consultants would like to make?

MEMBER HALNON: Just thank you to TerraPower for coming in. We greatly appreciate face-to-face communications when we can get it, so we appreciate it very much that you were here.

CHAIR ROBERTS: I'd like to reiterate what Greg said. I appreciate the presentations from both TerraPower and NRC staff. They were excellent. I think our questions got answered to the extent that it could be answered given the preliminary nature of the concept design.

With that, this meeting is adjourned.

(Whereupon, the above-entitled matter went off the record at 11:29 a.m.)

Staff Review of NATD-LIC-RPRT-0001, "Regulatory Management of Natrium Nuclear Island and Energy Island Design Interfaces"

Mallecia Sutton, Senior Project Manager, NRR/DANU

Reed Anzalone, Senior Nuclear Engineer, NRR/DANU

Jesse Seymour, Senior Reactor Engineer (Examiner), NRR/DRO

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

Agenda

- Review Chronology
- TR Overview and Review Strategy
- Safety Evaluation Overview
    - Plant design and transients
    - Safety classification using NEI 18-04
    - Regulatory evaluations
    - Limitations and conditions
- Conclusions

Review Chronology

- Pre-Application Public Meeting
  - November 17, 2021
- Submittals on Decoupling Strategy
  - White Paper: “Energy Island Decoupling Strategy” February 4, 2022 (voluntarily withdrawn)
  - Topical Report: “Regulatory Management of Natrium Nuclear Island and Energy Island Design Interfaces” October 4, 2022
- TR Accepted
  - November 16, 2022
- Audit Conducted
  - January 23, 2023 - March 10, 2023
- Final Draft Safety Evaluation Issued
  - August 10, 2023

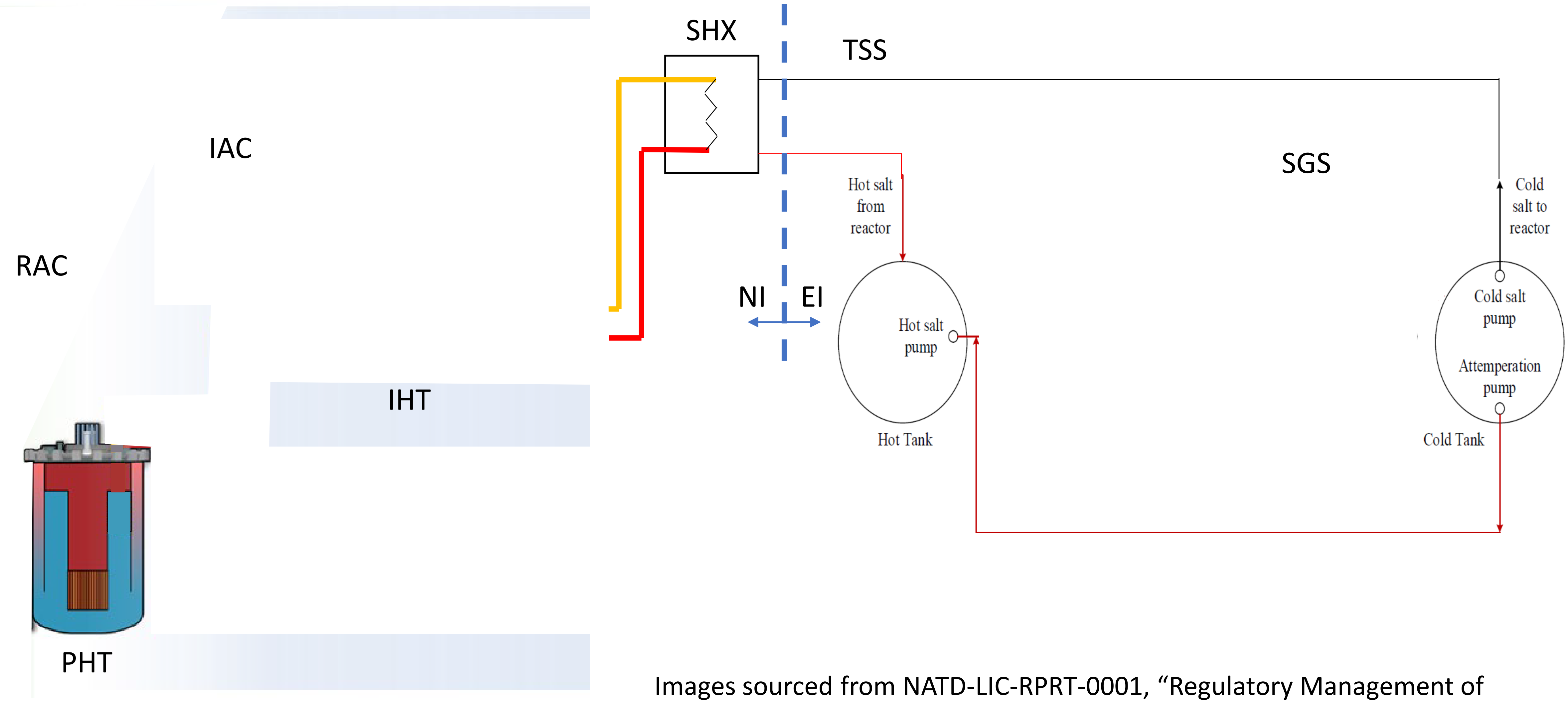
TR Overview and Review Strategy

- Purpose of TR:
  - “The independence of operation between the systems contained within the NI and the plant systems composing the EI is a key aspect of the Natrium design philosophy. The NI boundary conditions have been intentionally designed so the interrelationship with the EI does not impact the NI safety case.”
  - “[E]valuate regulatory impacts of the Natrium design interfaces with respect to the interaction of NI and EI systems”
- Review Strategy
  - Examine key aspects of Natrium design and analysis presented in the TR
  - Assess regulatory evaluations in the context of these key aspects
  - Propose appropriate limitations and conditions necessary for evaluations to be acceptable

Safety Evaluation Overview

- Sections 1-4 – Introduction and Background
- Section 5 – Staff Evaluation
  - Section 5.1 – Natrium Plant Design and Transients
  - Section 5.2 – Natrium Safety Classification of SSCs
  - Section 5.3 – Regulatory Analyses
- Section 6 – Limitations and Conditions
- Section 7 – Conclusions

Plant Design and Response to Transients



Images sourced from NATD-LIC-RPRT-0001, "Regulatory Management of Natrium Nuclear Island and Energy Island Design Interfaces" (ML22277A824)

Safety Classification Using NEI 18-04*

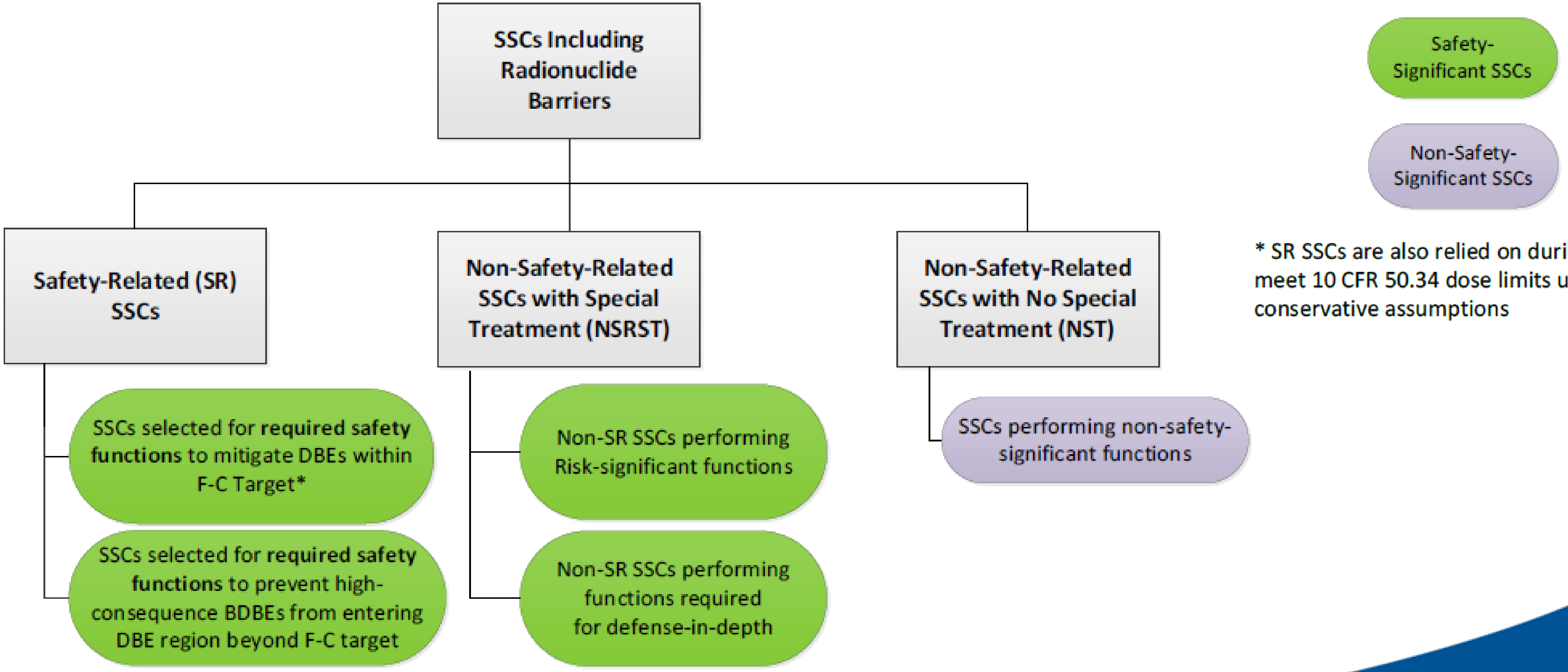
- NEI 18-04 endorsed in RG 1.233, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors"

- Risk-informed, performance-based safety classification is integrated with other aspects of NEI 18-04 process, including selection and analysis of licensing basis events and evaluation of defense-in-depth adequacy

- Different definition for safety-related SSCs than 10 CFR 50.2

*NEI 18-04, "Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development", Revision 1 (ML19241A472)

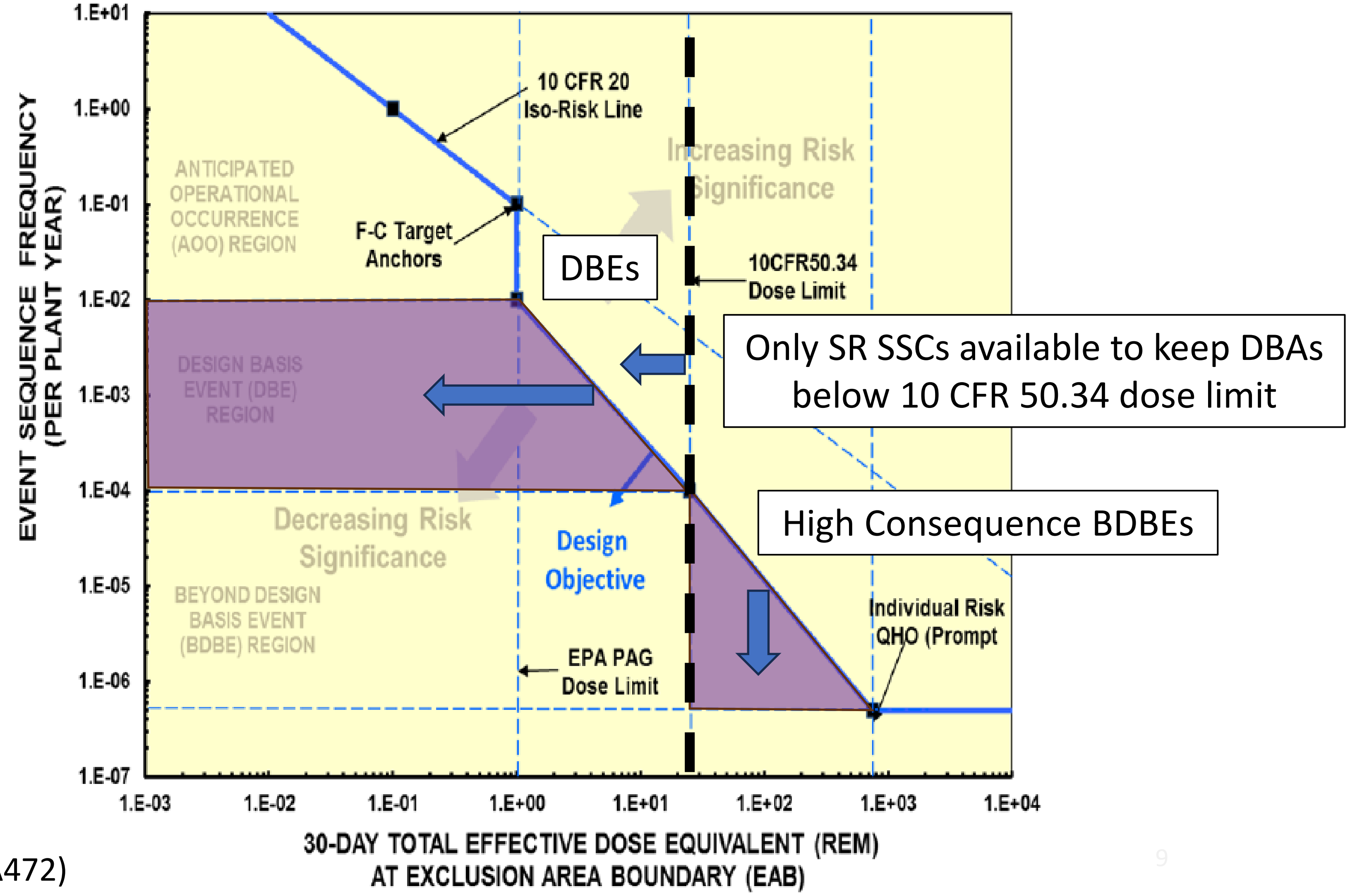
Safety Classification Using NEI 18-04



* SR SSCs are also relied on during DBAs to meet 10 CFR 50.34 dose limits using conservative assumptions

From NEI 18-04, Rev. 1 (ML19241A472)

Role of F-C target in Safety Classification



From NEI 18-04, Rev. 1 (ML19241A472)

Overview of Regulations Covered in TR

- 10 CFR 50.10, “License required; limited work authorization”
- 10 CFR 50.65, “Requirements for monitoring the effectiveness of maintenance at nuclear power plants”
- 10 CFR 50 Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants”
- 10 CFR 55, “Operators’ Licenses”

10 CFR 50.10 (“LWA rule”) Overview

- 10 CFR 50.10(c): “[n]o person may begin the construction of a production or utilization facility on a site on which the facility is to be operated until that person has been issued either a [construction permit]… or a limited work authorization [LWA] ….”
- 10 CFR 50.10(a)(1) provides scoping criteria defining construction.
- Rule issuance FRN (72 FR 57415) notes that scoping criteria were chosen to encompass “those SSCs that have a reasonable nexus to radiological health and safety or common defense and security”.

10 CFR 50.10(a)(1)

Activities constituting construction are the driving of piles, subsurface preparation, placement of backfill, concrete, or permanent retaining walls within an excavation, installation of foundations, or in-place assembly, erection, fabrication, or testing, which are for:

(i) Safety-related structures, systems, or components (SSCs) of a facility, as defined in 10 CFR 50.2;
(ii) SSCs relied upon to mitigate accidents or transients or used in plant emergency operating procedures;
(iii) SSCs whose failure could prevent safety-related SSCs from fulfilling their safety-related function;
(iv) SSCs whose failure could cause a reactor scram or actuation of a safety-related system;
(v) SSCs necessary to comply with 10 CFR part 73;
(vi) SSCs necessary to comply with 10 CFR 50.48 and criterion 3 of 10 CFR part 50, appendix A; and
(vii) Onsite emergency facilities, that is, technical support and operations support centers, necessary to comply with 10 CFR 50.47 and 10 CFR part 50, appendix E.

10 CFR 50.10(a)(1) Evaluation

Criterion	TerraPower	Staff
(i)	Not applicable because EI SSCs are NST.	Reasonable, consistent with NEI 18-04 safety classification definition. See L&C 3 regarding definition of "safety-related."
(ii)	Not applicable because EI SSCs are not used to mitigate accidents or transients or used in EOPs.	Consistent with plant design. Would not expect NST SSCs to participate in mitigation or prevention. Not enough information on EOPs. See L&C 5.
(iii)	Not applicable because NST SSCs would not be capable of preventing SR SSCs from fulfilling safety functions.	Consistent with NEI 18-04 safety classification definition.
(iv)	Applicable because failure of EI SSCs could eventually cause a reactor trip. Plan to seek exemption. Exemption basis would be the same for 10 CFR 50.10(a)(1)(iv) and 10 CFR 50.65(b)(2)(iii).	Agree with determination that criterion is applicable. Reasonable to use same exemption basis for 10 CFR 50.10(a)(1)(iv) and 10 CFR 50.65(b)(2)(iii). Not taking a position on prospective exemptions. See L&C 10.

10 CFR 50.10(a)(1) Evaluation

Criterion	TerraPower	Staff
(v)	Not applicable because no physical security program SSCs are on EI; CDAs will not be installed on EI prior to CP.	Appears consistent with design, but not enough information to support. See L&C 6.
(vi)	Not applicable because fires on EI will not prevent ability to maintain and achieve safe shutdown.	Adequate because EI SSCs are NST and safe shutdown can be achieved and maintained solely with NI systems.
(vii)	Not applicable because onsite emergency facilities will not be located on EI.	Consistent with plant design, but not enough information to support. See L&C 7.

10 CFR 50.65 (“Maintenance Rule”)

- Requires licensees to have a program that monitors the performance or condition of certain SSCs or demonstrates the performance or condition of these SSCs through appropriate preventative maintenance, to provide reasonable assurance that they are capable of fulfilling their intended functions.
- Scope of SSCs considered under the Maintenance Rule are in 10 CFR 50.65(b)
  - 10 CFR 50.65(b)(1) is similar to 10 CFR 50.10(a)(1)(i)
  - 10 CFR 50.65(b)(2)(i) through (iii) are identical to 10 CFR 50.10(a)(1)(ii) through (iv)

10 CFR 50.65 Evaluation

- TerraPower did not evaluate 10 CFR 50.65(b)(1).
- TerraPower determined criteria (i) and (ii) are not applicable. Staff discussions and conclusions are the same as for 10 CFR 50.10(a)(1)(ii) and (iii).
- TerraPower determined criterion (iii) is applicable and plans to seek an exemption. Staff discussion and conclusions are the same as for 10 CFR 50.10(a)(1)(iv).

10 CFR 50, Appendix B

- Appendix B provides QA requirements for the design, manufacture, and construction of certain SSCs.
- Appendix B applies to "all activities affecting the safety related functions" of SSCs that "prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public."

10 CFR 50, Appendix B Evaluation

- TerraPower asserted that all EI SSCs will be NST, and SSCs classified as NST under the NEI 18-04 process are not capable of affecting the SR functions of SSCs used for prevention or mitigation.
- Staff considered the role of NST SSCs and determined TerraPower's evaluation was acceptable
  - RG 1.233 Staff Position C.2 states, in part: "The staff expects that SSCs that provide essential support (including required human actions) for SR or NSRST SSCs will be classified in a manner consistent with the higher-level function, even if the supporting SSC is not explicitly modeled in the PRA."

10 CFR 55

- TerraPower states that the Natrium design removes direct interaction between the reactor and the turbine generator
  - Turbine operations would not be an apparatus or mechanism whose manipulation directly affects the reactivity or power level of the reactor
  - Natrium design should allow for a non-licensed individual to fully operate the turbine generator
- Staff evaluated that the nature of the TSS is consistent with Natrium not treating turbine generator operations as a “control” as defined under 10 CFR 50.2 and 10 CFR 55.4
  - A key consideration is the term “direct” and its specific meaning within the definition of “controls”

10 CFR 55

- The AEA Section 11 defines operators as individuals who manipulate the controls of utilization facilities; definition of “controls” is left to the NRC
  - Section 107 further mandates that individuals who operate utilization facility controls must be licensed by the NRC.
- Manipulation of the controls is restricted to licensed operators under 10 CFR 50.54(i)
  - Definition of “controls” in Parts 50 & 55 dates back to 1963 (28 FR 3197)
  - Narrowed from an earlier, broader definition; FRN notes that “this [current] narrower interpretation… is in accord with the original Commission intent.”
- The “direct” aspect of a “control” means they cause reactor power level or reactivity changes without needing something intermediate to make that happen
  - Natrium TSS is a significant intermediary from a reactivity standpoint

L&C 1 – Key Aspects of Natrium Design

- Applicants referencing TR must use a plant design that is substantially similar to what was discussed in TR. Any deviations from plant design discussed in TR that could affect SE conclusions must be justified when the TR is referenced.
- Staff underscores the importance of the design features that enable the independence of the NI and EI. While the regulatory evaluations may be relatively high-level, the staff's determinations were made in the context of the Natrium design and its capabilities.

L&Cs 2&3 – Safety Classification; Definition of “Safety-Related”

- L&C 2
  - Staff’s conclusions rely on the use of the NEI 18-04 process for safety classification and a determination that all EI SSCs are classified as NST.
  - Design process is iterative; so is NEI 18-04. As design matures, TerraPower will need to ensure EI SSCs continue to be NST for conclusions to be applicable.
- L&C 3
  - Definition of SR in NEI 18-04 is different from that in 10 CFR 50.2.
  - Some regulations explicitly reference 10 CFR 50.2 definition rather than simply saying “safety-related.”
  - Use of NEI 18-04 may require exemptions from 10 CFR 50.2 and regulations that refer to it.

L&Cs 4-7 – Evaluation of 10 CFR 50.10 and 10 CFR 50.65

- L&C 4 – TerraPower did not address definitions of “construction” outside of 10 CFR 50.10; this limitation makes the scope of the TR clear.
- L&C 5 – Staff has not reviewed EOPs for Natrium and TerraPower did not discuss in sufficient detail to ensure they do not rely on EI SSCs.
- L&Cs 6&7 – TerraPower did not discuss physical and cyber security programs or onsite emergency facilities in sufficient detail for staff to ensure the EI does not include SSCs that fall under the scope of 10 CFR 50.10(a)(1)(v) and (a)(1)(vii).

L&Cs 8-9 – Evaluation of 10 CFR 55

- L&C 8 – 10 CFR 50.54(j) not addressed in TR.
- L&C 9 – Since manipulating the EI does not directly change reactivity or power, operator licensing experience requirements under 10 CFR 55.31(a)(5) are not satisfied by operating the EI.

L&C 10 – Prospective Exemption Requests

- TR discussed basis for proposed exemptions.
- Staff reviewed for information but did not take a position on prospective exemptions in the SE.

Conclusions

TR is acceptable for referencing in future licensing submittals, subject to limitations and conditions.

Plant design and EI SSC safety classification [assumptions] are integral parts of staff's evaluation.

Abbreviations

BDBE – Beyond design basis event

CFR – *Code of Federal Regulations*

CP – Construction permit

CDA – Critical digital assets

DBA – Design basis accident

DBE – Design basis event

EI – Energy Island

EOP – Emergency operating procedure

F-C – Frequency-consequence

FR – *Federal Register*

FRN – *Federal Register* notice

IAC – Intermediate air cooling system

IHT – Intermediate heat transport system

L&C – Limitation and/or condition

LWA – Limited work authorization

NEI – Nuclear Energy Institute

NI – Nuclear island

NSRST – Non-safety related with special treatment

NST – Non-safety related with no special treatment

PHT – Primary heat transport system

QA – Quality assurance

RAC – Reactor air cooling system

RG – Regulatory guide

SGS – Steam generation system

SHX – Sodium/salt heat exchanger

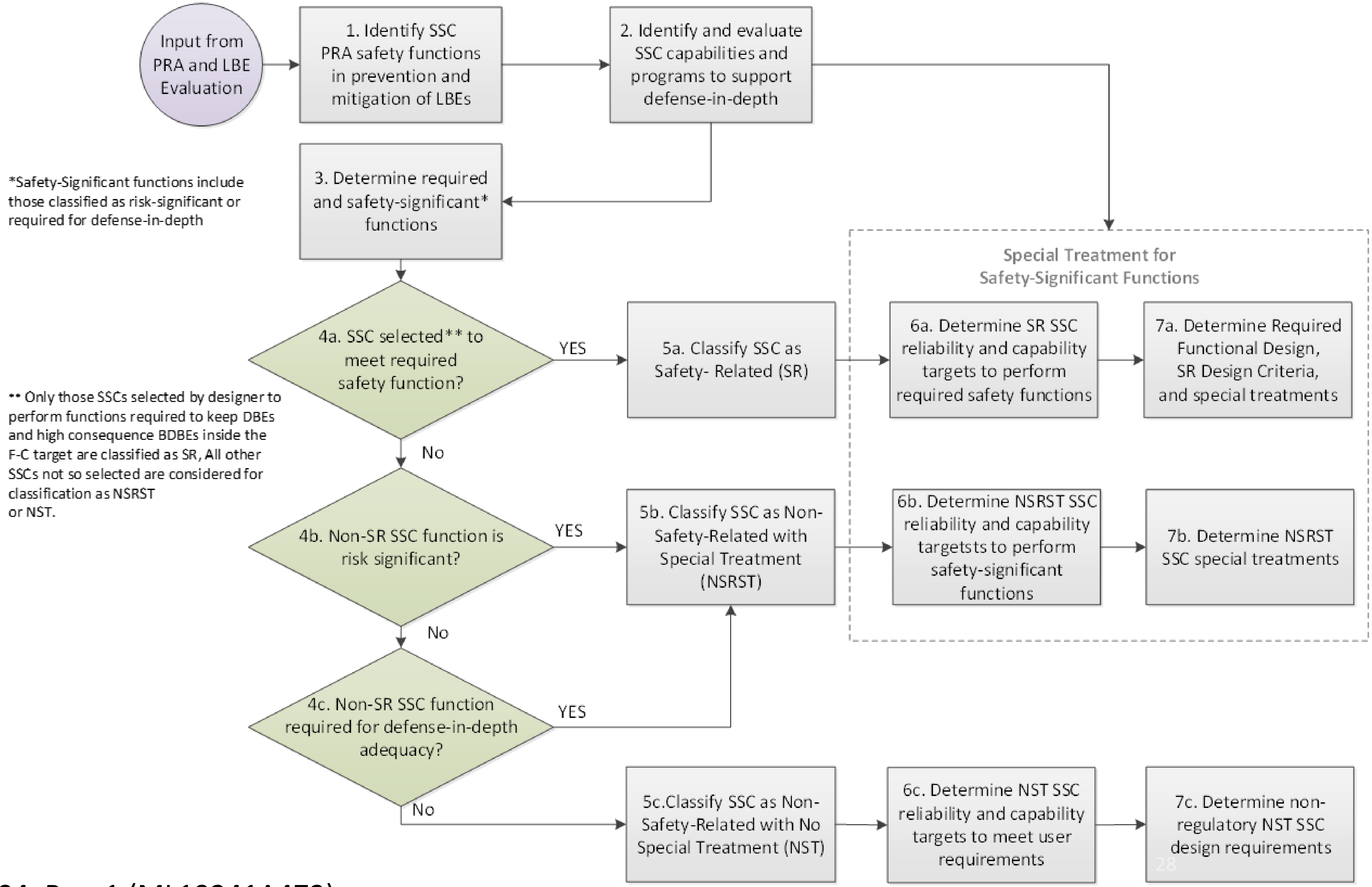
SSC – Structure, system, or component

SE – Safety evaluation

SR – Safety related

TR – Topical report

TSS – Thermal salt storage system



From NEI 18-04, Rev. 1 (ML19241A472)

TerraPower

August 17, 2023

TP-LIC-LET-0094
Project Number 99902100

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
ATTN: Document Control Desk

Subject: Submittal of Presentation Material for Advisory Committee on Reactor Safeguards Subcommittee Meeting

This letter provides the TerraPower, LLC presentation material for the August 23, 2023 Advisory Committee on Reactor Safeguards Subcommittee meeting (Enclosure 1).

This letter and enclosures make no new or revised regulatory commitments.

If you have any questions regarding this submittal, please contact Ryan Sprengel at rsprengel@terrapower.com or (425) 324-2888.

Sincerely,

Ryan Sprengel
Director of Licensing, Natrium
TerraPower, LLC

Enclosure 1: TP-LIC-PRSNT-0014, *Regulatory Management of Natrium Nuclear Island and Energy Island Design Interfaces*

cc: Mallecia Sutton, NRC
William Jessup, NRC
Nathan Howard, DOE
Jeff Ciocco, DOE

ENCLOSURE 1

TP-LIC-PRSNT-0014, Regulatory Management of Natrium Nuclear Island and Energy Island Design Interfaces

Regulatory Management of Natrium Nuclear Island and Energy Island Design Interfaces

a TerraPower & GE-Hitachi technology

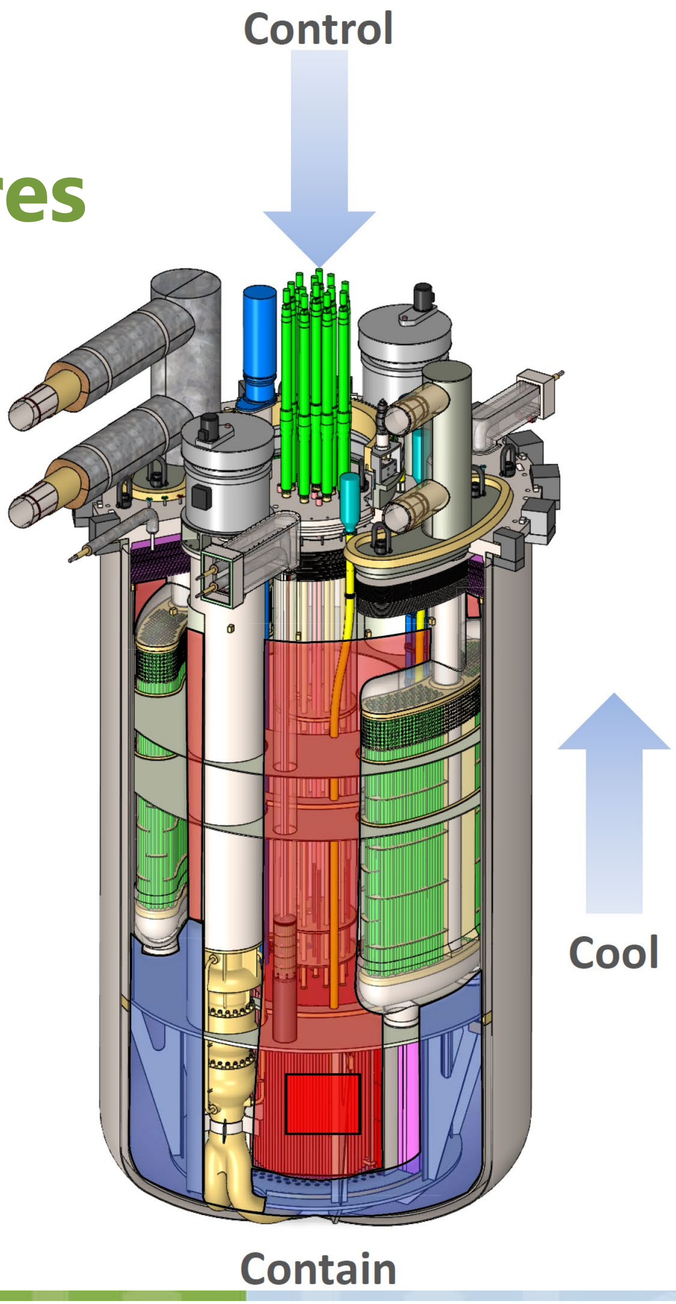
TP-LIC-PRSNT-0014

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Table of Contents

Natrium Safety Features

- Pool-type Metal Fuel SFR with Molten Salt Energy Island
  - Metallic fuel and sodium have high compatibility
  - No sodium-water reaction in steam generator
  - Large thermal inertia enables simplified response to abnormal events
- Simplified Response to Abnormal Events
  - Reliable reactor shutdown
  - Transition to coolant natural circulation
  - Indefinite passive emergency decay heat removal
  - Low pressure functional containment
  - No reliance on Energy Island for safety functions
- No Safety-Related Operator Actions or AC power
- Technology Based on U.S. SFR Experience
  - EBR-I, EBR-II, FFTF, TREAT
  - SFR inherent safety characteristics demonstrated through testing in EBR-II and FFTF



Control

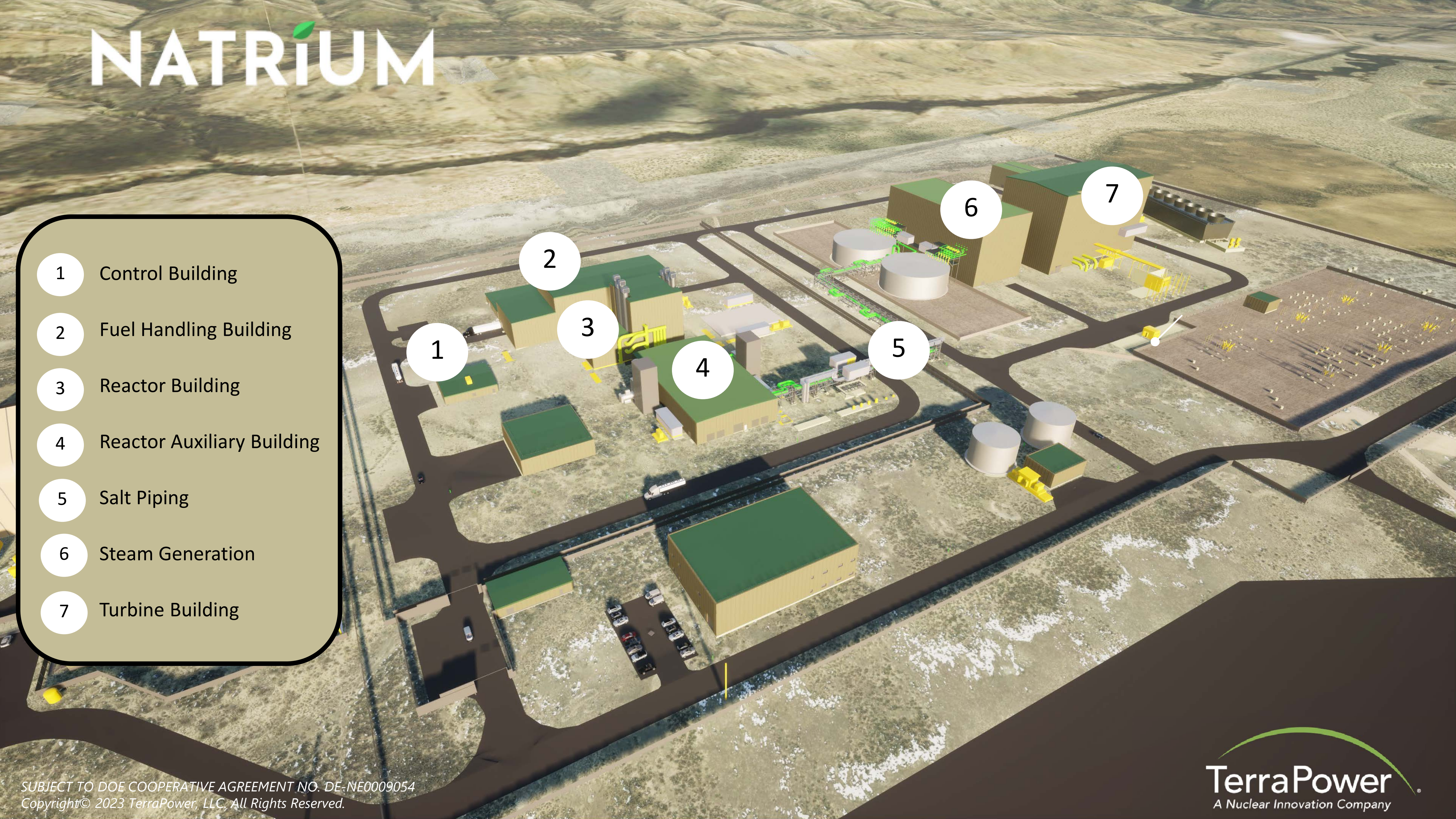
- Motor-driven control rod runback and scram follow
- Gravity-driven control rod scram
- Inherently stable with increased power or temperature

Cool

- In-vessel primary sodium heat transport (limited penetrations)
- Intermediate air cooling natural draft flow
- Reactor air cooling natural draft flow – always on

Contain

- Low primary and secondary pressure
- Sodium affinity for radionuclides
- Multiple radionuclides retention boundaries


NATRIUM
1 Control Building
2 Fuel Handling Building
3 Reactor Building
4 Reactor Auxiliary Building
5 Salt Piping
6 Steam Generation
7 Turbine Building
1
2
3
4
5
6
7
SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054
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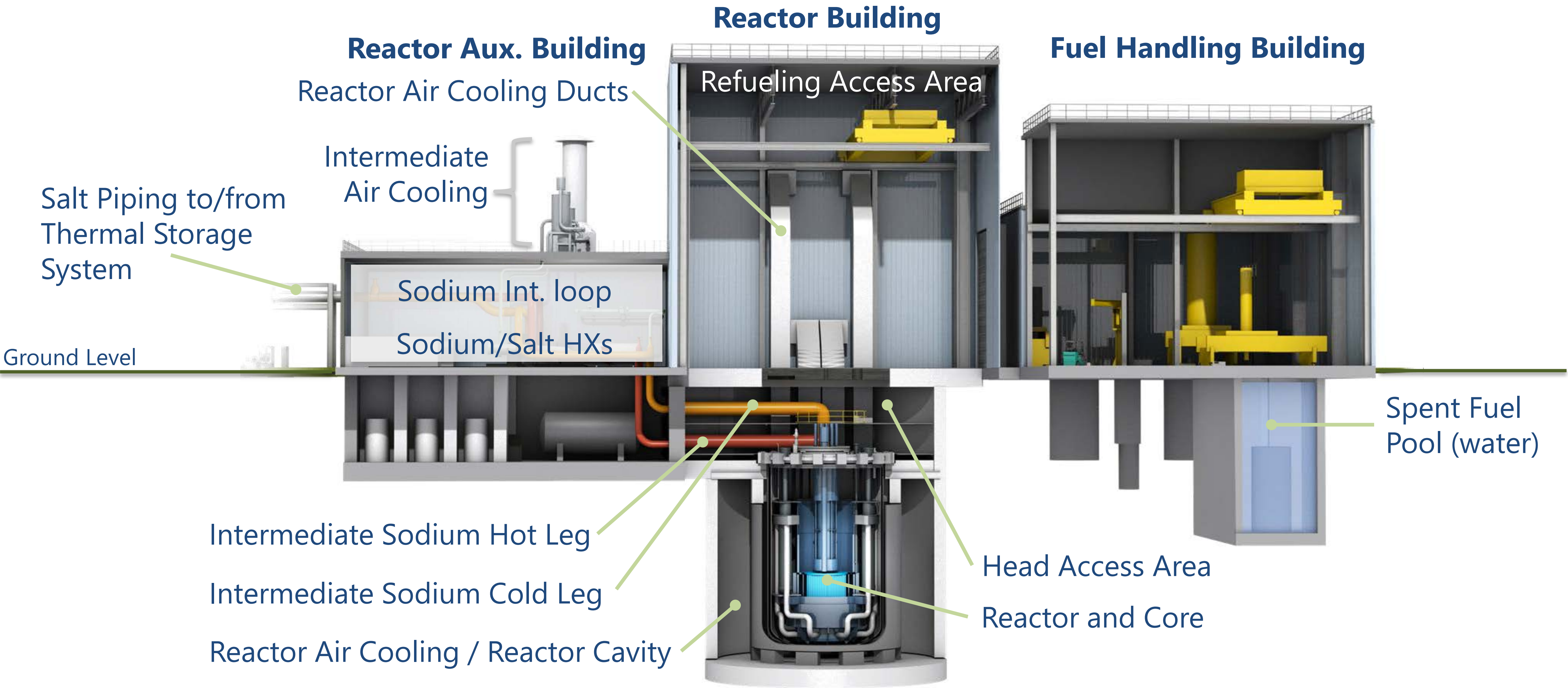
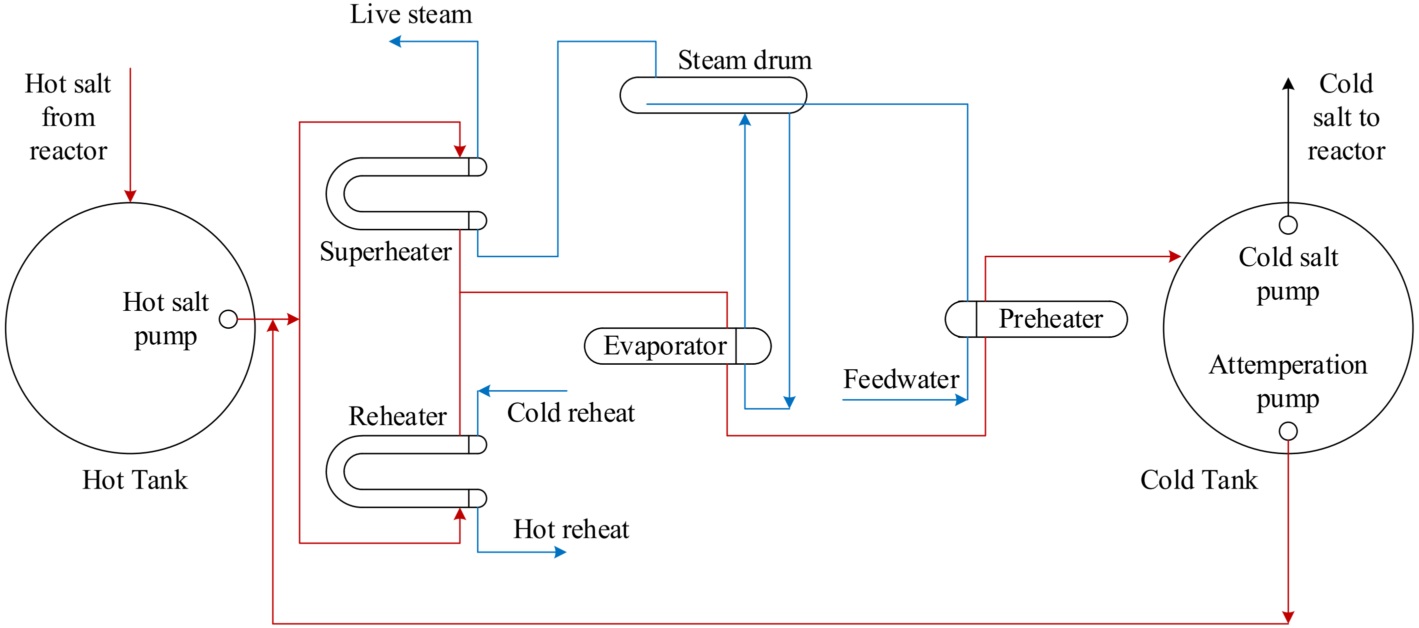

Reactor Building
Reactor Aux. Building
Fuel Handling Building
Reactor Air Cooling Ducts
Refueling Access Area
Intermediate
Air Cooling
Salt Piping to/from
Thermal Storage
System
Sodium Int. loop
Sodium/Salt HXs
Ground Level
Spent Fuel
Pool (water)
Intermediate Sodium Hot Leg
Intermediate Sodium Cold Leg
Reactor Air Cooling / Reactor Cavity
Head Access Area
Reactor and Core

Energy Island



SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

TerraPower NATRIUM

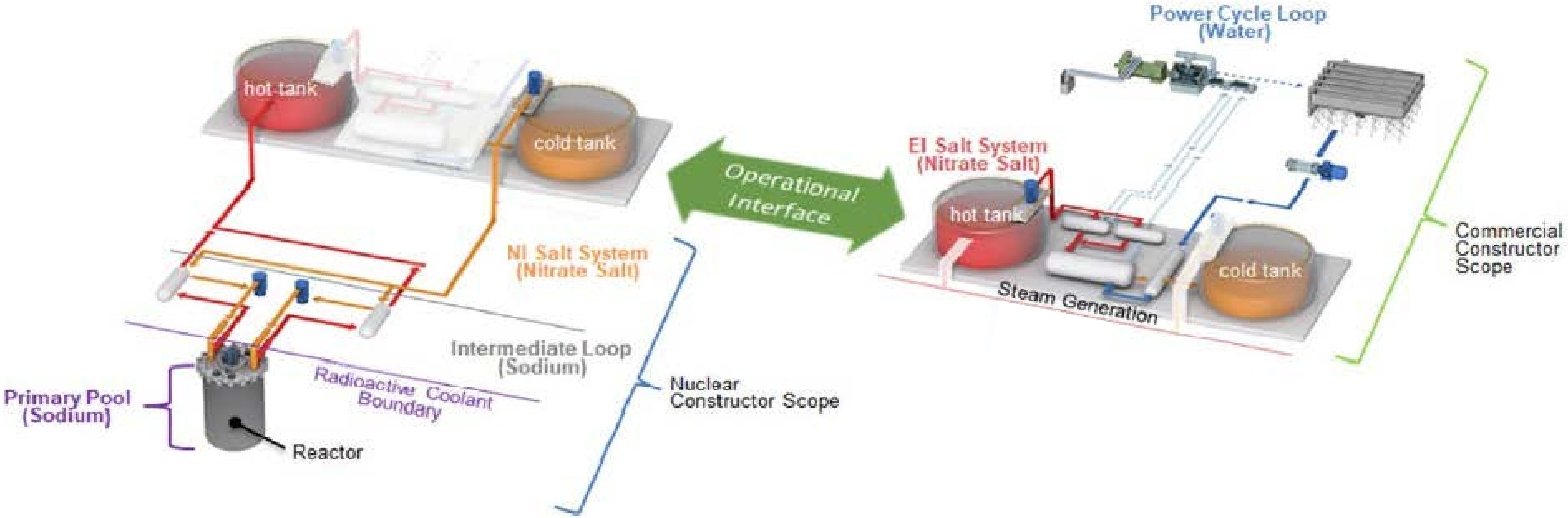
Operational Flexibility

Operational Flexibility

- Scope of NI command and control
  - Licensed Reactor Operator controls reactor power
  - Allows NI operators to focus on safely operating the nuclear heat source
- Reactor power independent of turbine output
  - Grid Operator controls turbine output based upon grid demand
  - Reactor remains at full power while turbine output variations are accommodated via salt tank inventory management
- Requirements related to salt tank levels, controlled bands, alert levels, and response times will be verified by initial modeling and reflected throughout design process
- Immediate reactor plant response to changes in EI heat rejection systems are not necessary

Operational Flexibility

- Molten salt storage tanks change the direct correlation between reactor power and steam demand

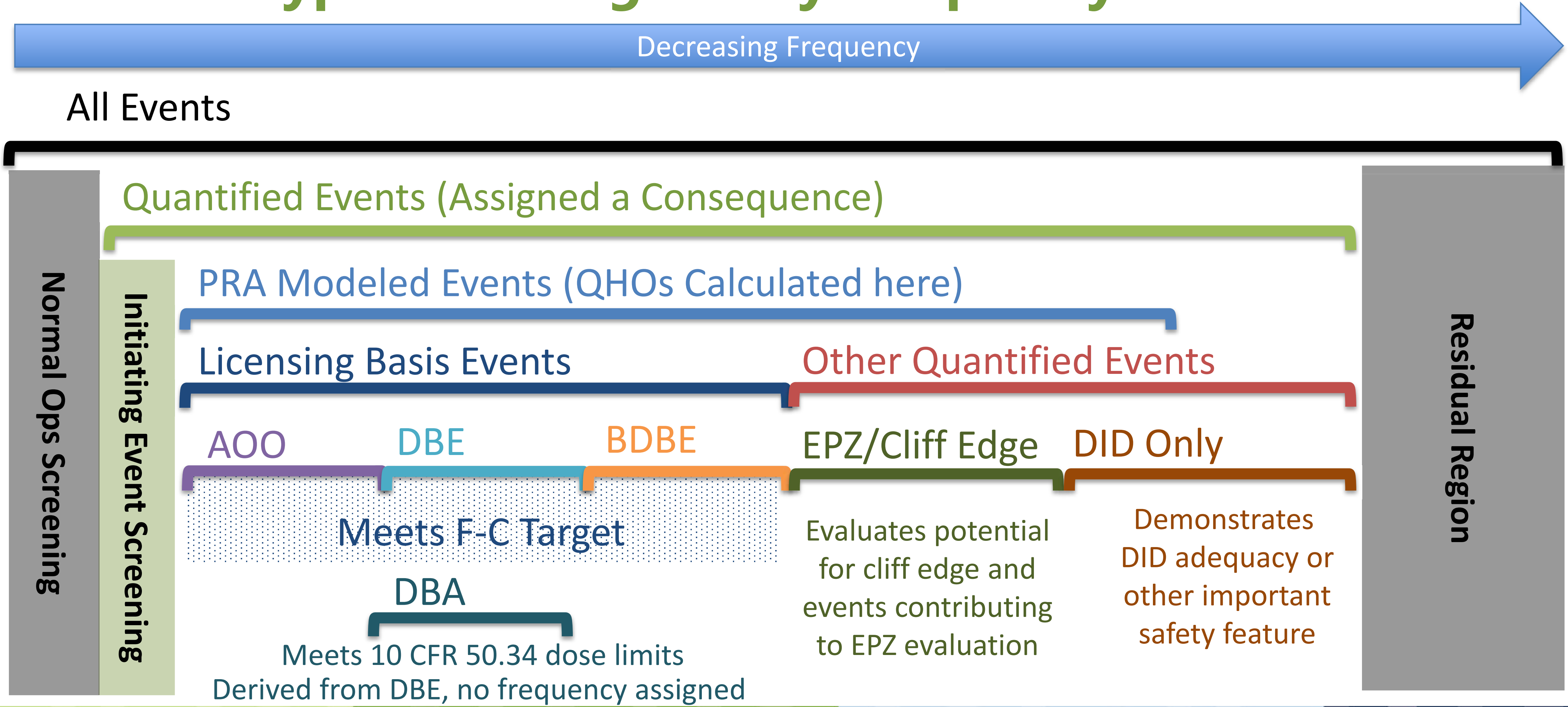


Transient Separation

EI Initiated Transients

- All failures associated with the EI are grouped into:
  - Loss of or reduced heat removal of IHT system via NSS:
    - Loss of salt flow
    - High salt temperature
    - Low salt pressure
  - Increased heat removal of IHT system via NSS:
    - Increased salt flow
    - Low salt temperature

Event Type Line Diagram by Frequency



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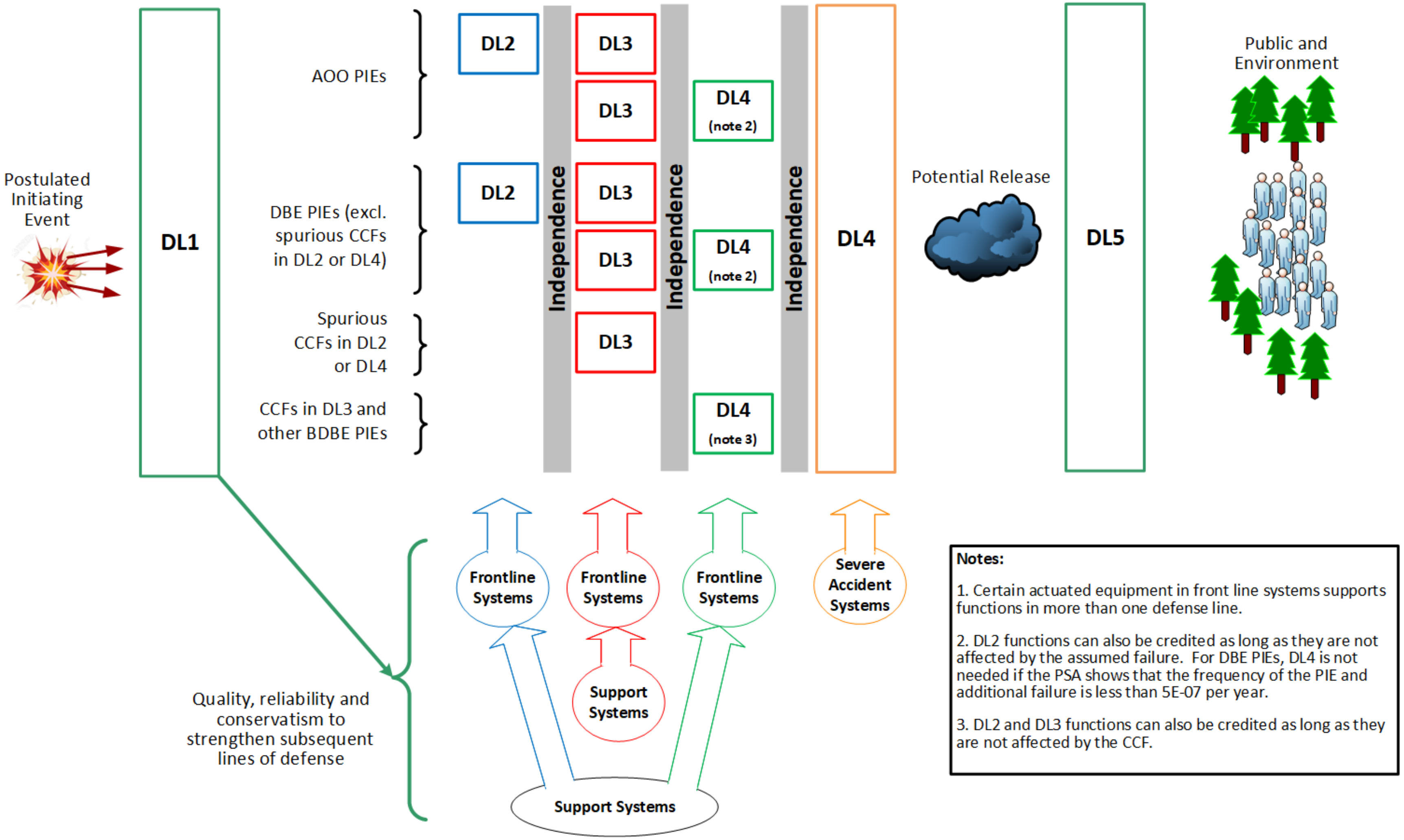
Transient Separation

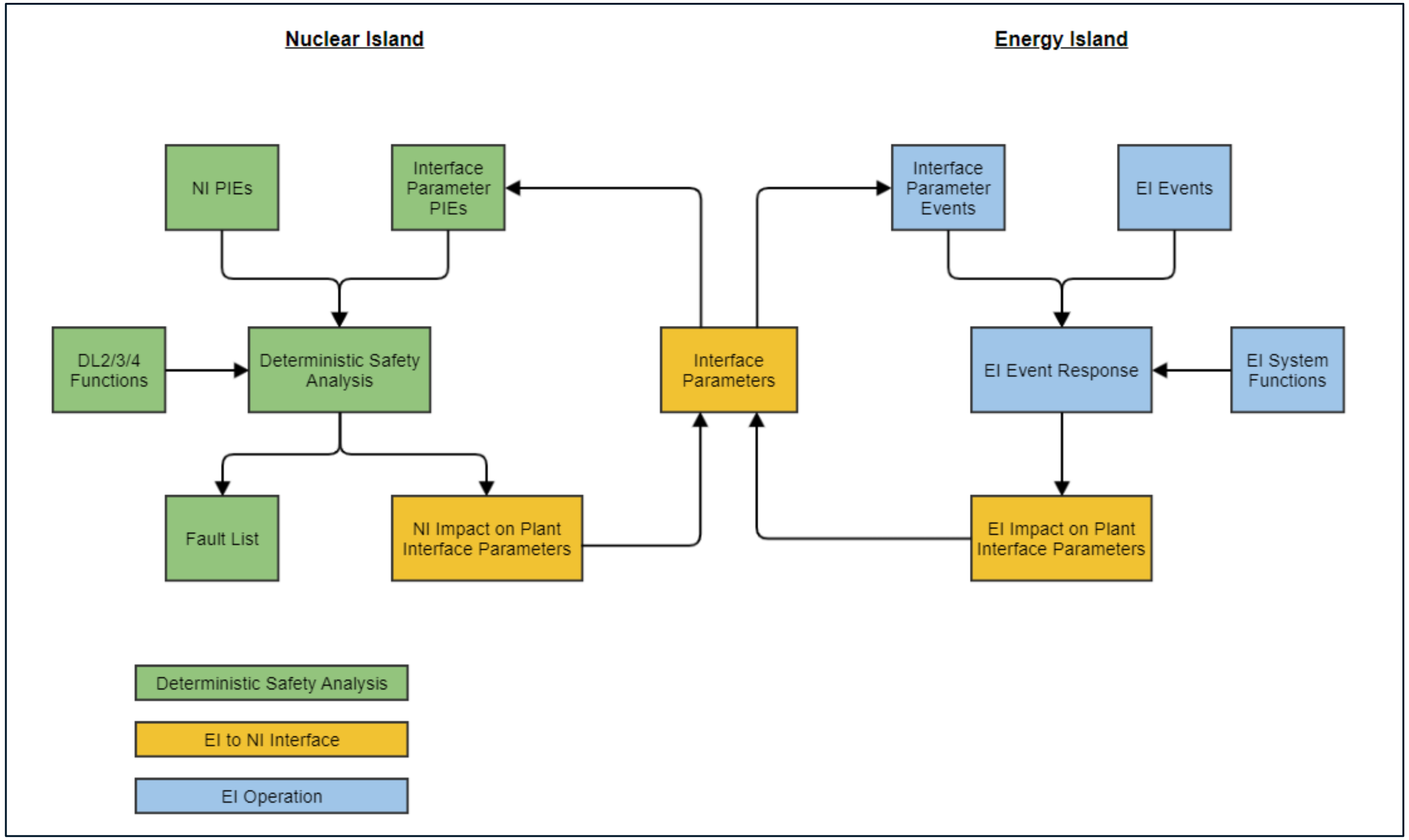
Defense-in-Depth

- Plant safety analyses only model PIEs that directly impact the NI
- All DL3 and DL4 functions are performed by NI systems



Transient Separation

- With operational flexibility, most events on the EI that would affect the NI in a typical nuclear power plant have no immediate impact
- EI events can lead to PIEs if resulting change to an *interface parameter* occurs
- Plant design ensures that EI SSCs are not required to perform any DL functions other than very few selected DL2 functions on the EI
  - Enables no safety-related DL3 SSCs on the EI



TerraPower NATRIUM

Plant Response to EI Transients

- Decrease or increase in heat removal from NSS leads to increased sodium temperature or decreased sodium temperature in IHT respectively
- Thermal inertia in IHT and PHT provides adequate time to respond to the event via signals monitored within NI
- Power runback:
  - Reactor power decreased by insertion of control rods at predetermined rate
  - IAC and RAC provide system heat removal
  - PSP/ISP flow decreased to target flow settings
  - NSS isolation
- Reactor SCRAM:
  - Reactor power decreased by control rod drop via gravity
  - IAC and RAC provide system heat removal
  - PSP/ISP ramp down
  - NSS isolation

Regulatory Impacts

Regulatory Impacts

- Future Exemption Requests
  - 10 CFR 50.2, "Definitions"
  - 10 CFR 50.10, "License required; limited work authorization"
  - 10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at nuclear power plants"
- Requirements not applicable to NST SSCs on the EI
  - 10 CFR 50 Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants"
- Turbine operation by a Licensed Operator is not required
  - 10 CFR 55, "Operators' Licenses"

Questions?

Acronym List

AOO – Anticipated Operational Occurrence
BDBE – Beyond Design Basis Event
CCF – Common Cause Failure
CFR – Code of Federal Regulations
DBA – Design Basis Accident
DBE – Design Basis Event
DID – Defense-in-Depth
DL – Defense Line
EBR – Experimental Breeder Reactor
EI – Energy Island
EPZ – Emergency Planning Zone
F-C – Frequency-Consequence
FFTF – Fast Flux Test Facility
HXs – Heat Exchangers
IAC – Intermediate Air Cooling System
IHT – Intermediate Heat Transport System
ISP – Intermediate Sodium Pump
NI – Nuclear Island
NSS – Nuclear Island Salt System
NST – Non-Safety-Related with No Special Treatment
PHT – Primary Heat Transport System
PIE – Postulated Initiating Event
PRA – Probabilistic Risk Assessment
PSP – Primary Sodium Pump
QHO – Quantitative Health Objectives
RAC – Reactor Air Cooling System
SFR – Sodium Fast Reactor
SHX – Sodium-Salt Heat Exchanger
SSC – Structure, System, and Component
TREAT – Transient Reactor Test