Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Regulatory Rulemaking, Policies and Practices Subcommittee
Docket Number:	N/A
Location:	Video Teleconference
Date:	Friday, September 23, 2022
Work Order No.:	NRC-2109 Pages 1-122

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

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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REGULATORY RULEMAKING, POLICIES AND PRACTICES

SUBCOMMITTEE

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FRIDAY,

SEPTEMBER 23, 2022

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The Subcommittee met via Video Teleconference, at 2:00 p.m. EDT, David Petti, Chairman, presiding.

COMMITTEE MEMBERS:

DAVID PETTI, Chair

RONALD G. BALLINGER, Member

VICKI BIER, Member

CHARLES H. BROWN, JR., Member

GREGORY HALNON, Member

WALTER KIRCHNER, Member

JOSE MARCH-LEUBA, Member

JOY L. REMPE, Member

ACRS CONSULTANT:

DENNIS BLEY

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

DEREK WIDMAYER

ALSO PRESENT:

AMY CUBBAGE, NRR

SACHIN DESAI, Public Participant

DONALD PALMROSE, NMSS

ANDREW PROFFITT, NRR

WILLIAM RECKLEY, NRR

JOHN SEGALA, NRR

JOSEPH STAUDENMEIER, RES

DUNCAN WHITE, NMSS

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

2:00 p.m.

CHAIR PETTI: Okay, it's 12:00 p.m., good afternoon, everyone, the meeting will now come to order. This is a meeting on the Advisory Committee on Reactor Safeguards Radiological Rulemaking Policies and Procedures Subcommittee.

I'm Dave Petti, Chairman of the Subcommittee, ACRS Members in attendance are Greg Halnon, Vicki Bier, Joy Rempe, Ron Ballinger, Charlie Brown. I do not yet see Walt Kirchner. Oh, there he is. Walt's in, so Walt's here as well.

Consultants who are on the Teams meeting are Dennis Bley and Steve Schultz. Derek Widmayer, the ACRS Staff is the designated federal official for this meeting.

The purpose of the Subcommittee meeting is to hear from the Staff concerning a draft white paper proposing a regulatory framework for fusion energy systems.

This Committee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate.

There is a session scheduled for the October 2022 full Committee meeting at which these matters will be presented and discussed, and the Committee plans on preparing a letter report on these matters at that meeting.

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

The Committee can only speak to its public letter reports. We hold meetings to gather information and perform preparatory work that will support our deliberations at a full Committee meeting.

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

The ACRS section of the U.S. NRC public website provides our charter bylaws, agendas, letter reports, and full transcripts of all full and Subcommittee meetings including slides presented at the meetings.

The meeting notice and agenda for the meeting were posted there.

As stated in the Federal Register notice and in the public meeting notice posted to 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 official five days prior to the meeting as practicable.

Today's meeting is open to public attendance and we have received one request to make an oral statement at the meeting.

Time is also provided in the agenda after the presentations and the statement from the member of the public are completed for spontaneous comments from members of the public attending and listening to our meetings.

Written comments from Helion Systems have been received and will be included in the record for this meeting. Today's meeting is being held virtually over Microsoft Teams, allowing participation of the public over their computer using Teams.

The bridge line has also been established to allow listening by phone. A transcript of today's meeting is being kept.

Therefore, we request that meeting participants on Teams and the bridge line identify themselves when they speak, and to speak with sufficient clarity and volume so that they can be readily heard.

Likewise, we request that meeting

participants keep their computer and/or telephone lines on mute when not speaking to minimize disruptions. We have been informed by one public stakeholder that they may record the meeting on Teams.

This stakeholder has been informed that they should comply with any local and state laws with respect to recordings of such events. At this time, I ask that Teams and telephone bridge line attendees make sure they are muted so we can commence the meeting.

We'll now proceed and I call on Andrew Proffitt to begin presentations.

MR. PROFFITT: Thank you, Dave. John Segala is going to give a few opening remarks before we jump in. We had a late swap-out for John. John, go ahead.

MR. WHITE: Okay, John, please, go ahead.

MR. SEGALA: Thank you. Good afternoon, I'm John Segala --

MS. CUBBAGE: There's an echo. Do you have another device, John?

MR. SEGALA: I don't think so. How about now?

MS. CUBBAGE: That's good.

MR. SEGALA: I'm John Segala, Special

Assistant in the Division of Advanced Reactors and Non-Power Production Utilization Facilities in the Office of Nuclear Reactor Regulation.

We're excited to be he knows today to discuss this important topic. To provide a little context, I wanted to start off with a little background. In 2019, NEIMA, or the Nuclear Energy Innovation and Modernization Act, was signed into law.

It defined advanced reactors to include fusion and it required NRC to develop a new regulatory framework by the end of 2027.

In the 2020 Staff requirements memorandum for the Part 53 rulemaking, the Commission directed the Staff to develop options for regulating fusion energy systems for the Commission's consideration.

We established a fusion working group with a diverse set of Staff from across the Agency including Staff from NRR, Research, NMSS, and the regions as well as agreement state representatives to evaluate current fusion regulatory practices, understand the technologies, develop regulatory framework options, and engage with stakeholders.

We previously briefed the ACRS full Committee in May of 2021 and benefitted from the feedback we received at that time.

Since that meeting the NRC Staff has continued to have extensive stakeholder engagement, enhancing our understanding of the fusion technologies, gaining insights on the hazards and risk associated with fusion, and receiving feedback on potential options for regulating fusion.

Today we plan to provide the ACRS Subcommittee an overview of the NRC Staff's efforts to develop options for regulating fusion energy systems as discussed in our draft white paper Entitled, Licensing and Regulating Fusion Energy Systems, that was made public last week.

We are looking forward to having discussions today and hearing the ACRS Members' thoughts and feedback on our draft white paper.

Thank you and I'll turn it over to Andrew now.

MR. PROFFITT: Thanks, John, I'm Andrew Proffitt, Project Manager in Advanced Reactor Policy and in NRR and I'm the lead Staff Member coordinating our fusion efforts.

We also have Duncan White here, a senior health physicist and the State Agreement of Liaison Programs in NMSS, and also another key Member Bill Reckley, Senior Project Manager in the Advanced

Reactor Policy Group, who is here with us as well.

Duncan and I will take most of the presentation but we also have Members of the working group here to help our in our discussion if we get into specific topics.

Like John said, we're excited to be here this afternoon with you to brief you on the progress and really give a little bit more detail as to what's in the paper and how we got to the draft white paper putting forward the options for the Commission to consider for regulating fusion.

We've been really busy since our last interaction with you all in May of 2021, developing these options and engaging our stakeholders. And we certainly understand how important our work is in providing regulatory certainty and predictability for an industry that's quickly advancing and evolving.

So, we've heard that feedback loud and clear from our stakeholders that certainty is needed on this topic and we're looking to move in that direction with these options and future Commission direction related to them.

MR. BLEY: Excuse me, Andrew? It's Dennis Bley. I don't think we asked this last time around. Could you tell us a little bit, kind of a voir dire on the NRC Staff?

Do we have any people degreed in fusion physics, fusion engineering?

MR. PROFFITT: We've got a few folks that I believe did master's and Ph.D. programs maybe a few years back when fusion was a little bit more popular. We have Joe Staudenmeier who has some expertise in fusion, we have Don Palmrose on the working group.

A couple of our folks on the working group do have some legacy, I guess I would say, fusion expertise and training.

MR. BLEY: From back then, some things will come up today. There might be things learned back then that we might want to revisit, whenever back then was.

MR. PROFFITT: So, moving forward here, we'll go to the next slide.

The agenda today, jumping right in, we'll give a little bit more background, touch on a little bit more of what John mentioned about our Commission and Congressional direction and some of our stakeholder engagement.

Moving to the fusion technologies, an overview of our understanding of what's under development for potential deployment here in the U.S., and then the hazards that are associated with those technologies.

And then we'll jump in the regulatory framework.

And so that's what we'll talk about, we'll go through some looks at the legislation, the Atomic Energy Act, and how fusion could maybe fit in different buckets, and kind of walk through the options that we have in the paper.

And then we'll end off here with our path forward and next steps.

MR. BLEY: Andrew, I apologize, the second thing is are you going to talk about potential hazards with respect to each of the technologies you talk about or kind of in general the hazards that might be considered here?

MR. PROFFITT: We were planning on doing a more general overview of the hazards we see from these types of technologies.

MR. BLEY: You may get some specific questions.

MR. PROFFITT: A little background, as I mentioned, the Staff is implementing the Commission and NEIMA direction, as John touched on, to prepare regulatory framework to support the commercialization of fusion energy systems.

So, you go back to 2009, the Staff wrote a paper on the regulation of fusion-based power generation devices and that's where the Commission affirmed that the NRC does have jurisdiction over fusion, regulating fusion and specifically, whenever such devices are of significance to the common defense and security or could affect the health and safety of the public.

Joy?

MEMBER REMPE: Actually, I wanted to wait until you got past the second bullet. My hand went up a little too fast.

MR. PROFFITT: No problem.

The other thing in that SRM from the Commission on the 2009 paper was to hold off, for the Staff to wait until commercial deployment was more predictable by way of successful testing before expending significant resources developing a regulatory framework.

So, fast-forwarding about ten years and NEIMA, Nuclear Energy Innovation and Modernization Act, directed the Staff to develop a regulatory infrastructure to support development and commercialization of advanced nuclear reactors.

And that, as John mentioned, included both fission and fusion reactors. Joy?

MEMBER REMPE: Now I want my hand up. If I go further in this definition in NEIMA, it talks about that advanced reactors in addition to being fusion and fission ought to have significant improvements compared to the commercial fleet.

And it mentions A through H, not only additional inherent safety features, lower waste yields, proliferation resistance and the ability to integrate into non-electric applications.

To your knowledge, is anybody being a gatekeeper on what all can get into the pot?

There's so many that are being considered, and this is beyond the scope of the SECY, but I would just like to bring up the point and ask if you know if anyone is trying to be a gatekeeper for this on what can be considered?

MR. PROFFITT: That is a good question. I'm not aware of a specific gatekeeper. We definitely view fusion specifically as how it's called out in the Act as falling under that purview of advanced nuclear reactor within NEIMA.

So, we are planning to have a regulatory framework put in place by the end of 2027, which is really the driver in NEIMA for us related to fusion. But I'm not sure, there's a few other folks from advanced reactors on the line, I'm not sure if anyone could maybe speak more to the question?

MR. RECKLEY: Andrew, this is Bill Reckley. I would just weigh in and, Joy, we've had the discussions in Part 53 and exactly what you brought up was the reason we started using commercial nuclear plant and really dropping advanced reactor, was because those criteria you mentioned in NEIMA were fairly broad.

Some were technical, some were economic, some were social, such that we didn't think it actually would be productive to be, as you mentioned, quote, a gatekeeper. And so that was the rationale in Part 53 for not even pursuing that.

MEMBER REMPE: So, in Part 53, you've now decided to emphasize commercial non-LWRS?

MR. RECKLEY: That is the term we use and we basically would accept anybody -- we would never use the rationale that you don't meet one of those criterias to say you can use Part 53.

MEMBER REMPE: Then I'm going to pull the string a bit further that in fusion, are you going to try and emphasize commercial applications as a distinction between some of the designs being discussed in the near term?

Because that was going to be a question I had when we get into a later slide, how many of these applications and designs have a way of producing power of the ones that are coming through in the near term?

I'm not familiar with all the designs. I did read one of the background papers that was submitted to us and there is apparently one individual organization that is trying to consider how to produce electricity but it wasn't clear to me that a lot of the others are yet to that stage.

MR. PROFFITT: We wouldn't necessarily see commercial in our presentation a little bit, but just to differentiate it from R&D that may be done at DOE or that maybe is being done currently that agreement states for the most part are actually overseeing through delegated authority from the NRC.

So, there's no major difference between it making power or not, certainly our thought is to regulate based on the potential hazards that a specific device or technology or design presents.

MEMBER REMPE: I'll hold the rest of my questions until later but thank you.

MR. PROFFITT: So, one other thing in

NEIMA, there's specifically a Section 103 where it requires the NRC to complete a rulemaking to establish a technology-inclusive regulatory framework for advanced reactors.

And again, we read NEIMA and our lawyers have helped us read NEIMA and to understand that fusion is included in this requirement.

And a little bit to the questions here, fission and fusion under that advanced nuclear reactor term from NEIMA are being treated separately by the Staff and on parallel paths.

So, we have Part 53 that we touched on a little bit, it would be for advanced fission reactors and we're on track there to complete that by mid-2025.

And then for fusion, following a Commission decision on our options paper, the Staff would complete implementation of the regulatory framework for fusion by the end of 2027 consistent with that NEIMA deadline.

Following NEIMA, that's what has brought us here today, the SRM on the Part 53 rulemaking, one of the earlier ones in 2020, that's where the Commission specifically directed the Staff to consider appropriate treatment of fusion in our regulatory structure by developing options for the Commission on licensing and regulating them.

Dennis?

MR. BLEY: Quick question on having the framework ready by 2027. Does that mean having rule language and rulemaking or just a paper describing a framework? Not just.

MR. PROFFITT: Good question. It would depend on the option that the Commission directed us on. I think there is some potential, the Staff has struggled with this question a little bit ourselves because the industry is relatively still developing and still maturing.

So, there's lots of different designs out there that are under consideration that have a whole spectrum of different hazards. And also, the intent of NEIMA would certainly not be for the NRC to do something that wasn't productive.

That would be the antithesis of NEIMA I think. We are planning, pending Commission direction and one of our options or several of our options do include some at least limited rulemaking.

So, we would plan on having that done by December 2027. Also, there's the potential for guidance development possibly to meet that rulemaking clause in NEIMA, but we would have deliverables completed by December 2027.

But that's also not to say that's going to be the regulatory framework that the NRC uses until the end of time.

Clearly, with a new industry there will be lots of lessons learned that we'll learn through early applications and licensing and operating that we would probably build on whatever is done by 2027 over the coming years and decades.

MR. BLEY: Thanks, that's a pretty thorough discussion.

As you read through these different technologies, I'd appreciate it if you'd give the Staff some idea of where they stand in the ability to have the data you need to be able to support looking at a rule, where they are in their development process.

MR. PROFFITT: We'll see what we can do. I'm not the technical expert in many of those areas but Duncan can maybe give it a shot and other folks on the line might be able to help us out as well. But we will do that, Dennis.

Moving onto the next slide, stakeholder engagement, you'll see lots of pretty logos here on this slide.

Consistent with NRC's values, our principles of good regulation and being responsive to early comments of the Staff, we really have extensively engaged the fusion stakeholder community while we've been seeking to understand the technologies, the hazards, and work on these options.

I'll walk through them a little bit. Obviously, DOE has some facilities for fusion R&D, has particle accelerators, and has regulatory authority and safety authority over the devices that are there. So, they have some safety documentation and reports on how they treat the hazards produced by these types of facilities.

We've got a couple commonwealth fusion systems, Helion have been very engaged with us along with other private companies helping us understand their technologies, what the hazards are they may possess.

And both of those actually have been in discussions with their agreement states on licensing R&D that they have going on and construction and building facilities that they are moving forward with to prove their designs.

You see EPRI there, they're really looking to take a lead in some of the R&D to support fusion devices and the materials that may be used in some of these devices and help the industry along in that manner.

The Fusion Industry Association, they're akin to an NEI for fission reactors. The Fusion Industry Association is seeking to be that advocate for the industry, and they've been helpful with us corralling public meetings and putting together a broad perspective of the different industry stakeholders.

The White House there, you may have heard some press earlier, this year they had a big White House summit on fusion and the White House and the administration along with the Department of Energy has a bold decadal vision for fusion.

And what they're looking to do there is through public-private partnerships have a fusion pilot plant done in the early 2030s. So, we're obviously looking to be responsive to that need.

The United Kingdom, we've been engaged with them. You may have seen some press on the United Kingdom, how they're treating fusion.

They're moving forward with regulating outside, not within their nuclear regulatory authority and continuing what they've been doing with R&D, but as a key, not categorizing it as a nuclear installation, how they would characterize large fission reactors.

And how maybe something you could say akin to our utilization facility term. The IEA there, internationally we actually have -- my Branch Chief, Steve Lynch, I think he's traveling back now from Vienna.

The IEA was having a meeting this week on fusion regulation and how different countries are treating fusion from a regulatory standpoint. The Union of Concerned Scientists and other NGOs have been involved in our public meetings and provided comments and discussion.

ITER, the largest fusion R&D facility that's out there that's being built and under construction right now, we've engaged with experts here in the U.S. that have dealt with ITER and also with folks over there in understanding some of their approaches to safety.

And the Organization of Agreement States obviously, as John mentioned, we've actually had some agreement state representatives on our internal NRC working group and they bring very good perspectives, being a little closer to some of the R&D and the permitting and the regular that's been done to date with fusion R&D.

So, we really had a broad engagement with our stakeholders. And just a couple of the things we've done, we've had six public meetings over the past year, so a little over a year where we've engaged our stakeholders on topics.

We've had presentations, we've had meetings where external parties have presented and we've solicited topics that they think are important for us to hear about.

And we've proposed topics as well in helping us understand the hazards and technologies in moving us to this place of putting these options together.

We had kicking off after the 2020 SRM of putting a date for us to developing these options, we had a joint public workshop held between the NRC, DOE, and the Fusion Industry Association.

We attended that White House summit and the follow-on DOE workshops related to that, international engagement, bilateral government-to-government meetings.

Also, additional coordination with the agreement states outside of just having those representatives on our working group.

We've presented dat their meetings that they have and really have been seeking to understand their perspectives, enfolding them as a key member in our developing these options.

And then as I mentioned with Helion and the commonwealth fusion systems, many other companies, we've had pre-application-type meetings very early on, meetings just to understand the technologies that are out there and what some of their timelines are potentially for moving forward with having the fusion energy systems built.

Go ahead, Joy?

MEMBER REMPE: In your discussions, I'm also trying to understand the landscape of what's coming down the pike soon.

And so could you give me a little more detail, and you can either do it in this slide or the next, but again, how many of the prototypes or demos in the near future are going to be able to produce electrical power?

What's the maximum thermal power rating for these near-term facilities? Do they include tritium storage in their site? Or are they going to ship it away and, again, how will the Staff deal with those issues and will they have a local limit on tritium accumulation?

I'm just wondering because when I look at your paper and the options, I want to know what's the near-term expectation of what would come down the pike? For example, one of the background information documents we were given talks about you need to have a Q greater than 10 to have meaningful electrical power production.

So, what's the near-term expectation for Q on some of these near-term concepts?

MR. PROFFITT: That's a really good question and things we've been thinking about as we've been putting the options together.

Right now, I don't know that these companies right now are able to get to a Q greater than 1 where they're producing more power with their technology than what they are putting in.

There's been lots of developments and probably since I took over here project managing this position, I see on my phone every day recommending me a new article on a fusion development.

So, there's lots of breakthroughs and advances that are going on with magnet technologies, with semiconductors, with lasers. So, there's really a broad scope of systems out there under consideration.

If you like to the FIA report on the spectrum of the industry, I think I've heard them say there's 25 or 26-plus, or maybe close to 30 or over 30 now at this point, companies and really, none of them are directly competing against one another for the same type of technology.

There's differences in all of them. But we have heard from several companies that are seeking to prove that they can produce more electricity with their technology than they put in within the next few years.

MEMBER REMPE: How many megawatts of electricity would they be producing?

MR. PROFFITT: There's a broad array of that. I don't think in the next few years we would be on that level but most of these designs, I believe are planned to be smaller.

So, just an example, everything we've heard from developers from FIA is there's no plans for anything even close to, say, an ITER scale. So, we are understanding right now that these things may be 50 megawatts of potential commercial device would be.

I don't know, Duncan, if you had anymore on the scale of what we're seeing out there?

MR. WHITE: Yes, I've seen things up to 250 proposed. Again, this is what they're shooting for down the road but again, the timeline we're looking at for that is the next decade, some time in the next decade.

MEMBER REMPE: Again, I've only read a small fraction of this in all but for the near term in the next five years, they didn't cite a megawatt electric thing and then they said after we prove this works, we're going to try and do the 50 megawatt electric.

And when they'd achieve that first objective for the near-term facility wasn't clear. So, it wasn't even clear to me but from what you're telling me, you think somebody will try and build something that's 50 megawatts electric by 2030?

MR. PROFFITT: I don't know that I would commit to that. I think what we see from the White House is a fusion pilot plant and their goal is that it would produce electricity in the first half of the 2030s.

The bold decadal vision would be 10 years now, so early in the 2030s they are hoping to have a pilot plant. But pending obviously quite a bit of work from the industry having any large-scale fusion power commercial industry --

MEMBER REMPE: Your answers are actually helping me but again, from what I'm reading, I'm trying to get a feel for how much -- I know from what I've read we don't have a lot of experience on it yet but how soon you'll start seeing some experience.

And I guess your response is we've got a bit of time here, is what I'm kind of inferring from your response? Your head is shaking up and down yes.

MR. PROFFITT: I think so.

MEMBER REMPE: Thank you.

CHAIR PETTI: This is Dave, just a comment on the question Joy asked.

What makes it so difficult to project into the future for some of these concepts is where they're at in their development trajectory and what they think that ultimate machine will look like based on what they understand today.

And there's uncertainties that make it difficult to really tie down the power level, sometimes the inventories of things that we'd be interested in from a safety perspective.

That makes it really difficult. That said, it seems like the job here that the Staff has is much more difficult than the range of fission reactors under consideration. The hazards here can range from very low to hazards that require some serious design and oversight.

So, the spectrum, it's more than logarithmic from one end to the other, and that's a huge challenge. And so at some point on that spectrum, it becomes important from the safety perspective.

Even though everything is young and many of these technologies aren't there, we need to get some metrics on what are the numbers that are going to be critical that help characterize the hazard and when you moving forward something that isn't an issue to public safety to one that is.

And that's challenging but I think it's doable based on my experience in the fusion program back in the day. So, thanks.

MR. PROFFITT: I appreciate that. I see a couple of other Staff from the working group had raised their hands. Maybe Jill and Don I think?

MR. PALMROSE: This is Don Palmrose with the NRC Staff, I'm a Senior Reactor Engineer in the Office of Nuclear Materials, Safety, and Safeguards.

I just want to point out that it gets to what Dr. Rempe was asking about. September 15th, there was a full Senate Committee hearing to examine the Federal Government's role in supporting the commercialization of fusion energy.

And one of the topics that you were bringing up were also raised in that meeting. So, that would be something that would be potentially of interest to the ACRS Committee.

MEMBER REMPE: Send the link or some additional information to Derek, Don, please, so that we can make sure we have access to it. Maybe Derek already has it and sent it and I just didn't pick up on it when I was reviewing the materials for this meeting.

But I would be interested in looking at it.

MR. PALMROSE: I'll try to put a link into the chat if that will work.

MEMBER REMPE: But also please just send something to Derek too, please, because the chat isn't preserved.

MR. PALMROSE: Understood.

MR. PROFFITT: Yes, we'll do that. Dennis, did you have your hand raised?

MR. BLEY: I had a quick one. Before we

get into the guts of your paper, you present some options and talk about the pros and cons. But you don't give any recommendations yet. Is that because you haven't gotten to that point yet?

You'll need some before you send it up to the Commission.

MR. PROFFITT: Yes, we plan to discuss our recommendation here as we're moving through the options just with the logistics of the white paper being put out.

We typically don't put our recommendation necessarily in the white paper but we will discuss that here.

MR. BLEY: You have formulated them, that's what I want to know?

MR. PROFFITT: Yes.

MR. BLEY: Great.

MR. PROFFITT: Let's move on to the next slide here. Duncan will take over for a few slides.

MR. WHITE: As said in the beginning, my name is Duncan White, I'm from NMSS. I'll briefly talk about the different technologies being developed right now in fusion.

As you can see from the slide, there are three basic technologies these could be grouped into, the magnetic, the inertial, which is basically a combination or ones with different alternative type of designs.

in terms of the magnetic, obviously these are the Tokamaks, the Spheromatics, such type which we'd use large hydro-magnetic fields to contain the plasma. A question came up about this is probably where most of the interest is right now, probably the commercial endeavors.

Probably at least half of them are pursuing some sort of magnetic confinement approach right now. In terms of inertial, again, the plasma is maintained by high-powered pulse lasers and again, there are not many companies, commercial endeavors, pursuing this but there are a few out there.

And then in terms of the magnetic inertial ones, again, there are a wide range of technologies being developed here in these and again, I'll talk about these very briefly. You see the fusion reactions there.

Again, I'll touch on those a little bit.

That's to say the DT reaction, the deuterium-tritium reaction is probably going to be the most common one. Again, that's what's being used in the magnetic and the inertial approaches, and again, some of these other aneutronic and low-neutricity reactions are also in that area too.

Just very, very briefly about Tokamaks. Again, they use magnets and a taurus or a spherical configuration to create a high plasma.

And again, the idea is these super-conducting magnets, which are cryogenically cooled, are designed to, hold the plasma in place, keep the plasma off the wall so that the fusion reaction can proceed.

The plasma is generally heated through high-energy neurons or electromagnetic waves of different frequencies to heat it. Again, with the advancement of computer technology, AI, again we're able to control these plasmas much better than they have been able to in the past.

And again, the fueling for the Tokamaks and similar designs are DT. Generally, the DT fuel is injected into the plasma at high velocities. Again, sometimes gas is injected into it to maintain a flow and keep power levels up.

Again, another alternative to Tokamaks is the accelerators. The accelerators are very similar to Tokamaks in the design but they have a twisted-ring-type shape to them.

And again, that's to make the plasma feel smaller and again, they are able to do this and have proper alignment with the magnetic fields by better computer modeling and use of AI.

Lasers, the laser technology, again, the plasma is created by high-power pulse lasers. NIF, which is the Lawrence Livermore device, probably the largest and most successful one uses 192 pulse lasers to create this.

Fuel is injected into the plasma in pellets which contain small quantities of DT and they are assessed to maintain a fusion reaction that has to be done probably 10 to 100 times a second and is sort of a fusion reaction.

Again, if you look at some of the combination type of devices that are out there, there are ones that are Z pinch, which they compress the plasma and the current. I'll let the engineers explain a little bit better because I'm an HP, I apologize.

Another way which is again being used for some alternative designs and for the magnetic one is something called fuel reverse configurations where the magnetic confinement has the plasma and it has its own electrical field which is induced by an electric current inside the plasma.

And again, this is redirected by reversing the currents in the plasma and usually, it's targeted at each other to create the output. I mentioned aneutronic and low-neutronic fusion reactions.

There's developments in those areas too. Again, the one that's listed there, the hydrogen proton one and the boron-11 one, are examples of aneutronic.

Again, the energy created is not carried by the neutrons, where all of the other ones are carried by neutrons but by charged particles.

In this case, this particular reaction the charged particle is an alpha particle and since there's no neutrons produced, there's little activation of materials. And again, to drive this reaction you need ten times the temperature of a DT reaction.

Low neutronics, again, there are a couple companies working on this again with reverse-field configuration, again using deuterium and helium-3. This produces an alpha particle and high-energy protons.

And again, some of the secondary reactions do produce neutrons here and tritium. But again, those neutrons in tritium is not used to drive the reaction. So, I know there's going to be questions so I will stop here and address hands raised.

Denis, please go ahead?

MR. BLEY: Duncan, thanks. I may be jumping the gun on your presentation here. One of the things people have considered in the range of hazards is arcing because of massive magnets and the very high currents.

In the experimental systems that are out there, have we had any experience with actual arcing and what kind of damage has actually occurred? You can get damage far from where the arcs occur if you get really recurrent ones.

MR. WHITE: I'll let Joe or Don answer that question maybe.

MR. STAUDENMEIER: This is Joe Staudenmeier. I don't think there's been any damage that has really crippled an experimental machine.

There have been incidences in the past I'm aware of where -- I mean the high-voltage capacitor banks, the one facility I'm familiar with from back when I was in graduate school.

The capacitors used to blow up on a fairly regular basis and have to be replaced. There's been instances where people left metal tools inside of vacuum vessels and you turn on the magnetic field and it gets thrown through the vacuum vessel and damages the vacuum vessel.

That would have to be replaced, I guess that's a significant damage but I guess the biggest electrical thing that people would worry about in a Tokamak is a plasma disruption and you can have very large forces on the structures that could cause structural damage to the facility.

And that could be an event that could lead to some sort of radiation release.

CHAIR PETTI: Joe, just a position of clarification, you may not be aware but in Europe this issue is of large enough concern that experiments were being conducted at FZK to look at arcing, largely because of the energy storage in the magnets is so large, near 100 gigajoules.

So, could it arc? And experiments were being conducted, models were actually developed to look at the events largely for ITER and DT-demo-type machines.

But there were active experiments going on given the step in terms of the power of the magnets for that machine and let's say laboratory experiments like Jet or TFTR when it was in operation.

MR. PALMROSE: This is Don Palmrose of the Staff again.

The only thing I could add is the one thing I remember from when I was doing my work as a graduate student on fusion was that one of the concerns was they had a compression ring to keep the magnets together to affect compression structure had failed and the potential for the magnet to physically destruct was a possibility.

That's the only thing I can think of but I'm not sure how much the newer designs, the more recent designs, if that would be a factor.

CHAIR PETTI: So, as I understand it, there are serious stress analyses that have to be done on those magnets, and particularly some of the high-field options and those are the things that are going to be designed to be within the stress allowables and the like.

But that's what the magnet engineers spend a lot of time deciding, stress analysis.

MR. WHITE: Thank you for the comments and it is obviously something -- we're going to have to look into the different technology areas when we're doing this, so thank you.

I'll go onto the next slide. Derek talks about some of the radiological and non-radiological hazards on the next slide if we want to do that.

Again, in terms of hazards, with these devices, Staff feels that the inventory on site is really what's going to drive any sort of radiological hazards or non-radiological hazards on site, again, unlike fission reactors where you do have chain reactions which have other means to compensate for and to stop.

Here you have a different set of issues. In terms of onsite inventory, it's really driven by the tritium and of course activated excavated material.

Particularly with Tokamaks you're going to have potentially large quantities of tritium on site in the reactor vessel, in the breeder beds, in the other parts of the facility where you're going to have to control that and deal with that.

Activated material could be anywhere, on stuff that neutrons come in contact with, which obviously is going to be in the reaction vessel, it's going to be in other parts of the magnets and parts of the devices.

Again, these types of things do work into the waste management issue.

The magnets and other components have lifespans that are going to have to be swapped out, they're going to have to be effectively stored, they might have to be decayed for a while before they can be disposed of.

Again, in terms of the facility, that's an important aspect of it. And again, we'll talk a little bit about it later but that will have to be managed by their license, however that's being done.

We talked about the Commission, waste management is going to be an important consideration.

We talked a little about how we're going to have routine effluent releases from these facilities, you're going to accident release and the accident releases could be -- again, we'll talk about the non-radiological hazards but those could cause some of those accidental the releases from different components.

We talked about arcing already but there's obviously there's other ones too. Some of these devices, even the low-neutronic device again produces protons that again require shielding.

So, when these types of operate, they'll produce radiation and workers in the area will have to be monitored for a variety of different -- obviously for tritium, for neutrons, for gammas.

The radiation protection program has to be a pretty robust program. I mentioned waste management. Again, tritium is a challenge to deal with, tritium gas or tritium water absorb into just about everything and it migrates pretty easily.

It could during an accident scenario be released for offsite -- it could result in some offsite doses, offsite releases. Non-radiological hazards, we talked about the arcing already.

Again, high magnetic fields, we're talking about super-conducting magnets, they require cryogenic cooling. Both of these could drive releases or hazards.

Thermal shock from plasma disruptions, what's going to happen at a commercial full-sized plant if you do have a problem with the plasma collapsing. What's going to happen? How is the magnet and how is the vessel going to withstand that?

There's a lot of thermal energy there that could drive leaks, there's hydrogen produced. One of the considerations too is dust, it could accumulate over time in these things. The dust could be contaminated with tritium, the dust could be activated.

And again, there's potential for explosions with that. And for the ones that use lasers, they're using very high-powered pulse lasers that if not used properly obviously could cause some damage, if not properly maintained.

Again, I'll just stop there, this is an overview of some of the hazards. I'll stop there and entertain questions.

MEMBER KIRCHNER: This is Walt Kirchner. Not to add to the complexity or the list but a very real consideration is chemical hazards, especially when you combine them with radiological hazards.

And also, depending on the concept, depending if it's a not direct conversion but through blankets and/or heat exchangers and a choice of the working fluid for the heat exchanger, it introduces another set of potential hazards to consider, obviously, design-specific.

That has been incorporated in the considerations in 10 CFR 53.

MR. WHITE: I certainly would agree with that again.

Depending on the complexity of these facilities, a commercial facility particularly, you're going to have a number of different systems which are going to be particularly handling tritium.

And again, these all represent potential release pathways and again, I think that's something that's going to be very design-specific.

Some of the commercial facilities are going to use -- a Tokamak facility will have a large number of different components and they're going to have tritium that's going to be moving through them and potentially activate a material from the corrosion and stuff.

And again, these are all going to have to be considered in the analysis.

CHAIR PETTI: Duncan, this is Dave, is this your last slide on the hazards? Are you moving on from that?

MR. WHITE: Yes, as I said we wanted to give you a high level. If you want a bit more, go ahead.

CHAIR PETTI: Let me just give you my comments. As I read the white paper, I felt the hazards were not presented in the proper context.

For every case where something was cited as being not a problem, I can provide two or three references in the literature where it says it is a problem. There are many cases where what it looks like, someone did a measurement in a current machine and how you take that to a power reactor is completely different.

My favorite is low tritium mobilization and a loss of vacuum event that was done in Jet. Jet has no decay heat, Jet has no active cooling, it's inertially cooled so the air comes in and there's nothing that happens.

But in a real power-plant, if the air comes into the plasma chamber, the walls are hot even after the reaction shuts off because of decay heat. It heats up, the hot air has to go somewhere, it goes back out the hole, however it came in.

This was looked at extensively, experiments were done in Japan, analysis was done. So, again, for the small machine it's not an issue but for the power-plant on an engineering scale it is.

And that's just one of about six where I read what I read was just not complete enough and would lead one to misrepresent the span of hazards that are potentially there.

And that's the option the Commission has in terms of which way to go. And so I'm just one Member, but I have a number of recommendations to work on that section to provide better balance.

It does not recognize decades of work done by the fusion community looking at the safety issues associated with fusion across concepts. There's this other thing that everything is focused on NEIMA.

That's not true.

If you go back far enough, and you have to go back before Google searches, you'll find that the community studied a lot of these configurations and they looked at a variety of blankets, they looked at a variety of confinement concepts and what does it mean?

And that's the thing that I think is missing. Just a comment.

MR. WHITE: Thank you for that feedback. Any other comments? We'll move on to the next slide then.

MR. PROFFITT: Thanks, Duncan, I'll pick it up for a slide here and then I'll hand it back over to Duncan.

Based on what we found in talking with folks and understanding what concepts are in development and understanding the potential hazards that Duncan went through, we needed to go back to our authority, our legislation, the Atomic Energy Act, and look and see where could these things fit within the frameworks that we have?

And so way back in the 2009 SECY, that's when we started this work, doing a bit of an analysis of where fusion energy systems could logically fit.

And two of the options that we came up with, we either categorized them as utilization facilities or building off of the particle accelerator definitions that we have in the legislation that we have in treating them under NRC's byproduct material licensing.

So, we furthered that analysis here. Here I'll go through a legal assessment of the utilization facility. I'll just briefly read what is actually in the act here, and this is the definition of a utilization facility in the act.

Any equipment or device except an atomic weapon determined by rule of the Commission to be capable of making use of special nuclear material in such quantity as to be of significance to the common defense and security or in such manner as to affect the health and safety of the public.

Or peculiarly adapted for making use of atomic energy in such quantity as to be of significance to the common defense and security or in such manner as to affect the health and safety of the public, or any important component part especially designed for such equipment or devices determined by the Commission.

Let me just take one step back here and mention the Atomic Energy Act does not explicitly mention fusion in the act. That is why we're looking at some of these other buckets where fusion could potentially fit.

With utilization facility, the key there in that definition would be related to fusion. It could be the statement of peculiarly adapted for making use of atomic energy in such quantity as to be of significance to common defense and security or in a manner to affect health and safety of the public.

So, that would be the clause where you could potentially rope fusion in if you made those findings, and then the Commission would then need to determine by rule that these types of facilities were in fact utilization facilities.

So, that leads into the next bullet there where our current regulations, which are in 10 CFR 50.2, do not include fusion. They're really built around special nuclear material for both of those definitions that we have there.

CHAIR PETTI: Andrew, just a question on the first bullet, these things are so long. But this statement in the third line, sorry, the fourth line, peculiarly adapted for making use of atomic energy.

That could be interpreted to mean both fission and fusion.

MR. PROFFITT: Certainly.

CHAIR PETTI: As I read it, I thought the Commission, the SECY, says that NRC does have authority over commercial fusion power, is that correct?

MR. PROFFITT: Correct.

CHAIR PETTI: But I understand the second one is sort of an implementation thing, it doesn't include it?

MR. PROFFITT: Correct.

CHAIR PETTI: Thanks.

MR. PROFFITT: And so the Staff, based on our understanding of the design so far, we have certainly found that they could impact public health and safety. So, there is an argument that could be made to categorize them under the utilization facility approach.

That's the point here is to say fusion could fit in this bucket. If there are any other questions specifically to how utilization facilities are defined and categorized I can take them here or I'll pass it to Duncan to talk a little bit about the legal assessment.

MR. BLEY: Andrew, it's Dennis. It fits without any change to the regulation, right, for utilization facility?

MR. PROFFITT: We would need to add a regulation, we would need to change our regulatory definition of utilization facility. It could fit within the act, the Atomic Energy Act, definition of --

(Simultaneous Speaking.)

MR. BLEY: Not your regulations?

MR. PROFFITT: Correct.

MEMBER HALNON: This is Greg. I understand how you can fit and shoehorn it in but was it intended? There's plenty of documentation before these are put in place to see if it was actually intended.

I say that because if it was not intended but it fits, it may fit in the definition but the conglomerate of regulations and discussions after may not be applicable. So, was it intended to be there and just the words didn't match?

Or are we just trying to shoehorn it into a definition so we can apply a bunch of regulations?

MR. PROFFITT: I think that's one of our struggles as we've been developing these options. Really, we're looking to fit fusion into different frameworks that maybe weren't 100 percent envisioned with fusion in mind.

And we're also considering things like the hazard they pose, the risks that are involved with the technologies and trying to take that into account as we're putting it into something.

And then to also go back Joy's original comment of when is this going to happen and what's the certainty and what scale? Certainly, that's one of our considerations too because we could develop a framework outside of these.

There could be new legislation. We've had some interest from at least some Members of Congress in potentially modifying legislation to be more specific or specifically address fusion.

But our mindset from the get-go is let's look at what frameworks we have and see if something that we do have can fit for now at least given some of the uncertainty that's out there and the timelines and things like that without going off to do a bunch of work in developing a completely new framework.

Especially given the broad array of potential designs and technologies that are out there, it would be a significant undertaking to develop a completely new framework from scratch to address these things.

MEMBER HALNON: I understand that and I appreciate that. I think if we find a definition that allows it to fit, then if it wasn't necessarily intended, that gives me a skeptical eye on every requirement we put onto it and any requirement that we don't put onto it that makes sense.

So, maybe not a complete framework but certainly an outline of what a specific framework would look like. And then you could determine if each one of those items fit in the regulation.

So, it's a comment and I think as we go forward and get down the road, we'll probably get more clarity on that.

MR. RECKLEY: Andrew, this is Bill Reckley.

If I can, I would just say, Greg, we've researched this for the current paper as well back for the 2009 paper and at the time, Congress did intentionally change some of the language in terms of atomic energy to include fusion.

But the reason for that is you have to put yourself back in 1954. To be quite honest, it was because of the hydrogen bomb, not because of commercial fusion for electricity.

But nonetheless, they did change it specifically to address fusion reactions back in that timeframe.

MEMBER HALNON: Thanks, Bill, like I said, I think will become more clear as we go through and discuss hazards and different design basis issues as well. Thanks.

MEMBER KIRCHNER: Thanks, Bill, for that, this is Walt. You didn't finish, the application that was envisioned that one time was called Plow Shares and I'll stop there for you to let people look that up and see what that was about.

But that was an advanced application of fusion energy.

CHAIR PETTI: Andrew, Number 2 on the second bullet, that was added to support that application?

MR. PROFFITT: Yes, that was specifically added related to SHINE.

CHAIR PETTI: I assumed that's what it

was.

MEMBER KIRCHNER: Dave, that was added specifically for accelerator and transmutation of waste. The concept was to use a subcritical assembly of the waste materials driven by accelerators.

CHAIR PETTI: So, just to argue it, if you think about it, Part 50 had Item 1 and then something came up that was close and you needed to modify the definition. Here you do the same thing, you'd somehow extend it and add another definition for fusion.

There's precedent for expanding what you mean as you run into the specific application, if you will.

MR. PROFFITT: Certainly, we would agree with that.

Joe Staudenmeier, did you put your hand up?

MR. STAUDENMEIER: Yes, Number 2 it was not added for accelerator transmutation of waste, it was SHINE specifically. If you look at that docket number, that's the SHINE docket number.

MEMBER KIRCHNER: I stand corrected, that's right. It pre-dated that, yes.

MR. STAUDENMEIER: Yes, I think that was back in the 1990s, accelerator transmutation of waste.

There was no modification back then but that was one of the discussions that came up when we were looking at modifying that.

It came up about if they wanted to do something more general that would encompass something like accelerator transmutation of waste, that it could cover those types of things in addition to SHINE.

But they thought the most expeditious way to do it was just to limit it to SHINE and not think too much about other unintended consequences and therefore keep it specific to SHINE.

MR. PROFFITT: Yes, and specifically, I guess the point of this slide is to say fusion could fit, it's not a direct fit but it's a viable option for the Commission to consider.

MR. STAUDENMEIER: Thanks, got it.

MR. PROFFITT: I'll pass it back to Duncan here.

MR. WHITE: Another possible framework to put fusion under is Part 30 and using particle accelerator.

The definition of byproduct material under 11E3 states that anything that's made radioactive by use of a particle accelerator and is produced, extracted, or converted after for a commercial, medical, or research activity.

In terms of considering fusion under a byproduct framework, you first have to consider the fusion energy systems operate like a particle accelerator, and the second part of it is, is there correct material converted to use for commercial or medical research?

If you look at that 30.4 definition, which is the definition in the actual regulations there, again, there's the second definition that's listed there, the 72 Federal Register one.

This is the definition that's mentioned in the statements of consideration for the rule that adopted the particle accelerator. It gives some parameters on what the machine is and what it can do.

If you take a fusion device, that can make a case that says that a fusion device does operate in a similar manner to a particle accelerator because it does create conditions conducive to fusion reactions by accelerating the charged particles through electromagnetic interactions in a vacuum and charging the result in particle or other radiation into a medium.

Again, it's not the perfect fit and it certainly does not apply to all of the technologies that are out there. So, someone said earlier about horseshoeing, we're doing a little bit of that here too.

But again, there's similarities there where we control to say that a fusion device does operate in a similar manner to a particle accelerator. Again, we talked about vacuum chambers, we talked about discharge into plasma and into walls, partial kinetic energy by raising temperatures.

There's some types of particles that are used, there's acceleration of particles used. The second part of the definition mentioned is, and this becomes a little problematic for some of the technologies that are currently out there, about their use for commercial or medical research activity.

If you look at for commercial devices, we mentioned before some systems that use aneutronic or low-neutricity reactions. And as I mentioned earlier, those use the reactor material that is produced or the radiation produced is incidental to the fusion process.

And for that reason, they don't really fit under the definition of a particle accelerator. And again, we'll come back to this later in terms of where we landed but again, it does present a problem because, again, it does not cleanly fit into that definition.

But it does provide a potential option for the Commission to look at in terms of what framework to put it under. Again, I think we'll just stop there and answer any questions.

CHAIR PETTI: Walt had his hand up.

MR. WHITE: Please go ahead.

MEMBER KIRCHNER: I had to find my mic. When I look at this Duncan and Andy, I see your dilemma. It seems to me with Joy's questions in mind that if we do have time, how difficult do you feel it is to -- maybe I'm getting to the end of your presentation.

But at this point it seems to me a good stopping point to take stock and say, okay, let's wish and hope that fusion is successful, that it makes large amounts of electricity or energy.

It certainly doesn't want to make large amounts of byproduct material and some of the concepts like Tokamaks clearly are not particle accelerators. So, I can see your dilemma.

You've got Congress putting a timeline in front of you of 2027, but it would seem to me there is time to consider a framework that might not force you down the road of 10 CFR 5052 or something that follows the risk-informed spirit of 53.

I can see using byproduct material for research purposes where you're not really intending to make large amounts of electricity or energy, you're experimenting and you don't want to impede that by curating a large regulatory infrastructure that holds back the science and the development of potential concepts.

So, I wanted to pose that. I know you've got options and you also are going to have some recommendations so maybe I'm getting in front of your presentation.

But it seems to me at this juncture, does it make sense to consider and does the time allow the potential for a new framework that might be somewhat akin to 10 CFR 53, or an appendix to 10 CFR 53 that would follow not necessarily the 2027 deadline?

It's an observation question, maybe it's premature in your presentation.

MR. WHITE: I think, as I said, we'll go into a little bit of detail into the options, I talk about the options and the pros and cons for them.

Again, as I said, both have their limitations and again, any sort of alternative framework is again, because of where we have start and work with, which is the Atomic Energy Act, it really leaves us with not a lot of flexibility in terms of what path we go down and what we can develop as new.

For example, again, one of the options you're going to hear about, we looked at a risk-informed option, but again, it has to be grounded in what we have already in the act.

And again, unless Congress adds something to the act to specifically add fusion to it, right now we're kind of in that place in terms of how to proceed with this.

MEMBER KIRCHNER: But you certainly want to utilize and certainly don't want to produce a lot of byproduct materials. So, it seems to me that taking a success-oriented view of fusion and its future, it would be under the utilization.

That would suggest some variant on 10 CFR 50 that was more appropriately scaled as to Greg's comments, to the technology at hand and the potential risk as well.

MR. WHITE: Yes, but as I said, one of the things we looked at is again, it gets back to a basic issue about Part 53 for these devices and looking at 53 is designed for advanced fission reactors and we do have a portion in there, a placeholder there, for fusion.

But again, to implement the full suite of requirements that are required for advanced reactors, it goes way beyond I think what these machines and the risk involved for the machines are.

You would have to do a lot of I don't want to call them exemptions but you would have to scale back.

In hindsight, the Part 30 approach with the particle accelerators, in some cases some things in there will work fine but some things potentially for commercial you're going to have to scale it up quite a bit.

And it may go beyond what really Part 30 is capable of doing.

CHAIR PETTI: This is Dave.

Just some background, this issue of whether fusion is in a particle accelerator has been around for a long time. When the DOE commissioned the fusion safety standard that was done in the 1990s, this was one of the issues.

And at that time, the assessment was that it really didn't fit when one was looking at large engineering demonstrations and follow-on power-plants.

So, it's always a question.

Given Part 53, I'm not convinced it's the right thing but you could create a Framework C and it would certainly be streamlined over what's Framework A and Framework B, because many of the subparts probably wouldn't be applicable.

But it would fit in the flavor of a risk-informed option.

MR. PROFFITT: Certainly, I appreciate that. And just to frame a little bit more these assessments and working through, obviously going back to 2020 when the Commission asked for options for the Staff to put forward.

So, that's really the basis of what made us look at these and see if they were viable. And so that's what we've done in the paper so far, is to say there's not really a perfect fit necessarily but there are some fits that could work and leverage a lot of what we currently have.

And so that's what we're seeking to do here, point out there's utilization facility framework, there's a byproduct material framework, and fusion could potentially fit in them.

I'll go to the next slide for you, Duncan.

MR. WHITE: A summary and overview of

where we are with regulatory shipment of fusion R&D right now, again there's an emphasis on R&D.

A lot of you are familiar with the Department of Residential Facilities, the two primary laboratories are Lawrence Livermore with the National Ignition Facility and Princeton with the different Tokamak designs they've had over the years to FTR and such.

The agreement states have been regulating fusion R&D for some time under their Part 30 compatible regulations or under their existing race to control requirements for particle accelerator lasers.

I highlighted a few there, academic institutions, New York, University of Rochester has had an initial program for a couple decades there. They have tritium onsite, they do experiments there.

California, similar type of thing, the university associated with Lawrence Livermore does experiments too.

Commercially, there is a company out in Washington, Helion, who has a small material license and again, it's being regulated because of the accelerator, because of its materials. It's being done under Part 30 right now.

The Commonwealth of Massachusetts has been in discussions, pre-application, with Commonwealth Fusion Systems, CFS. Again, they are in the process of building a larger R&D Tokamak type of design.

They use about 5 grams of tritium and again, this will probably be finished some time next year and the application will be, according to the State, submitted in the early part of next year.

There's a couple states that particularly have done a little bit of licensing involving fusion R&D. They have run into a couple issues with the current framework under Part 30.

One of them is tritium accountability. Again, it's keeping track of the tritium. They had to issue the exemption because in the regulations if you lose a certain amount of material you have to report that.

The challenge with fusion facilities is tracking the tritium and they issued an exemption that required the licensee to come up with a program of how to track that. And again, then we talked to someone about waste management.

The challenge with activation products, with components is it's material-dependent. From knowing what you have there, how much you have, effectively measure this amount of material since it's again a challenge in terms of how you track that.

The same state that tritium mentioned that they have because of a company that's holding some of their activated components in storage is how do you track the amount of inventory of material there?

Again, we pointed this out already, the current scope of Part 30 does not cover all fusion systems. Again, you'll see low-neutricity reactions present a particular problem.

Questions?

MEMBER REMPE: This is Joy, I have couple of questions.

On this last bullet, how many near-term applications are you expecting to see for these two systems mentioned in response to this last bullet?

And then on the third bullet, is there an upper limit for tritium accountability or waste management that you expect to be challenged in the near term by what is allowed for Part 30 because of anticipated increased scope and magnitude of the devices that are coming through the pipeline?

MR. WHITE: Again, understanding the quantities of tritium, they have a challenge with accountability is again something that is being licensed right now with what Massachusetts is going to see.

We're in that range right now for doing that.

MEMBER REMPE: I'll make sure I understand your response. Right now someone is coming through that will have more tritium than what currently Massachusetts can authorize using Part 30?

MR. WHITE: I apologize.

Right now, the facility in Massachusetts, which is a Tokamak-type design, that's the largest one we know in the near term. There are other potential applications coming in next year but I don't know the quantity of material that they're coming into ask for at this point.

MEMBER REMPE: So, right now no one has talked to you about, hey, we're going to bumping the limits of Part 30?

MR. WHITE: No.

MEMBER REMPE: And then I guess I still haven't heard the answer to the last bullet and I have a question about do they have to come up with some sort of maximum hazard analysis and is it pretty cut and dry what they're going to do?

If they can't ship the tritium offsite and they're just accumulating it, one needs to think about whether their maximum credible accident is indeed a maximum challenge. Because I'm just thinking about safety and where we fall into this.

ACRS doesn't review Part 30 applications obviously and is there a point in the near term where we would want to deviate from that current approach? What is the limit and how well is it monitored that they've properly considered the challenges?

MR. WHITE: Under Part 30 the licensees are given a maximum possession limit of material they're allowed to possess. And that material would include waste products, it would include any activation products.

So, again, that's how they're licensed. That maximum possession limit is also the basis for how much financial assurance they are to provide to remediate the site if necessary.

That limit will also drive the offsite hazard analysis. Again, in Part 30, if you have more than 2 grams of tritium, you are required by regulations to do an offsite evaluation of potential offsite doses.

If you exceed 1 rem offsite, you are required to have an emergency plan. Now, that doesn't say necessarily that these facilities will have those doses offsite but they have to go through the evaluation and do that and demonstrate why their offsite doses would not exceed 1 rem.

Again, preliminary information, we have seen because they're dealing with tritium they would easily be under the 1 rem requirement for offsite. But again, they have to do that evaluation.

This is for current designs out there. Again, the company I mentioned is coming with an application and Massachusetts will have to do that evaluation.

MEMBER REMPE: How close are they going to be to the 1 rem?

(Simultaneous Speaking.)

MR. WHITE: The numbers we've seen have been well under 10 millirem.

MEMBER REMPE: So, we're a way from approaching the part 30 limit?

MR. WHITE: Yes.

MEMBER REMPE: That's one of the answers to the questions I wanted to really -- and this last bullet, are there any of these designs coming through in the near term that don't fall within Part 30 and how hard is it to include that?

MR. WHITE: Currently, the Washington

facility uses a low neutricity reaction right now. They do have a byproduct lesson for sealed sources but right now they have a permit to vent very small quantities of tritium that they produce right now with their machines right now.

As they scale up, when the question becomes obviously, what are they going to do with this tritium? This company, one of the things they have talked about doing is collecting the tritium and possibly collecting it and selling it.

That's one possibility they are looking at. But if they sell that tritium, we could make the argument going back that they now are using the tritium for commercial use and we can argue that it could fall under the regulations.

However, if they take that same material and ship it to a waste site, it would be hard to make that same argument.

MEMBER REMPE: So, they are already using Part 30 even though it's a low-neutricity reaction? So, your last bullet is kind of a moot point since you're already allowing these other types of facilities to use Part 30.

And if they're clever, what I'm hearing is they could in a safe manner ship the tritium offsite and then let another organization sell it?

MR. WHITE: Yes but I'll make it very clear, because companies are still in the research phases right now, the current Part 30 allows us to cover that because research is one of the activities that is in the 113 definition.

As we approach commercial size, that may not be the case. Again, it depends on how they approach it.

MEMBER REMPE: And then I guess I'd be curious on how soon is that going to happen? Are we still talking beyond 2035?

MR. WHITE: Yes, that depends on their continued development and where they're going to land.

CHAIR PETTI: Duncan, just a point for the members to know, the number that was used in the old days, 1 rem at a typical site boundary is about 50 grams of tritium. It could be 37, it could be 62, you know when you do the dose calculation.

But it's kind of a rough rule of thumb so it gives you an idea of that's the release that would have to happen.

MR. WHITE: That sounds about right.

CHAIR PETTI: Steve, you have a hand up?

MR. SCHULTZ: Duncan, you just mentioned

some elements of the agreement state with regards to their current participation in the work so far and it's mentioned at the end of the white paper the agreement states will be continuing in the development of the regulation as a stakeholder.

As the units are scaled up to commercial operation, what are you going to anticipate the role of agreement states to be in regulation? Is that going to change dramatically and will the relationship with the NRC between the agreement states and the NRC change then?

MR. WHITE: It probably could.

Again, right now the NRC under the agreement obviously these types of facilities would essentially fall under, however, in the past the Commission has allowed states to return a portion of their agreement where either they don't have a need for it or they're unable to support it.

I'll give the particular which is used, which is the review of sealed sources and devices that some states do have such programs and some states that have maybe only one or two manufacturers sometimes choose to return that to the NRC.

And through that, because of resources, they return it because they don't want to hire the extra Staff for one or two licensees. When we have met with the states, some of the states expressed similar opinions with commercial fusion.

They have one or two facilities, they don't see it as a particular advantage to hire additional staff and to bring the expertise on staff. And if there's an option for the states to return that portion of their agreement to the NRC, they would seriously consider it.

MR. SCHULTZ: That helps a lot, thank you.

CHAIR PETTI: Duncan, at this point we've been going at it for more than an hour and a half. I'm just thinking maybe we should take a break now and then come back?

MR. WHITE: Sure.

CHAIR PETTI: Let's break and come back at 10 minutes before the hour, about 14 minutes' break. Thanks, everybody.

(Whereupon, the above-entitled matter went off the record at 3:37 p.m. and resumed at 3:50 p.m.)

CHAIR PETTI: Okay, we're back. Are you guys ready to keep on going?

MR. PROFFITT: Sounds good, Dave, I'm here and I'm taking the next slide. Perfect time for a break, we can jump into the options here. So, the first one in the paper is the treatment of the fusion energy systems as a utilization facility.

So the path here would be to regulate them under Part 53 and if this option was selected by the Commission we would update Part 53, would be the plan forward here.

And then additionally, we would update the 10 CFR 50.2 that I mentioned earlier that defines in our regulations what a utilization facility is.

Part of the thing with this option, we feel the potential hazards of the current designs that we've been made aware of and have had talks with the industry on are very different than typical utilization facilities.

And certainly, 50 and 52 and to some extent 53 are pretty prescriptive with regards to being based around fission-based reactors.

One example there would be 10 CFR 100 and siting, things like that, it's all based around the source term from fission products, which obviously these fusion energy devices do not contain.

None of the fusion energy systems that we're categorizing and addressing within this paper contain special nuclear material. If they did, we would certainly bump them into the utilization facility framework.

Some of the other considerations due to legislation and the Atomic Energy Act, there's requirements such as Price Anderson related to financial protection that would need to be addressed.

There's certainly restrictions on foreign ownership control and domination, there's the licensing processing and the mandatory hearings that are involved with utilization facilities.

One of the key things and concern we've heard on the restrictions on foreign ownership with some of these companies that are out there are receiving investment from international investment in their companies. And that would certainly present an issue for them potentially.

And then near-term licensing essentially before, if there was licensing that needed to be done before we fleshed out this complete framework that addressed fusion, it would not be easy.

It would be a pain of trying to fit fusion into a regulatory framework that was really written around fission-based reactors. And specifically, 50 and 52 were focused on the large light water reactors that are currently in operation.

And certainly, we see the systems especially in the near term as being significantly lower hazard potential than those facilities.

Any questions on Option 1?

MEMBER HALNON: Yes, this is Greg. On the third bullet there, the financial protection restrictions on foreign ownership and mandatory hearings, it almost feels like you're putting that on there because you don't think that's necessary for fusion.

Is that the purpose? You just don't think that's necessary, or is that just listing a few the extra stuff the AEA requires?

MR. PROFFITT: Sort of a mix.

Certainly for some, as we've talked about there's a large array of hazards and something that was a very small potential hazard happened to be lumped in necessarily with Price Anderson and needing to have that liability related to them because being a small hazard facility that produced energy probably wouldn't make sense.

So, there are things that would need to be dealt with for a lot of the facilities that we see that we think would maybe not be appropriate for all of these to be applied to them.

And certainly, and I'll get a little bit more to stakeholder feedback here in a bit once we get through the options, but there's been a lot of stakeholder feedback around some of these types of things as feeling they shouldn't fit specific designs.

MEMBER HALNON: That makes sense, I agree with that, although on foreign ownership I think I would beg to differ that that is still very important. That restriction is huge, especially in today's political environment.

So, just my comment.

MR. PROFFITT: I'll kick it back over to Duncan to talk about the next option. You're on mute, Duncan.

MR. WHITE: I apologize for that.

For the byproduct material framework option, we have two-step options here. Again, we regulate fusion energy systems using Part 30 and the current framework we feel could accommodate near-tearm commercial fusion energy systems.

And as we talked about earlier, those will legally be included under the definition of particle accelerator. One option is to do rulemaking, a limited rulemaking, to include and add a technology-inclusive definition of fusion energy systems to the scope of Part 30.

We'd add definitions, for example, for defining fusion, fusion facility, commercial fusion facility again is something that would come out during the regulatory development.

Also, we would do guidance with rulemaking to complement that.

The other thing we'd do besides adding definitions under this option would be to add definitions along the lines of what a content of what an application is and what it would need to cover, which again would be design-specific.

This option does add some regulatory protectability for issuing clarity for the stakeholders, it does produce the potential for exemptions. We talked a little bit about that earlier, maybe we'll possibly address some of those in such a rulemaking option.

And again, the guidance will be important here and guidance is also important under the no rulemaking option because again, we would depend on solely on guidance for this no rulemaking option to regulate fusion energy systems.

However, the no rulemaking options, there's less regulatory protectability than doing rulemaking unless consistency implementation with the agreement states, because again, if we do rulemaking the agreement states would have to adopt compatible requirements as the NRC for fusion devices.

So, that's the downside there and I'll point out we may not be able to include all the fusion energy systems under this framework unless we do rulemaking. Questions?

MEMBER HALNON: This is Greg again. I know I'm picking on words, I apologize, but can you do a no rulemaking option under the AEA? You're supposed to regulate this, not suggest how you do it. It can only be a suggestion.

MR. WHITE: One of the things, obviously NEIMA also uses the word rulemaking in that particular piece of legislation. So, a plain reading of NEIMA would say the no rulemaking option is not really a viable approach.

But again, it's a possibility. I certainly agree, if you just do guidance there is generally no opportunity or limited opportunity for public input.

I'll go back to Andrew.

MR. PROFFITT: Thanks, Duncan.

Moving onto the third option that we have is a hybrid approach so that would be a couple different possibilities there.

But essentially, such an option would be able to better address the differences in the potential radiological hazards associated with a variety of technologies, something that could be tailored directly towards fusion.

But there's also two different ways we could do this and we've thought about one being you basically use Option 1 and 2 but there's a decision criteria that's established.

And that criteria would likely need to be based back on that utilization facility definition that we've talked about in the atomic energy act.

But you would develop some type of criteria to either kick the specific application or specific device into the Part 30 byproduct-material-type framework or into the utilization facility model framework.

That's the diagram on the left there and that would be in Part 53. So, there is some potential limitations with this type of an approach. One, there's not necessarily something on the near term that we would see as 100 percent tripping such a criteria that we would develop.

Certainly, we don't have a specific criteria necessarily in mind but it would be hazard-based, maybe some inventory, potential maximum inventory that if you went over that you would be treated as a utilization facility versus a byproduct material, or some offsite consequence.

You would be treated one way or the other. The second option would be the consolidated approach, a whole new part of the regulations to fully address fusion. And you would have increasing requirements based on the hazard consequences.

So, we really feel like this second approach is built into a potential longer-term of either of the first two options, whether it be to include another Part 53 as a utilization facility or to include fusion under the byproduct material framework.

We really see both of those longer-term options essentially morphing as the industry will mature into this consolidated approach as we tailor one or the other frameworks to really address what we're seeing with the fusion industry.

MEMBER BROWN: This is Charlie Brown, could I ask a question?

MR. PROFFITT: Yes, go ahead.

MEMBER BROWN: I've been listening to the options, kind of interesting. I have a tough time figuring out why we would do it as byproduct or a hybrid.

We're trying to produce electricity out of the fusion plants and why would we deny them some of the same overall characteristics that you show on Slide 10 to a fusion plant that's producing electricity that we have with a light water reactor or other reactors?

Byproduct just doesn't seem to make sense to me. Obviously, I'm not very smart on all this stuff, it would just seem to me the object is to produce electricity for the country, not to have byproducts coming out of it.

Anyway, that was my thought, I didn't hear anything that pushed me out of that.

MR. WHITE: One thing to point out, electricity is not the only thing that's being mentioned by all parties developing fusion. We've also heard people interested in using fusion to produce isotopes.

The helium-3 and stuff like that, some of these fusion reactors can be used to produce some of the fuels that wants to be used. There's some interest in doing that.

It's not exclusively electricity, although that's a stated goal of a number of one. There are other things being considered again by other companies.

MEMBER BROWN: That's a big investment, though, isn't it?

There are other methods to produce the isotopes we have and the fusion is always in the past. I'm just going back, remembering reading the first articles on how wonderful this stuff was back in the 1950s.

That's how old I am. But electricity as opposed to hydrogen bombs was the new end all be all, just as the fission reactor approach we were taking in the 1950s when we started. That's why I asked the question.

It seems to me if you're going to spend billions and billions and billions, because that's what it's going to be by the time we get there, I'm not objecting to that, it's just going to be a lot of money.

And you'd like to have some popular support relative to what it does for the country overall and relative to, quote, clean energy for utilization purposes.

That was my only thought, I understand the differences, it's just up in the air but it's just a thought process.

MR. WHITE: As I said, obviously there has been discussions in the literature about the availability of tritium, if that's going to continue, is it going to be available if we have a number of fusion plants go online?

And then again, some have been talking about someone can produce fuel for other designs, that's just a possibility. I don't think that's their end goal, I think their end goal is a number of them really want to achieve success.

And hopefully there are other options that people are seriously looking at that we've been informed about.

MEMBER BROWN: Thanks.

MR. WHITE: Thank you for the question.

CHAIR PETTI: Andrew, my question on these two sub-options is, is the consolidated approach -- how different would they be that they would potentially merge together in this consolidated approach?

MR. PROFFITT: The bifurcated approach

would really just be we would develop a criteria to kick it one way or the other.

We would still need to do work within Part 30 and within Part 53, so really, it would be you're doing Option 1 and 2 in addition to developing some type of criteria to kick it to --

CHAIR PETTI: So, it's critical to get the criteria?

MR. PROFFITT: I'm sorry, I didn't hear that.

CHAIR PETTI: So, it's critical to get the criteria established?

MR. PROFFITT: Yes, absolutely, that would be critical and we would also need to make sure we develop that so it was clear to the public, to all of our stakeholders, to industry certainly to understand where they would fit.

Because there could be uncertainty over them developing a design and developing an application that they thought they were tailoring it to one framework and if it didn't go that way, they were kicked one way or the other, that would obviously produce a lot of uncertainty for them.

CHAIR PETTI: The other question is, is it more work to do the single graded framework than working on the two separate ones? Or is it about the same amount of work, it's just how it's packaged?

MR. WHITE: I think the consolidated approach would be more work because again, you would basically have to have probably a new part of the regulations that address both.

And it would have to be written in a manner, and this has to be done by 2027, that would include any commercial research, create a broad umbrella to regulate and oversee the different approaches.

And it would have to be wholesome enough that you could base your regulation on that. And again, it would be clearly more work. Decision criteria for bifurcated would be easy, I'm not saying that.

But again, you would basically talk consolidated writing a whole new part of the regulation to do that.

MR. PROFFITT: And the additional things we're thinking about with that potential approach would be obviously, the industry is budding right now, very nascent right now, and just getting going with people, these companies, seeking to prove a concept with Q greater than 1 in the next few years.

So, the combination of being at the very early stages of the industry and also with the broad array of technologies and scope of hazards that are out there, it would be a difficult job to really develop a completely new framework that would be successful for the time and investment that we were putting into it to be something worthwhile.

MR. RECKLEY: This is Bill.

Andrew, if I can, I think, Dave, from a technical standpoint, it would be much more work, as Duncan and Andrew have said, especially if you start to build in some of those factors into that consolidated framework, like when would Price Anderson apply?

When might you use different hearing procedures? Those kinds of things. From a technical standpoint, it might not be much different but it would be complicated to start to build in those other options.

Whereas the bifuracted approach, you could say right or wrong it's already decided for you. Once you make that decision criteria and you say utilization facility, then under the act, foreign ownership would be restricted.

That's why it would be somewhat

complicated, especially if you started to build in some of those other considerations.

CHAIR PETTI: That helps a lot because technically, I didn't see it being that different but it's all the other stuff that has to be touched on. Thanks.

MR. PROFFITT: Duncan, did you want to talk a little bit about what we're planning to recommend in the SECY?

MR. WHITE: Sure. As you mentioned earlier, we've had internal discussions and are aligned on where we're going to go with this. We're going to be recommending that we regulate fusion energy systems under a byproduct material framework doing limited rulemaking.

And our decision was based on a number of factors. First, we noted that Part 30 provides a broad framework for regulating material that include the risks by these fusion systems. Because they're already being done by agreement states.

We also know the projected risk from these systems are at least a few orders of magnitude less than the fission facilities, the commercial fission facilities that are operating.

Part 30 framework also allows it to be

scalable in terms of a risk-based approach, commensurate with the diversity of the proposed systems and the reactor material and radiation present.

Again, one of the tasks under NEIMA is to make this technology as inclusive as possible, and this is where the limited rulemaking comes in.

Again, by doing limited rulemaking we can ensure that Part 30 does address all anticipated fusion devices and in addition to that provides better regulatory predictability and consistency across NRC and all agreement states' jurisdictions.

We also noted that by updating Part 30 and potentially including content of application requirements in the regulations to complement it with guidance that we can scale up areas that we've foreseen that really we need to beef up under the byproduct material requirement approach.

These would be things like emergency planning, physical security, and importantly, facility design requirements and radiation safety for treating paneling systems are a few the areas that I think we can address there.

The other thing we noted is that if we look at commercial irradiators, NRC regulate the commercial irradiators for 25 years more or less on a case-by-case basis.

It was done with very limited regulations, it was done mostly by guidance, and it allowed that industry to mature and the designs to standardize and provided an option when the industry matured enough that we actually adopted in 1993 Part 36 to formalize that.

We kind of see the same thing here with fusion too. As we talked about earlier, right now the industry is not mature, there's a lot of designs out there and as things evolve over time, this would potentially be a first step.

And again, later on we'd potentially go back where we would want to make things more standardized and be more inclusive of what's out there as things evolve.

That's the general approach of why we're doing that. Andrew, do you want to add anything else to that?

MR. PROFFITT: No, I think you covered most of it. It looked like maybe some questions were popping up.

CHAIR PETTI: This is Dave. I'm really surprised. To me, Option 3 gives the regular the most flexibility, particularly the left-hand side one, where basically, you decide some criteria and you can go into 30 if you fit.

But if you don't you have to go into a utilization facility and you can decide that based on inventory of tritium.

And I would tell you the problem I think, my personal opinion having spent a decade leading the fusion safety program in the United States is an understanding of uncertainty on all these numbers.

These are significantly greater than the uncertainties on any of the advanced reactors that we're going to see.

And how one has to think about those uncertainties in terms of the safety, in terms of providing estimates that you feel bound some of the uncertainties, Option 3 just gives you more flexibility going forward.

Because basically, Option 2 is the lower branch of that Option 3 but if you're wrong and things turn out worse than anticipated or it isn't as bounded as what they thought, Option 3 gives you that flexibility to capture that, whereas Option 2 may not.

MEMBER REMPE: Dave, before the Staff answers, if they would have more guidance and limits, if they had limits on what the amounts are, which are the current Part 30 limits, but have guidance about consideration of uncertainty and then wait and say if things start exceeding this the person is going to have to have a lot of exemptions or do something else rather than trying to coming up a Part 53 utilization model when they don't know what the design is, would that make you happier?

CHAIR PETTI: My feeling is that the decision criteria are really important and one should spend some time working on that, independent of which way to go. And yes, I don't think there's a need to decide which way to go tomorrow.

Because none of these systems in terms of the larger-scale power reactor engineering demonstration, whatever you want to call them, that are out there, are many years away.

But you've got this 2027 hard deadline that you're up against.

MEMBER REMPE: So, maybe what they need are some better criteria rather than to try and figure out something when there's so much uncertainty on what the design is and the timeframe.

I'll defer to the Staff but I really think that's what you're trying to say.

CHAIR PETTI: Basically, you're trying to make a decision when the technology readiness level of many of these concepts, the uncertainty in plasma physics is high and the uncertainty in the nuclear technologies and how they get implemented is very high.

The perspective, I know there's many of the proponents that don't like ITER but if you go back to 1990 when ITER was first conceived and you look at ITER today and trace some of that, a lot of stuff was because they didn't understand well enough at the beginning that the design forced them to come to grips with, if you will.

Design is an incredibly powerful tool and it can so inform you, and to have to make a decision at this point when so much is still foggy for some of these concepts, it just seems like it can put you in a box that you might not want to be in.

So, I would have thought flexibility would be the most important thing.

MR. PROFFITT: I'll add a little bit there.

I think this is where the Staff sees it as working from Option 1, a utilization facility approach, would be trying to work from a restrictive framework that's built for large, relatively large, hazard systems.

CHAIR PETTI: Let me stop you there, Andrew. Do you think SHINE is a high-hazard facility? I don't think so.

MR. PROFFITT: Part of SHINE, and I'm not an expert on SHINE, but part of my understanding of SHINE is they actually sought to be addressed as a utilization facility and wanted, volunteered to be put under that umbrella.

And just to add a little bit, it would be working back from a framework, trying to scale back, whereas working from a byproduct material framework would be scaling up. And we think it does have that ability to scale up.

We do think it's flexible. I think what Part 30 does now, it regulates gauges, all the way up to panoramic irradiators that are pretty high.

And additionally, letting that framework scale as the industry matures we feel like would be appropriate given trying to develop a consolidated framework.

You're right, a decision criteria like we said would be easier potentially than a consolidated framework.

But trying to develop a consolidated framework and you guys know how resource-intensive any rulemaking is, really, but certainly something where you're developing a completely new part of the regulations, to try and be wholly inclusive of the potential fusion industry in the country and the hazards the different technologies and devices may possess would certainly be a big undertaking.

And I think we've heard during some of the discussion here that it's likely premature.

So, that's where we feel like Option 2, the byproduct material framework, it addresses the hazards that we're seeing from the devices, tritium being obviously one of the number one deactivated materials.

The types of hazards that are there is what Part 30 was built to address. And certainly, we're acknowledging it will need to be scaled up and we think a rulemaking will make it clear that, one, fusion fits there, and two, give us that scaling more directly.

And then obviously, guidance will continue to grow as we move forward.

MEMBER KIRCHNER: Dave, this is Walt. I'd like to make an observation. I certainly am not well versed in Part 30 but I've been since this discussion started thumbing through it and there's a big conceptual difference between Part 30 and a fusion machine.

And that is by and large starting with my luminox watch and I think tritium for many of the systems is going to be the highest hazard. It's not going to be a sealed like my luminox watch.

This is an active system and almost any system that produces electricity needs temperature, usually high temperatures that makes control of tritium a much more difficult undertaking.

We've seen it with SHINE, although we can't discuss that in detail or shouldn't here, certainly, tritium management is one of their biggest design challenges and I think that's going to be the same case for at least those magnetic confinement systems that go with the tritium-fueled system.

So, that's a lot different than a sealed source, a lot different than a sealed source. You do have some provisions in 30 I see.

For one, you do not have a sealed source but by and large, as Dave has pointed out, you're generally not looking at the scale that you would see in a fusion device.

So, I'm curious, what would you change and have you at least conceptually at this point gone through Part 30 and thought through what significant changes would be needed to regulate a fusion device under Part 30 that is actually built at scale to make power?

For example, Schedule C on 30.72, quantities or radioactive materials requiring consideration of the need for emergency plan, I don't see tritium in the list.

And that gets to Dave's point about having at least some nominal threshold where a lot more attention would be required by the regulator in licensing such a facility.

MR. WHITE: Tritium is in there and again, besides obviously emergency planning is one area we talked about, in a commercial facility obviously one of the things I mentioned earlier was physical security.

The potential quantities would have to be addressed under physical security requirements, although you still would have to do that. But that would require some potential changes to Part 37 to do that.

Tritium is not listed in Part 37, it's one area that may need to be changed. I mentioned a lot of items that are handled and regulated under Part 30 is actually done with guidance, the other reg guides, other NUREGs are used.

They're hooked or tied to the guidance document, which is the licensing guidance document that a licensing reviewer and the applicant would have to use to submit an application.

So, just because it's something not listed in Part 30 doesn't mean we're not making it a regulatory requirement. We would have other, draw on other guidance that the Agency has developed to license such a facility.

MR. PROFFITT: Duncan, do you want me to pull up the backup slides we had on Part 30? Do you think that would help?

MR. WHITE: If you want to do that but I think those slides just talk about the different areas you would look at, what would be in the application. It doesn't help for where the Committee is looking for, where are the gaps?

I think that's really what they're looking for and certainly, I think we recognize we would have to scale up portions of Part 30 to address some of these fusion energy systems to do that.

CHAIR PETTI: I have another question. Codes and standards, quality, design requirements relative to safety, those would all have to be added to Part 30?

MR. WHITE: Potentially, yes.

CHAIR PETTI: It would be very helpful to have a little checklist, take a look at your utilization facility requirements, and what are the ones that you think would pour over that make sense?

My basic concern is all of this rests on what you think the hazard is, and it should based on what you think the hazard is. It's tritium but I want to tell my colleagues activated dust is not a small problem, given the system operates at vacuum.

And you are activating tungsten potentially, a nice wonderfully activated material, activated steel. I have yet to see any fusion concept that the plasma won't bump against the wall and create the dust.

The question is how much? And that's incredibly difficult to answer because of uncertainties in physics.

And it would just help understand which rules you think you have to take from, and my guess is you would take from utilization rules because you're getting closer and closer to aspects of the utilization.

Again, I'm talking more technically than I am about the non-technical rules like Bill had talked about. Because I'm also frankly worried that you're going this way because it is also the one you can meet by 2027 and that still may not be the right thing to do.

I understand schedules are real but that's a concern that I have, and so you may get a letter that's going to disagree with you guys depending on what the rest of the Committee says when we do this in full Committee.

MEMBER HALNON: This is Greg.

That was kind of the earlier comment about shoehorning it into a definition and then allowing the rest of it to take hold.

There's going to be a tremendous amount of scrutiny on every requirement and what requirements have not been put on it that we may think need to be.

And when you do guidance you're not really regulating, that's sort of an end-around way of doing it. So, I agree, either a checklist or it's an outline or some kind of framework that is not necessarily regulatory language, but here's the boundaries and the limits and the things that we're looking for.

And how do you define adequate protection? That's a big question but how do you distill that down into what's required for these things? And I agree, a lot of Part 30 won't apply but a lot of it will, maybe some of Part 50 and 52 will apply.

And it's not just technical, it is the legal aspect about foreign ownership and decommissioning and all of those other things that have to come into play as well.

So, I agree with you, Dave, there's something we need to kick around awhile.

CHAIR PETTI: We didn't get into the waste issues but I would tell you, if the machine, if the physics works absolutely perfectly and in ten years from now they're talking about a power-plant, there are no alloys available that will not produce greater than Class C waste.

The alloys that the fusion community has talked about, they're called low-activation materials that are not ready yet, they won't be ready in ten years.

MEMBER BALLINGER: It's sort of like buying a box of cereal that's low fat. What's the starting point?

CHAIR PETTI: Right, but today if you have to pick a material you have to pick a stainless steel, that's going to activate in any of these situations, when you're talking about power-plant fluences where this thing is operating 24/7 or close to it, you're going to get significant activation in either DD or DT to challenge the waste limits.

So, they'll be greater than Class C. And it all depends on the impurities, it has nothing to do with the base metal.

You can go back, there's tons of papers in the literature, tons, on this and how does a fabricated controlled material like niobium, to produce niombium-94, which is one of the worst isotopes in the waste management regulations.

It's those sorts of things that are underneath all of this that will need to be looked at beyond the nearer-term operational stuff. It will be really nice if you guys could for the full Committee meeting come up with a short checklist.

It doesn't have to be perfect yet but what you think needs to be reported into Option 2 because it isn't all fleshed out enough.

MEMBER REMPE: If they went with Option 2 or 3 and basically had a complete list of criteria and then said we can't do the upper path of this figure on Slide 12, the utilization facility, at this time until there's more operational experience, would that satisfy NEIMA?

MR. PROFFITT: That's a good question, I think that's something we would have to consider and speak with the lawyers about. They're the ones that advise us on the specifics on meeting NEIMA.

MEMBER REMPE: Because it surely seems strange to spend a lot of effort on figuring out the upper path when we don't really have a good idea of what the facility would be like.

It just seems like a waste of somebody's funds and effort.

MEMBER BALLINGER: I'm in the wasted funds camp. I don't think the actual proponents of individual concepts know what they need.

They can say what they think should happen and then when things actually get going, should they get going, only to discover that they made the wrong set of criteria. And so here you are stuck with a set of rules that don't even apply.

It worries me.

CHAIR PETTI: And honestly, my thought on the letter was Option 3, the bifurcated approach, get to work on those decision criteria but fleshing out all of this other stuff, you need more operating experience.

You can't really characterize the two hazards of some of these facilities at their power-plant vision until you get more operating experience.

MEMBER BALLINGER: To give you a bit of a dumb example, because it's a little better now than it was 20 years ago, the erosion rate of the first wall, there are people that say the erosion rate is going to be X and you say, well, X is thicker than the wall.

Then they come back and say, all right, the erosion rate is X but the deposition rate is also X.

CHAIR PETTI: Right, I know that whole story, Ron, I've seen it in action.

Again, this is all some of the uncertainty stuff that makes it really hard to in fact think about these things in the traditional nuclear safety approach where you're trying to bound things, you're trying to in essence work backwards if you will.

You sometimes can't do that easily because there's just too much uncertainty at this point.

MR. PROFFITT: Yes, and that's where I'll say I think in starting from the byproduct material framework, we feel like it largely addresses the hazards that we're seeing today.

It's been successful in oversight of R&D to date and we feel like as the technologies mature, as there's a potential industry, and as there's operating experience, we feel that it can scale appropriately up as we're getting to those points.

CHAIR PETTI: I completely agree. All the current R&D facilities, Part 30 is not a problem. I see that fitting because it allows innovation and it allows the technologies to be matured.

But if you could get to those decision criteria, you could get a sense for how soon and if you could get there or not, and better inform what is the right option.

MR. PROFFITT: Duncan, do you have anything else to add?

MR. WHITE: No.

MR. PROFFITT: Anything else on the options? I was going to move forward to stakeholder feedback and then our path forward.

MEMBER KIRCHNER: Just, Dave, if I may, this is Walt, can I just ask a question? When you talk about Part 30, you're specifically only talking about Part 30.

Because I was going through the later parts, 31, 32, and such, it's interesting to look at those because some of them require things like radiation protection, training, radiation safety officer, et cetera.

You will have a lot of those kinds of hazards in one of these fusion devices that's actually built to make, I presume, 24/7 electricity. You are just specifically saying 30?

MR. WHITE: We're saying Part 30 because that's where the framework is. Again, we should quickly point out there are other -- Section 31 through 39 also works off of Part 30.

And some of the licenses we write for other things, there's maybe not a lot of particular regulations but we also pull from Part 20 in other areas too, from other guidance.

MEMBER KIRCHNER: Yes, I presume 20 would be applicable.

MR. WHITE: Yes, there are other things that are applicable. We would --

MEMBER KIRCHNER: But going back to this idea, I don't know if gap analysis is the right way to describe it but it would seem to me that if your recommendation is to go with 30, and I agree with Dave, for research and development this is great.

That way, you get more and more experience, more and more opportunities to try different materials, whether it's the first wall or whatever, or your gas handling systems et, cetera.

At some point, and I'm taking a positive view that fusion might be successful there, you're scaling up and I'm repeating myself but, boy, it sure feels like a utilization facility to me.

Now, I wouldn't want to stick the fusion community with 10 CFR Part 50 or Part 52. I think Part 53 has a much more flexible promising framework to start from.

But it would seem to me some kind of gap analysis or something is necessary to say looking forward, we'll go with this option for the near term so that the research and development can proceed.

But at some point when the scale-up occurs and the hazards become more complex, et cetera, then things like operator requirements, radiation protection access, material control, et cetera, those things that are part of the utilization facility, they may not be the very prescriptive things that are in 10 CFR 50 or 52.

But they come into play and it would seem to me that would be a necessary next step to flesh out what's needed going forward to regulate fusion power. I'll stop there, I'm repeating myself.

MR. RECKLEY: Andrew, this is Bill.

If I can, I would just weigh in that whether it's utilization facility under 53 and we're basing some of these same struggles with the variety of the hazard, all the way from micro-reactors to large facilities, what you have, and this has been a criticism of 53, but you do have somewhat of a methodology of how is it going to proceed under that framework?

And basically saying what are your inventories, where are they? That same thing would come in for fusion. What are your inventories, what's in the plasma, what's in the structure through activation?

Largely, what would be in the blankets, the breeder blankets, and being processed and being stored in the form of tritium, look at your hazards. Where are your energies? Dave talked about the magnetic and someone else mentioned chemical and thermal.

Those things that can be disrupted to

potentially contribute to a release, all of those things need to be assessed and we've built -- again, traditionally on the reactor side, we've focused very much on that.

That's done in materials too. I'd be the first to admit I'm not a materials guy either.

I think what we're talking about for some of these larger fusion facilities would be way on the upper end of what we've done under Part 30 and considered, and the complexity of the safety analysis that would be done and so forth.

But it can be done under that framework is all we're trying to say. And if an emergency planning zone is needed, 30 can accommodate it. If there's financial assurances that are needed because of potential releases, that can be accommodated.

So, I just wanted to get that in. From a technical standpoint, we think either framework can build up and I think Andrew said it pretty well. To some degree, if you start with utilization facility, we think we might have to scale down.

But if you start with materials, there's nothing that prevents us from scaling up requirements and conditions on the license and all kinds of things. But I would defer to Duncan because that's his area.

Anyway, I just wanted to get that in.

MR. PROFFITT: Thanks, Bill. I see another hand. Dennis, go ahead.

MR. BLEY: I want to take a little different tack here. Think a bit, if you will, after this meeting about Dave's discussion and about the flexibility of Option 3. We haven't got to the stakeholder comments yet and I'm going to jump on that.

I haven't read all of them, I don't know what they are but I suspect, I wonder if you think Option 2 is something much more in line with what the stakeholders want. I suggest to you that in five years, wherever you start now may change quite a bit.

But by the time you have to actually use this, which is some time later, things will change and nobody out there is going to give you much credit for aligning with the stakeholders in the early part of the project.

And if it leads to complications later, they'll be blaming you for it, not themselves for having pushed you in this direction. So, it's just another way to look at it.

And the flexibility idea, given what we know now just feels crucial for you.

MR. PROFFITT: I appreciate that. Let's move on to feedback, that was a good segue into that. So, the majority of feedback we've received has been supportive of the byproduct material approach.

Some of the folks we've engaged with on that include the National Academies and their report, bringing fusion to the U.S. grid. I'll note the framework seems appropriate and like we've mentioned here can scale with the technologies.

Agreement states, in our discussion with the agreement states they're supportive of the byproduct material approach and the potential involvement of them in the licensing.

Commercial developers have been nearly unanimous I would say around the byproduct material approach. They've presented at many of our public meetings, many have written letters recently to the Chairman and then you guys also received a letter from Helion.

And then also some of the international partners, I think I mentioned earlier the U.K. is taking a different approach to fusion in their nuclear program, but we've heard support through that realm as well, from our international folks.

And kind of like we've discussed, the

utilization facility approach is viewed as not aligned with the risk presented by fusion facilities and then it introduces a lot of regulatory uncertainty given that they would really need to work back from a higher hat of requirements and they may need exemptions.

There may be items that aren't applicable to fusion but maybe they feel like would not be applicable to them but maybe the Staff would, so it would create quite a bit of uncertainty in moving through the licensing process.

And then we also had a little bit of limited feedback, it may be similar to some of what we've heard today. It's sort of just pausing on fusion for now given the uncertainty and then it may be further away than some of the news articles say.

And we've also heard some feedback that anything other than the utilization facility approach would be inappropriate.

That's a little bit of a highlight of what we've heard now, so I kind of jumped the gun maybe on stakeholder interactions before in some of the feedback we've heard when I covered the earlier slide.

MR. BLEY: You'll recall that in the 1970s, that's when I was in graduate school and half of the department was fusion, the projection for commercial fusion power was 20 years for sure.

MR. PROFFITT: Yes, it was certainly a joke when I was going through school a little after the 1970s that it's always kind of 30 years away. But we are trying to be responsive to our stakeholders.

Obviously, we have to be responsive to NEIMA and the requirements in NEIMA. And maybe it's just because I'm on fusion now in my phone, here's my meetings and all that, but there has certainly been promising advancements that seem to be making fusion closer.

I'll stop there.

CHAIR PETTI: It's too late in the afternoon to gu9 that. Keep on going with the long discussions.

MR. PROFFITT: All right, so path forward --

MR. RECKLEY: I'll just say, Andrew, predictions are hard, especially about the future, or however that quote was.

MR. PROFFITT: Our path forward, and I think this is key and it goes to some of the concerns raised by the Committee here today, we're going to continue to fulfil our mission protecting public health and safety.

So, regardless of where these things end up, yes, the licensing process will be maybe a little bit different and some processes may be easier than others and some may be better tailored for near-term fusion or longer-term fusion or big concepts or small concepts.

But regardless of the framework that it ends up in, the majority of the same information will be necessary for licensing.

So, while a decision is made in the near term to pick a path, we really don't see that necessarily being a huge impact on what the requirements are going to be on the facilities when we get to applications and licensing.

So, we're going to put forward the options to the Commission by the end of this year and they will come back and direct us where they feel the appropriate framework is and we'll move to implement that with rulemaking or guidance pending their decision, in line with the NEIMA deadline.

And obviously, stakeholder is going to continue and even ramp up, especially ramp up, if there will be rulemaking but certainly, if there's guidance development we'll continue to engage our stakeholders.

Right into the next steps, I'll just mention we're planning to deliver the options SECY by the end of next month, ahead of a Commission meeting that's scheduled on fusion in early November.

CHAIR PETTI: I just have a question for Derek. Our letter developed in October will be able to get to the Commissioners before the November 8th meeting?

MR. WIDMAYER: We can try. Regardless of whether it gets there, they won't make a decision on the SECY for quite a while. So, they'll certainly have your letter before they make a decision.

CHAIR PETTI: Okay, thanks.

Members, any other comments, noting that we are almost an hour behind schedule on a Friday afternoon? With that, one public comment. Please identify yourself for the record and give us your comment.

MR. DESAI: Hi, this is Sachin Desai. I'm trying to get my camera ready. Thank you very much for an excellent presentation and I really appreciate the chance and opportunity to listen to this exchange.

We recognize the incredible benefits that ACRS brings to public safety and it was one of the first things I visited when I was an NRC law clerk, was an ACRS hearing.

A little about myself, sorry, I'll introduce myself, my name is Sachin Desai, I am General Counsel for Helion Energy. That's the Washington-based fusion company that was discussed before.

I've worked my legal career in nuclear safety, starting actually, as I mentioned before, at the Atomic Safety licensing Board, where one of my first events was an ACRS hearing, which was really a special event and helped guide how I look at a lot of safety issues going forward.

Just a note about our Washington company, we're one of those magneto-inertial fusion devices, so that third category of device. We have a little bit about ourselves in the letter that we've sent.

Our goal is to produce a 50 megawatt electric device. The thermal aspect, it doesn't exactly work perfectly because our approach involves using changes in magnetic fields to directly capture the energy produced from the fusion reaction.

We do have some heat that's produced but primarily we try to directly convert the energy. We produce tritium because our plan is to use a deuterium-helium fuel cycle.

The tritium would absolutely have a commercial purpose, I know that came up before.

We plan to either sell the tritium or we restore the tritium in the case of the helium-3, which would then be our fuel used commercially in our fusion device or sold to other users of helium-3.

I wanted to just call out that we provided some limited comments in advance of the hearing and I want to take a second just to call out a couple points that may reflect on aspects of the discussion today.

First, I know you hit on diversity, diversity was definitely an important part of the discussion and it's an important part of the fusion industry. I'll note that Figure 1 of our comments had the little chat that talks about some of the diversity.

It looks at some of the other companies in this space that have come before the NRC or otherwise received fundraising allowing them to build demonstration devices.

And just a couple points on diversity, of the five companies that are shown, two are pursuing non-deuterium tritium fuels, four are pursuing non-Tokamak approaches, and one that is pursuing an Tokamak approach.

I can't speak for any other company but we're is pursuing quite a different approach than what either is planning.

So, there's a lot of incredible diversity in the field that does speak to the need to build something that can scale, that can recognize those with limited impacts and continue to educate as the industry evolves.

We have a perspective that we've shared with the NRC Staff on among those options or how we think fusion might be regulated. The first thing I'll say to start that off is we certainly believe that fusion has risks and hazards that have to be regulated.

And a regulatory framework for fusion would enable safe and effective deployment of this device. We believe that we are in support of the NRC Staff's examination of this issue.

It's time to start learning about this, it's such a complicated field. We provided some analyses and we call them out in our letter but I'll point in particular to a March 2022 presentation.

We cite some of the slides in the letter that talk about the results, and also a letter that we provided in August of 2022, which does direct one-to-one comparison of fusion devices and particle accelerators from a legal but also a technical perspective.

Our perception, and this is how we think about it, the picture behind me is a picture of our Operating 6 generation research device.

When we think about how our plasma accelerator, that's the definition of the device and our technology, when we think about how our plasma accelerator is regulated from a safety perspective, how we think about safety from ourselves, we look at DOE guidance on accelerators, we talk to people that work on developing accelerators and find that our stories and our issues are largely aligned.

Certainly, there are things that as fusion develops will be unique to this technology but we believe that fundamentally, the types of risks involved with fusion devices stem from a particle accelerator approach and other industrial facilities.

So, it makes sense to use that as a foundation going forward for a framework, and as fusion evolves we can evolve with it.

I'll just note that you might find this of interest as well, we explored in a June 2022 presentation the materials framework a little more closely. We've had a chance to dive into it, 30 but as well as the other parts, 32, 36 in particular, 37.

The materials framework is capability of handling a fair amount of diversity. Back when I used to work, I worked with a number of Part 30 licensees before moving to Helium.

We had licensees that had millions of curies of radioactive material, particularly the panoramic irradiator example, but others as well.

A number of licensees in the medical space, I would look to Part 35 for example in the medical use space, and some of the manufacturers that deal with unsealed sources.

Large medical psychotrons that produce byproduct material for medical applications deal with very complicated safety issues and we work very closely with agreement state regulators, or in many cases they're directly regulated by the NRC.

Those are excellent examples.

The one thing we try to do that this Committee may find of interest is in our June presentation, Slides 16 to 30, is we took a look, we recognized there's a number of things that would want to be examined from a health and safety aspect, whether it be NRC or agreement state oversight.

And we listed them down and we said this is our starting point of a list of things we might want to look at. We talked about shielding, operator requirements, shutdown, decommissioning, financial assurance, emergency planning.

And we started to list some of the rules in Part 30 or the Part 30 chapter that could be applicable. We found that Part 36 had a number of really interesting requirements too.

There they talked about construction issues, they talked about shielding regulations and there was a lot there that as a starting point seemed applicable. And then you can take from Part 35.

Part 35 for medical use actually is really interesting because they have examples of subparts scales horizontally of different types of technologies and how there are aspects of Part 37 that then scale vertically in terms of the risks and the requirements going up with different risk levels.

So, there's a lot there that I think could be very interesting and if you're curious about how you could take the tools that exist in the broader Part 30 framework and apply them to fusion as a starting point for the devices anticipated in the future, that may be helpful.

But also, the last thing I want to add is there's a lot of really interesting questions that are coming up and we want to serve as a resource. We would be happy to come and answer your questions about our technology.

One thing we are doing based on feedback from working with federal and state stakeholders including state regulators is we're going to try to provide webinars and trainings about some of the issues involved in fusion, neutrons, tritium, things like that.

Those trainings will be made publicly available over time but if there's questions, if you have questions about how the technology and our approach has been a safety case, we'd be happy to address them potentially by a presentation about what we do in these areas.

We wanted to call out some things in the letter that may be helpful to you but also just again reiterate that we want to serve as a resource. This is a complicated area, we're learning it as you are.

We have some pretty ambitious goals we seek to demonstrate in electricity from fusion in 2024 and put a device on the grid by the early 2030s if not sooner.

But there's a lot to do here and there's a lot to learn and we are happy to share that information with the Committee as well as the NRC Staff and any other stakeholders.

Thank you, I hope I didn't go too long on a Friday but thank you very much for your time.

CHAIR PETTI: Thank you. Any other members from the public have a comment, please identify yourself and make your comment. Okay, I'm not hearing any. It is late on a Friday and I certainly don't want to hold the Staff.

I just would say when we talk about this in our October full Committee, we certainly don't need all these slides again. You can give a more concise presentation since you've got everybody but one member of the Committee here now.

So, does any Member of the Committee have any final comments before we close, or any questions from the Staff on the full Committee presentation before we break for the day?

MEMBER REMPE: Real quick, will the Staff have a slide talking about their planned path forward for the full Committee meeting?

MR. PROFFITT: Do you mean a recommended option, Joy?

MEMBER REMPE: You verbally told us, this is what we're thinking about. Are you planning to have a slide that documents this or are you probably just going to stay where you are because it's just a white paper?

MR. PROFFITT: Yes, I'm not 100 sure on that. I don't want to commit to it but we'll certainly discuss it.

MEMBER REMPE: Okay, thanks.

CHAIR PETTI: Any other questions slash comments? Okay, given the late hour let's adjourn the meeting and we'll see everybody at October full Committee weekend. Thank you all, have a good weekend.

(Whereupon, the above-entitled matter went off the record at 5:01 p.m.)

Advisory Committee on Reactor Safeguards

Regulatory Policies and Practices Subcommittee

Licensing and Regulating Fusion Energy Systems

September 23, 2022

United States Nuclear Regulatory Commission

Protecting People and the Environment

Agenda

- Background
  - Commission and Congressional direction
  - Stakeholder engagement
- Fusion Technologies
  - Overview of concepts under development
  - Potential hazards
- Regulatory Framework
  - Legal assessment
  - Current treatment of research and development
  - Options for Commission consideration
- Path Forward

Background

- SRM-SECY-09-0064
  - Commission affirmed NRC jurisdiction over commercial fusion energy devices "whenever such devices are of significance to the common defense and security, or could affect the health and safety of the public"
  - Directed the staff to wait until commercial deployment of fusion technology was more predictable before expending significant resources to develop a regulatory framework

- Nuclear Energy Innovation and Modernization Act (NEIMA) - January 2019
  - Directs NRC to complete a rulemaking to establish a technology-inclusive, regulatory framework for commercial advanced nuclear reactors no later than December 2027
    - "advanced nuclear reactor" defined as including both fission and fusion

- SRM-SECY-20-0032
  - Commission directed the staff to develop options for their consideration on licensing and regulating fusion energy systems

Stakeholder Engagement

U.S. DEPARTMENT OF ENERGY

Commonwealth Fusion Systems

EPRI

HELION

FUSION INDUSTRY ASSOCIATION

UK Atomic Energy Authority

IAEA International Atomic Energy Agency

OAS Organization of Agreement States

Union of Concerned Scientists

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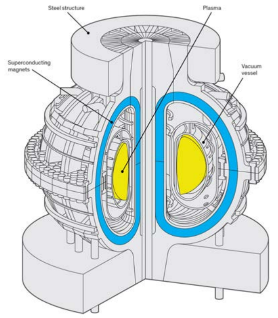
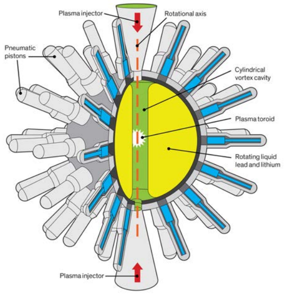
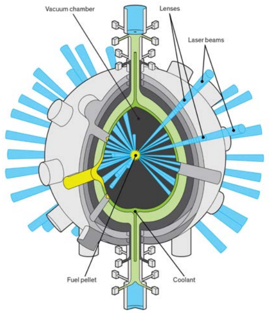
Fusion Technology: Concepts Under Development



Confinement Approaches

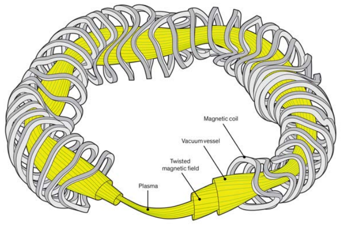
- Magnetic
- Magneto-Inertial
- Inertial

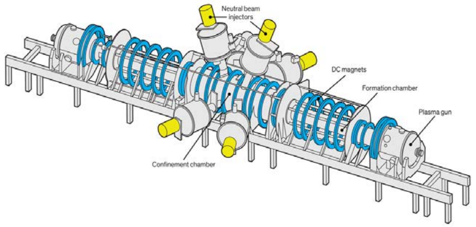




Fusion Reactions

- DT
- $P^{11}B$
- $D^{3}He$





Fusion Technology: Potential Hazards

- No special nuclear material; no chain reaction
- Hazards driven by inventory of radioactive materials on site
  - Tritium and activated material
  - Effluent and accident releases
  - Radiation produced during operations
  - Waste management
- Non-radiological hazards – design specific
  - High magnetic fields
  - Thermal shock from plasma disruptions
  - Thermal energy causing leaks
  - Hydrogen or dust explosions
  - Cryogenic releases
  - High-power lasers

Legal Assessment: Utilization Facility

- Section 11cc. of the AEA defines utilization facility:

  "(1) any equipment or device, except an atomic weapon, determined by rule of the Commission to be capable of making use of special nuclear material in such quantity as to be of significance to the common defense and security, or in such manner as to affect the health and safety of the public, or peculiarly adapted for making use of atomic energy in such quantity as to be of significance to the common defense and security, or in such manner as to affect the health and safety of the public; or (2) any important component part especially designed for such equipment or device as determined by the Commission."

- NRC regulations defining utilization facility in 10 CFR 50.2 do not include fusion:

  (1) Any nuclear reactor other than one designed or used primarily for the formation of plutonium or U–233

    - *Nuclear reactor means an apparatus, other than an atomic weapon, designed or used to sustain nuclear fission in a self-supporting chain reaction.*

  (2) An accelerator-driven subcritical operating assembly used for the irradiation of materials containing special nuclear material and described in the application assigned docket number 50–608

Legal Assessment: Particle Accelerator
(Byproduct Material)

- 10 CFR 30.4 states:

  Particle accelerator means any machine capable of accelerating electrons, protons, deuterons, or other charged particles in a vacuum and of discharging the resultant particulate or other radiation into a medium at energies usually in excess of 1 megaelectron volt. For purposes of this definition, accelerator is an equivalent term.

- 72 FR 55868 states:

  A particle accelerator is a device that imparts kinetic energy to subatomic particles by increasing their speed through electromagnetic interactions. Particle accelerators are used to produce radioactive material by directing a beam of high-speed particles at a target composed of a specifically selected element, which is usually not radioactive.

- Section 11e(3)(B) of the Atomic Energy Act (AEA) defines byproduct material as follows:

  e. The term "byproduct material" means–

  ****

  (B) any material that–

  (i) has been made radioactive by use of a particle accelerator; and

  (ii) is produced, extracted, or converted after extraction, before, on, or after the date of enactment of this paragraph for use for a commercial, medical, or research activity;

  ****

Current Regulatory Treatment of Fusion R&D

- U.S. Department of Energy facilities
  - Lawrence Livermore
  - Princeton
- Agreement States under Part 30 compatible regulations and State Radiation Control Requirements for particle accelerators and lasers
  - Academic institutions – New York and California
  - Commercial – Washington and Wisconsin
  - Pre-application – Massachusetts
- Agreement State licensing of fusion R&D have issued limited exemptions under current framework
  - Tritium accountability
  - Waste management
- The current regulatory scope of Part 30 may not cover all future fusion energy systems
  - Designs that use aneutronic or low neutronicity reactions

Option 1: Treatment as Utilization Facility

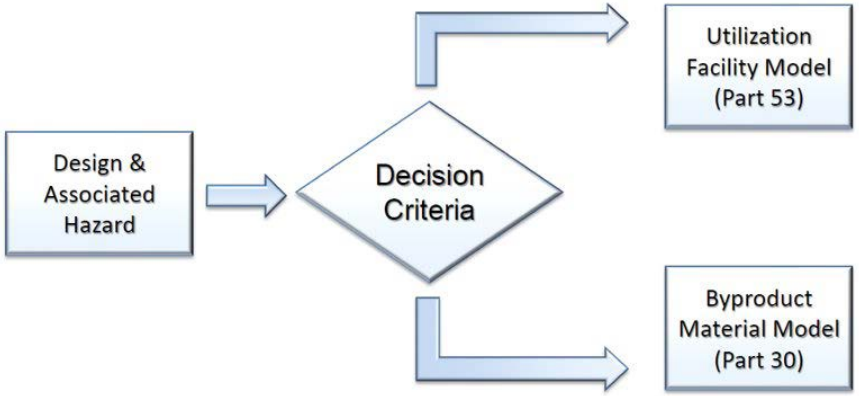
- Regulate fusion under the utilization facility framework (i.e., Part 53)
  - Rulemaking to add fusion energy systems to the definition of utilization facility in 10 CFR 50.2
- Potential hazards of current fusion energy systems are different than typical utilization facilities and more akin to byproduct material facilities
- Atomic Energy Act (AEA) has additional requirements for utilization facilities including:
  - Financial protection (Price-Anderson)
  - Restrictions on foreign ownership
  - Mandatory hearings, etc.
- Near-term licensing would likely require significant exemptions to appropriately regulate based on hazard levels

Option 2: Regulate Under Byproduct Material Framework

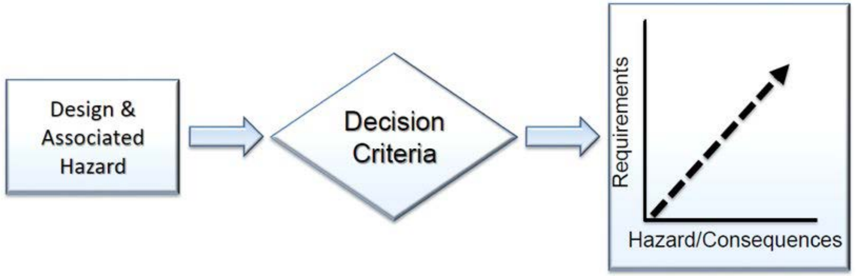
- Regulate fusion energy systems under byproduct material regulatory framework (Part 30)
- Current framework can accommodate 'near-term' commercial fusion energy systems
  - Devices that can legally be included under the definition of particle accelerators
- Rulemaking to add technology-inclusive definition of commercial fusion energy systems to scope of Part 30
  - Adds regulatory predictability for industry and clarity for public stakeholders
  - Reduces potential for exemptions to appropriately regulate
  - Guidance will be developed in parallel with rulemaking
- No rulemaking option:
  - Less regulatory predictability than rulemaking option and potential for less consistency in implementation by Agreement States for licensing and oversight of radioactive material
  - May not apply to some inertial fusion energy systems that cannot be reasonably defined as particle accelerators

Option 3: Hybrid Approach

- Intended to address the differences in potential radiological hazards associated with a variety of fusion technologies and designs
  - Bifurcated approach: A bifurcated framework that would distinguish between different commercial fusion energy systems, addressing some using a utilization facility model and others using a byproduct material model.



  - Consolidated approach: A new single, graded framework that would address any commercial fusion energy system. Distinctions between regulatory requirements, based on hazards for different technologies would be located within the same part of NRC regulations.



Stakeholder Feedback

- Majority of feedback is supportive of the byproduct material approach to regulating fusion energy systems
  - National Academies of Sciences, Engineering, and Medicine
  - Agreement States
  - Commercial developers
  - International partners
- Utilization facility approach viewed as not aligned with the risks presented by fusion facilities and introducing regulatory uncertainty for nascent industry
  - Starting from a framework developed for fission-based systems
  - Limitations on ownership and investment
- Limited feedback
  - NRC should do nothing as commercial fusion industry is still too far away
  - Any framework other than NRC's utilization facility approach is inappropriate

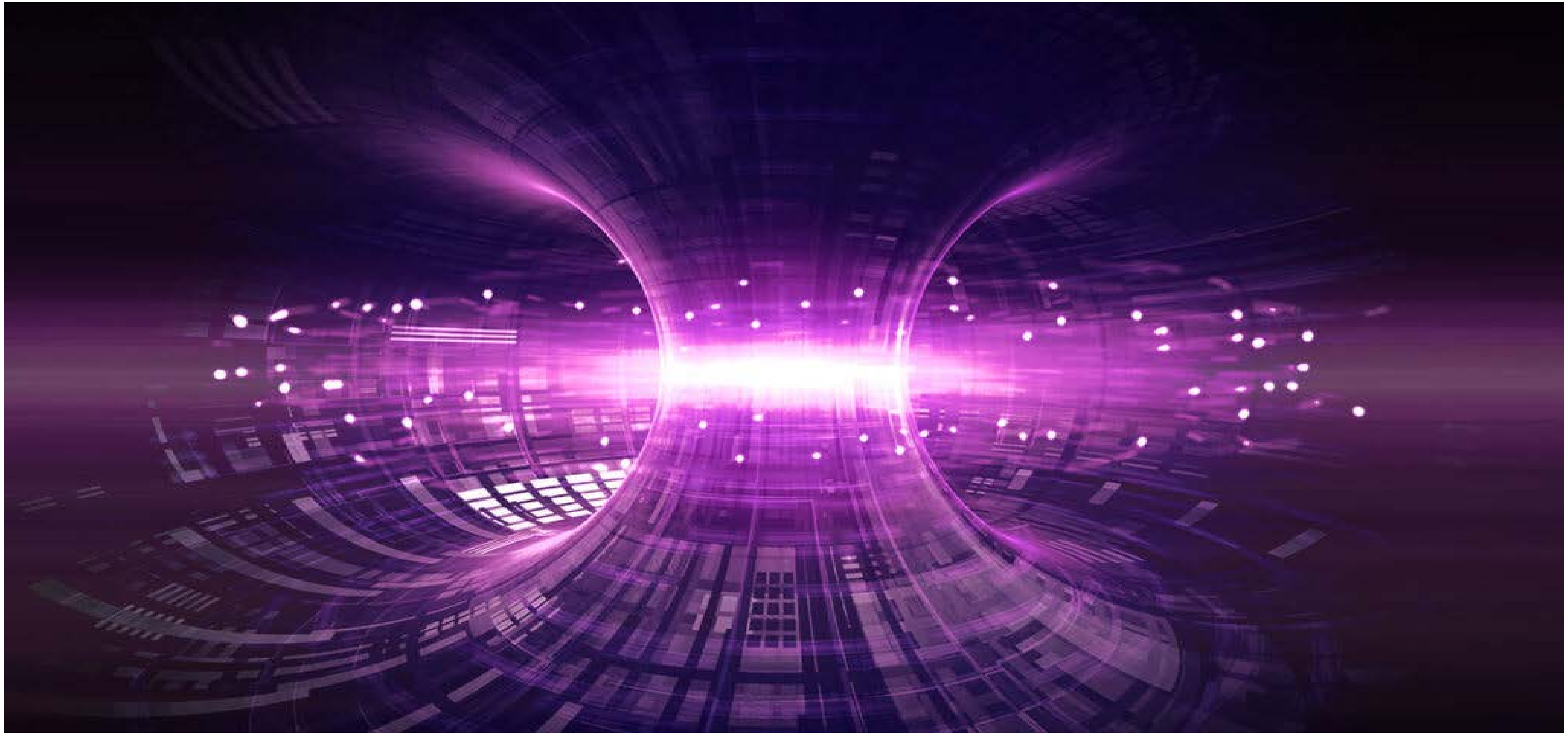
Path Forward

- NRC will fulfill its mission of protecting public health and safety through regulatory oversight of commercial fusion energy systems
  - Design and hazard analysis will determine the scope of requirements needed to support a license for the safe use of radioactive materials
  - Regardless of the regulatory approach, similar information will be needed to evaluate the design and radiological hazards associated with a fusion energy facility

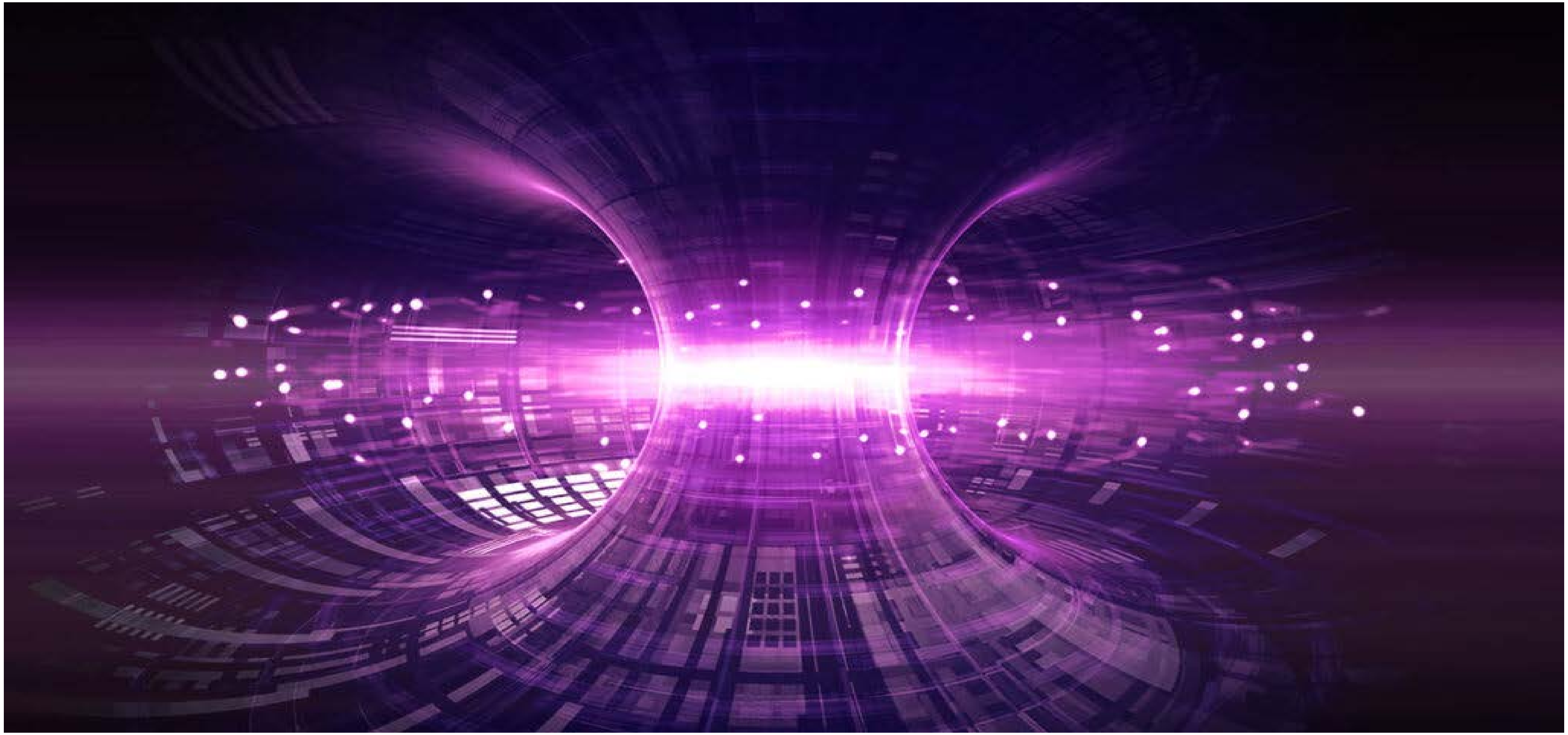
- Commission will direct the staff to implement the appropriate regulatory framework for fusion energy systems
  - Staff will continue stakeholder engagement
  - Rulemaking and/or guidance will be completed by the end of 2027 (NEIMA deadline)

- Next steps
  - Staff to deliver options SECY to Commission in late October 2022
  - Commission meeting on fusion energy systems scheduled for Tuesday, November 8, 2022

Discussion



Back-up Slides



Agreement State Program

- Section 274 of Atomic Energy Act
  - Established federal/state roles
  - Recognized States' experience
  - Promotes cooperative relationship
  - Promotes orderly regulatory pattern
  - Established in 1959
- First Agreement State in 1962
- Currently 39 Agreement States
  - Agreement States regulate 88% of materials licensees
- All programs periodically reviewed to ensure adequate to protect public health and safety and compatible with NRC requirements

Specific License Requirements for Part 30

- Radionuclides (maximum possession limits)
  - Tritium
  - Activation Products
- Emergency plans
- Financial Assurance and Decommissioning
- Training
  - Operator training
  - RSO qualifications
- Facility design requirements – construction, acceptance testing, codes and standards, facility modifications, equipment qualification

Specific License Requirements for Part 30 (2)

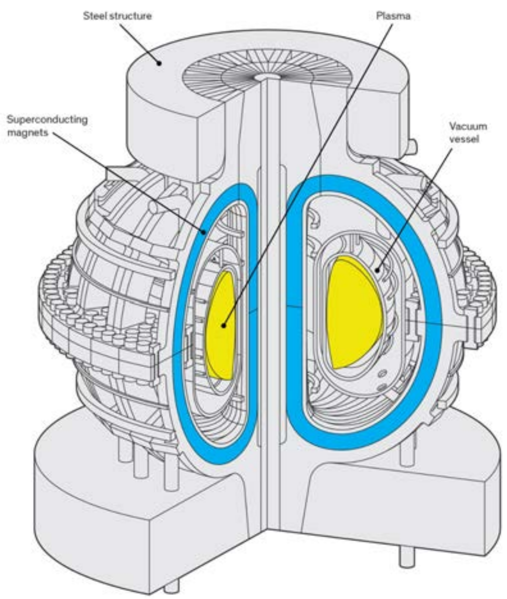
- Radiation Safety Program
  - Personnel monitoring
  - Radiation monitoring
    - Routine surveys
    - Contamination control
    - Effluent and Environmental Monitoring
  - Operating and Emergency Procedures
    - Procedures for safe use of radionuclides
    - Security of materials
    - Inspection and Maintenance
    - Equipment Testing Requirements
    - Attendance during operation
    - Reporting Requirements
  - Routine Audits

Specific License Requirements for Part 30 (3)

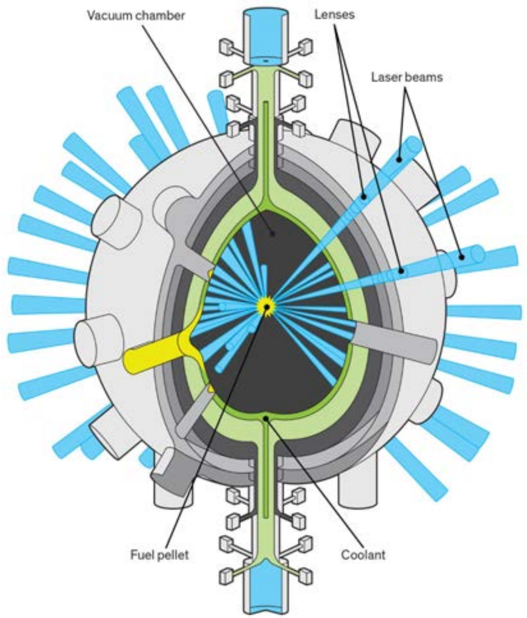
- Waste management
- Environmental protection regulations – Part 51
- Other Hazards – e.g., ozone, chemicals, lasers

Fusion Technologies

Magnetic Confinement Fusion

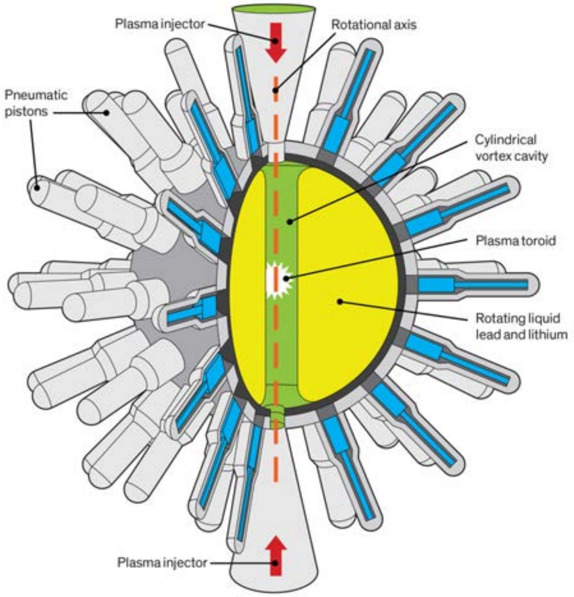


Inertial Confinement Fusion

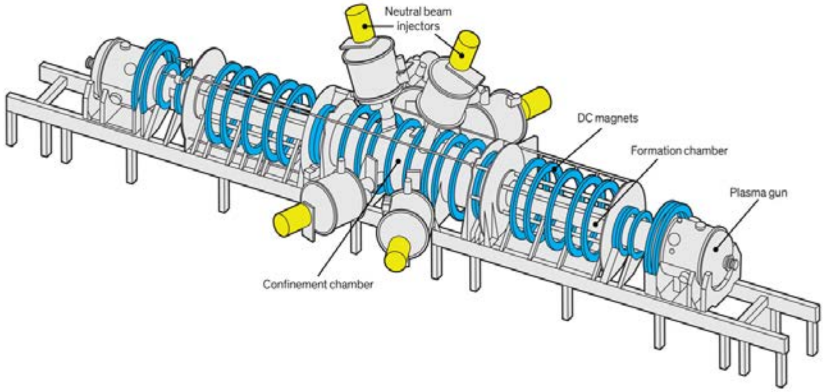


Fusion Technologies

Magnetized Target Fusion



Field Reversed Configuration



U.S.NRC
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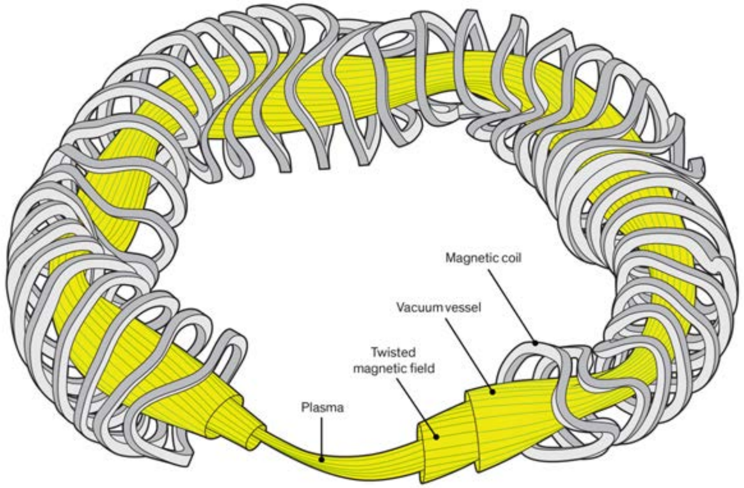
Protecting People and the Environment

Fusion Technologies

Stellarator



There are three general approaches to fusion energy

Magnetic Fusion Energy (MFE)

Low n
High τ_E

Magneto-Inertial Fusion (MIF)

Medium n
Medium τ_E

Inertial Fusion Energy (IFE)

High n
Low τ_E

September 16, 2022

Joy Rempe
Chairman
Advisory Committee on Reactor Safeguards
U.S. Nuclear Regulatory Commission

SUBJECT: Comments in Advance of ACRS Meetings on Fusion

Dr. Rempe,

Helion Energy, Inc. ("Helion") recognizes and appreciates the dedicated work undertaken by the Advisory Committee on Reactor Safeguards ("ACRS") to advise the U.S. Nuclear Regulatory Commission ("NRC") on important matters of public health and safety.

We understand that the ACRS is holding meetings in September and October on the regulation of commercial fusion energy devices. We offer the below limited comments in advance of these meetings to aid the ACRS's evaluation. These comments (I) further describe of the diversity of the commercial fusion energy industry; and (II) summarize certain previously submitted analyses by Helion on fusion's safety case, including as compared to particle accelerators and other industrial uses of radioactive materials. They are intended to build on and align with the NRC staff's analysis of commercial fusion in its draft white paper "Licensing and Regulating Fusion Energy Systems."[1]

We hope to serve as a resource to ACRS as it evaluates this exciting field and would be happy to support a direct briefing or answer questions as helpful.

I. The Diversity of Approaches in Commercial Fusion

A. Commercial Fusion is a Diverse Industry, Distinct from ITER-Style Approaches

There are currently over two dozen private-sector companies pursuing commercial fusion. Each is pursuing a distinct approach to fusion, with innovations that amplify fusion's already strong inherent safety case. Appendix A provides a broad outline of this diversity in the fusion community.

[1] White Paper - Licensing and Regulating Fusion Energy Systems (Draft, Sept. 13, 2022) ("Draft White Paper").

Importantly, these private sector approaches differ substantially from large-scale public fusion research projects such as the ITER project in Cadarache, France. Such research projects may have understandably been used in the past as archetypes for commercial fusion devices, and the ACRS appears to have looked to ITER in its 2020 analysis.[2] But the approaches being pursued by the private sector today stand in stark contrast. A look at a sample of five private fusion companies in North America that have each raised over $200M (Helion, along with Commonwealth Fusion Systems, General Fusion, TAE Technologies, and Zap Energy) immediately highlights many distinctions between these approaches and ITER.[3]

Figure 1: Example Differences in Private Sector Approaches Compared to ITER
(Sample: Five Private Fusion Companies in North America that Have Raised > $200M)

Diversity in Confinement	• Four of the five approaches do *not* use tokamaks (and the other uses a high-field, compact approach).
Diversity in Fuel	• One of the five approaches uses D-^{3}He fuel; and another p-^{11}B fuel.[4] Those approaches that use D-T fuel take advantage of newer methods to breed tritium than associated with ITER.
Low Inventories	• Tritium inventories are expected to be much lower than the kilogram quantities associated with ITER.[5]
Small Scale	• All private sector approaches are anticipated to require much smaller site footprints than ITER.[6]

ITER represents an incredibly safe approach to electricity generation that takes advantage of fusion's inherent safety benefits.[7] However, ACRS is encouraged to evaluate the *even stronger* safety cases supported by the diverse private sector approaches being pursued.

B. Helion is an Example of the Success of Diverse Approaches

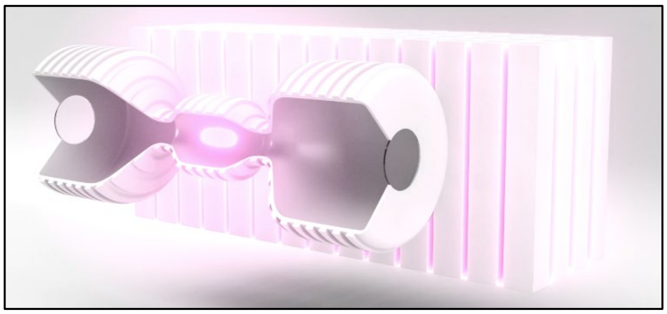
Helion's *Plasma Accelerator* technology enables pulsed, non-ignition fusion and direct capture of fusion energy, resulting in small, efficient, fusion energy devices with no need for a steam cycle balance of plant. We intend to use deuterium and helium-3 fuel, which substantially reduces the

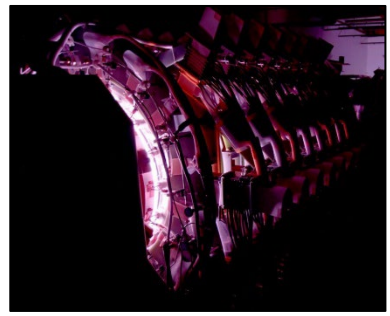
[2] *See* ACRS Letter to Chairman Kristine Svinicki, Re: 10 CFR Part 53 Licensing and Regulation of Advanced Nuclear Reactors, at 3 (Oct. 21, 2020).
[3] Fusion Industry Association, The Global Fusion Industry in 2022 Survey, at 6 (listing the five companies in North America with over $200M in private sector funding). In this letter, following Helion, the other companies are listed in alphabetical order. Any information provided concerning companies other than Helion is based on Helion's understanding after review of publicly available sources.
[4] D-^{3}He fusion results in much fewer, and lower-energy (2.45 MeV) incidental neutron emissions (produced via D-D side reactions) with lower activation impacts; p-^{11}B fusion offers even lower incidental neutron emissions.
[5] *See* I.R. Cristescu *et al.,* IAEA Nuclear Fusion Journal, *Tritium Inventories and Tritium Safety Design Principles for the Fuel Cycle of ITER* (June 25, 2007). One reason ITER is anticipated to have kilograms of tritium on site is because it does not intend to breed tritium in substantial quantities, and thus would need to store tritium. A commercial D-T fusion device would instead actively breed tritium during operation, which would keep overall tritium inventories lower. General Fusion has estimated that its commercial fusion power plant will have 2-4 grams of tritium in total inventory at any time, and Commonwealth Fusion Systems has estimated 50-90 grams. *See Updates on Plans for Fusion Demonstration Plant in the UK* (Oct. 21, 2021) (slide 27, pdf page 29); Commonwealth Fusion Systems, *Fusion Attributes in the Private Industry Context* (Mar. 30, 2021) (slide 6, pdf page 81) (ARC fusion device).
[6] For example, Helion expects that a 50 MWe Helion generator and related power electronics would be able to fit within a small set of shipping containers, and thus when deployed occupy a far smaller site footprint compared to ITER.
[7] Although the private sector approaches differ from ITER's, ITER is still fundamentally different from a fission reactor because it cannot sustain a chain reaction, a defining facet of fission reactors. Moreover, ITER (along with private sector designs) does not need active cooling upon shutdown. ITER Website, *Frequently Asked Questions, Could a Fukushima-type Catastrophe Occur at ITER?*

already-low radiological impacts associated with fusion. An overview of our approach is provided in our March 2022 NRC public meeting presentation,[8] and on our website.[9]

Helion has built and operated six prototypes since 2008, which have demonstrated the viability of our approach. Our most recent 6th-generation prototype, called "Trenta," was the first private-sector fusion device to reach fusion-relevant plasma temperatures of 100 million degrees (and did so on a reproducible basis as part of a 16-month, 10,000-pulse campaign).[10] Our accomplishments have been audited by a former technical leader at Sandia National Laboratories, and we have presented our results at multiple technical conferences.[11]

Figure 2: Images of Helion's Fusion Devices





(Left: An artist's conception of a commercial Helion fusion device. Right: An angled view of one of Trenta's plasma formation sections; the fuchsia color seen in this right photo comes from plasma ionization (Balmer Series spectra).)

Following Trenta's successful operating campaign, we raised $500 million in 2021, fully funding our efforts through commercialization. Our focus is now on development of our 7th-generation prototype, called "Polaris." We intend to demonstrate *net electricity* from fusion with Polaris in 2024. Thereafter, we plan to start working towards deployment of the world's first commercial fusion power plant, with a capacity of 50 MWe.

Our 6th generation prototype Trenta is licensed by the Washington Department of Health under its particle accelerator framework. Licensing for the 7th-generation Polaris device is ongoing in close cooperation with the state regulator, and we have recently obtained the x-ray/particle accelerator registration for the first phase of Polaris operations.

II. Commercial Fusion's Safety Case

Helion believes that applying an appropriate and risk-informed regulatory framework for commercial fusion can enable the timely deployment of this technology, as well as build public trust and acceptance. We applaud the NRC staff on its thorough regulatory evaluation of fusion technologies, spanning two years and multiple public meetings to solicit stakeholder input. Its

[8] Helion Energy, *Supplemental Safety Case Analysis* (Mar. 23, 2022) (slide 108).
[9] www.helionenergy.com. We also have a video available online that describes our approach in more detail.
[10] World Nuclear News, *Helion Passes 100 Million Degrees Celsius* (June 23, 2021).
[11] *See, e.g.,* D. Kirtley *et al.*, 2021 IEEE Symposium on Fusion Engineering, *Helion Presentation on Vacuum Vessel and Diverter Design and Results of 16-Month Operation of the Trenta Magneto-Inertial Fusion Prototype* (Dec. 17, 2021); D. Kirtley *et al.*, 60th Annual Meeting of the APS Division of Plasma Physics, *Overview of Staged Magnetic Compression of FRC Targets* (Nov. 5, 2018); J. Slough *et al.*, IAEA Nuclear Fusion Journal, *Creation of a High-temperature Plasma Through Merging and Compression of Supersonic Field Reversed Configuration Plasmoids* (Apr. 13, 2011). Additional papers, presentations, and patents/patent applications describing our technology are listed on our website or available upon request.

Draft White Paper reflects a thoughtful and well-reasoned first-principles analysis of fusion's safety case and regulatory options, after taking in copious information from public and private sector sources.

Following this extensive process, the NRC staff found that the risks of fusion energy "appear lower than typical utilization facilities and more similar to byproduct material facilities."[12] This is not a conclusion that fusion is zero-risk, but an acknowledgement that risk-informed regulation of commercial fusion is possible—and perhaps more appropriate—under a byproduct materials approach compared to a utilization facility approach. Helion concurs with the NRC staff's determination that "[t]he Part 30 approach provides a scalable and technology neutral basis for the licensing and oversight of the wide range of fusion energy systems currently under development."[13]

To aid the ACRS in its own review, we summarize below certain analyses previously shared with the NRC—using Helion as an example—that speak to the close alignment of fusion's safety case with particle accelerators and industrial facilities over fission reactors.

A. March 2022 Analysis – Commercial Fusion Impacts are Distinct from Fission

In March 2022, Helion presented directly on the anticipated impacts of its planned commercial 50 MWe fusion devices.[14] We shared the following findings for example:

- **No need for post-shutdown cooling (slide 116).** We estimated that the approximate device temperature increase upon shutdown would be less than 20 °C in room air conditions, and radiation from activation products would decay sufficiently to permit entry into the Plasma Accelerator main room within a few days after shutdown.

- **Minimal impacts in accident scenario (slide 119).** We estimated that even in hypothetical, extreme bounding scenarios (e.g., the whole vacuum vessel is turned into dust, freely released into the air), the estimated maximum dose to the public or workers would be just 11.3 mrem, 1/9th of the annual public dose limit.

These strong results in the case of Helion are driven in part by the lower materials inventory and neutron emissions associated with the Helion's approach. As discussed in the March presentation, Helion's device is anticipated to have only on the order of 0.015 mg of tritium within the fusion medium at any time, generated as products of each fusion pulse that are subsequently exhausted (slide 110).[15] Cleanout of the vacuum vessel through a gas puff, glow discharge, or similar mechanism can be performed between fusion pulses to keep tritium adsorption on the vessel surface limited. Furthermore, neutron output in the case of Helion's 50 MWe device is anticipated to be on the scale of 10^{18} n/s, orders of magnitude lower than what is anticipated for ITER (up to ~10^{21} n/s).[16] Neutrons emitted by the Helion device are 2.45 MeV; this energy is below the activation thresholds for many materials, resulting in a limited activation profile

[12] Draft White Paper at 7.
[13] Draft White Paper at 8.
[14] *Supra* note 8.
[15] Tritium and helium-3 are both produced as a result of D-D side reactions that occur during the D-^{3}He fusion pulse.
[16] ITER Newsline, *Counting Neutrons to Measure Fusion Power* (June 13, 2016).

compared to higher energy neutrons. The Helion approach is but one of many innovative avenues being pursued across the private sector that enhance fusion's already strong inherent safety case.

B. August 2022 Letter – Commercial Fusion Impacts Align with Particle Accelerators

In a letter submitted to the NRC staff on August 12, 2022,[17] Helion outlined the safety considerations for commercial fusion devices and how they align with various particle accelerators in both operational and accident scenarios. In particular, we discussed how the *types* of risks associated with fusion devices are essentially the same as found in particle accelerators, indicating that the regulatory approaches to address those risks can also align (see pages 6-8 of the letter for further details).

Figure 3: Commercial Fusion Device Impacts
(Aligned with General Particle Accelerator Impacts)

Operational Impacts
(1) Neutron and Photon Radiation. Both fusion devices and other particle accelerators emit neutrons and/or photons as subatomic particles move within the device and upon particle collisions. The neutron emission rate may be greater in the case of fusion, but often at lower energy levels. **(2) Radioactive Material Input/Output.** Both fusion devices and other particle accelerators can require radioactive materials as input constituents or output radioactive materials, including tritium. The accelerator community, including operators of high-energy cyclotrons for medical isotope production, has significant experience handling intentional and incidentally produced radioactive material in relatable contexts. **(3) Incidental Activated Material.** Both fusion devices and other particle accelerators can irradiate shielding or other device components, activating the materials. Although potentially emitting more neutrons, the lower-energy 2.45 MeV neutrons anticipated from Helion's fusion approach for example activate fewer materials than the higher-energy neutrons from many particle accelerators (e.g., a cyclotron emitting 30-MeV neutrons that can cause spallation, therein producing tritium in the shielding, soil, and groundwater).
Accident Impacts
(1) Release of In-Device Material & Dust. Both fusion devices and other particle accelerators can have radioactive material within the device's operating medium or on the vacuum vessel surface that can be released in some fraction in an accident scenario. In the Helion example, the activated material and tritium if released are estimated to contribute to only a small percentage of annual background dose. **(2) Release of In-Process or Stored Generated Materials.** Both fusion devices and other particle accelerators have to manage the radioactive byproducts coming off the particle accelerator, such as medical radioisotopes or tritium. In the case of Helion, tritium will be independently stored after generation.
***Avoided* Impacts & Hazards**
(1) No Criticality. Neither fusion devices nor other particle accelerators can sustain a chain reaction. Both devices turn off on demand, and passively deactivate in the event of a material abnormality. **(2) Limited Inventory.** Both fusion devices and other particle accelerators have a low inventory of radioactive materials in the device at any time, whereas a fission reactor typically holds an entire uranium core (a year or more worth of fissionable material and fission products) in the reactor vessel.

[17] Helion Energy, *Classification of Fusion Devices as Particle Accelerators; and Supplementing Common Defense & Security Discussions* (Aug. 12, 2022).

C. June 2022 Analysis – Part 30 Tools Can Create a Foundation for Fusion Regulation

As stated above, Helion agrees that an appropriate and risk-informed regulatory framework for commercial fusion can enable and enhance deployment. To this end, in June 2022, Helion openly discussed example design and operational topics potentially warranting regulatory oversight—and explored how existing tools in 10 CFR Parts 30-39 could serve as a foundation to address them (see slides 16-30, pdf pages 59-73, in particular).[18] In line with Option 2 of the Draft White Paper, these tools could eventually be implemented through guidance and/or development of new, scalable regulations within the byproduct materials regulatory framework. We concur with the NRC staff that the facility approach to regulating panoramic irradiators in 10 CFR Part 36 can be explored as a model for future regulation of fusion devices.[19]

* * *

Thank you for your time in reviewing this letter. We hope that this additional information on the diverse fusion technologies being pursued and their safety case can aid the ACRS's analysis.

As the ACRS continues its review, we hope to serve as a resource to the committee. To this end, a member of the ACRS in a May 2021 meeting with the NRC staff suggested that "additional training and oral presentations of the different technologies" may prove useful.[20] Helion would be excited to support any such effort, including through a live briefing to the ACRS accompanied by a diverse set of fusion companies, or by answering additional questions by ACRS members.

Sachin Desai
General Counsel
Helion Energy, Inc.

Cc: Members, Advisory Committee on Reactor Safeguards

Scott Moore, U.S. Nuclear Regulatory Commission
Derek Widmayer, U.S. Nuclear Regulatory Commission
Andrew Proffitt, U.S. Nuclear Regulatory Commission

David Kirtley, Helion Energy, Inc.
Michael Hua, Helion Energy, Inc.
Scott Krisiloff, Helion Energy, Inc.

[18] Helion Presentation, *AEA Common Defense and Security and Application of Materials Framework Tools for Fusion* (June 7, 2022) (pdf pages 44-75).
[19] Draft White Paper at 6.
[20] Transcript of ACRS May 6, 2021 Meeting, at 77.

Appendix A – Diversity of Approaches to Commercial Fusion Energy[21]

[21] The Global Fusion Industry in 2022 Survey, at 7, 10.