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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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685TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY

MAY 6, 2021

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The Advisory Committee met via Videoconference, at 9:30 a.m. EDT, Matthew W. Sunseri, Chairman, presiding.

COMMITTEE MEMBERS:

MATTHEW W. SUNSERI, Chairman

VICKI BIER, Member

DENNIS BLEY, Member

CHARLES H. BROWN, JR. Member

VESNA B. DIMITRIJEVIC, Member

GREG HALNON, Member

WALTER L. KIRCHNER, Member

STEVE KRAFT, Public Participant

JOSE MARCH-LEUBA, Member

DAVID A. PETTI, Member

JOY L. REMPE, Vice Chairman

PETER RICCARDELLA, Member

DIEGO SAENZ, DHS

ACRS CONSULTANT:

MICHAEL CORRADINI

DESIGNATED FEDERAL OFFICIAL:

DEREK WIDMAYER

ALSO PRESENT:

CYRIL DRAFFIN, USNIC

SCOTT MOORE, Executive Director, ACRS

QUYNH NGUYEN, ACRS

DONALD PALMROSE, NMSS

WILLIAM RECKLEY, NRR

JOHN SEGALA, NRR

JOSEPH STAUDENMEIER, RES

MARTIN STUTZKE, NRR

NANETTE VALLIERE, NRR

DUNCAN WHITE, NMSS

P R O C E E D I N G S

9:30 a.m.

CHAIR SUNSERI: Good morning, everyone. The meeting will now come to order. This is the second day of the 685th meeting of the Advisory Committee on Reactor Safeguards. I'm Matthew Sunseri, the Chair of the ACRS. I'll now call roll to confirm a quorum and that clear communications exist.

Vicki Bier?

MEMBER BIER: Here.

CHAIR SUNSERI: Dennis Bley?

MEMBER BLEY: Here.

CHAIR SUNSERI: Charles Brown?

MEMBER BROWN: Here.

CHAIR SUNSERI: Vesna Dimitrijevic?

MEMBER DIMITRIJEVIC: Here.

CHAIR SUNSERI: Greg Halnon?

MEMBER HALNON: Here.

CHAIR SUNSERI: Walt Kirchner?

Walt Kirchner?

Jose March-Leuba?

MEMBER MARCH-LEUBA: Yes.

CHAIR SUNSERI: Dave Petti?

MEMBER PETTI: Here.

CHAIR SUNSERI: Joy Rempe?

MEMBER REMPE: Here.

CHAIR SUNSERI: Pete Riccardella?

MEMBER RICCARDELLA: I'm here.

CHAIR SUNSERI: All right. And myself. So we're just lacking Walt right now. I'm sure he'll join when he can.

The Designated Federal Officer for this meeting is Mr. Derek Widmayer. During today's part of the session, we will take up an information briefing on fusion that will end up sometime before lunch. So, in the time period between the end of that session and our lunch break, we will pick up work on the recommendations and conclusions for our interim letter report on Part 53.

We'll work on that until lunch, and then following the lunch break, we will take up the NuScale control room staffing letter report, and that should begin at 2:30 Eastern Time for those wanting to participate in that activity.

A phone bridge line has been opened to allow members of the public to listen in on the presentation and Committee discussions. We have received no written or oral comments or requests to make oral statements from members of the public regarding today's session. There will be an

opportunity for public comment. We have set aside time in the agenda for comments from members of the public who attend or are listening to our meeting. Written comments may be forwarded to Mr. Derek Widmayer, the Designated Federal Officer.

A transcript of the open portion of the meeting is being kept, and it is requested that the speakers identify themselves with sufficient clarity and volume so they may be readily heard. Additionally, participants should mute themselves when not speaking.

And as a follow-up to yesterday's opening remarks, you know that we have two new members of our Committee that have been appointed since the last full Committee meeting, Vicki Bier and Greg Halnon. Yesterday, we got a chance to introduce Greg, and this morning we're going to do the same for Vicki. I'm going to turn on my camera and make this a little bit more personal.

Dr. Vicki Bier is a professor emeritus in the Department of Industrial and Systems Engineering and the Department of Engineering Physics at the University of Wisconsin-Madison. Her areas of specialization include risk analysis, decision analysis, and operational research. She has more than

40 years of experience in risk analysis -- you must have started when you were five -- for the nuclear power, chemical, petrochemical, and aerospace industries, as well as homeland security and critical infrastructure protection.

Dr. Bier earned her bachelor's in mathematical scientist from Stanford University and a doctorate in operations research from the Massachusetts Institute of Technology.

Welcome, Vicki. We're looking forward to your engagement with the Committee, and if you have anything you would like to say.

MEMBER BIER: You know what? Thank you for the nice introduction, and I'm honored to be part of the Committee. I've admired the work of the Committee for, I mean, probably close to 40 years. So it's a dream to be able to contribute. Thank you.

CHAIR SUNSERI: Great. Well, thank you.

And so we can close these cameras now.

At this stage, I'll open the floor to members if you have any questions or comments before we start today's deliberations.

(Pause.)

CHAIR SUNSERI: All right. Well, we'll get into the first topic, then, which is the

information briefing on fusion, and I'll turn to Dr. Dave Petti to lead this session.

Dave?

MEMBER PETTI: Thanks, Matt. It looks like I might be having some internet issues. So if I drop off, just keep on going.

Bill, you're back. You've really a glutton for punishment here. Does your management want to say anything, or do you just want to start?

MR. RECKLEY: John Segala was going to provide a couple opening remarks.

MEMBER PETTI: Okay.

John?

MR. SEGALA: Okay. Thank you.

Good morning. I'm John Segala, the Chief of the Advanced Reactor Policy Branch in the Office of Nuclear Reactor Regulation.

In January of 2019, the Nuclear Energy Innovation and Modernization Act, or NEIMA, was signed into law and required NRC to complete a technology-inclusive, risk-informed, performance-based regulation for advanced reactors, which we're calling 10 CFR Part 53, as you all are aware.

NEIMA did define advanced nuclear reactor as a nuclear fission or fusion reactor. On April 13th

of 2020, the staff issued a rulemaking plan for 10 CFR Part 53 in SECY 20-0032. And on October 2nd, the Commission issued its staff requirements memorandum approving the staff's proposed approach for the rulemaking, and they directed the staff to develop a paper considering the appropriate treatment of fusion reactor designs in our regulatory structure by developing options for Commission consideration on licensing and regulating fusion energy systems. This paper is due by the end of 2022.

The NRC staff has been engaging with the Department of Energy, the fusion industry, and other stakeholders such as the joint DOE, NRC, and Fusion Industry Association public forum on October 6th of 2020 and the NRC public meetings on January 26th and March 30th of 2021, where the staff has begun seeking stakeholder feedback on possible approaches for licensing and regulation of commercial fusion facilities.

Today we plan to provide the full Committee an overview of the NRC staff's efforts to develop options for regulating fusion energy systems, as discussed in the NRC staff's draft white paper entitled Preliminary Options for Regulatory Framework for Fusion Energy Systems that was made public last

week. As we firm up the options, we plan to come back and brief the ACRS subcommittee and full committees.

We look forward to having discussions today and hearing the ACRS members' initial thoughts and feedback. Thank you.

Does it go over to you, Bill, now?

MR. RECKLEY: Yeah, I think so. Thank you, John.

This is Bill Reckley with the staff. So, as John mentioned, we are in the beginning stages of developing options. We have a working group with representatives from NRR, NMSS, Nuclear Material Safety and Safeguards, the Office of Regulatory Research, Office of General Counsel, and members from agreement states on our working group.

And what we're going to go over today is just some of our first thoughts on options that we might develop. And, as John mentioned, they would ultimately go into a Commission paper, and we would be back before -- our expectation is that we would be back before the ACRS appropriate subcommittees and then to the full Committee in regards to that options paper.

So, just as a little bit of background, back in 2009, the question was posed as to whether the

NRC would even be the regulatory Agency for fusion energy systems. And that resulted in that time frame in a paper, SECY 2009-64. And the staff prepared and provided, in that time, options for consideration, and they are listed here, which was primarily just to maintain the status quo and leave the questions unanswered or for the Commission to actually make a decision and affirmatively state that the NRC would have regulatory jurisdiction.

And down below the SRM, the Staff Requirements Memorandum, for that paper, the Commission did make a decision and assert that the NRC would have jurisdiction over commercial fusion energy devices, provided that those -- the deployment of such devices could affect the public health and safety of the public.

The other direction in that SRM back in 2009 was for the staff to basically stand by and wait for the technology to develop to the point where things were more predictable before we spent the resources to actually develop a regulatory framework.

So the staff between 2009 and the passage of NEIMA, which is on the next slide, slide 3, the passage of the Nuclear Energy Innovation and Modernization Act, ten years after that original paper

-- and as John mentioned, within the definition of advanced nuclear reactor, they included nuclear fission or nuclear fusion. And so, with the passage of NEIMA, we needed to start to think about that question again and what would be a regulatory framework for fusion.

So we prepared -- and John went over this. We prepared -- and we talked about it yesterday to some degree. We prepared a rulemaking plan primarily aimed at fission -- advanced fission reactors. And, again, that's the Part 53 effort. But we did address fusion within the rulemaking plan, and the SRM.

For SECY-2032, the rulemaking plan, the Commission gave us some direction on Part 53. And largely, that was related to the schedule. And then they also directed us to develop this options paper for consideration of licensing commercial fusion energy systems.

So, as soon as we got that, we began interactions with the Department of Energy Office of Science, Fusion Energy Sciences, to start the process of education for the staff, in large part, and then also to set up interactions with the community that up to this point we have had limited interactions with the fusion community.

So that kind of brings us up to our current activities. We are continuing our interactions with DOE, and they've been a great help to us in terms of both putting us in touch with stakeholders, providing education on both the technologies and on the safety analyses that have been performed to date. We are continuing interactions with stakeholders through, as John mentioned, a couple different public meetings that we've had.

As we talked about yesterday on Part 53 --

MEMBER BLEY: Bill?

MR. RECKLEY: Yes?

MEMBER BLEY: I wanted to put you on the spot, but I don't think I quite can. In the SRM, the Commission said you should wait until the commercial deployment of fusion is more predictable, but I guess NEIMA just kind of voids that thinking. NEIMA says do it now.

(Simultaneous speaking.)

MR. RECKLEY: Yes. And the schedule in NEIMA, as we maybe go into the last bullet on this slide -- the schedule in the legislation was to have the rule -- the framework done by rulemaking by 2027. The Commission's Staff Requirements Memorandum, or SRM, on our rulemaking plan said to have Part 53 --

set a goal to have Part 53 done by 2024.

In our response to the Commission's SRM, which was, going back a slide, the 30-day response in that memorandum that the staff sent back to the Commission, we did make an observation that one option would be to try to do Part 53 by 2024 but to acknowledge that fusion, no matter which option might be chosen, we could set out to complete by 2027. That would still meet the legislative date but would give us a little more time for the Commission both to give us directional options and then to develop the framework for fusion energy systems.

So, as we did mention yesterday --

(Simultaneous speaking.)

MR. RECKLEY: Yes? Please go ahead.

MR. CORRADINI: This is Mr. Corradini. I understand what you just said, but I'm not completely clear. So you're expecting to have a rulemaking completed on fusion by 2027, or it's just a list of options by 2027? That's what I didn't --

MR. RECKLEY: No, the rulemaking to address fusion would need to be done by 2027. The options paper that we're currently working on would -- we're setting out with a goal of having that done this year or early next year so that the Commission could

then make a decision, and we could incorporate that into our rulemaking activities to have it done by 2027.

MR. CORRADINI: Okay. Thank you for the clarification.

MR. RECKLEY: Okay.

So, as we develop Part 53, the third bullet on this slide -- as we develop Part 53 -- and as we mentioned yesterday, we are trying to keep Part 53 technology inclusive up to the point that if the Commission were to decide that the -- and we'll get into the options a little bit in a minute, but if the Commission were to decide to treat fusion facilities as utilization facilities, similar to fission power reactors, that we could come back in and make adjustments to Part 53 and not necessarily have to make major revisions to accommodate it.

And that's why we're up at basically a fairly high level in that rulemaking in terms of specific technical requirements. So that's one of the reasons. So what we're doing at the current time is starting to prepare for and put pen to paper on this Commission paper that would identify options for Commission consideration.

Again, DOE has been a great help to us in

that regard. So has the public meetings where individual developers have provided summaries of their designs and some of the safety considerations that they are putting into their design efforts.

The second bullet is pretty -- it's an important point here that this paper is looking at the longer-term commercial deployment of fusion energy systems. The ongoing research and development activities by private firms or others that fall under the NRC's jurisdiction we can handle on a case-by-case basis. And that is largely through the materials program because at this point in R&D, the amount of radioactive materials is manageable and the machines are running for short durations, so you're not getting large activations of structures.

You're not getting some of the other aspects of the longer-term commercial fusion program like tritium breeding and some of those things. So, at the present time, we're continuing, either the NRC or agreement states, to handle R&D facilities under the current program.

Yes, Mike?

MEMBER PETTI: Bill? Oh.

MR. RECKLEY: Dave?

MEMBER PETTI: Just a question if you've

thought about it. You know, there's the commercial I'm-going-to-produce-electricity mission. There's these really short pulse machines like you've been talking about that would be handled case by case. But there's a couple facilities in between there that -- this would be facilities to test blankets. Okay?

And there's lots of different options out there. And you'd need neutrons and you'd need a fair amount of tritium, but not run, you know, at higher variability like a power reactor, but still enough.

Where does that fit? I mean, that could also incite DOE, in which case, you know, you guys wouldn't have to be involved. But if someone decides commercially they want -- a private company wanted to do that, you know, could that fit in the continuum here of things we're talking about?

MR. RECKLEY: I think it could. And as we talk about our options for even the commercial facilities, I think you'll see that we have a lot of latitude in the materials program to accommodate something like that if it should be proposed.

But in addition to that, when I say on a case-by-case basis, I mean, we could bring in -- even if we treat it as materials licensee, bring in a lot of different requirements to address the potential

hazards. And in a -- wouldn't even rule out that we'd have the capability at that time, even for that -- well, I'll leave it there.

The case-by-case basis is kind of how we would address that. And we would have all the options the Agency has to address if that kind of a proposal was brought forth. But --

MR. CORRADINI: Bill, just to follow on Dave's point -- but he probably knows. I'm not clear. Is there a clear demarcation in terms of inventory of various radioactive species that would cross over between a case-by-case review for a facility, or is it the time of operation or some combination of those that would be the point where you would go away from case-by-case to this new process?

MR. RECKLEY: My short answer will be we would go -- we would only be able to go beyond a case-by-case assessment once we get this rule in place. Up until that time, we would have to address any -- or we'd have to assess any particular activity on a case-by-case basis with the default being we would handle them under the materials program.

MR. CORRADINI: So, just to follow that up, then, what things are on the horizon between now and 2027 that you would probably have to handle case-

by-case?

MR. RECKLEY: All we're aware of at this point is further progress on the actual machines that are looking to advance the plasma side. So individual developers, individual companies, are proposing to build new test facilities of various -- we'll get into the technologies, but of either the tokamak or TURis designs, and other companies are looking at other potential fusion designs. But they're still looking primarily on the reaction side, the plasma side.

MR. CORRADINI: Okay. Thank you.

MEMBER PETTI: But I think that, you know, that makes sense at this point. Just, again, depending on how long your horizon is to think about these things, I think there are some criteria that could be established for when you get to a point where you really have significant hazards that are characteristics of facilities that you could put down so that people would know, here's an off-ramp.

You know, you exceed these -- it's a combination, in my opinion, of inventory and characteristics of the plasma that lead to activation that you could say, okay, you're here. You're going to go in this direction. If not, you're going to go in a different direction.

I think you could kind of paint that road, if you will, with criteria. I think it's doable.

MR. RECKLEY: And we'll actually get into that discussion in terms of what we're considering or what we propose to give to the Commission as options. Well, what you just described there is our third option, a combination approach.

So we are looking -- the third bullet here -- at the fusion technologies. I won't even pretend to be able to describe the science. So we have Joe Staudenmeier from our Office of Research, and he had some experience. And Don Palmrose in NMSS had some experience.

So, for now, we have a few staff who have some expertise, and then we're also, again, interfacing with the Department of Energy, including their Fusion Safety Program at Idaho, to help us in this effort.

I mentioned we're coordinating with agreement states, and they're actually participating in our working group. And we're assessing and developing options, and we'll get into that in the next few slides.

I did want to mention that one of the challenges is the diversity of designs and hazards.

And much of the literature has focused on the magnetic confinement, the tokamak designs that have been under development both within the United States and Europe, and now the big project to build such a facility, the ITER facility in France.

So, although that's been much of the focus, there are also other proposals that the companies and the Department of Energy has looked at, including inertial, such as the National Ignition Facility, and magneto-inertial, which is a combination of the two. And an example of that is perhaps the general fusion design.

The diversity even extends to, what are the reactions involved? Most of the discussion is deuterium and tritium, the DT reaction. But there are also proposals for the proton and boron-11 or deuterium and helium-3. So those things are under development, and the different designs have been a variety in terms of the radiological hazards, the chemical hazards, and other hazards associated with the facility.

So one of the decisions as we developed the options was and remains, do we try to make it broad enough -- technology inclusive of all the fusion technologies? Or do we focus, for example, on the

magnetic or tokomak-type designs? At this point, our plan is to try to be technology inclusive and develop a program that could handle any of these technologies should they develop.

So one of the questions I guess I'll leave with the Committee is, as I go through the rest of the slides, I'm not providing much discussion on the technologies or the associated safety analyses. And we could do that -- we might get the help of DOE and maybe Idaho to help us with that.

But before we come with the options paper or at the same time we come to the subcommittee -- again, the kind of question I'll leave is, if you want briefings on the technologies, what to consider in the safety assessments, we can help arrange that. But you're not going to hear very much of that today.

So I'll leave that just as something for you to ponder as you go through the planning process. And when we give you a schedule for the paper, which would likely be in the fall time frame, if you want us to get about the same time or even before that briefings on technologies and safety considerations for fusion, we can do that.

MEMBER BLEY: Bill?

MR. RECKLEY: Yes?

MEMBER BLEY: You mentioned you had to decide whether you're focusing on one kind of machine or others when you're trying to keep it technology neutral. Have you thought about that -- it's hard for me to think of a reason why you'd focus on one. I mean, one's had a lot more work, but it's still not there yet. And maybe something else could catch up and pass it.

But where do you stand on that part?

MR. RECKLEY: We're planning to try to develop this so that it would be inclusive of any of these designs. And so where that can come into play -- and Dr. Petti mentioned this a little bit, too, when we get into the options later on is, are there thresholds?

For example, I'll just mention the inventory of tritium. That would be a consideration. Well, for a large ITER-type machine, that's a large inventory, kilograms. For some of these other machines, even some of the other magnetic machines might be smaller and have less inventory.

Some of the technology, such as those using -- you know, that aren't using or would propose not to use tritium in the reaction would then not have any inventory, right? But right now our plan is to

try to address any of those.

But when you look elsewhere -- and we've participated in some discussions, for example, at IAEA. Given other countries are more focused on one technology, the discussions have been more focused, for example, on the tokamak or variations of the tokamak design.

MEMBER PETTI: So Bill?

MR. RECKLEY: Mm-hmm?

MEMBER PETTI: Just a number I wanted to get on the record, kilograms of tritium sound like a lot for ITER. But for a power reactor, the number is 55.8 kilograms per gigawatt thermal per year. Okay?

So if you had a gigawatt thermal plasma that's only putting 300 megawatts on the grid, you're burning 55.8 kilograms per year. That's a massive amount of tritium. It's more tritium than we know today, which is why they have to breed. Okay?

So the numbers can get staggering as you go from the little experiments that you talked about to the commercial reactors. It's a good number to remember.

MR. RECKLEY: Yeah. And I'll just open it up to people who may remember, but -- on our working group, the discussion. But the -- once in a few

years, hopefully by the schedule, by the end of the decade, when ITER was to start up, they were going to use some significant fraction of the world inventory of tritium at that point.

(Simultaneous speaking.)

MR. RECKLEY: -- going to Dave's point that at some point, you need to start to breed tritium to support the technology. So -- and that becomes one of the -- again, I don't have many slides on the technology, but that really does become, then, part of the hazard assessment is the whole breeding and separation and handling and storage of tritium that -- so it's not just the tokamak and the plasma. It's also the whole rest of the facility that is breeding/treating tritium to put back into the machine.

MEMBER KIRCHNER: Bill, this is Walt Kirchner. And at high temperature, if the breeding blankets are part of the power conversion system, which is very problematic with containing tritium.

MR. RECKLEY: Right. And -- yeah. Point well taken. And in many cases, or what I've seen, anyway, the blankets are right next to the plasma.

So, as we're looking at regulatory approaches, even back in 2009, we looked at what would

be the approaches we have, and as many of you are aware, the Agency as a whole breaks down largely into reactor and materials in terms of our regulatory programs.

And so, in 2009 and up to this time, we continue to look that we really have options that are either treated as a utilization facility -- that is like we handle fission power plants -- handle it like a materials licensee, and examples there might be an accelerator or a large radiator where the amount of radioactive material can vary, but it can be significant.

And the need to provide protections can be significant, or to come up with a hybrid or new approach for fusion, and what we have there is a graded approach, as we've talked about, of trying to accommodate a wide variety of potential inventories and potential release mechanisms that might be associated with various technologies.

So I'll talk about each of those options a little bit, and this is really where we are. We've identified them. We've done a little work to talk to stakeholders about the various options and the pros and cons. But we're just beginning to put down some thoughts, and we are continuing to assess risks as one

factor. That's not the only factor, but it is one factor that could go into the Commission's decision.

So, in terms of treating them as a utilization facility, the legal and technical framework in the Atomic Energy Act and in our regulations currently, for a utilization facility, focus on those that use special nuclear material. This is the fission side.

But the Atomic Energy Act does give us latitude to expand the definition, and it's largely up to the Agency if we want it to include another facility within the utilization facility definition. And, actually, you could see an example of that for the medical isotope facility SHINE because our previous definition was for a reactor, which was self-sustaining.

And given SHINE uses a neutron generator, an accelerator, it didn't meet the definition. So we included it in a case-specific rulemaking to include the medical isotope facilities within the definition of utilization facility. So we could -- you know, as a rulemaking activity, we could just generally expand the scope of utilization facility to include fusion devices.

As you're well aware, the focus on

utilization facilities has been, up to this point, large light-water reactors. That's part of the challenge we talked about yesterday of trying to bring in other reactor designs, even more so a challenge for fusion because we'd actually even have to change the definition of utilization facility to include it.

It does give us a good basis both within the rules, whether it be Part 53 or longstanding practice, to look at design requirements on the design, construction, operation, decommissioning of the machine, as well as all the controls on handling specific radionuclides.

It has traditionally involved extensive licensing reviews, environmental impact statements -- the Atomic Energy Act does include for utilization facilities a need for mandatory hearings either at the construction permit or the combined license stage. So the legal and technical framework is there if we were to choose this route.

The staff is currently looking at the fusion technologies. We're looking at the DOE orders and standards. I think it's Standard 6002 that DOE prepared for fusion safety. It's looking at a magnetic confinement machine, but it goes through the considerations, as do other DOE orders on both reactor

and non-reactor sources of looking at inventories, looking at energies that might drive their release and so forth. So we're currently assessing that body of work, which is actually quite extensive.

We are looking at the ITER safety analysis. One of the contributions is -- ITER is an international activity, and one of the U.S. contributions was to work on the safety analysis. And that was done by folks at Idaho National Lab. So we're looking at that safety analysis and talking with the Fusion Safety Program at Idaho and also the Fusion Energy Sciences folks in Germantown.

Speaking of which, they have helped us, the DOE -- our counterparts at DOE have set up briefings for us, one of which was from the Idaho folks on the safety analysis for ITER. Another one was from representatives from ITER on tritium controls that they foresee. You know, they're currently in the process of looking how ITER will support the research and development of tritium breeding, for example. And also, that was an opportunity to also bring in some of the historical DOE work at the national labs. So that was very useful.

I mentioned we have interactions with IAEA. There was a recent National Academy study.

Actually, there was a couple National Academy studies. And we're looking at the potential risks, and we're also, in that vein, looking and interacting with developers and other stakeholders through our public meetings.

One of the things from the public meetings is feedback -- and this is largely from developers and industry organizations -- that they don't see the utilization facility model as aligning with the risk posed by fusion energy systems.

And so that's a point of discussion, and again, one of the reasons for that is that the developers are -- it's a wide range of technologies, and so it's kind of understandable that they look at both the ITER safety analysis as being -- as addressing hazards beyond what they plan to have for their facilities, and they likewise see the traditional approach to fission reactors as being built for hazards beyond what they envision for their facilities. So --

(Simultaneous speaking.)

MR. CORRADINI: Bill?

MR. RECKLEY: Mike? Yeah. Go ahead.

MR. CORRADINI: So it's the inventory that is the essence of their thinking it doesn't align? Or

is it the way the designs are evolving that it doesn't fit? Because based on what Dave said and what I understand, the inventories for these large machines will be significant. So what was their basis -- what was their technical basis for saying it doesn't align?

MR. RECKLEY: Well, keep in mind, again, that some of the developers have much smaller machines, and some of them are proposing fusion reactions that don't involve tritium. And so they would see -- at least those developers would see that even ITER would not represent what they think is the risks.

Again, the staff's not making any judgments at this point, but --

MR. CORRADINI: That's fine. But you've answered my question. I forgot about that class of machine. I should have remembered.

MR. RECKLEY: Dave?

MEMBER PETTI: Bill, just a question here. In terms of utilization facilities, the TRIGA reactors that sit at many of the universities, and there's one at an Air Force base somewhere -- you guys regulate those, right?

MR. RECKLEY: Yes, and they're under a different class license. They're under the 104

research and test reactors. But yes, we regulate those.

MEMBER PETTI: Okay. I mean, you know, just the hazards, right? I mean, I'm sure there's a fairly low hazard. So my view is there's lots of flexibility with respect to hazard here that maybe the fusion developers just don't appreciate the breadth of regulation that you guys deal with.

MR. RECKLEY: Right.

MEMBER PETTI: Yeah.

MR. RECKLEY: And much of the concern goes to this second bullet, which is the -- to some degree, it's less technical. But one of the comments we got specifically listed out kind of an assessment of what comes along with calling it a utilization facility beyond the technical reviews. And I already mentioned mandatory hearings, so that's one.

Another is inclusion under financial protection requirements, the Price-Anderson Act. Just as an example, for a utilization facility over 300 megawatts electric or the equivalent, it's not only the requirement that they have financial protection against a potential release, but keep in mind under Price-Anderson, it would also put them into secondary pool, in which they would have to contribute if there

were an accident at another utilization facility, meaning at a fission power plant.

There are restrictions because of the history of utilization facilities and the use of special nuclear material. There's limitations on foreign ownership that come along with calling it a utilization facility. I mentioned, again, the licensing processes and mandatory hearings are defined in the Act. So there are limitations in what we could do on that administrative or licensing side. And if it's a utilization facility, it does preclude licensing by agreement states.

And then an observation, actually, from the National Academy study is sort of a concern that just to promote the development of the technology, there needs to be a sense that the regulatory burden is going to be commensurate with the risk. And perception is that a utilization facility licensing process is more onerous than it would need to be.

And so, again, these are largely the feedback that we've gotten, so they're the observations from stakeholders and including the National Academy study. So that's basically where we are in assessing utilization facilities.

MEMBER BROWN: Bill?

MR. RECKLEY: Yes?

MEMBER BROWN: This is Charlie. When I read the white paper that I guess you all developed, you soft-pedaled -- I kind of read it -- maybe I'm just being overly sensitive -- is that they viewed the byproduct approach being allowing them to do things with less oversight and less meddling by outside activities and regulation. And that's why they were really -- that's the way I read several of the paragraphs in the white paper.

Maybe I'm just -- most people that develop stuff would just as soon have nobody walking in and out of their facilities and telling them how to do things or what rules they have to follow, and that's kind of the way I read it. Maybe I'm thinking about it wrong, but --

MR. RECKLEY: I wouldn't disagree with the premise, Charlie. I don't know I'd word it -- they wouldn't word it exactly that way either, but --

MEMBER BROWN: Of course not.

MR. RECKLEY: -- but yes. And the argument -- and I'm going to turn this discussion over to Duncan White from NMSS to talk about byproduct materials, but I think it's a perception that it's less regulation. I think as Duncan's going to get

into, I'm not sure they fully appreciate the latitude that we have to be intrusive, kind of using your term, even for a materials licensee.

But with that, Duncan, are you on and unmuted to take over?

(Simultaneous speaking.)

MEMBER BROWN: Can I ask one other thing relative to that? The purpose is to develop electrical power. And regulating based on byproduct as opposed to utilization just seemed to be, again -- the intrusiveness or the approach -- power is power. And byproducts are a material regulation as opposed to generating what we really want to generate. Am I thinking of that in the wrong direction, or --

MR. RECKLEY: Well, again, we're not taking stands yet. But the only thing I would remind people is that the structure that we have, based on the history, the evolution, is production -- under Part 50, we address production and utilization. And what those facilities are producing or using is special nuclear material, uranium, plutonium, so forth, whereas fusion is not using those materials.

(Simultaneous speaking.)

MR. RECKLEY: Using different materials and radioactive materials, but not special nuclear

material. But just a distinction.

MEMBER BROWN: Okay. Thank you. Just a slightly different perspective. That's all.

MR. RECKLEY: Right. Okay.

Duncan?

MR. WHITE: Yes. Good morning. I'm Duncan White. I'm from the Office of Nuclear Material Safety and Safeguards, and I'm going to talk about byproduct materials.

Under this approach, the thing that is frequently pointed out by industry that makes this particularly applicable to this technology is that when the Energy Policy Act was passed in 2005 and the regulations were doctored by NRC in 2007, the -- we included a definition of a particle accelerator.

Again, this was -- the purpose of the Energy Policy Act was to add radium as a -- radium-226 as an isotope under NRC jurisdiction for security purposes. But the other thing that was done at the same time was there was an interest of regulating PET isotopes to use in -- of course, use in medical diagnostics. And they included the particle accelerator definition in there, and there is one in Part 30 for particle accelerators.

Regarding regulation of byproduct

material, Part 30 provides the basic framework for it, and then there are additional parts from Part 31 to Part 39 that are specific to different types of uses, like radiography, well logging, commercial radiators. Those who are not particularly a separate part, we normally would use guidance as a means to do the licensing for them.

I'll give you an example here on the third bullet here. Volume 21, again, is specific to materials used for accelerators. And again, just to point out really clearly here, the NRC does not actually regulate the accelerator per se, but it would regulate the material produced by the accelerator. For, again, the original intent back in '07, you would have a particle accelerator that would hit a target. We would regulate what's the target and the material produced on the target and any activation products to do that.

Bill talked about the flexibility in how we do our licensing and the guidance, and again, our approach to Part 30 does give us a lot of flexibility. And again, in our design hazard analysis we'll trim the scope of requirements for license use, again, be it a portable gauge all the way up to a commercial radiator or even a fusion energy system. But it would

just be scaled up accordingly based on what's to be regulated and what the risk and design needs are particular to that.

Go to the next slide.

The scope of requirements here are on this slide and the subsequent slides, what those particular things are that we look at into Part 30 again. These are the colorful topical areas we would look at and how we would go through them.

But again, we should point out here regardless of how -- if we use the byproduct approach, the utilization or hybrid approach, we're going to be asking for similar information to evaluate the hazards for any fusion energy system. Again, be it a DOE commercial or ITER type of thing, we're going to ask a lot of similar questions.

And this gets back to, you know, Bill's comment at the end before is that we can get very intrusive and ask a lot of questions with regard to Part 30 for licensing these things. Again, obviously, for radionuclides, obviously we're looking at tritium and activation products.

Just some things about emergency plans is there is a requirement in Part 32 to require an emergency plan if there's a potential to have an off-

site dose of 1 REM, as we saw through the emergency or critical accident.

There is a table in Part 30 that gives the fault values where the applicant or licensee has to consider that. And that threshold for tritium is two grams. And, again, we have some R&D facilities out there right now that are either using that amount or plan to use about that amount, and they would have to come in to look -- provide an analysis of what those potential accidents would be, you know, least pathways and such, to demonstrate that -- you know, why they would not need an emergency plan.

Again, just because you're above two grams doesn't mean you need an emergency plan. You have to do the evaluation; demonstrate you're going to have less than 1 REM at the boundary. If you're going to be above 1 REM, then you have to have a full-blown emergency plan.

And we do have -- there is one facility in Massachusetts that does use large quantities of tritium and does have an emergency plan. It's a commercial manufacturer, and they do require -- they do have an emergency plan for their tritium they have on-site. So we have used this in the past.

Again, financial assurance and

decommissioning is based on -- in large part based on the possession limits for radionuclides. We have training requirements. Again, for Part 30, we have a named RSO and all licenses. You often have use -- and anyone who's going to be using rad material and has to do with -- they have -- are simply named on the license or the requirements to use material is listed on the license.

I'm sorry. Is there a question for Dr. Petti or --

MR. CORRADINI: Just a quick question. The example you said in Massachusetts with emergency plans, are you allowed to say what the inventory is that they had to develop or that is on-site?

MR. WHITE: Actually, I don't recall what it currently is. It's changed over time.

MR. CORRADINI: So, in order of magnitude, is it 10 grams, 100 grams --

(Simultaneous speaking.)

MR. WHITE: I think it's under 10 grams. It's probably in the single-gram numbers.

MR. CORRADINI: Okay. Thank you.

MR. WHITE: Okay.

Dr. Petti?

MEMBER PETTI: Yes. My question is -- and

again, this may not actually make sense legally. I see this, you know, Part 30 utilization power reactors sort of as a continuum. And when you -- you know, how do you know when to go Part 30 versus utilization versus reactors?

It sounds like the difference between Part 30 and utilization really is, are you using special nuclear material? You know, if someone wanted to use 200 grams of tritium, could they come in under Part 30, or would they be pushed more towards a utilization facility just because of the hazard of that much tritium?

MR. WHITE: I think we would consider it under Part 30, but again, that's something we would have -- you know, again, what they're particularly looking at. But no, we've never had to say something like that.

MEMBER PETTI: Yeah. So there's no hard, you know, criteria one way or the other; it's all sort of case-by-case and looking at the whole facility and what it's going to be doing and all that?

MR. WHITE: That's correct.

MEMBER PETTI: Okay.

MR. WHITE: Yeah. That's right.

So okay. Again, under Part 30, we're

looking at facility design. Again, large number of Part 30 licensing deals with particular uses, material, particular devices. But the one description that really stands out, and it's been probably the closest we have analogy to a fusion energy system of a large facility -- you know, a facility that may be engaging in here -- is a commercial radiator is the way that facility is licensed. It's licensed as a facility.

Again, it's a whole integrated approach to ensuring the safeties and protection of workers and the public from, often, millions of curies of cobalt that are used in the pool.

Going to the next slide --

MEMBER REMPE: Actually, before you leave that slide, I have a question. Again, I'm not a fusion expert. But I am wondering about site requirements, size of the site with respect to how much waste is produced and the need to be shipped somewhere and how soon that shipping would need to occur, and the facilities that would be able to receive it, since Part 53 is supposed to be looking at the whole life cycle.

It's similar to some of the questions I raised with respect to microreactors previously. I'm

just kind of thinking, is there going to be some additional concerns that ought to be considered in the site itself?

MR. WHITE: That's a great question, and it's going to be a point later on. In these set of slides, I will be covering waste, and I'll be happy to try to address your question there.

MEMBER REMPE: Sounds good. Thank you.

MR. WHITE: Okay.

Again, go to the next slide.

Again, important aspect of Part 30, obviously -- and again, it'll be under Part 50 -- would be the Radiation Safety Program for workers on-site, for the public, and again, part of this safety programs is operating emergency procedures. And again, what you see listed up there is some of the ones may be considered here.

Again, the number of procedures may be extensive, and we'd expect so for a fusion energy system to be -- required to be licensed. And these procedures, again, a key one would be, obviously, inspection and maintenance. Again, with the comps and the complexity of some of these machines being talked about, the rather extensive plans will have to be reviewed for that. And again, under Part 30 -- we

look at this all the time. Again, the analogy under Part 30, current way to do this is for commercial radiators.

Again, inspection and maintenance is critical to the safe operation and continuing operation of those facilities because of the high -- again, there they have high gamma fields that do play havoc with equipment.

We mentioned testing requirements. We mentioned before there -- again, under Part 30 and similar requirements of radiography radiators sources, there are agency standards and all sorts of third-party standards that have to be met. Again, these are all -- would be covered and, again, required here too.

Again, another area would be, obviously, routine safety audits, routine -- other routine audits, and programs like that.

Yes, question?

MEMBER KIRCHNER: Duncan, yes. This is Walt Kirchner. Have you any experience with facilities that have associated chemical hazards and byproduct materials as well?

MR. WHITE: Yes. That's on the next slide, actually.

(Simultaneous speaking.)

MR. WHITE: Great question. Great question.

Okay. Let's go to the next slide since I keep putting them off.

One of the questions asked about was waste management. Again, these fusion facilities will produce waste. Waste is considered part of their inventory. They have to have their space to do that.

For example, one of the unique things that you will have at a fusion facility is you're going to have activated components. Those could be quite radioactive, depending on what they're made of and how long they're in the fields, in the neutron fields. They have to be stored, safely stored. They have to have a place to put them.

And to get back to questioning, that will be done when licensing. Again, the licensee, the applicant, would have to come in and demonstrate how they're going to do that, how they're going to handle that, before we'd issue the license.

Again, having spent a summer at a DOE facility where they have accelerators, they had a whole plot of land where they kept this stuff. And it was cordoned off, it was controlled, and they had maintained the area until they could properly dispose

of it or recycle it.

MR. CORRADINI: So, Duncan, this is Corradini. You don't have to go back, but to kind of follow on Walt's question and Dave's, are there current facilities under Part 30 that are licensed that not only have large inventories, as you were talking, cobalt radiators, but also generate half the deal with residual heat simultaneously as well as other hazards?

It's the combination of the three to me that make the fusion facility unique compared to some of the examples that you were identifying for us.

MR. WHITE: Yes. There really isn't anything to these -- with these scales. There are small -- again, accelerators do -- there are small accelerators, like used in PET facilities, that do generate -- the device itself becomes activated.

There are some R&D facilities that do use accelerators that use part of the building that do -- they have a similar type of, you know -- similar type of waste and similar type of activities which make it somewhat analogous here to fusion energy. But, again, what's really being anticipated, no, there's nothing -- I can't think of anything that's to that scale. Again, this is what does make it unique is that --

MR. CORRADINI: Okay. Thank you so much.

MR. WHITE: Yeah.

MEMBER HALNON: Duncan, this is Greg Halnon. On the security aspect, what is the -- does Part 30 encompass the security, or would you look at Part 73 as part of the --

MR. WHITE: The way the materials work is we do -- Part 37 of the regulation does deal with material security. It is focused around the IAEA isotopes that are -- there are 20 of those. Tritium is not listed as one of them. So, from a security standpoint, there wouldn't be a particular special requirement beyond that. There is general security requirements in Part 20 that would absolutely apply here.

The other thing, obviously, that has been raised by National Academy and has been raised elsewhere is, obviously, when we deal with tritium and large quantities of tritium, you're dealing with -- it may -- that could be considered preparation concerns. And that's something that's raised and the working group's aware of.

But the way the current Part 30 license regulatory structure is, material security is tied to 20 radionuclides and over certain quantities, and

tritium is not one of them right now.

MEMBER REMPE: So, with respect to the waste management -- this is a little different than my concern with the microreactors where there may not be a place available that's licensed to take them and take the lid off and take the fuel out and things like that. They'll come in with a license, saying, we're ready to go, and -- power production -- and let's send it somewhere later.

Is there a place that can handle the waste that's downstream, the large amount of waste that would be associated with a power production facility for a fusion reactor is what I'm curious about, because if they say, oh, we'll ship it later, that's okay with the current fleet, I guess, because we found a way to deal with the instances on-site when they didn't have a place to ship it to later.

But I'm just wondering if the NRC will let that happen again, or is there a place that can handle this so this isn't a concern with fusion is what I'm trying to get to, if that makes sense.

MR. WHITE: It does. There are commercial waste facilities out there that will take this waste material for a price, of course. That's a viable option. It's not cheap; it's very expensive.

What people sometimes have done with certain radiated components, they have recycled material. For example, some material has been recycled -- we've had cases where we've had contaminated metal from inadvertent source meltings and stuff, and some of that material ended up in shielding at DOE facilities.

So there's ways to recycle some of this material, but there are also other ways to -- there are low-level waste disposal options for this, for these --

(Simultaneous speaking.)

MEMBER REMPE: Okay, as long as they can handle that capacity. I knew there were ways to do it, but I didn't know --

MR. WHITE: Yeah.

MEMBER REMPE: -- if we'd be suddenly flooding the system.

MEMBER PETTI: So, Joy, for the power reactors, it's unclear, but there's a big push in the community to develop what are called low-activation materials so that they will all qualify for shallow land burial. And that's all about the impurities in these materials.

So stainless steel is not a low-activation

material, but there are steels that are low activation and there are other materials that qualify. And that's where the push is to see if those materials will perform the functions they need to do infusion. But at the end, all you'd have is material in shallow land burial.

Now, it is a lot of material when you look at the power reactor. And so there's also been work to look at recycling, but, you know, that's way down the line. But that's --

MEMBER REMPE: It's way down the line, but you've got to think about it with the way that Part 53's looking. And, again, the capacity is what I was curious about. But if they can have a credible path, then that needs to be established that they need to think about that in this Part 53.

MR. WHITE: Yeah. That's true. One of the things, too, with waste at fusion facilities, again, is how much waste are you really going to generate? If you take away the components, you know, there's -- you're getting the tritium, and lots of tritium. And tritium, as everyone knows, has a propensity to absorb into a lot of things, metals, everything. And how much waste will be generated? That's another consideration. And the licensing

process, is there enough space to do that? Is there a place to send all this stuff? That has to be considered.

Regarding byproduct material -- was there a question?

MR. RECKLEY: No, I was just going to say Scott Moore has had his hand up.

MR. WHITE: Oh, I'm sorry.

Go, Scott.

MR. MOORE: Thanks, Duncan. It's good to hear from you, Duncan.

Part 34 of the members is also unique in one way, and it's that -- for the ACRS. And it's that the ACRS's scope does not extend to Part 30. The ACRS's scope only extends to reactors and waste. So the only way that a Part 30 action could be reviewed by the Committee would be if the Commission or the staff referred it to the Committee. And so that's a point for the Committee to consider.

That's it, Duncan. Back to you.

MR. WHITE: Thank you, Scott --

MEMBER BIER: I have a quick question also. This is Vicki Bier. And this may be too far into the weeds of the science. Maybe it'll come up at a later time. But I just wanted to understand, with

regard to material damage at operating fusion power reactors, is there a thought that that might require sort of more and more intense regulatory oversight than what we have at fission reactors on the material side at -- either because of risk or because of, kind of, the uncertainty about the risk?

MR. WHITE: Bill, you want to take that one?

MR. RECKLEY: I think that we'll have to look at that, and as -- where they are now -- and Dr. Petti mentioned they're researching materials. So all of that would have to be considered.

So I'm not sure I can say it would be more so, but certainly it's going to be an area that we have to look at because an option to use better material, as Dave mentioned, would be to actually put constraints on when do you need to stop operation, maybe replace components, because you want to keep under a certain activation level.

But all of those things are kind of in play right now. So I'm sorry I don't have a specific --

MEMBER BIER: No, that's fine. Just making sure it's kind of on the radar and whatever. Thanks.

MR. RECKLEY: Diego, you had a comment?

MR. SAENZ: Yeah. This is Diego Saenz, and some of you may know me from when I worked at the NRC. I did a lot of MELLA+ presentations. Now I'm with the state of Wisconsin as the agreement state representative, one of two.

But I wanted to contextualize something for folks because I'm not sure this has been fully appreciated. So NEIMA uses the term fusion reactor, but that is not defined anywhere. And I also don't think it lends itself to the self-sustained or critical mass type quantity that we have with utilization facilities.

So there's actually been quite a bit of -- I don't know if concern or anxiety, but if this were to go forward, I know the ACRS is thinking a lot about this ITER type and power facilities, but it's not clear to me that this wouldn't just swallow everything where fusion occurs. And that's where there's a lot of concern.

So I think that there's been some misunderstanding of the industry's concerns because I think that they're -- they are thinking of these type of devices, for example, those that we have currently licensed in Wisconsin, which, as Bill talked -- it's

an accelerator, and we license that tritium and those activation products. But there is no risk of, you know, self-sustained reaction or something like this. These are --

(Simultaneous speaking.)

MR. SAENZ: Yeah. Go ahead.

MR. CORRADINI: So this is Corradini. Are you talking about the Phoenix nuclear accelerators?

MR. SAENZ: Yeah.

MR. CORRADINI: Okay. So I guess I'm aware of that, but when I put such a device in combination with a subcritical solution, which you'd find in SHINE, for example, then it falls into -- well, the rule has changed for it, but it seems to logically fall into a utilization site.

I understand where you're coming from, but as the systems get more complex, that's, I think, where the hesitancy is by some of the members.

MR. SAENZ: Yes. So, to contextualize this for you -- so you're aware of that. So imagine that same device, they now want to do neutron radiography. And that's what we've licensed them to do. So not at SHINE, in other sites -- and even SHINE has now come forward with a -- has requested a license from our state for R&D, and we have licensed them to

do R&D work. So that's currently licensed. So that's --

(Simultaneous speaking.)

MR. CORRADINI: I just want to make sure I understood the context of your example.

MR. SAENZ: Yeah. So the context -- and that's a perfect example. They want to do neutron radiography. They have no intention of being power positive or anything like that, but they just want the neutrons, again, for a different purpose.

So, in SHINE, they're using it to maintain the subcritical configuration. But they see benefit in using those for radiography. And there's some concern that those would get swallowed up into Part 53 and, you know, into mandatory hearings and to all of these things for devices that -- you know, frankly, that is a huge burden for that scale of operation.

Thanks.

MR. WHITE: Thanks, Diego. Continuing on, with regard to -- I'm sorry. Go back one slide. I'm sorry.

(Simultaneous speaking.)

MEMBER KIRCHNER: -- going to ask, Duncan, if you could address systems with chemical hazards, in particular --

(Simultaneous speaking.)

MR. WHITE: I remembered your question. I was going to get there. Yes.

MEMBER KIRCHNER: Thank you.

MR. WHITE: Okay.

With regard to Part 30 and environmental protection requirements in Part 51, again, licensing for Part 30 does have to comply with Part 51. The large majority of material uses are categorically exempt under Part 51. There are some exceptions to that. And, of course, their fusion is not covered -- currently not covered under Part 51 at all. So, again, looked at it today. One would have to probably look -- consider NEPA requirements with regard to a fusion application to Part 30.

Some of the other hazards -- one of the things was, yes, under Part 30, we do look at some non-radiological and how they could impact the use of their material. A good example, I think, of this is with commercial radiator facilities. There are limitations written into license that only allow the radiation of only very small quantities of certain chemicals, certain volatile chemicals and certain other materials because of the potential fire hazard.

Again, this was based on experience from

the early days where they had some serious fires and damages to radiators. And again, this is why this is important, because commercial radiators do radiate a number of surgical and medical products, which are often kept in small quantities of chemical solutions to keep them clean.

Also, one of the main fusion designs, the inertial ones, use a lot of lasers, high-powered lasers. And, of course, that would have to be considered again when we're evaluating their use, the use and how it impacts the radioactive material and their safety systems within a facility.

Now, going to the next slide, I think we've covered --

MEMBER KIRCHNER: Before you go on, Duncan, this might be in the weeds, but I was looking over your list of things, and one that comes to mind is fire safety.

MR. WHITE: Yeah.

MEMBER KIRCHNER: So that's another factor that looms pretty large with any system that would have a significant inventory, particularly of tritium or activated products, and/or using unique chemical coolant systems, some that may be flammable and/or toxic.

MR. WHITE: Agreed. That's -- and, again, we've seen such a wide range of designs out there and proposed designs that that's something we'd have to consider. That's why it's listed up there, because we'd have to look at that and consider that when we do the licensing. And it doesn't matter if you're doing it under byproduct or utilization or hybrid approach. You're going to have to do that evaluation.

Back to regulation, I think we've covered most of this already. With regard to DOE and NEIMA, there is an instruction to have a pilot project up by the end of this decade. Again, that facility may or may not be built on a DOE facility. If it is, it would be under DOE regulatory oversight.

We've talked a lot about agreement states, and Diego addressed a lot of this already. Again, some of you probably -- most of you probably already know agreement states do assume regulatory authority from the NRC. NRC discontinues their authority. This is based on Section 274 of the Atomic Energy Act.

And this would encompass fusion research facilities. And, in fact, Diego mentioned that Wisconsin does regulate Phoenix and some of their work. There's also been other fusion work that's been under agreement state jurisdiction for a while.

There's the LLE at University of Rochester in New York. There's a couple facilities in California. And one thing that's being looked at and planned right now is the Commonwealth Fusion System's SPARC facility, which is -- they're talking to the Commonwealth of Massachusetts right now to build that facility under a byproduct license. Working on that now.

So we do have -- the bottom line is we do have some experience here. The agreement states have some experience here with working with fusion research facilities, some commercial facilities. So that's kind of -- and their participation in this working group has been very helpful in terms of kind of helping us, looking at the breadth of activities that need to be done and some of the challenges common to licensee facilities and some of the regulatory aspects of it.

Okay. We'll go to the next slide.

MEMBER KIRCHNER: Duncan, this is Walt Kirchner again. When the agreement states do that, do they typically use Part 30 as the outline, or something comparable?

MR. WHITE: Yes. Yes, they do. Agreement states have to have compatible regulations to NRC, so they have equivalent Part 30 in their regulations. So

they would follow that approach.

A number of agreement -- the guidance documents I mentioned in earlier slides, the NUREG-1556, those are jointly developed with the agreement states. And a number of agreement states either use those guides or use very similar ones where they insert -- basically, they insert their requirements instead of the NRC requirements in there.

So agreement states generally use the same approach that we would do. Again, there may be site differences from state to state, but for the most part, they use the same general approach that we do for licensing byproduct material.

Then feedback we've gotten on this approach, as Bill previously mentioned, industry and the developers are very keen on the byproduct material approach. Again, a thing that they point out numerous times is how similar it is to accelerator provisions.

One thing that we have -- and, again, they point out that Part 30 is designed for byproduct material, what tritium is. It's not a fission reactor. And, again, this is generally how they're selling and approaching this.

We also get feedback that they say agreement states -- and something we agree with is

that agreement states do have experience with licensing and inspecting fusion activities. In the previous slide, we mentioned a few of those.

So I think the next -- I think we're going to move into the hybrids discussion next. Are there any more questions on byproduct?

MEMBER PETTI: Yeah, hold on. Just -- this is when we usually take our break, so this might be a good spot as you finish the slide. But we take our usual 20-minute break. So why don't we do that and go into recess and reconvene at 20 after the hour?

CHAIR SUNSERI: That sounds good to me, Dave.

(Simultaneous speaking.)

CHAIR SUNSERI: -- if that's okay with the presenter.

MR. WHITE: Yes.

CHAIR SUNSERI: Okay. So we'll recess till 20 after. Thank you.

(Whereupon, the above-entitled matter went off the record at 11:00 a.m. and resumed at 11:21 a.m.)

CHAIR SUNSERI: So, we are ready to reconvene. We will continue on with the fusion discussion. Dave?

MEMBER PETTI: Yeah. I don't know who's talking. Is that Bill now? Are we back to Bill? Or do I --

MR. RECKLEY: Yes, we did. Yep, this is Bill Reckley again. So, we'll finish out with the -- with the last of the possible approaches we've identified today for the options paper.

And it basically involves either developing a new or taking a hybrid approach that would try to take advantage of existing frameworks. That includes those developed by the NRC for various types of licenses, approaches taken by DOE, and appropriate role for the Agreement States.

We would try to make it a graded approach, looking at the hazard and the potential for radiological releases. It's kind of a graded approach is what we would set out to establish.

As I mentioned earlier, we would look to try to make this technology inclusive for all the different potential fusion designs, all the potential fusion reactions that are being investigated.

And to try to reach that appropriate balance where we're looking at the hazards and the risks. And then the associated regulatory processes that a license -- that an applicant would face.

And try to make sure that the regulatory process is not somehow out of sync with what we're trying to accomplish in terms of public health and safety.

So, the first of the two hybrid approaches, when we presented this at a stakeholder meeting, and it might have been better terminology, but we called this a fragmented approach.

Where we would look at a potential applicant, and have some kind of decision criteria. This would go to, as we've discussed before, inventories of tritium, or other radionuclides.

It may involve an actual calculation of potential offsite consequences. But, come up with some decision criteria and use that to channel that application either to a byproduct material process using the regulations largely as they exist now under Part 30.

Or, if the decision criteria went the other way, then the application would be channeled to Part 53. And would be treated as a utilization facility.

So, this -- this would result in the end in at least the potential for some fusion energy systems to be licensed under byproduct material, and

other fusion energy systems to be treated as a utilization facility.

The other hybrid approach that we've talked about, is where we focus on trying to consolidate all fusion energy systems under one set of regulations. And acknowledge that the variety of technologies include a range of hazards and potential consequences.

And we tried to grade the requirements. And Duncan had gone through, you know, the ability to set different thresholds for different regulatory activities, including emergency planning and financial protection.

The potential that we're going to get into in Part 53 discussions going forward. You know, the personnel and the requirements on potential licensing or other requirements on personnel.

All of those things could be graded under basically what would become a new regulation. Potentially even a whole new Part.

So, just a working number. I sometimes refer to this as Part 45. Somewhere between materials and utilization facilities.

But again, at this point we would be just looking to develop that option for Commission

consideration.

So, the feedback that we've gotten has been limited for the hybrid model. I don't -- I'm not sure many stakeholders have thought this all the way through.

And the staff is still kind of contemplating what could be associated with this. This would also be an area or an approach that could involve us going back to Congress and suggesting that an actual change to the Atomic Energy Act would facilitate us going forward.

I had mentioned before, there are some -- some issues trying to fit these into a utilization facility, given the long history of utilization facilities being really focused on special nuclear material.

There's also some questions on whether all the fusion technologies really fit kind of a definition for an accelerator. Which was the, as Duncan mentioned, which was the change to the Act in 2005 to include byproduct material produced by an accelerator.

And there's been some discussion. And back and forth as to whether various fusion technologies actually are accelerators.

The --

MEMBER KIRCHNER: Bill, This is Walt. If I might just interject since I spend a lot of time following EPAC 2005.

Those revisions were written specifically with medical isotopes in mind. Production of the radioisotopes for medical applications.

Perhaps the language is more generic than that. But, certainly there was no consideration of a, say a laser driven fusion system in the writing of EPAC 2005.

MR. RECKLEY: And yeah, that goes -- thank you. Walt. That goes largely to the point. That when Congress was putting that language in, they didn't have this in mind.

So, the question both from a technical and legal assessment, will be whether there's enough wiggle room in the language that they did put in, to include fusion energy systems.

And that's an ongoing -- that's an ongoing assessment that we have. The hybrid approach would give us an opportunity to tailor the requirements to the radiological hazards.

We can do that within Part 30. And as Dave mentioned, we have the ability to do graded

approaches even for utilization facilities and the technical reviews.

But, this we could actually write for the specific hazards. And write the regulations in the -- using the terminology that fusion uses in terms of, you know they don't -- they don't typically refer for example to decay heat.

It's after heat or something to reflect that the -- that the array -- that that phenomena is associated with the irradiation of the structures and so forth.

And so, in terms of the potential hazards that you -- that we could write this part, if we write a new part, in terms of threats, not threats. That's the wrong word.

Potential sequences involving you know, magnetic transients and dust, and as Dave mentioned, focus on, particularly on things like the tritium breeding blanket.

Just -- there's a whole bunch of things that are different about these machines. And if we started from scratch, we could -- we could tailor the requirements to those hazards and to the actual underlying technology.

There has been some discussion that either

the hybrid model could work. And it was seen as favorable by some.

But, I think those that would favor it would not foresee some of the things in the Act from the utilization facilities carrying over to this hybrid. Things like applicability of Price Anderson foreign ownership.

And maybe even ACRS review as Scott pointed out. That's required in the Act for utilization facilities, but not for byproduct materials.

So, in summary, we are still closer to the beginning then the end of this assessment. We're looking at designs and technologies and hazards to try to determine the right scope.

As Duncan mentioned, and I think it is worthy of repeating and emphasizing, regardless of the approach, we're going to be looking, technically we're going to be looking basically at the same -- the same information or requesting the same information in order to make a safety judgement.

And that goes to the inventories, and the energies that can drive the releases and so forth. So, that would be done under any of the three options that we talked about.

And in the end, the Commission is the decision maker. So, the product that we're currently working on, that we've been assigned, is to develop options for Commission considerations.

And we just thought that this would be a good thing to come today, kind of talk to you about where we are, what we're developing. Set out that -- that the schedule would be this fall.

Perhaps as early as this fall we would have a draft of the paper that we would be preparing to send up to the Commission.

And I think that the ACRS review of that would be a good thing. And that we were planning on it.

The other question about whether you would want additional information, and we can line up people from DOE or Idaho, or even individual developers, to go into more discussion of the hazards and the safety assessments.

You know, I'll leave that open, and you can get back to us if you would have any interest in us setting that up.

So, go ahead, Dave.

MEMBER PETTI: So Bill? Yeah. So, it seems to me, I don't like the -- that hybrid approach

you had talked about.

The key is the decision criteria, right? What puts you on the road to Part -- to Part 30 versus utilization facility?

That's where, I think, the rubber will meet the road.

MR. RECKLEY: Yeah. If we reduce the existing frameworks, and actually bifurcate, and treat some, one way and the others, the other way, then it would be very important to have.

And you do have to look, to be honest, you have to look at when you set stuff up like that, do you set out unintended consequences. Right?

So, you set that limit on X grams of tritium. And then have applicants start to try to gauge the whole technology to keep below that threshold.

That might be an okay thing. But, it's something to think about.

MEMBER PETTI: Yeah. But, I mean, even -- even in a graded approach, I mean, we -- mentally we still have to have to have some sort of criteria on how to figure out how to grade.

MR. RECKLEY: Right.

MEMBER PETTI: You've got a brand new

licensing framework, right? Because there is a point at which, you know, the hazards get significant when you get lots of neutrons.

And you know, holding the plasma for under a second is not an issue from a neutron standpoint. But, holding it for about 15 minutes or a bit longer, I can see, you know, you're going to start to activate stuff.

And so you've got to worry, again, more worker safety issues than public safety. But again, important in addition to the tritium inventories.

MR. RECKLEY: Right. And again, as we've gotten the feedback from stakeholders, one of the -- you know, one of the things to consider and one of the things that consolidated approach, like the Part 45 approach could do, perhaps better than the bifurcated either Part 53 or Part 30, is that distinction in what comes with a utilization facility?

All of those legal requirements like Price Anderson mandatory hearings, foreign ownership, those restrictions, are they appropriate? Would people -- but again, the nice thing about where we are, is we only have to point these things out at this point, for the Commission to consider.

We need to consider it, I guess, into

developing a recommendation for them. But, we don't have to solve all these problems right now.

We only have to identify them, say there's a path to resolution, and what that might be for the staff -- for the Commission to make a decision.

And then once they decide and tell us what path to do on, we'd have to work out, no matter what they decide, there's a whole bunch of details that we're going to have to work out, as you've mentioned.

MEMBER PETTI: Okay. And is one path seen, the amount of path just about the same? Or do you think it's different?

MR. KRAFT: Bob, -- Bob, Steve Kraft. I had my hand up. Sorry. Yeah, so I'll make this quick.

I think something that NRC needs to think about, in the definition of advanced reactor, I went back and looked at the staff --

(Simultaneous speaking)

MEMBER REMPE: So, there is someone on the public line who is talking on the phone who needs to mute himself now.

MR. KRAFT: I just believe that -- only saying what Jeff said earlier.

MEMBER PETTI: Can we please mute the public line?

(Simultaneous speaking)

MR. KRAFT: In one respect, because of the phrase such as. And I don't know how that can --

(Stopped public line)

MR. RECKLEY: Okay. I'm not sure at this point, Dave, that we've made a distinction yet. And it will be part of what we have to assess, is whether any of those three options would be easier or harder.

I think in terms of time and level of effort, probably developing a whole new part would be the most extensive.

MEMBER PETTI: All right.

MR. RECKLEY: And that -- that usually is the case, right?

MEMBER PETTI: Yeah. Yeah.

MR. RECKLEY: It might be the best answer. I mean, if you ignore everything else, it might be the best answer, because it could be -- everything could be tailored to the technology and the hazards.

But, it also would be the most resource intensive, so.

MEMBER PETTI: Right. But, that's part of the paper you put will --

MR. RECKLEY: Right.

MEMBER PETTI: Flush that out.

MR. RECKLEY: Right.

MEMBER PETTI: Great. Okay.

MR. RECKLEY: Right.

MEMBER PETTI: Thank you. That helps.

MEMBER KIRCHNER: Dave, this is Walt. You know, one thing that occurs to me is that if you could do Part 45, quote/unquote, that would cut lose the staff from all the complications that trying to make 53 so inclusive that it includes fusion machines.

It would just -- it seems to me it would make life simpler for the staff for -- getting to closure on 53, if it could be cut loose from the requirements to address fusion and public considerations of the fusion machine in 53.

MEMBER PETTI: Yeah. I kind of thought about that too.

MR. RECKLEY: Given I have a foot in both camps, I think about it a lot, so. And it's a good -- it's a good point, Walt.

And that will also be something that we would bring out later.

MEMBER KIRCHNER: Well, the other thing -- I guess it's not my place. This would be one member's opinion, and not a recommendation from the Committee.

That Bill, that time is -- you're under a,

already for 53, under a tight schedule with direction from the Commissioners.

Realistically, a fusion reactor is still a while off.

MR. RECKLEY: Yeah.

MEMBER KIRCHNER: To have it to the number of advanced fission reactors that are potentially on your plate already. And more may be coming.

So, I think a consideration of realistic timing as to when a commercial fusion reactor that could actually generate electric, would be available to connect with the grid, is well off.

I don't want to debate how far well off is. But it's certainly not near, anywhere near the schedule that you're working against to complete 53.

MR. RECKLEY: Right. And yeah, just to reinforce, the stakeholders generally, the fusion related stakeholders basically agree that there's no need for an aggress -- as aggressive a schedule for fusion as there is for the advanced reactors on the fusion side.

And just for calibration point, the national academy study, when it was laying out what would be an aggressive schedule to get a pilot plant up to actually make electricity, was looking at the

period between 2035 and 2040, so.

Any other questions?

(No response)

MR. RECKLEY: Okay.

MEMBER PETTI: I guess not. Then I guess we can open up the line for public comment now.

MR. DASHIELL: The public bridge line is open for comments. So, please make sure you unmute your device before speaking.

CHAIR SUNSERI: Go ahead Dave, make your request again.

MEMBER PETTI: Yeah. Anybody on the public line wish to make a comment?

CHAIR SUNSERI: It looks like somebody is trying to talk, but I can't hear anything.

MEMBER PETTI: Yeah. I don't hear anything either.

CHAIR SUNSERI: Well, this is the kind of technical challenge we encounter when we are forced to mute the public line because of disruption.

So, at this point, I would say it looks like somebody is trying to say something. But, we're not going to be able to get them connected.

So, anybody that's interested in making some remarks, can provide those in writing to us. And

we will include them with the record of this meeting.

Go ahead Dave. Back to you.

MEMBER PETTI: Yeah. No, I think I'm going to thank Bill. I think this helps kind of put the whole fusion thing in a better context.

It's a difficult task given the really wide range of facilities, both in terms of the technologies, but in also the emissions.

When you're talking about a facility that would hold a plasma for under one second versus something, you know, steady state, there's huge differences.

And that's the real challenge. And I think Bill, you guys have done a good job at sort of laying that out, and laying out the options, so.

MEMBER HALNON: Hey Dave, this is Greg Halnon, just one more quick, if I could?

MEMBER PETTI: Yeah.

MEMBER HALNON: Just my opinion is the statement on slide 21 kind of says it all. And I'll just read it.

Opportunity to tailor regulatory requirements to specific radiological hazards for various fusion technologies. That -- my opinion is that nuclear is just too important to try to force fit

something into a regulation that maybe or possibly covers all the aspects.

I really think that in my opinion, we need to keep nuclear, especially new technologies such as fusion, and the potential unique hazards, in the forefront from specific regulations. So, as we go forward, we can talk more about that.

But, the second thing, there was an offer for some of us novices in fusion to get some additional training and oral presentations of the different technologies.

I for one would vote that I could use that. You know, I know very little bit about fusion. Enough to know that it's opposite of fission.

But, other than that, I could use some tutoring on the emerging technologies. So, as we go forward, that might just be one vote for out of many.

MEMBER PETTI: Okay. Thanks. Any other members?

(No response)

MEMBER PETTI: Okay. Then I turn it back to you Matt.

CHAIR SUNSERI: Okay. Thank you, Dave. And thank you to this staff. And Bill, I don't -- Bill Reckley, I don't know how you had the energy to

do this.

But, you're quite amazing. So, thank you for hanging in there with us for a day and a half now on some very technical stuff.

We are -- can do a transition here. Let me check with Dennis Bley. Dennis, are you and Derek prepared to start, to continue reviewing the draft letter report on -- interim report to Part 53?

MEMBER BLEY: Sure.

CHAIR SUNSERI: Okay. Well, let's make that transition then. And we will work on this until 1:30. And then at 1:30, we'll take a lunch break.

So, I guess we'll turn it to you.

MEMBER BLEY: Okay. Before you do, I know we had a break not too long ago. Maybe we could take a short break before we get into this.

I don't know if Derek would too?

MR. WIDMAYER: Yeah. I second that.

CHAIR SUNSERI: Okay. We need some time to get this -- the stuff up. So, we'll take a what? Ten minutes?

So, we'll start at 12:00? We'll recess until 12:00. We'll reconvene at 12:00.

(Whereupon, the above-entitled matter went off the record at 11:48 a.m.)

Advisory Committee on Reactor Safeguards

Developing Options for a Regulatory Framework for Fusion Energy Systems

May 6, 2021

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

Background

April 2009 SECY-09-0064

- Request for the Commission to establish Regulatory Jurisdiction over commercial Fusion systems. In summary:

1) Maintain Status Quo, or
2) Commission asserts (or not) jurisdiction over commercial Fusion systems.

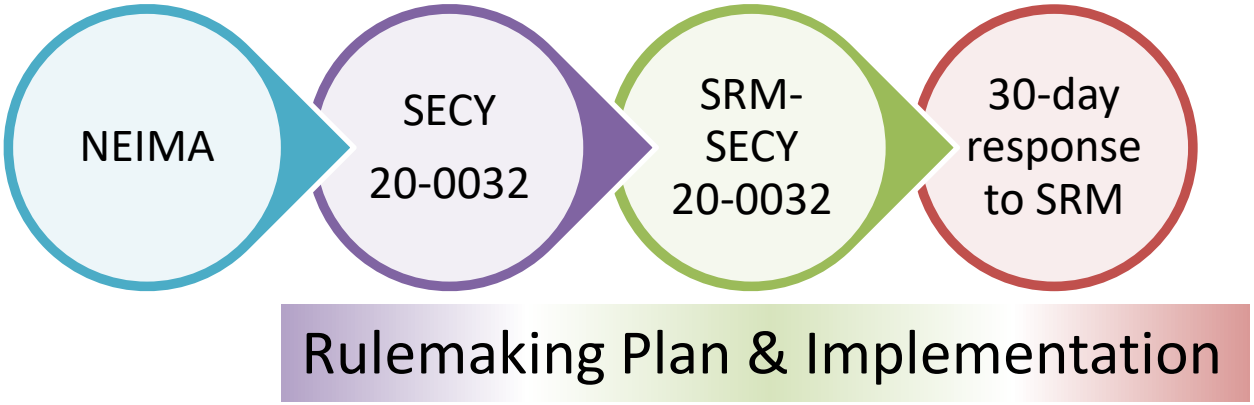
July 2009 SRM SECY-09-0064

- Commission approved staff's option 2: "…**the NRC has regulatory 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."**

- "**The staff, however *should wait until commercial deployment of fusion technology is more predictable*, by way of successful testing of a fusion technology, before expending significant resources to develop a regulatory framework for fusion technology**."

Background

- Nuclear Energy Innovation and Modernization Act (NEIMA) was signed into law in January 2019 and requires the NRC to complete a rulemaking to establish a technology-inclusive, regulatory framework for optional use for commercial advanced nuclear reactors no later than December 2027
  - (1) ADVANCED NUCLEAR REACTOR—The term "advanced nuclear reactor" means a nuclear fission or **fusion reactor**, including a prototype plant… with significant improvements compared to commercial nuclear reactors under construction as of the date of enactment of this Act, …



Commission Direction on Rulemaking Plan

- In SRM-SECY-20-0032, the Commission:
  - Approved the staff's proposed approach for the rulemaking
  - Directed the staff to provide:
    - a schedule with milestones and resource requirements to achieve publication of the final Part 53 rule by October 2024
    - key uncertainties impacting publication of the final rule by that date
    - **options for Commission consideration on licensing and regulating fusion energy systems**
  - Directed the staff to develop and release preliminary proposed rule language intermittently, followed by public outreach and dialogue.

*(SRM 10/2/2020- ADAMS ML20276A293) **(30-day SRM response 11/2/2020- ADAMS ML20288A240)

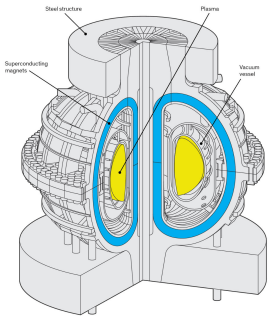
Current Activities

- Continuing interactions with DOE/Fusion Energy Sciences
- Continuing interactions with stakeholders such as the October 2020 public forum and NRC public meetings held on January 26 and March 30
- Regulatory framework for advanced reactors (Part 53) being developed to accommodate fusion technologies as much as possible to maintain flexibility for future
- May recommend separate rulemaking for commercial fusion facilities that would extend beyond 2024 but would be completed before 2027.

Developing Commission Paper

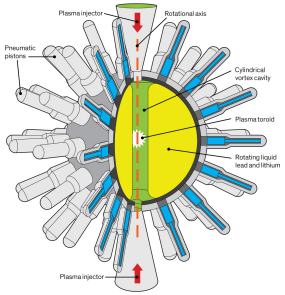
- Gathering information on fusion technologies
- Focusing on potential long-term commercial deployment
  - Near-term R&D facilities handled using existing requirements on a case-by-case basis
- Assessing potential risks posed by possible commercial deployment of various fusion technologies and possible regulatory approaches for commercial fusion facilities
- Coordination with Agreement States, and
- Developing and assessing options for regulatory approaches considering technical, policy, and legal issues

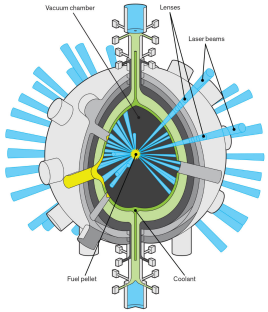
Challenge – Diversity of Designs and Hazards



Fusion Technologies

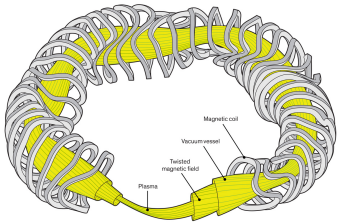
- Magnetic
- Magneto-Inertial
- Inertial

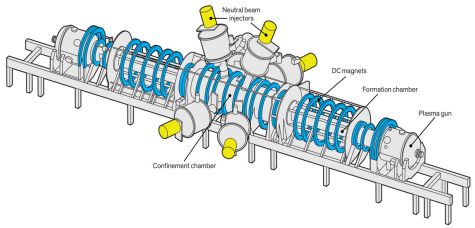




Fusion Reactions

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





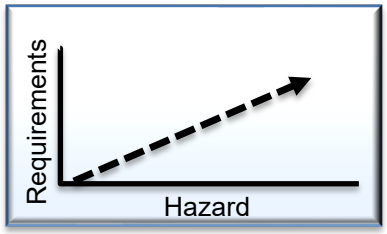
Radiological Hazards
Chemical & Other Hazards

Regulatory Approaches

- Preliminary assessments left open the regulatory approach for commercial fusion reactors
- Possible approaches include treatment similar to:
  - Nuclear (fission) power plants

  - Materials (e.g., accelerator)

  - Hybrid or new approach



Regulation of Reactor Facilities

- Legal and technical framework defined in Atomic Energy Act and NRC regulations for utilization facilities (currently those using special nuclear material (SNM))
  - SNM is plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235
- NRC historical focus on large light-water reactors
- Technical requirements on design, construction, operation and decommissioning
- Traditionally involved extensive licensing reviews
- Environmental Impact Statements
- Mandatory hearings

Assessing Fusion within Reactor Framework

- DOE safety orders
- ITER safety analyses and licensing
- DOE facilitated briefings from representatives from INL (safety analysis) and ITER (tritium controls) with more planned
- Interactions with International Atomic Energy Agency
- Interactions with National Academy of Sciences study
- Researching potential risks for variety of potential fusion technologies and designs
- Interacting with developers and other stakeholders

Feedback (Utilization Facility)

- General feedback from developers/industry organizations that they do not see utilization facility model aligning with risks posed by fusion energy systems
- Potential ramifications associated with utilization facility model, including:
  - Price Anderson Act
  - Foreign ownership
  - Licensing processes and mandatory hearings
  - Precludes licensing by agreement states
- Need for approach that minimizes unnecessary regulatory burden to support developing and deploying fusion energy

Regulation of Byproduct Materials

- Legal and technical framework defined in Atomic Energy Act and NRC regulations
- Revised by Energy Policy Act of 2005 to include material made radioactive by use of a particle accelerator
- Guidance for various uses of byproduct material provided in NUREG-1556, “Consolidated Guidance About Materials Licenses”
  - Volume 21, “Program-Specific Guidance About Possession Licenses for Production of Radioactive Material Using an Accelerator”
- Flexibility in safety and environmental reviews given wide range of possible applications

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

Regulation by DOE and Agreement States

- Pre-commercial demonstration of fusion may be conducted under DOE oversight and requirements if the private sector fusion company performs activities at a DOE facility. The company would not be subject to NRC/Agreement State licensing or specific regulations.
- Agreement States have licensed fusion research facilities. As a general matter, the byproduct material licensing of fusion-related activities have not gone beyond the requirements for possessing tritium or production of neutrons by companies, universities or other research institutions. Examples include:
  - Phoenix Neutron Generators (Wisconsin)
  - Laboratory for Laser Energetics (New York)
  - Planned approach for Commonwealth Fusion Systems' SPARC facility (Massachusetts)

Feedback (Byproduct Material)

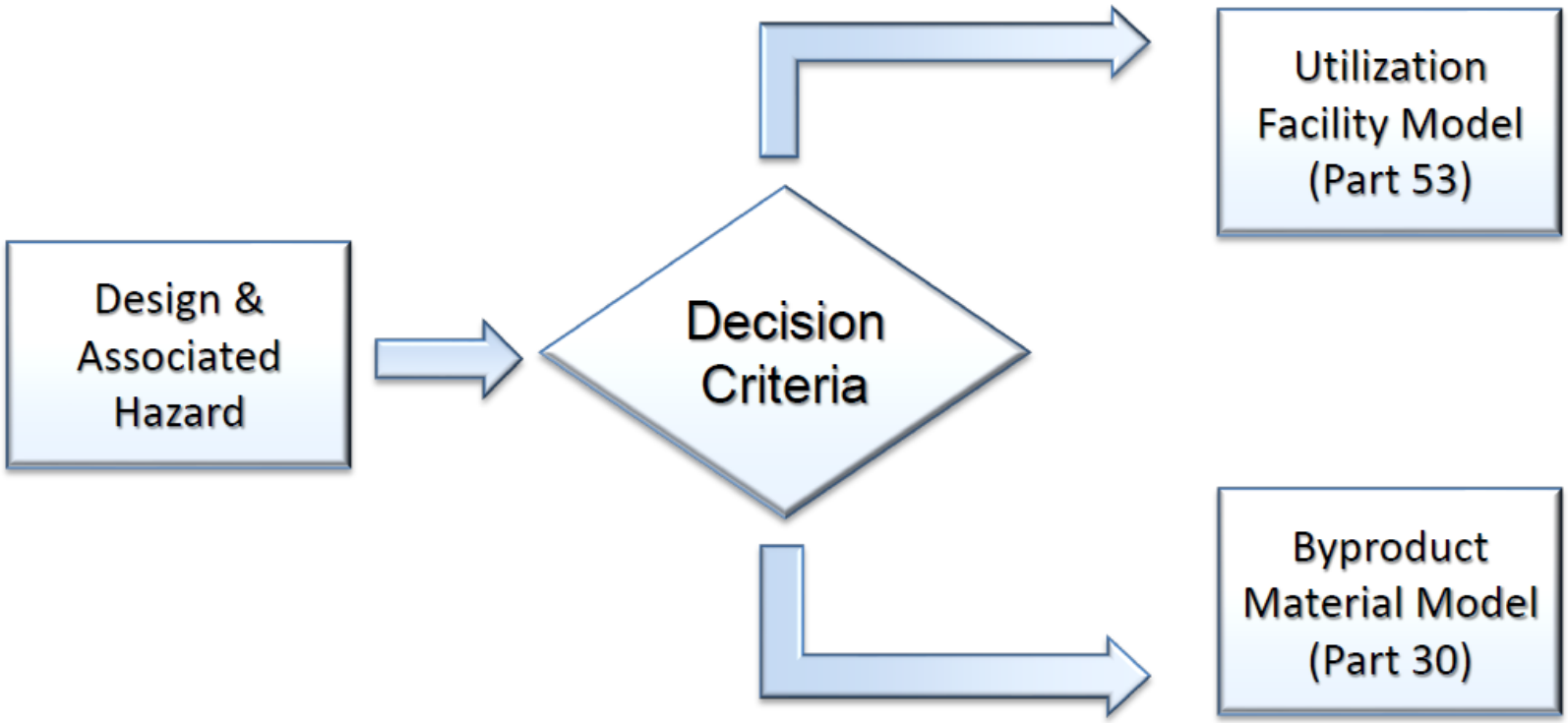
- General feedback from developers/industry organizations that byproduct material approach is favored
- Stakeholders view NRC's regulations in Part 20 for general radiation protection and Part 30 for handling byproduct materials as appropriate for fusion energy systems
- Possible questions on the applicability of accelerator provisions to all fusion technologies
- Agreement States have experience with licensing and inspecting R&D fusion activities that can be leveraged

Possible New or Hybrid Approaches

- Leverage existing framework (NRC, DOE, Agreement States, etc.) to extent practical,
- Risk-Informed, Performance based approach,
- Technology-Inclusive for various Fusion systems (fuel types and facility designs), and
- Graded and scaled approach that balances requirements against hazard/risk and consequences.

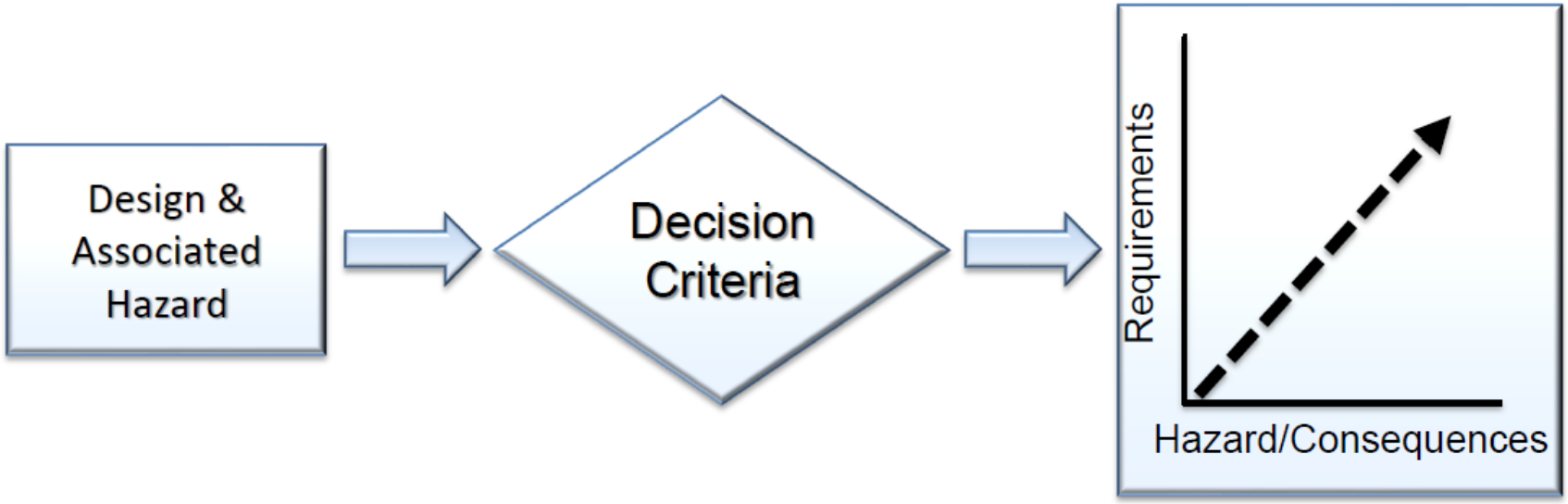
Hybrid Approach

- *3a-Within current framework (fragmented)*:



Hybrid Approach

- *3b-Within a dedicated Fusion framework (consolidated):*



Feedback (Hybrid Approach)

- Limited discussions with developers/industry organizations on possible hybrid approaches
- Could be associated with changes to the Atomic Energy Act to better accommodate fusion energy systems
- Opportunity to tailor regulatory requirements to specific radiological hazards for various fusion technologies
- Opportunity for graded approach based on potential consequences
- Stakeholders favored establishing a regulatory approach for Fusion systems outside the 10 CFR 53 due date of October 2024 but before October 2027.

Summary

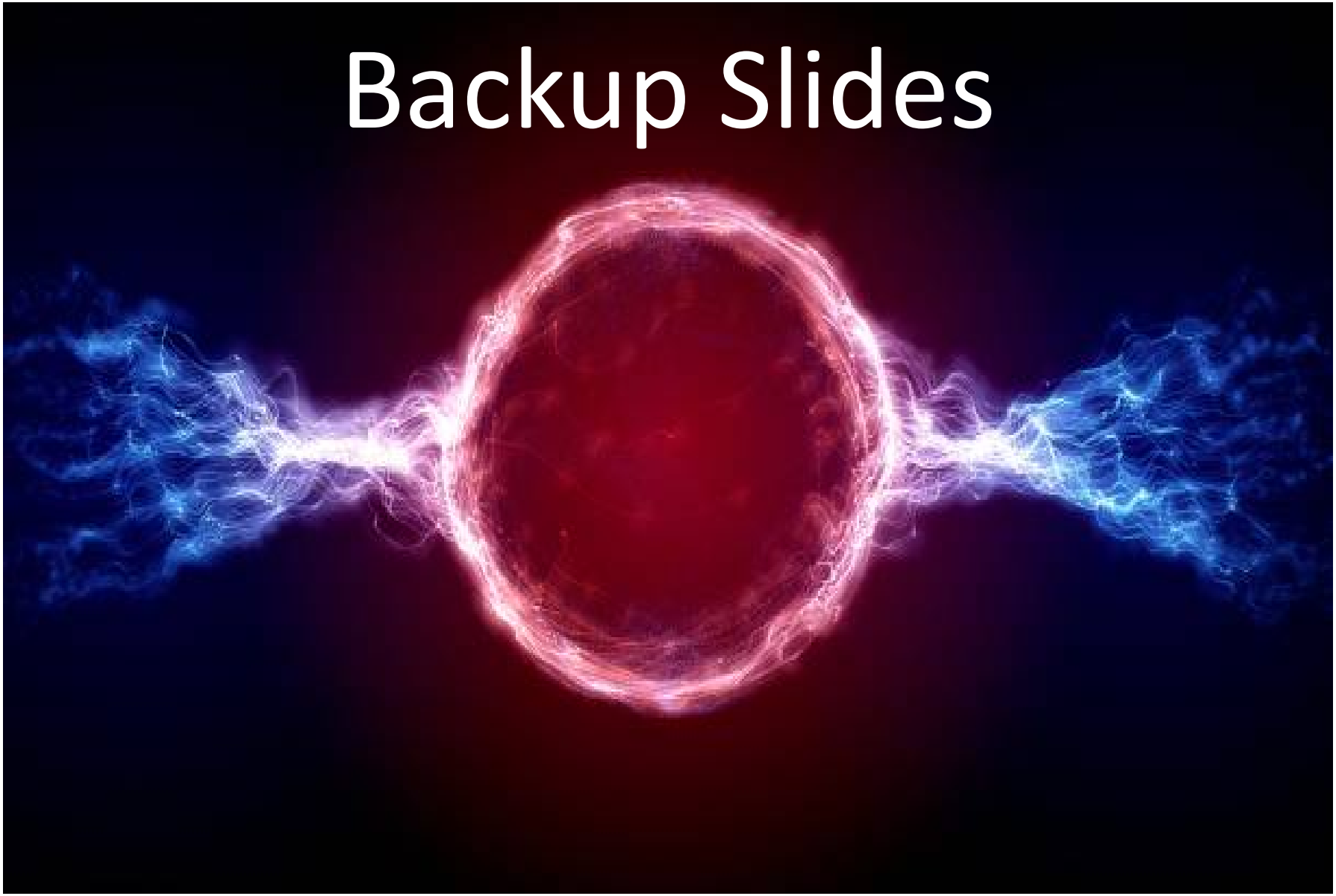
- Design and hazard analysis will determine the scope of requirements needed for a license for the safe use of radioactive materials
- Regardless of the regulatory approach, similar information will be needed to evaluate the design and radiological hazards associated with a commercial fusion facility
- The NRC Commission will make the final decision on the regulatory framework prior to the start of any rulemaking for fusion energy systems

Path Forward

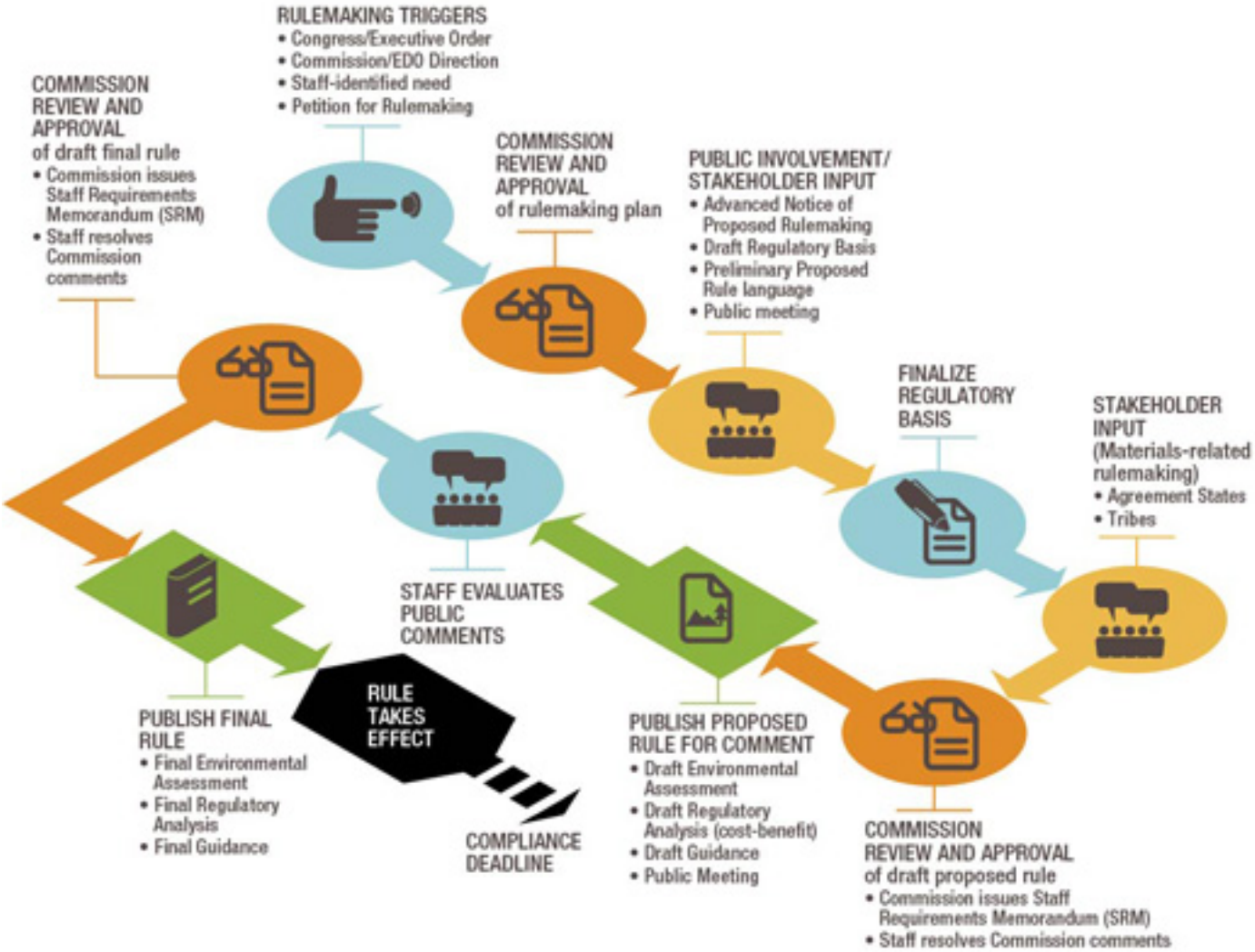
- NRC Developing Technology-Inclusive Regulatory Framework
  - 10 CFR Part 53, “Licensing and Regulation of Advanced Nuclear Reactors”
  - Decide on how to address fusion either within Part 53, within existing regulations, developing new regulations within materials realm, or combination
  - Scope to also include accelerator-driven system designs
- Process to include extensive interaction with public stakeholders

Discussion

Backup Slides

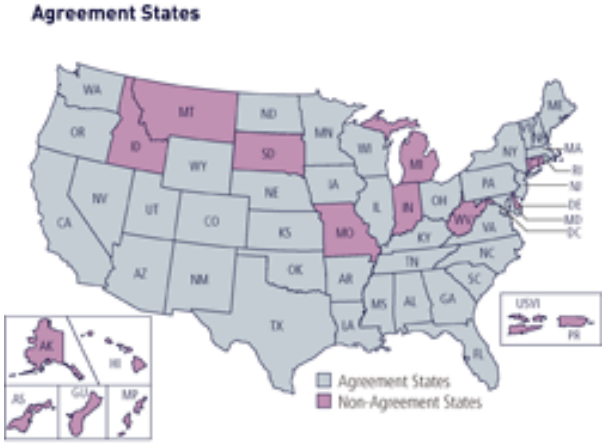


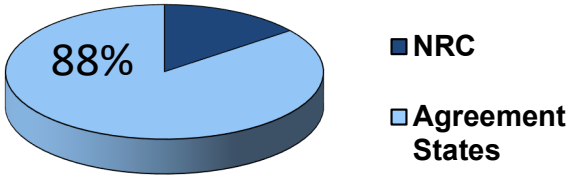
A TYPICAL RULEMAKING PROCESS



Agreement State Program

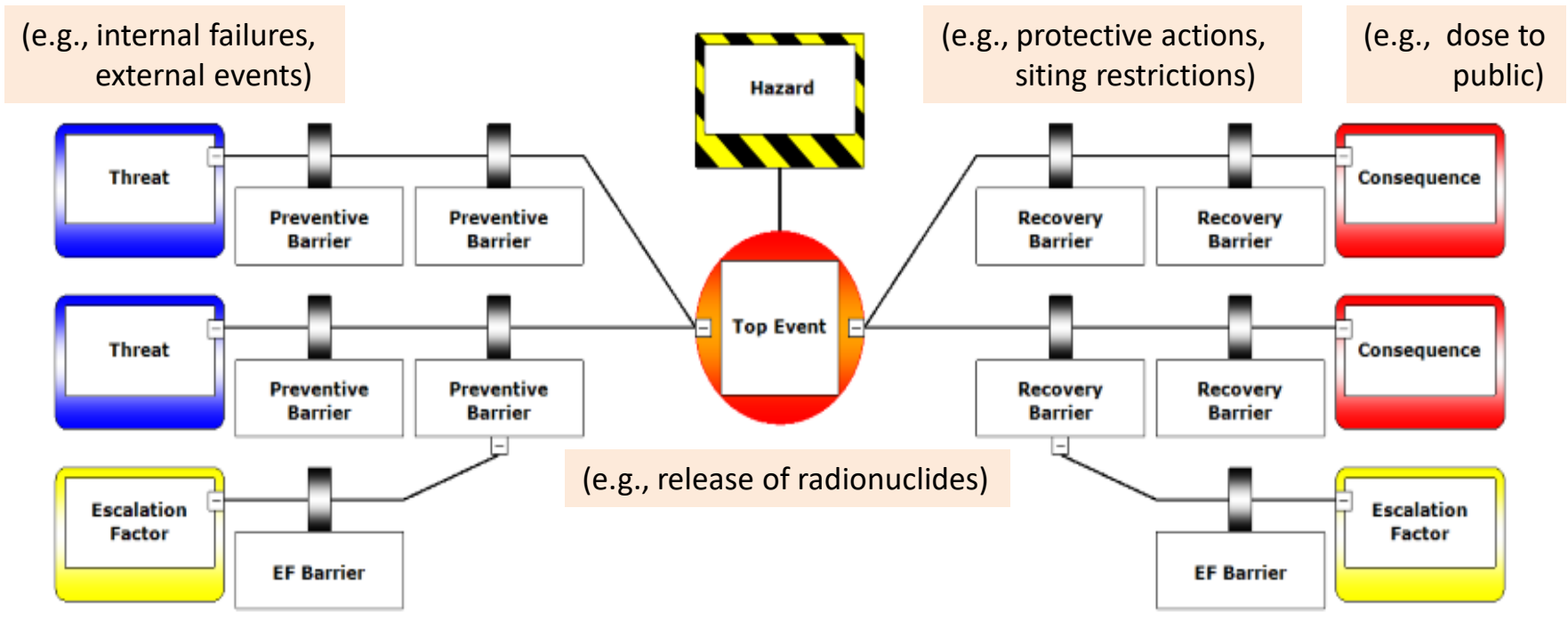
- Section 274 of Atomic Energy Act
  - Established federal/state roles
  - Recognized States' experience
  - Promotes cooperative relationship
  - Promotes orderly regulatory pattern
  - Established in 1959
- First Agreement State in 1962
- Currently 39 Agreement States





Specific Radioactive Material Licenses

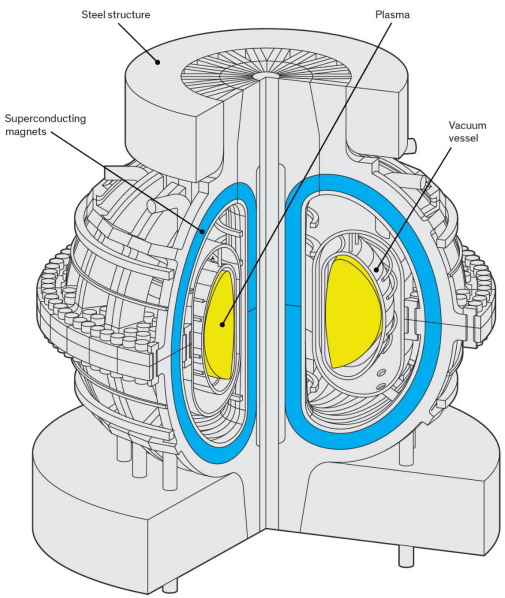
Integrated, Risk-Informed Approach



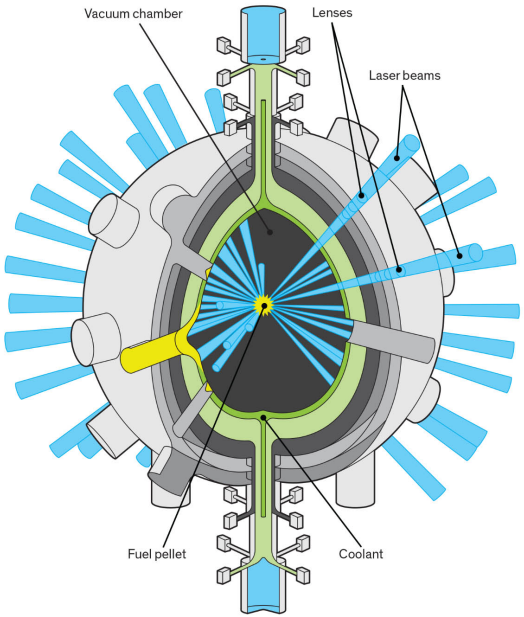
Bow-Tie Risk Management Figure

Fusion Technologies

Magnetic Confinement Fusion

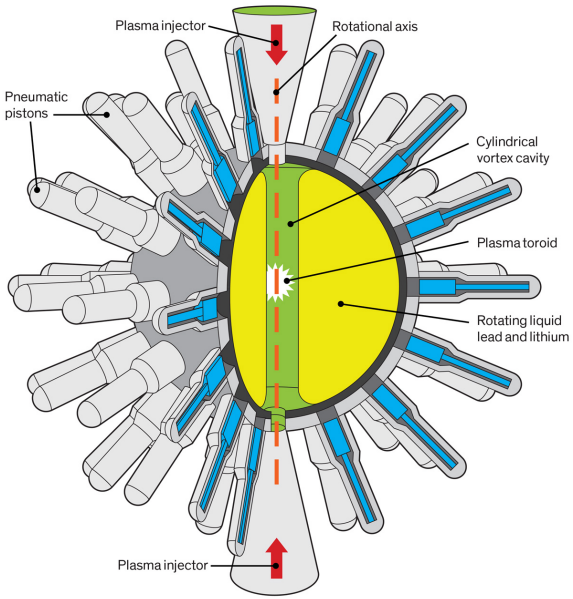


Inertial Confinement Fusion

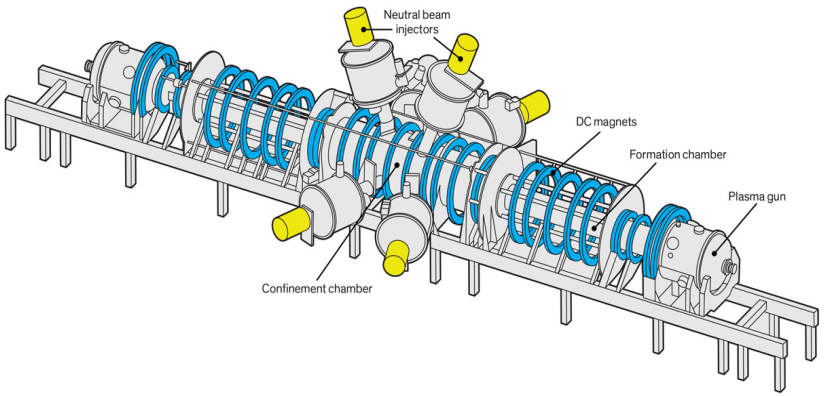


Fusion Technologies

Magnetized Target Fusion

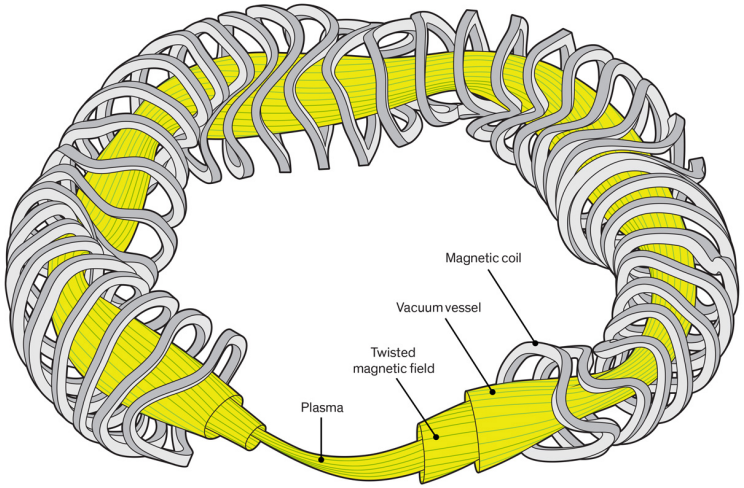


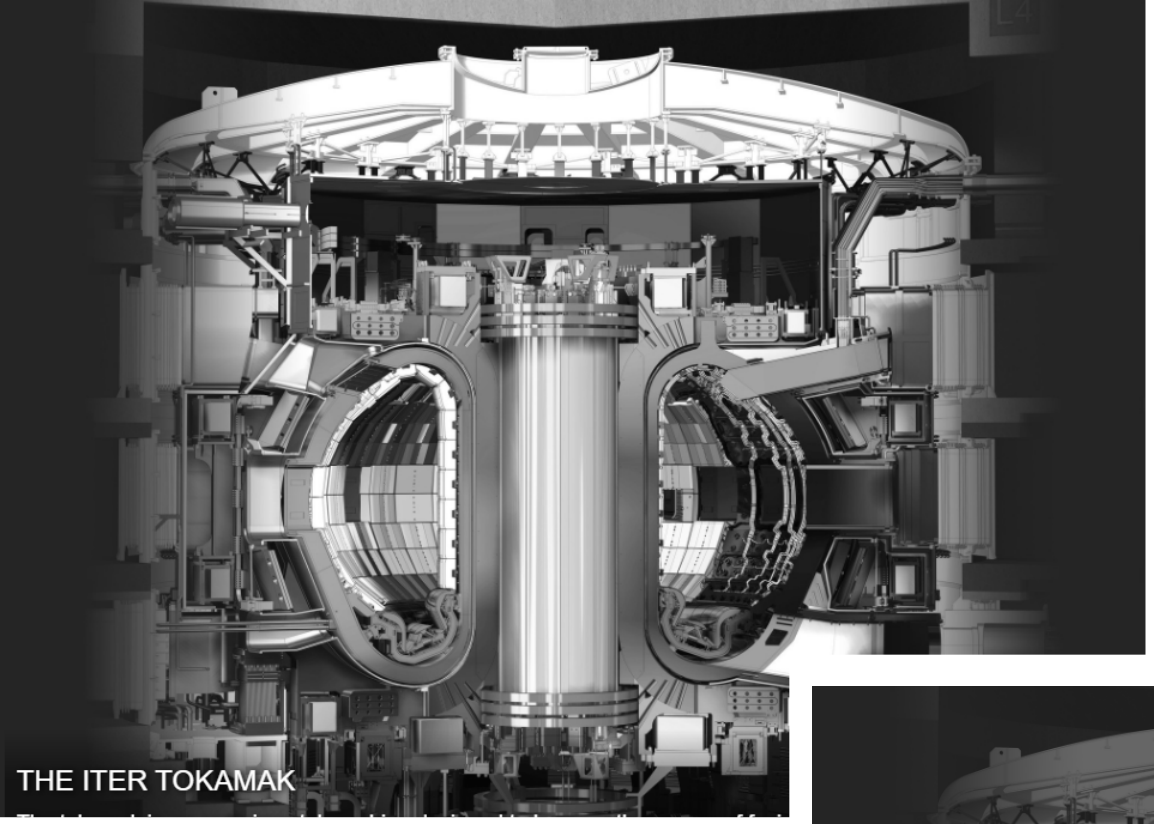
Field Reversed Configuration



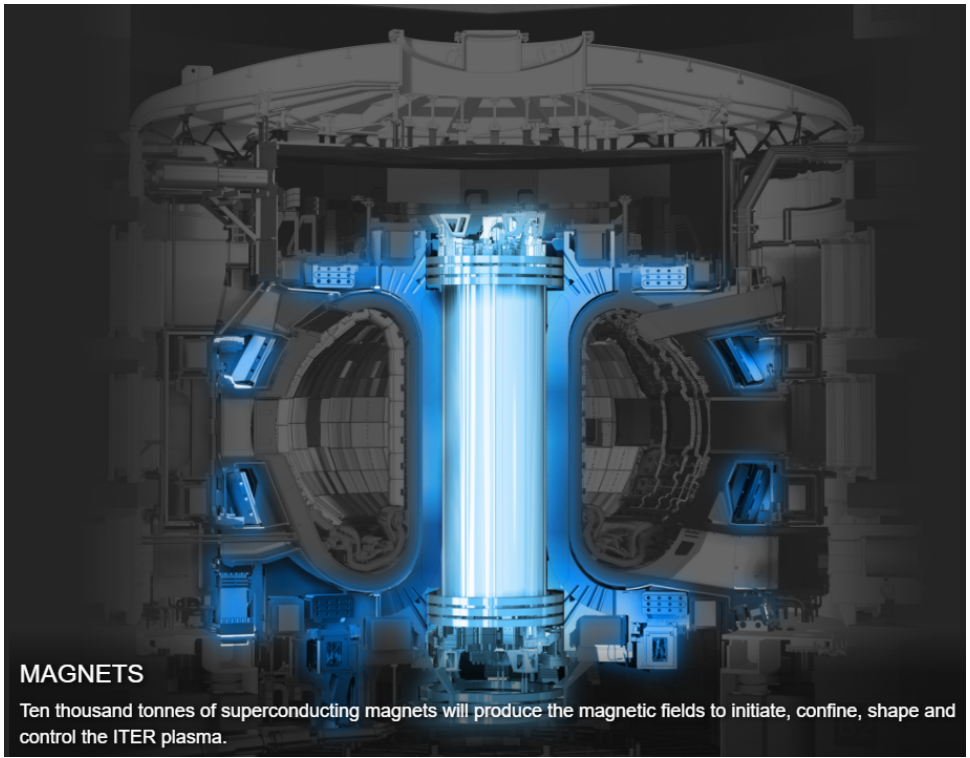
Fusion Technologies

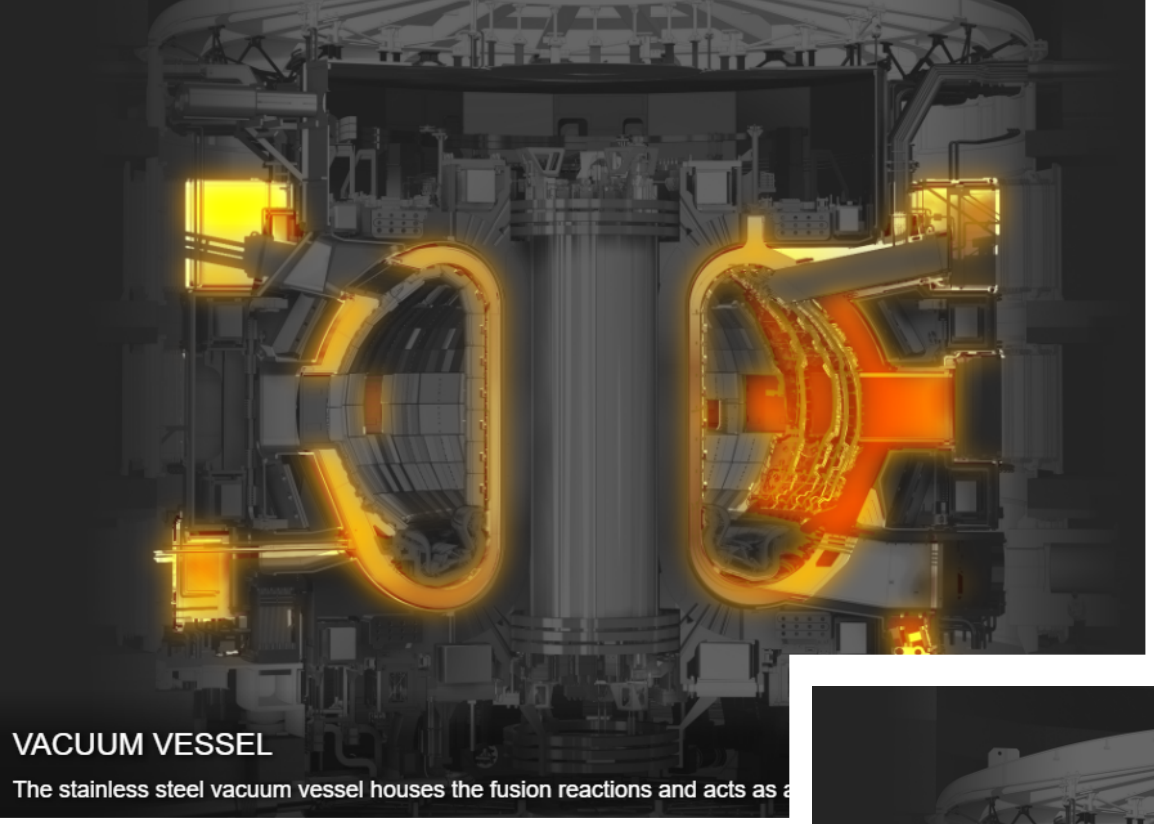
Stellarator





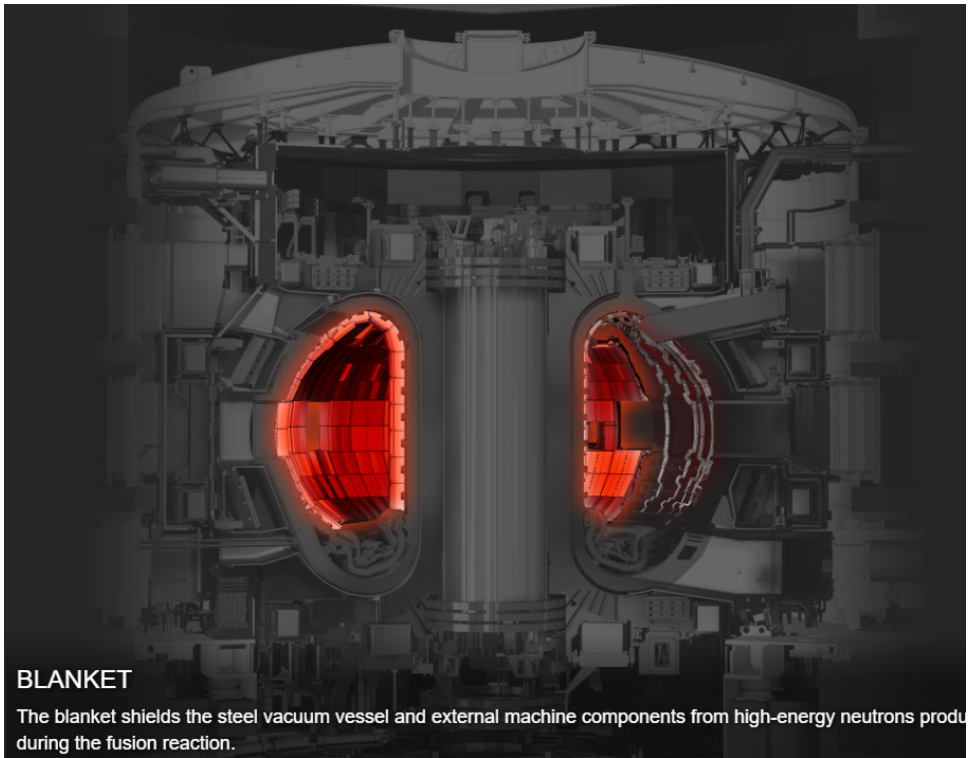
https://www.iter.org/mach





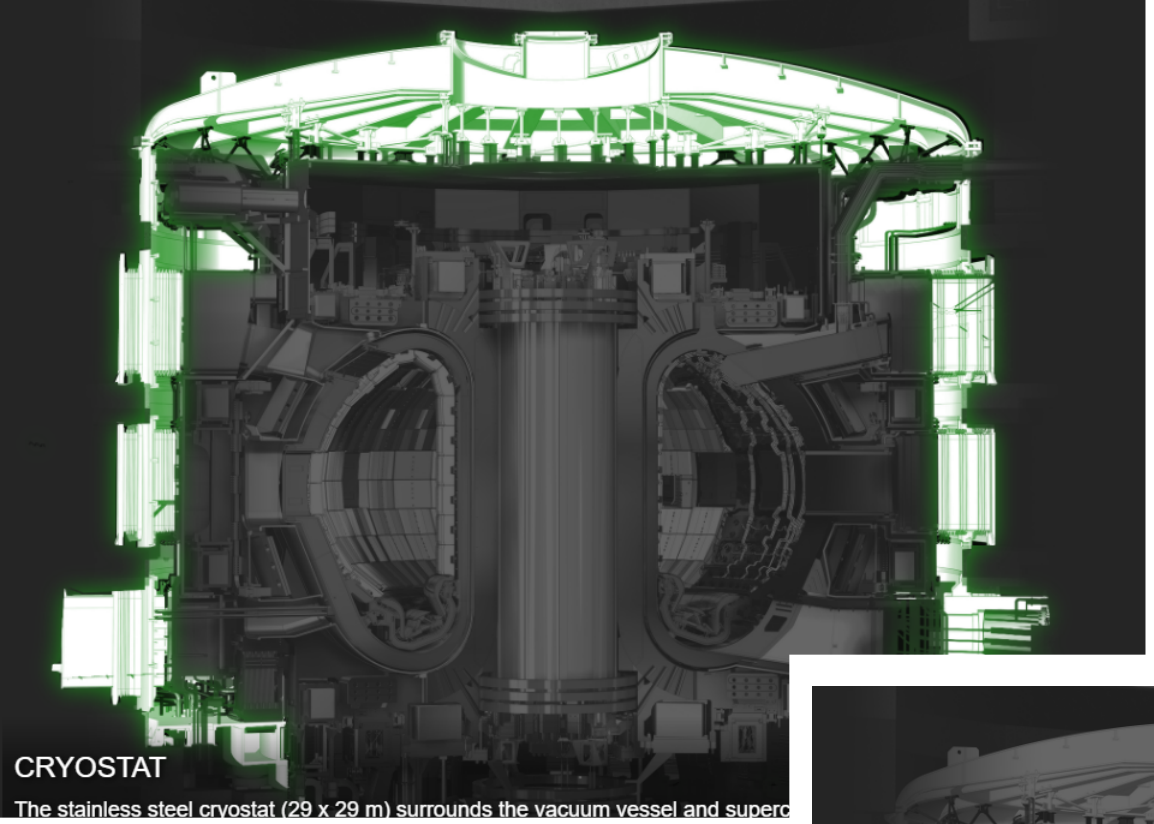
VACUUM VESSEL

The stainless steel vacuum vessel houses the fusion reactions and acts as a



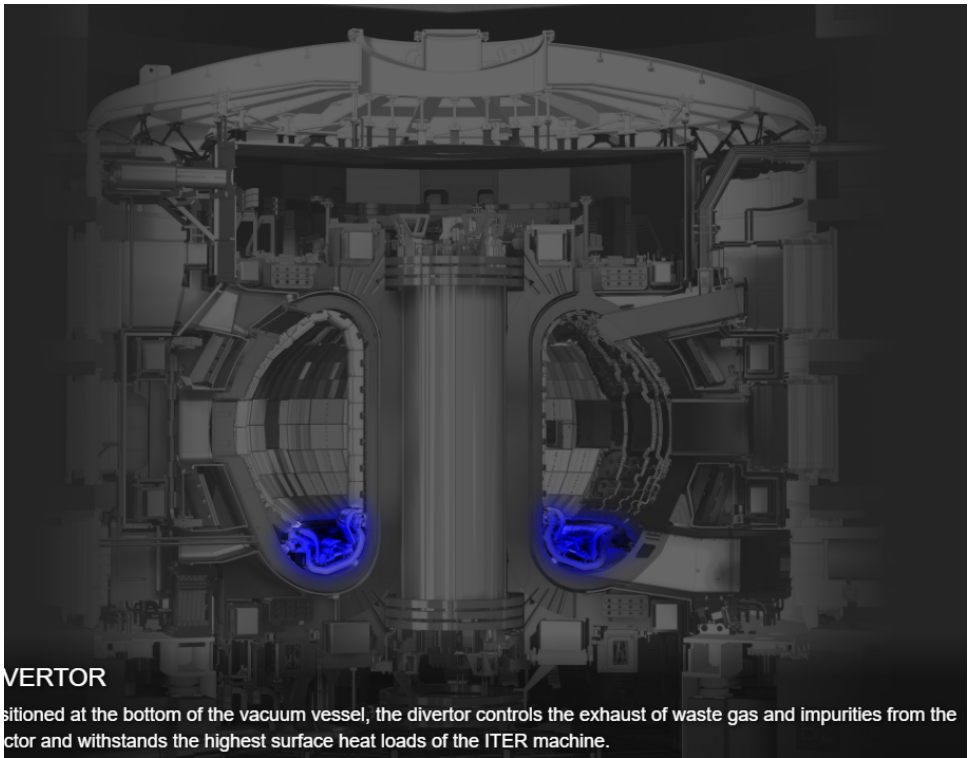
BLANKET

The blanket shields the steel vacuum vessel and external machine components from high-energy neutrons produ during the fusion reaction.



CRYOSTAT

The stainless steel cryostat (29 x 29 m) surrounds the vacuum vessel and superc



VERTOR

sitioned at the bottom of the vacuum vessel, the divertor controls the exhaust of waste gas and impurities from the ctor and withstands the highest surface heat loads of the ITER machine.

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

Commonwealth Fusion Systems
tokamak energy
CTFusion
TYPE ONE ENERGY
tae TECHNOLOGIES
iter

generalfusion
ZAP ENERGY
COMPACT FUSION SYSTEMS
Helion Energy
HYPERJET FUSION CORPORATION

NIF
UR LLE
first light

CTFusion
As Brilliant as the Sun