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Developing a Regulatory Approach for Fusion Energy Systems

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August 17, 2021

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Regulatory Approaches

- Preliminary assessments left open the regulatory approach for commercial fusion reactors
- Likely approaches:

Nuclear (fission) power plants
(Production/Utilization)

Hybrid Approach

Materials (e.g., accelerator)
(Byproduct Material)

Challenge – Regulatory Considerations

- Common defense and security, or public health and safety?
- Does the current definition of “Utilization Facility” in Section 11 of the Atomic Energy Act (AEA) of 1954, as amended, support inclusion of fusion systems?
- Does the current definition of “Byproduct Material” in Section 11 of the AEA, as amended, support inclusion of fusion systems?

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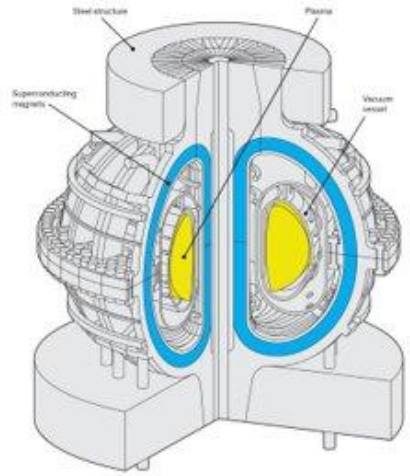
Challenge – Diversity of Designs and Hazards

Fusion Reactions (Fuel)
- **DT**
- pB-11
- DHe-3

Fusion Technologies
- Magnetic
- Magneto-Inertial
- Inertial

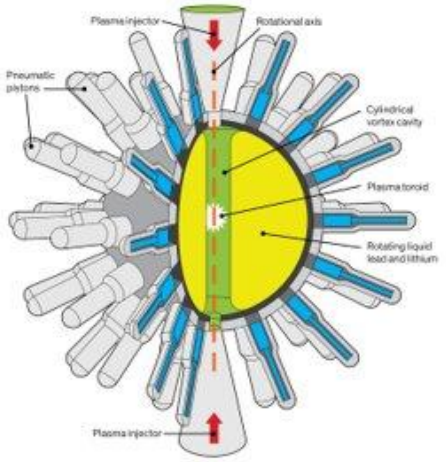
Radiological Hazards
- Potential Accident Scenarios
- Offsite Dose Consequences
- Activation

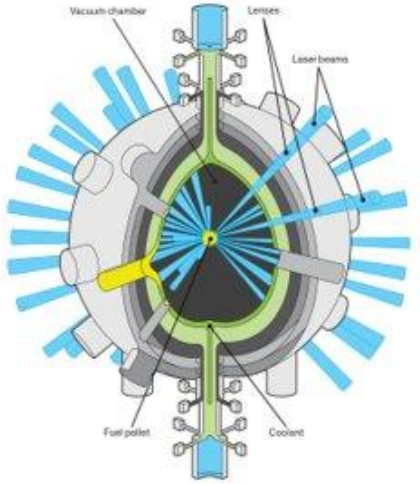
Three General Approaches to Fusion Energy



Magnetic Fusion Energy

Magneto-Inertial Fusion





Inertial Fusion Energy

Production/Utilization

- Legal and technical framework defined in Atomic Energy Act and NRC regulations for utilization facilities (currently those using SNM)
- 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
- Part 53 can accommodate fusion, if utilization approach approved

Challenges and Considerations with Production/Utilization Approach

- Some R&D fusion activities already licensed using byproduct material approach
- Some fusion devices are similar to accelerators/cyclotrons in design and hazards
- Avoiding regulating by exemption
- Devices whose most significant hazards could be non-radiological (e.g., pB-11 devices)
- Are statutory requirements for production/utilization facilities appropriate for all (or some) fusion devices (e.g., Price Anderson Act, foreign ownership, and mandatory hearings)
- Precludes oversight by Agreement States

Byproduct Material

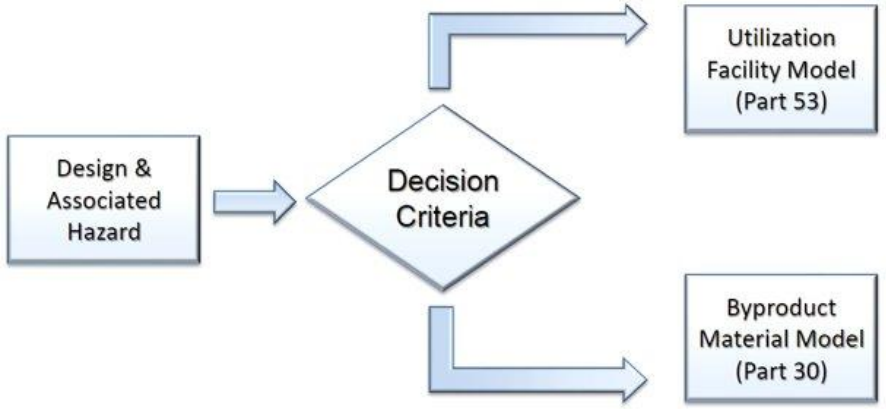
- Legal and technical framework defined in Atomic Energy Act and NRC regulations
- Certain materials made radioactive by use of a particle accelerator are byproduct material
- Guidance for various uses of byproduct material provided in NUREG-1556, “Consolidated Guidance About Materials Licenses”
- Flexibility in safety and environmental reviews given wide range of possible applications

Challenges and Considerations with Byproduct Material Approach

- Regulating the Material versus regulating the Device
- Tritium and Proliferation
- Tritium produced by fusion reaction
- Accelerators as the basis for fusion designs
- Unique devices with non-radiological hazards

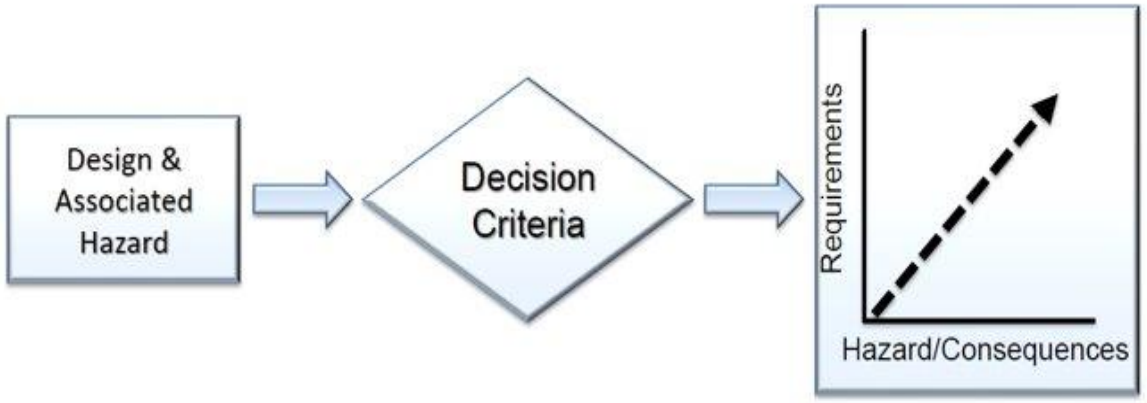
Considerations for Possible Hybrid Approaches

- 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.



Customized Application Approach: use with current framework

Consolidated Approach: use with a dedicated fusion framework



Graded Approach

- A graded approach will likely be needed for all regulatory options presented such that frameworks are commensurate with the anticipated risk/hazards
  - Elements of a utilization facility approach under 10 CFR Part 50, 52 or 53 could be scaled down.
  - Elements of a byproduct approach under 10 CFR Part 30 could be scaled up.
  - A hybrid approach (fragmented or consolidated) needs to be scalable to balance regulatory requirements against a wide variety of designs
- Any scalable approach needs clear and predictable decision-making criteria to ensure consistency and regulatory certainty.
  - External stakeholders can provide insights and allow for a better understanding of fusion technologies and their risks

E-47 Committee on Commercial Nuclear Power

- Monitor and provide input on proposed regulatory framework for Advanced fission and fusion reactors per NEIMA

- Currently developing white paper on fusion regulatory guidance for near-term facilities

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Next Steps

- Continue to engage regulatory partners and stakeholders via public meetings and any other regulatory vehicles to better understand concepts for decision-making criteria.
- November 2021 – Issue Revised White Paper & Second ACRS Briefing
- May 2022 – SECY Paper to Commission

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
- Commission will make the final decision on the regulatory framework prior to the start of any rulemaking for fusion energy systems