

# Fusion Regulatory Framework



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\*Presenting in a personal capacity, opinions are my own

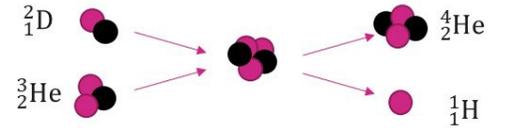
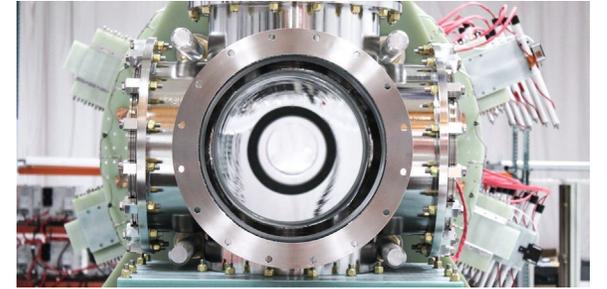
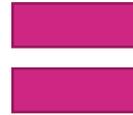
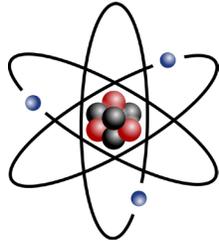
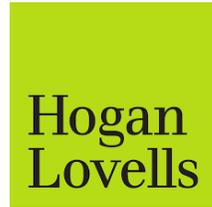
# Agenda

- Background
- Basics of Regulation
- Deep Dive – NRC Regulation
  - Choosing a Framework
  - Going Forward
- Life Lessons

# Background

# My Background

Cornell  
*Racing*



# Helion Background

- Fusion power company founded in 2013
- Based in Everett, WA
- 160+ team members
- First private company to reach 100 M°C

See our Profile on Real Engineering!

<https://www.youtube.com/watch?v=bDXXWQxK38>

# Helion's Technology: How it Works

## 1. Formation

Deuterium and helium-3 are heated to plasma conditions and confined in an FRC.

## 2. Acceleration

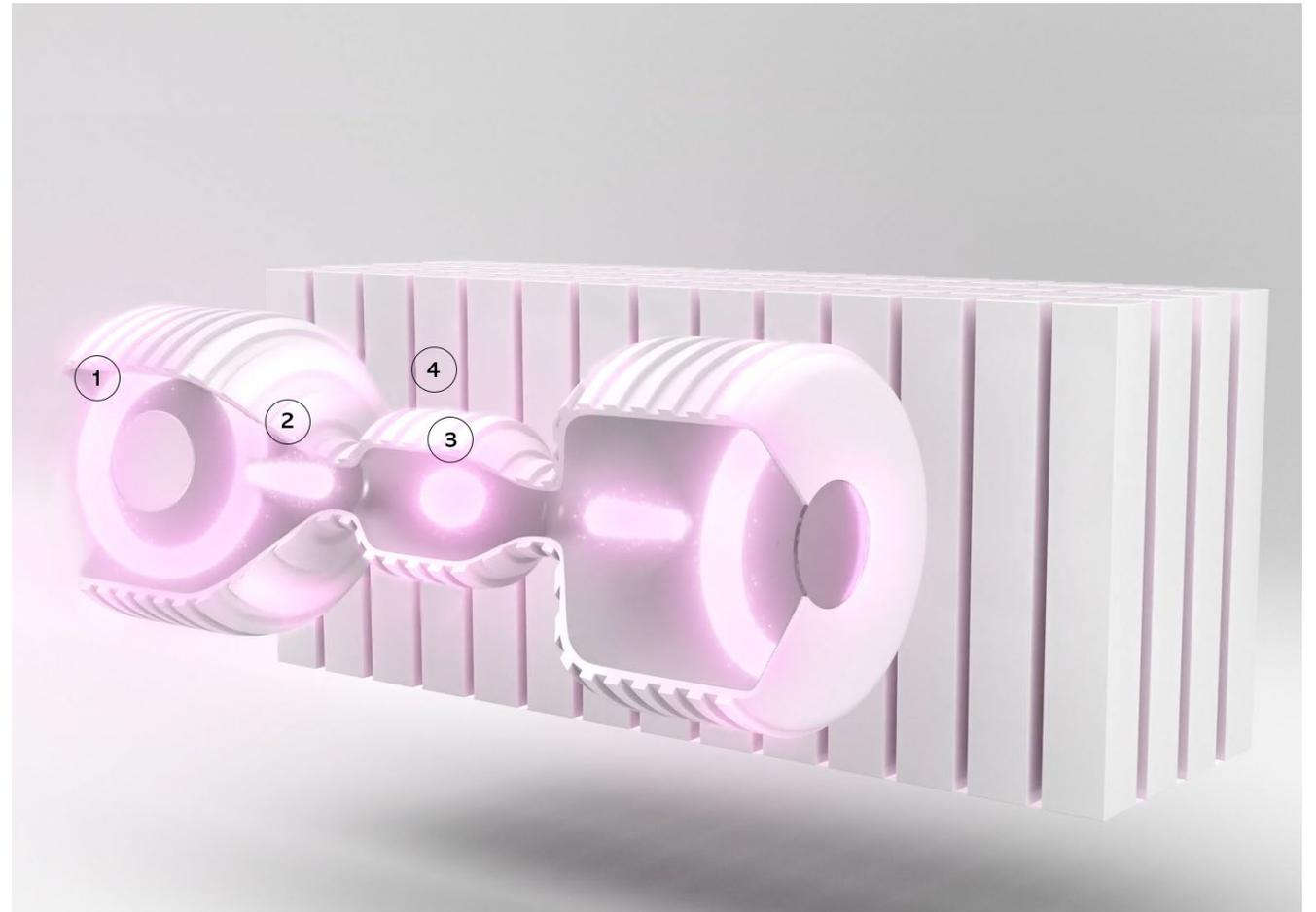
Magnets accelerate the FRCs until they collide in the center of the device.

## 3. Compression

The merged plasma is compressed by a magnetic field to fusion conditions.

## 4. Energy recovery

The plasma expands and energy is directly recaptured.



# Basics of Regulation

# Why Regulation

- Protects Interests of Third Parties
- Builds Public Acceptance
- Enables Scaling

*(When Done Right)*



Home ▶ NRC Library ▶ Document Collections ▶ Regulations (NRC, 10 CFR)

## PART 30—RULES OF GENERAL APPLICABILITY TO DOMESTIC LICENSING OF BYPRODUCT MATERIAL

[Full Text Version](#) (290.04 KB)

### General Provisions

#### Sec.

[30.1 Scope.](#)

[30.2 Resolution of conflict.](#)

[30.3 Activities requiring license.](#)

[30.4 Definitions.](#)

[30.5 Interpretations.](#)

[30.6 Communications.](#)

[30.7 Employee protection.](#)

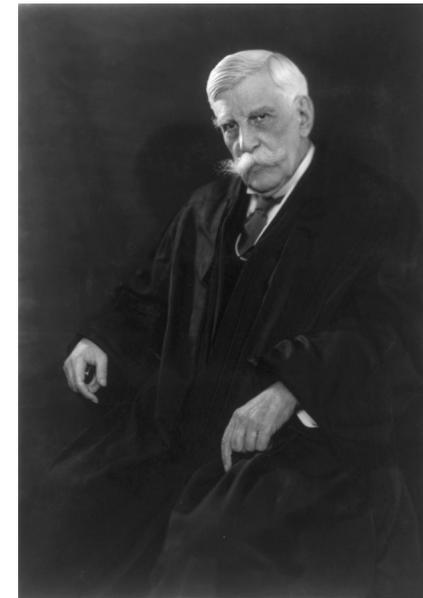
[30.8 Information collection requirements: OMB approval.](#)

[30.9 Completeness and accuracy of information.](#)

[30.10 Deliberate misconduct.](#)

#### Exemptions

[30.11 Specific exemptions.](#)



Oliver Wendell Holmes

# How Regulation



## Congress delegates to agencies

- High-level guidance (“intelligible principle”)
- Deference to agency technical decisions (decreasing)
- Court oversight (increasing)

# Key Aspects

**Framework**  
(e.g., Atomic Energy Act)



**Rules**  
(e.g., 10 CFR Parts XX)

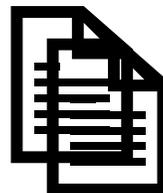
- Establishes limited but key requirements (e.g., # of licensing steps)
- Different frameworks for different public perceptions of risk
- Placement w/in a framework driven by legal reading (but not always)

- Establishes detailed substantive requirements w/in a framework
- Technically driven, but language always litigated (“single-fault tolerant”)
- Rules often supplemented by guidance

1 page of  
statute



100 pages  
of rules

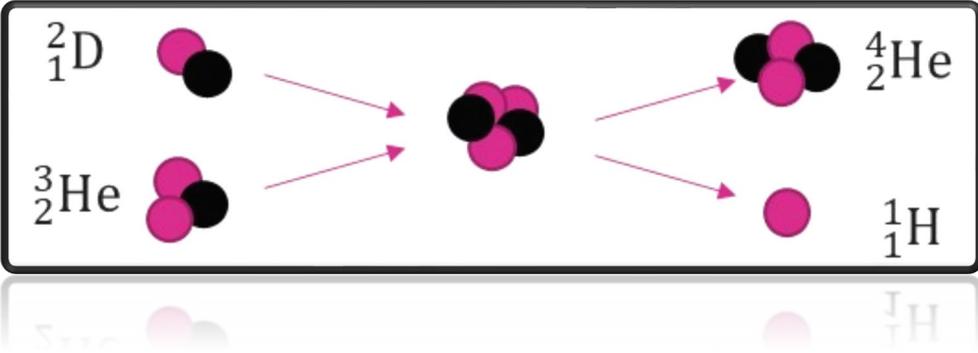


10,000 pages  
of guidance

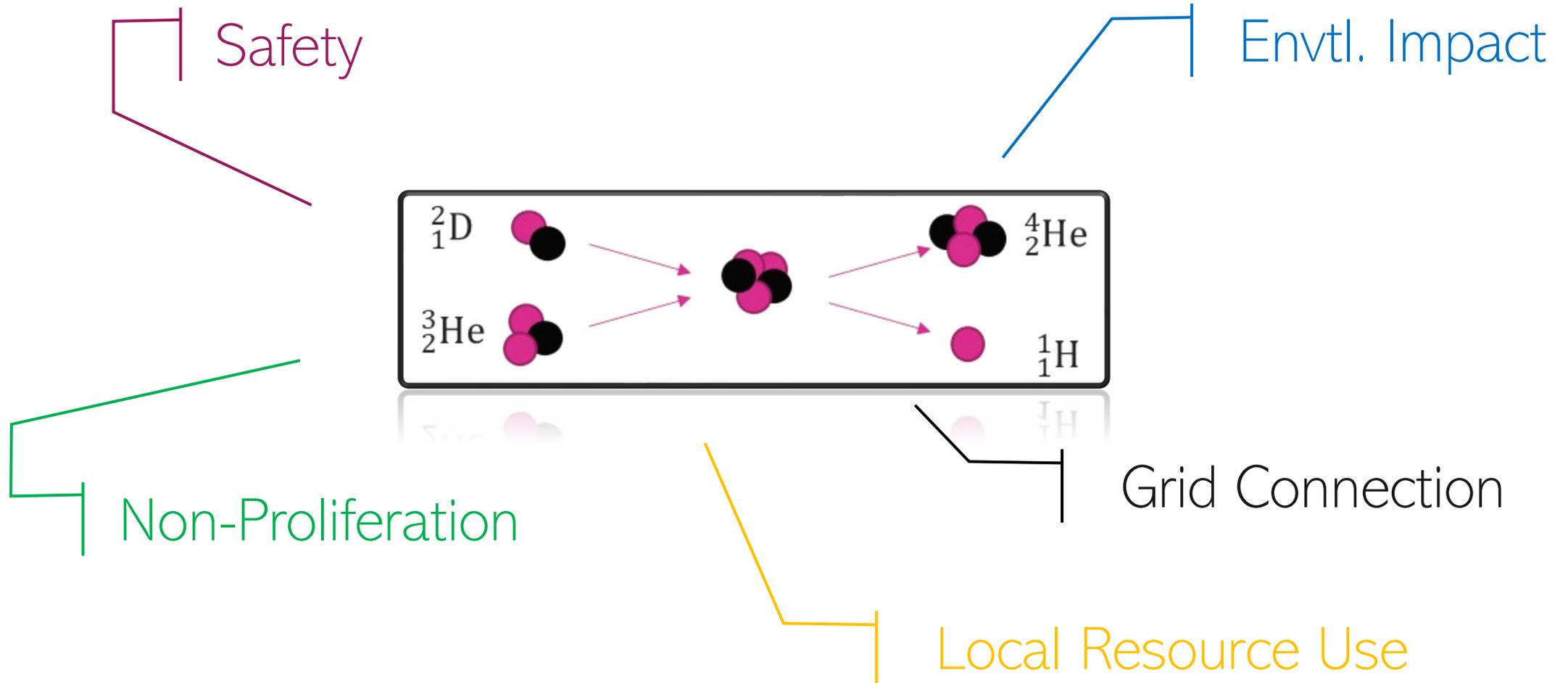


# Deep Dive – NRC Regulation

# Why Regulation of Fusion Energy



# Why Regulation of Fusion Energy



# Sample Laws to Consider

- Atomic Energy Act (Safety & Security)
- National Environmental Policy Act
- Treaty on the Non-Proliferation of Nuclear Weapons
- Federal Power Act
- Nuclear Energy Innovation Modernization Act
- Energy Policy Act
- Price Anderson Act
- Occupational Safety and Health Act
- Clean Air Act
- Clean Water Act
- Nuclear Waste Policy Act
- Energy Reorganization Act
- State health and safety laws
- State environmental laws
- State tort laws
- State utility laws
- Convention on Nuclear Safety
- International Safeguards Agreements
- Paris & Vienna Conventions
- Convention on Supplementary Compensation
- Statute of the IAEA
- *And more!!*



# Deep Dive – NRC Regulation

## Choosing a Framework

# Atomic Energy Act – Framework Options



Materials Framework  
(Industrial Facilities &  
Particle Accelerators)  
("Parts 30-39")



Utilization Facility Framework  
(Nuclear Reactors)  
("Parts 50-53")

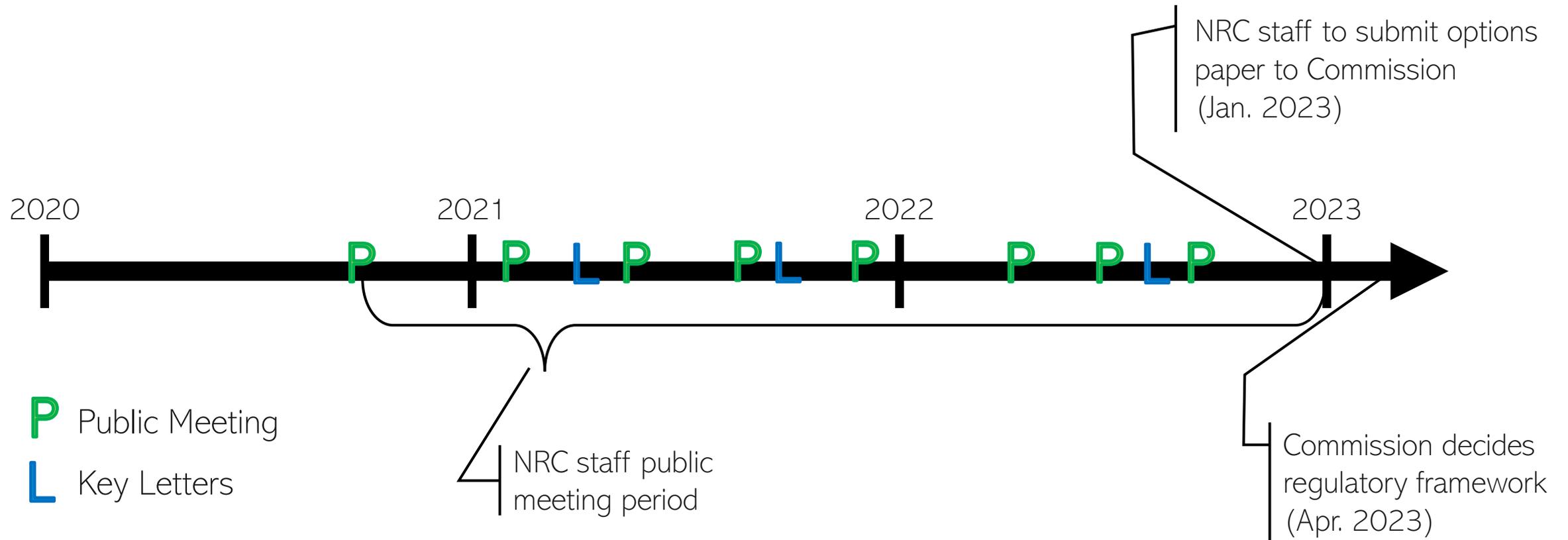


Hybrid Framework

Atomic Energy Act mentions of fusion = 0

Provides space for techno-legal evaluation

# NRC Public Meeting Process – Framework Selection



# Techno-Legal Case – Fitting Fusion

## **Two Definitions of Accelerators**

### **Energy Policy Act of 2005 Rulemaking (72 FR at 55,868)**

“A particle accelerator is a device that imparts kinetic energy to subatomic particles by increasing their speed through electromagnetic interactions.”

### **NRC Regulations (10 CFR 30.4)**

“*Particle accelerator* means any machine capable of accelerating electrons, protons, deuterons, or other charged particles in a vacuum and of discharging the resultant particulate or other radiation into a medium at energies usually in excess of 1 MeV.”

***Potential threshold question as to how fusion fits within the US radiological protection framework***

Source: January 6, 2021 Presentation to NRC

# Techno-Legal Case

## Two Definitions of Accelerators, cont.

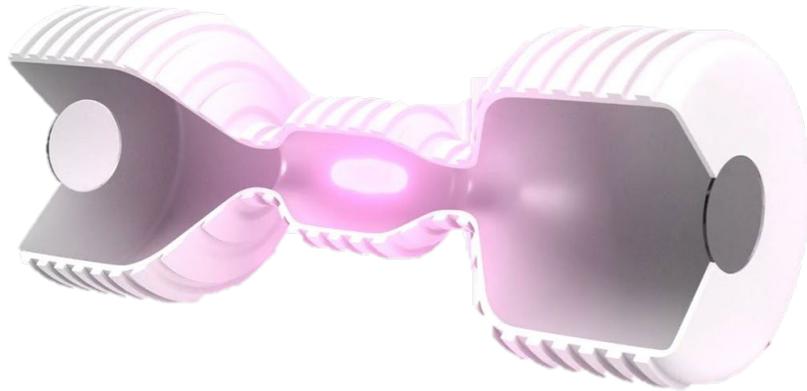
### Energy Policy Act of 2005 Rulemaking (72 FR at 55,868)

"A particle accelerator is a device that imparts kinetic energy to subatomic particles by increasing their speed through electromagnetic interactions."

- ✓ **All fusion devices** impart kinetic energy (i.e., raise temperature)
- ✓ **All fusion devices** use subatomic particles (i.e., plasma)
- ✓ **All fusion devices** work via electromagnetic interactions (e.g., magnets, magnetic fields, lasers, plasma "pinches")

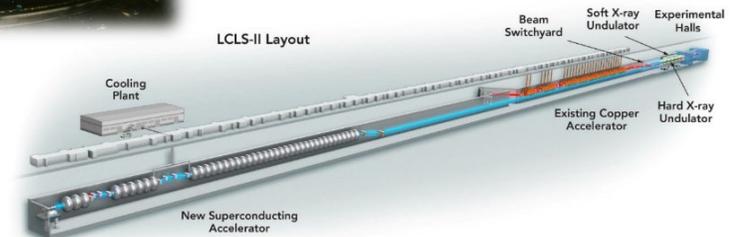
# Techno-Legal Case

## Fusion Device



- Neutron and photon radiation
- In-process fuel/accelerated particles and exhaust
- Activated shielding

## Accelerator (inc. Cyclotron)



- Neutron and photon radiation
- In-process fuel/accelerated particles and exhaust
- Activated shielding

**Key Concept: Fusion's impacts are fundamentally similar to that of a particle accelerator.**

# Techno-Legal Case

## Analysis Results for Accident Scenario 2

FUSION  
INDUSTRY  
ASSOCIATION

**Description:** VV is punctured, building walls and filtration and/or detritiation are damaged such that there is 10% leakage of HTO

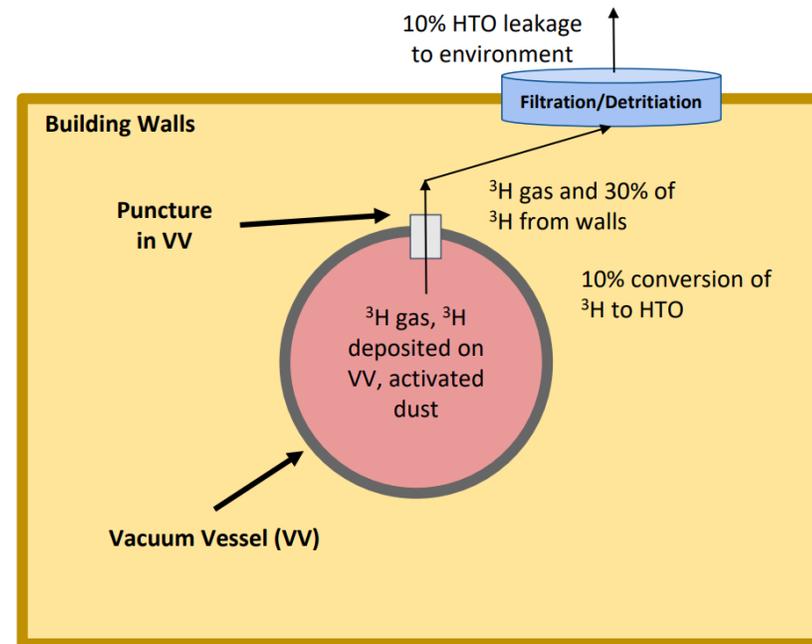
- All tritium gas and 30% of tritium on wall leaves the VV
- Of the tritium leaving VV, 10% is converted to HTO
- 10% of HTO is released into the environment at a release height of 10 m (height of building)

**HTO Emitted = 0.15g**

- $(0.1 \text{ g} + (.3)(50 \text{ g}))(.1)(.1) = 0.15 \text{ g}$
- $(^3\text{H Gas} + (\% \text{ off wall})(^3\text{H on wall}))(\% \text{ to HTO})(\% \text{ leak}) = \text{HTO emitted}$

**Offsite Impact: < 40 mrem** ← *Less than the 100 mrem annual public dose limit to the public*

The United Kingdom Atomic Energy Authority calculated a one in a million in one year probability of this level of accident occurring in one year, using the REPPiR 2019 approved code of practice



- Dept. for Business, Energy & Industrial Strategy, "Towards Fusion Energy: The UK Government's proposals for a regulatory framework for fusion energy," Presented to Parliament by Sec. of State for Bus., Energy, and Industrial Strategy by Command of Her Majesty, (2021).
- Fusion Safety Authority, "Technology Report – Safety and Waste Aspects for Fusion Power Plants," UKAEA, UKAEA-RE(21)01, Issue 1, (2021).
- Radiation (Emergency Preparedness and Public Information) Regulations (REPPiR), (2019).
- P. Ebey, "Conversion of Tritium Gas into Tritiated Water (HTO): A Review with Recommendations for use in the WETF SAR" LA-UR-01-1825.
- A. Bell, "The Safety Case for JET D-T Operation," JET-P, (1999).

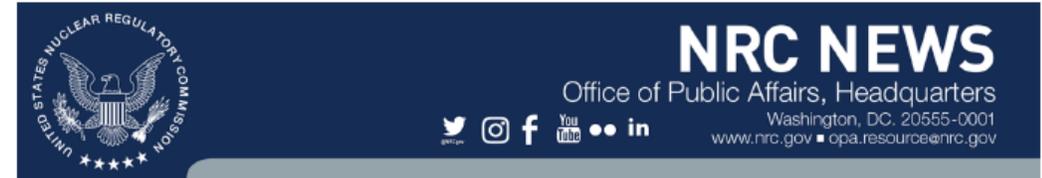
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Source: March 23, 2022 Presentation to NRC

# Findings

- NRC Staff – Hybrid Approach
  - Part 30 can handle fusion & can scale
  - Unclear on how to address unknown unknowns
- Commission – Materials Framework Approach
  - Part 30 works, let's use that

*NRC Chair Christopher T. Hanson:* “Licensing near-term fusion energy systems under a byproduct material framework will protect public health and safety with a technology-neutral, scalable regulatory approach.”

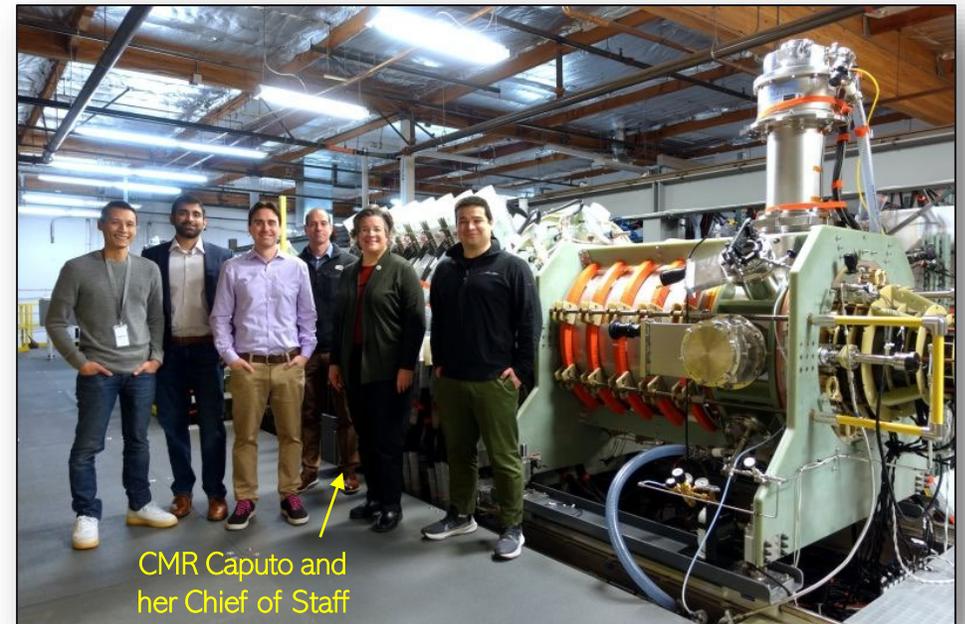


No: 23-029  
CONTACT: [Scott Burnell](#), 301-415-8200

April 14, 2023

## **NRC to Regulate Fusion Energy Systems Based on Existing Nuclear Materials Licensing**

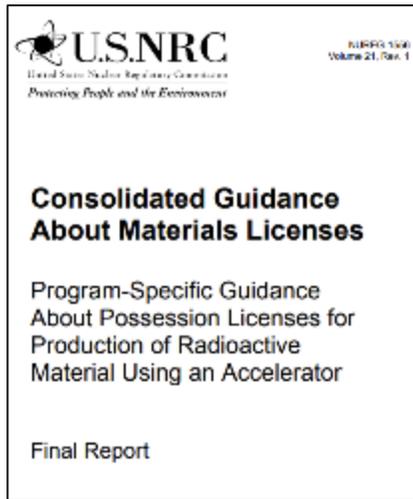
The Nuclear Regulatory Commission has [directed the staff](#) to create a regulatory framework for fusion energy systems, building on the agency's existing process for licensing the use of byproduct materials.



# Deep Dive – NRC Regulation

Going Forward

# Implementation of Materials Framework



## Available Vehicles

Guidance  
(e.g., NUREG rev.)



New Part  
(e.g., Part 38)

<a href="#">Part 30</a>	Rules of general applicability to domestic licensing of byproduct material
<a href="#">Part 31</a>	General domestic licenses for byproduct material
<a href="#">Part 32</a>	Specific domestic licenses to manufacture or transfer certain items containing byproduct material
<a href="#">Part 33</a>	Specific domestic licenses of broad scope for byproduct material
<a href="#">Part 34</a>	Licenses for industrial radiography and radiation safety requirements for industrial radiographic operations
<a href="#">Part 35</a>	Medical use of byproduct material
<a href="#">Part 36</a>	Licenses and radiation safety requirements for irradiators
<a href="#">Part 37</a>	Physical protection of category 1 and category 2 quantities of radioactive material
	
<a href="#">Part 38</a>	Licenses and radiation safety requirements for well logging

## NRC Considerations

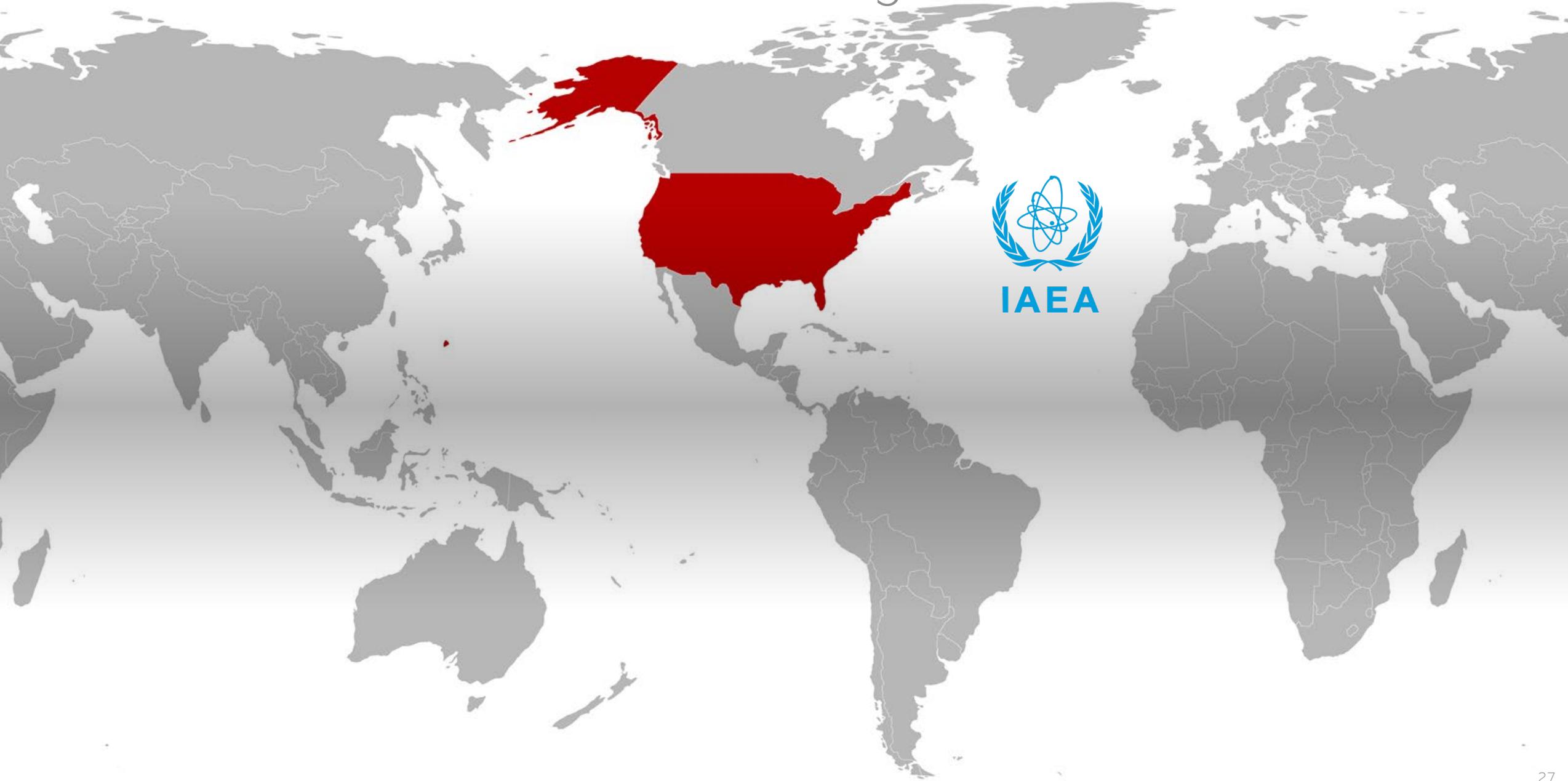
- Legal permissibility (role of guidance vs. rules to incorporate desired controls)
- Ability to support Agreement State implementation
- Ease of resolution (simplest path often best path)



# Tritium Management



# International Regulation



# Factory Production



Source: Boeing / Creative Commons

# Life Lessons

# “Winning” at Nuclear Regulation Is Not Everything



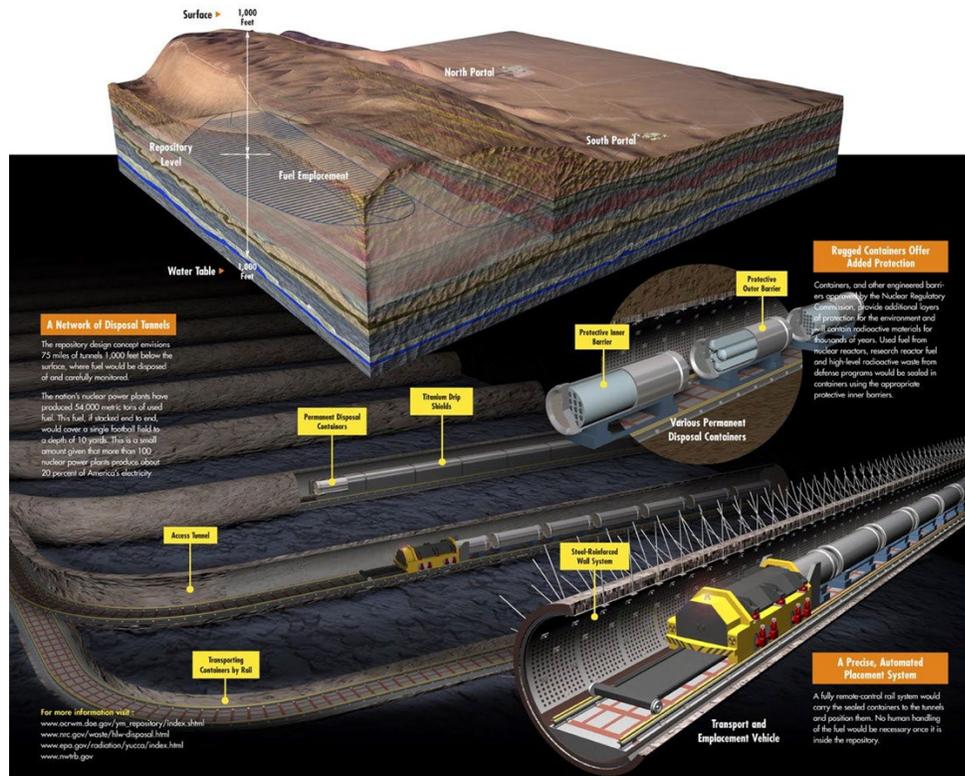
Indian Point Nuclear Power Plant

# Today's Regulatory Battles Reflect Past Challenges



Crow Butte Uranium Mine

# Regulatory Approval is Only Part of Public Acceptance



Yucca Mountain DOE Slide

## Features of the Social License Method

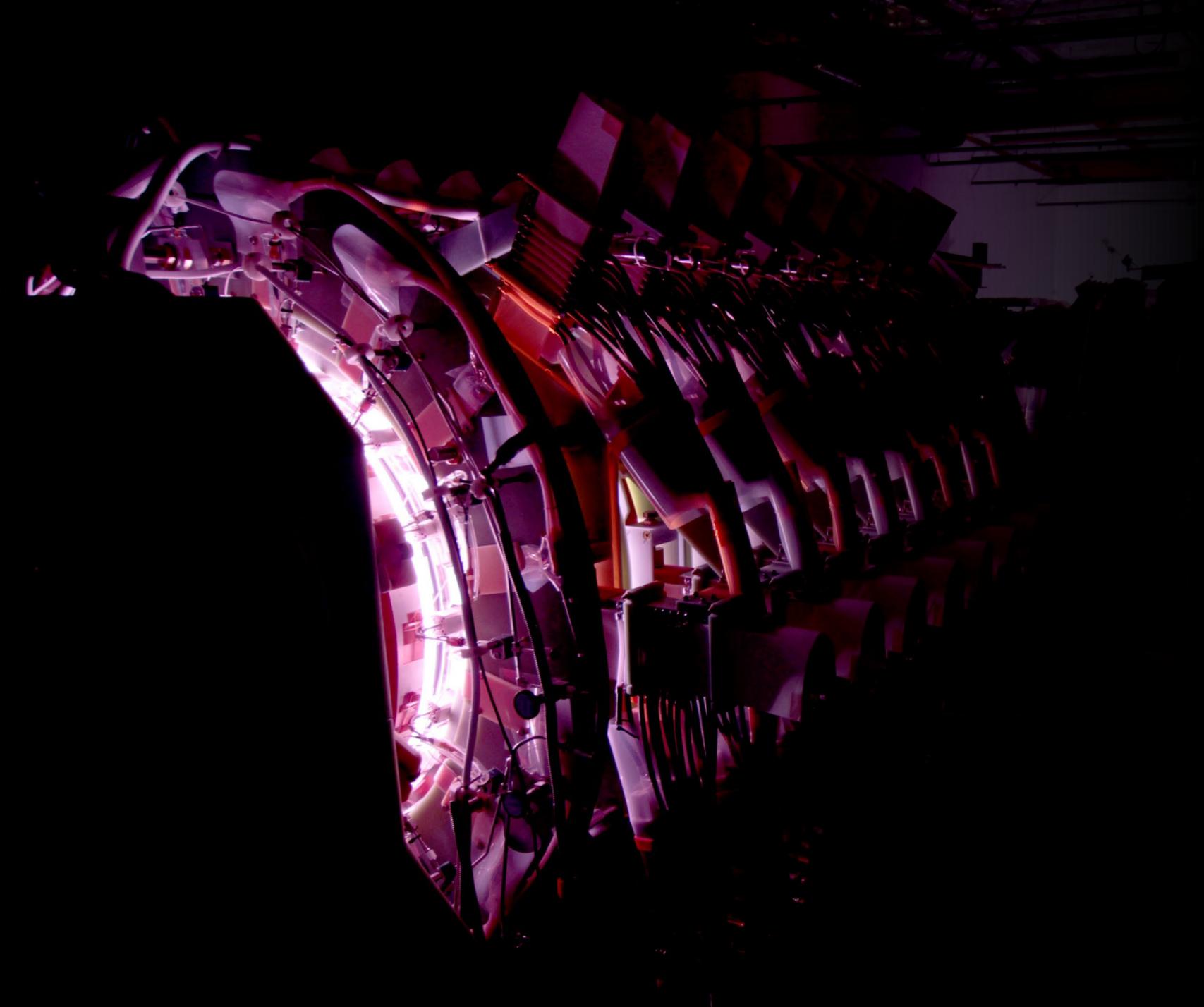
A two-way **process** that opens expertise to new questions and perspectives:<sup>1</sup>

- More than "education," public relations, or "letting the public see the experts at work"<sup>2</sup>
- Project proponents have to learn from and meaningfully consider input from non-experts
- Addresses what people actually worry about, rather than what they "should" worry about
- Creates a sense of "procedural justice," even for opponents of a particular activity<sup>3</sup>
- Acts as a form of peer review that generally improves outcomes for proponents and society<sup>4</sup>

Far more than a legal license or permit<sup>5</sup>: successful examples see regulatory compliance as only a starting point for social acceptance<sup>6</sup>

1. Stilgoe, J. The received wisdom: opening up expert advice. Demos, London, 2006. <https://www.demos.co.uk/files/receivedwisdom.pdf>
2. Raman, S, Mohr, A. "A social license for science: capturing the public or co-constructing research?." *Social Epistemology* 28:258-276 (2014).
3. Ollinger, G. "Changing Knowledge, Local Knowledge, and Knowledge Gaps: STS Insights into Procedural Justice." *Science, Technology, & Human Values* 38:250 (2013).
4. Reed, MS. "Stakeholder participation for environmental management: A literature review." *Biological Conservation* 141:2417-2431 (2008).
5. Rooney, D., Leach, J., Ashworth, P. "Doing the Social in Social License." *Social Epistemology* 28:209-218 (2014).
6. Gunningham N, Kagan RA, Thornton D. "Social license and environmental protection: why businesses go beyond compliance." *Law & Social Inquiry* 29:307-341 (2004).

Source: Seth Hoedl Presentation to NRC (March 30, 2021)



Questions?

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