

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

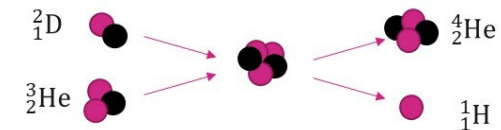
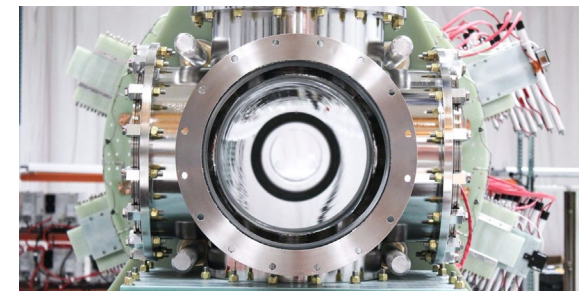
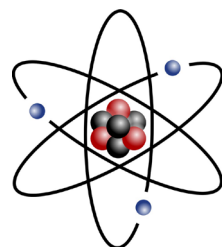
Background

My Background

Cornell
Racing



Hogan
Lovells



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

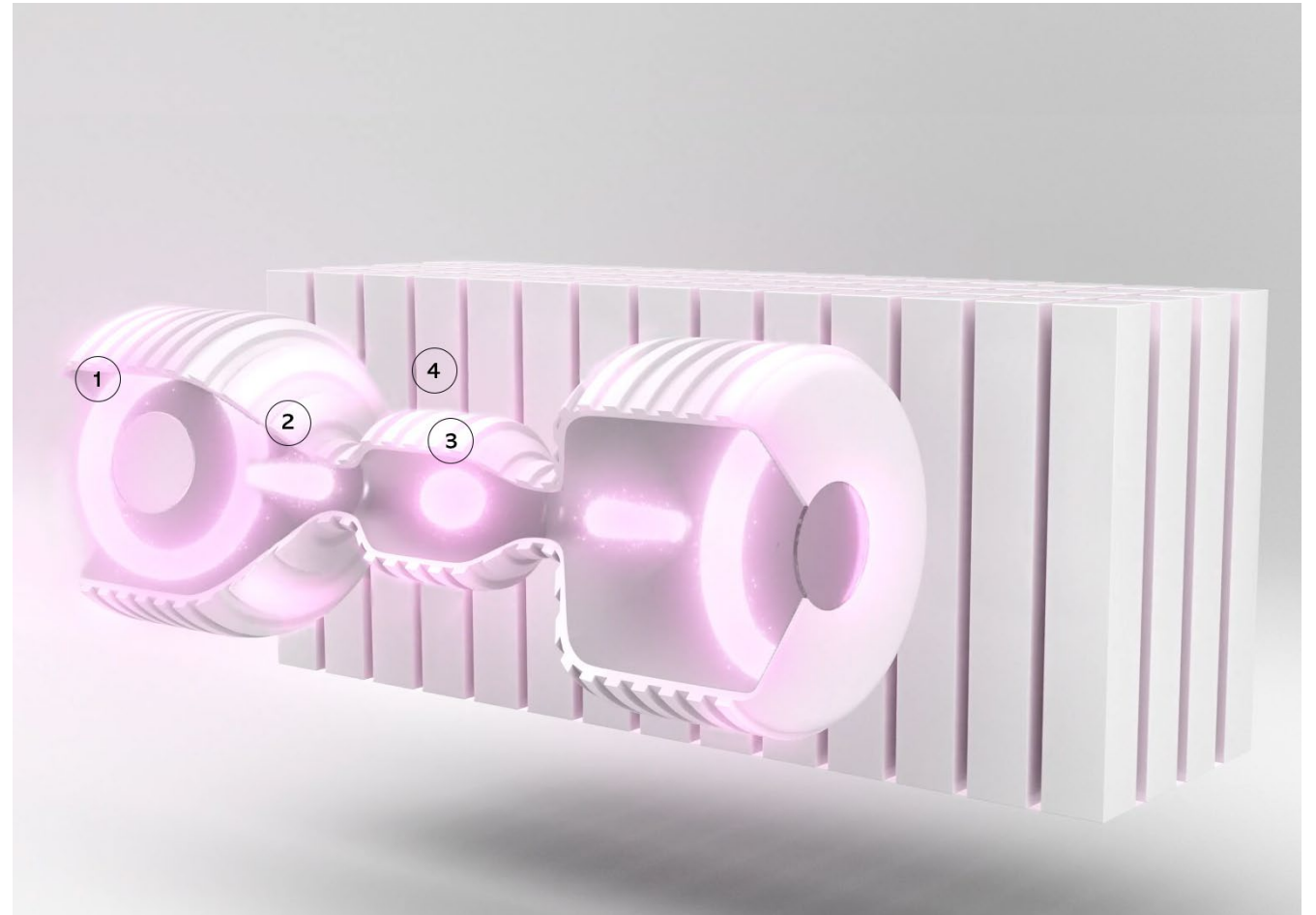
Magnets accelerate the FRCs until they collide in the center of the device.

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

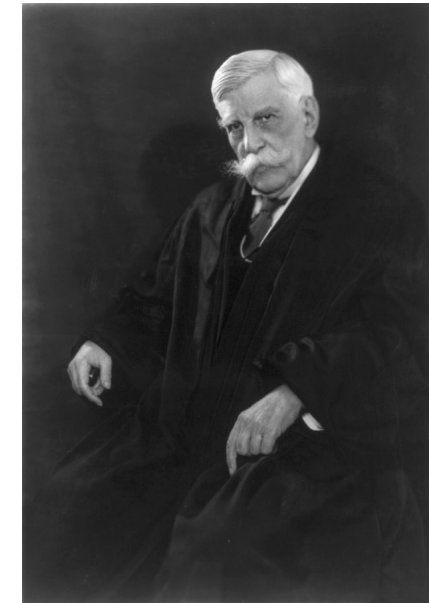
Why Regulation

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

(When Done Right)



The screenshot shows the U.S. Nuclear Regulatory Commission (NRC) website. The header includes the NRC logo, navigation links (FAQ, AGREEMENT STATES, FACILITY LOCATOR, WHAT'S NEW, SITE HELP, INDEX A-Z, CONTACT US, EMAIL UPDATES), a 'REPORT A SAFETY CONCERN' button, and a search bar. Below the header is a navigation menu with links to NUCLEAR REACTORS, NUCLEAR MATERIALS, RADIOACTIVE WASTE, NUCLEAR SECURITY, PUBLIC MEETINGS & INVOLVEMENT, NRC LIBRARY, and ABOUT NRC. The main content area displays the title 'PART 30—RULES OF GENERAL APPLICABILITY TO DOMESTIC LICENSING OF BYPRODUCT MATERIAL' in green. Below the title, there is a link to the 'Full Text Version (290.04 KB)' and a section titled 'General Provisions'. Under 'General Provisions', there is a list of sections: 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, and 30.10 Deliberate misconduct. Below this list is a section titled 'Exemptions' with a link to 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)

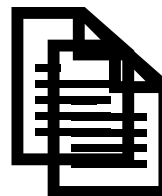
- Establishes limited but key requirements (e.g., # of licensing steps)
- Different frameworks for different public perceptions of risk
- Placement w/in a framework driven by legal reading (but not always)

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

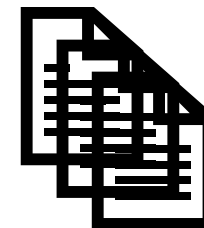
1 page of
statute



100 pages
of rules

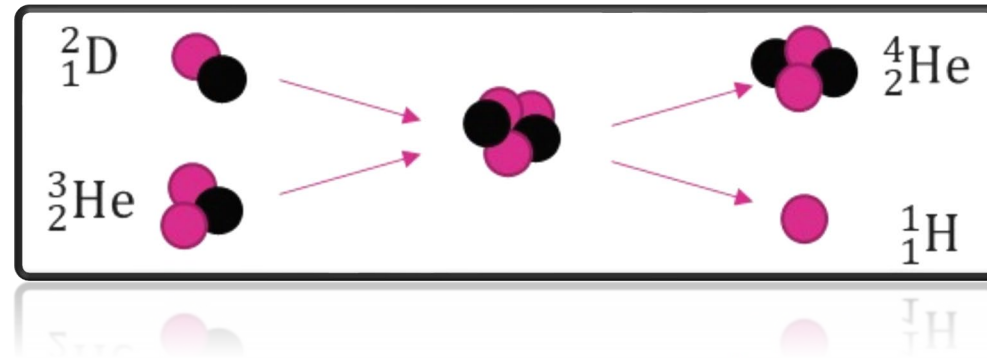


10,000 pages
of guidance

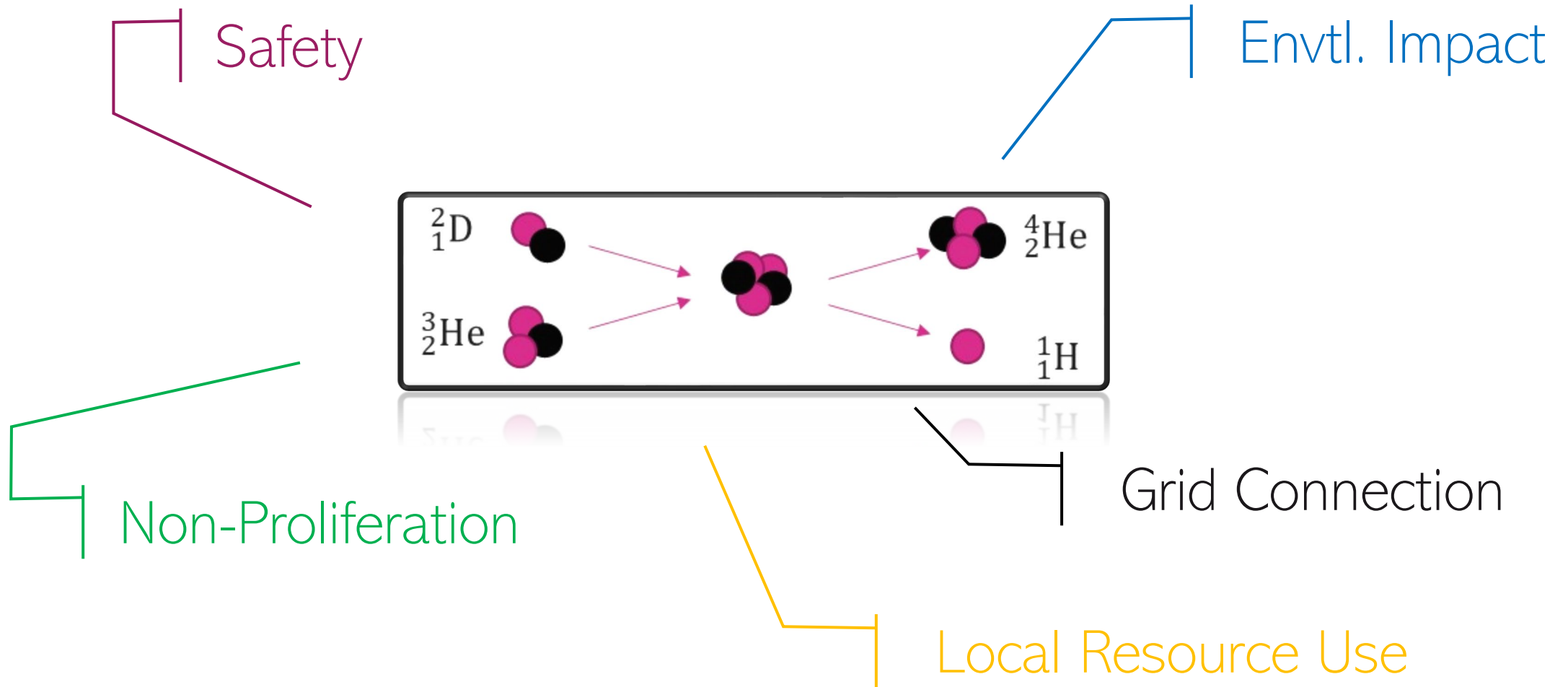


Deep Dive – NRC Regulation

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")

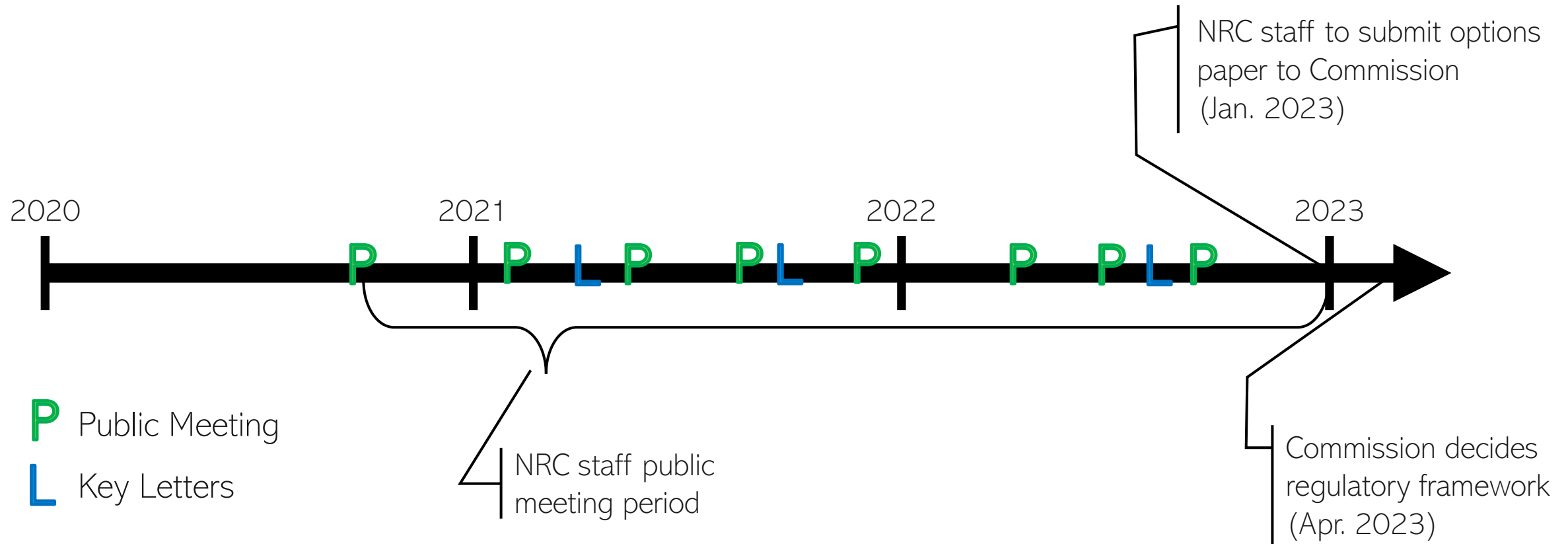


Hybrid Framework

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.

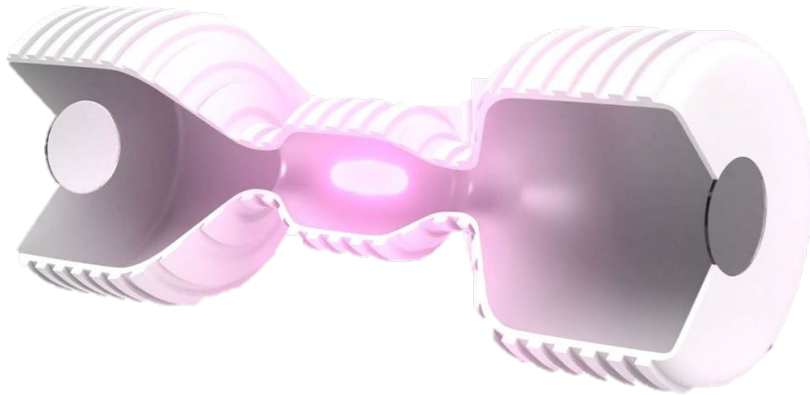
Energy Policy Act of 2005 Rulemaking (72 FR at 55,868)

"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")

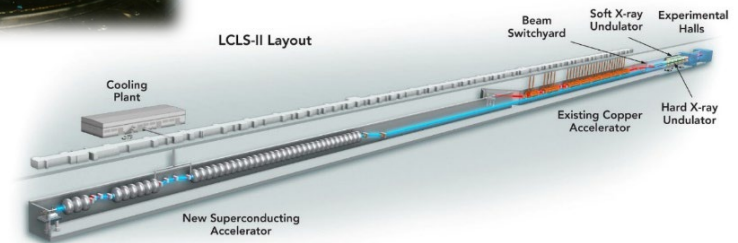
Techno-Legal Case

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

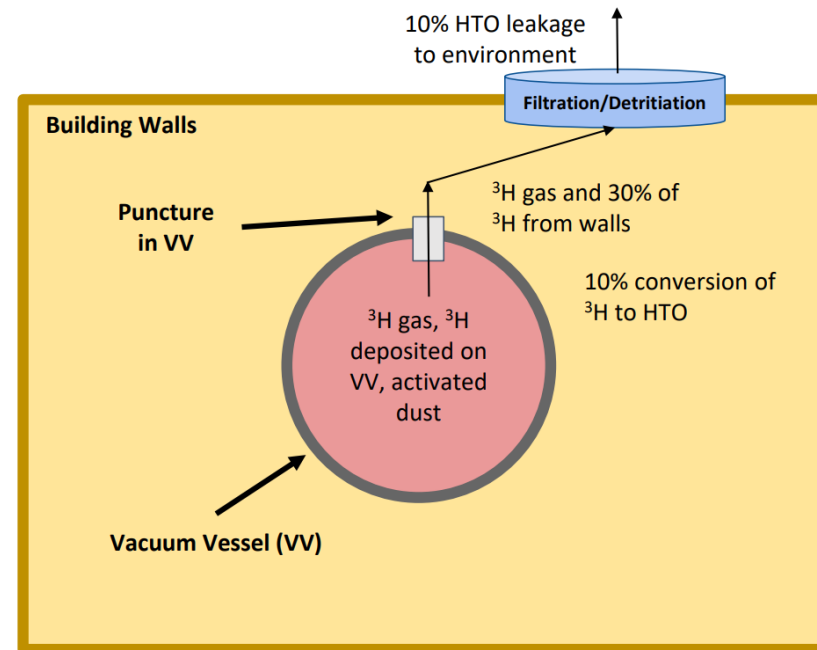
- All tritium gas and 30% of tritium on wall leaves the VV
- Of the tritium leaving VV, 10% is converted to HTO
- 10% of HTO is released into the environment at a release height of 10 m (height of building)

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 REPIR 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 (REPIR), (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).

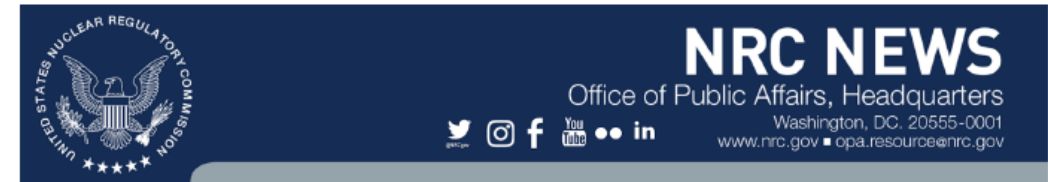
72

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.

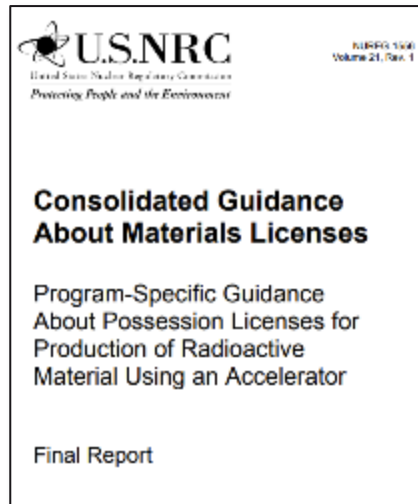


CMR Caputo and
her Chief of Staff

Deep Dive – NRC Regulation

Going Forward

Implementation of Materials Framework




Available Vehicles

Guidance
(e.g., NUREG rev.)



New Part
(e.g., Part 38)

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

Licensing at State Level

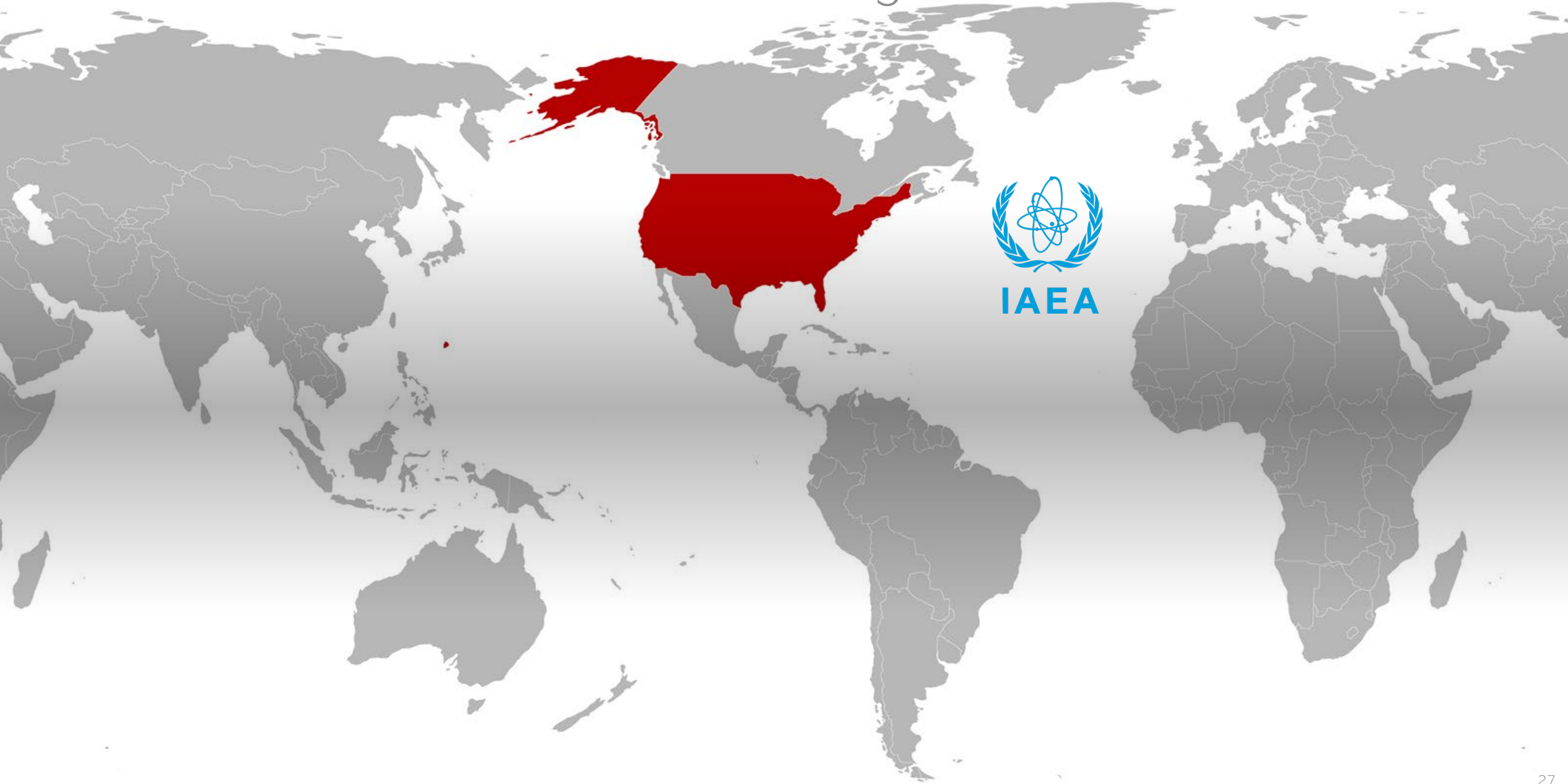


Source: NRC Website

Tritium Management



International Regulation



Factory Production



Source: Boeing / Creative Commons

Life Lessons

“Winning” at Nuclear Regulation Is Not Everything



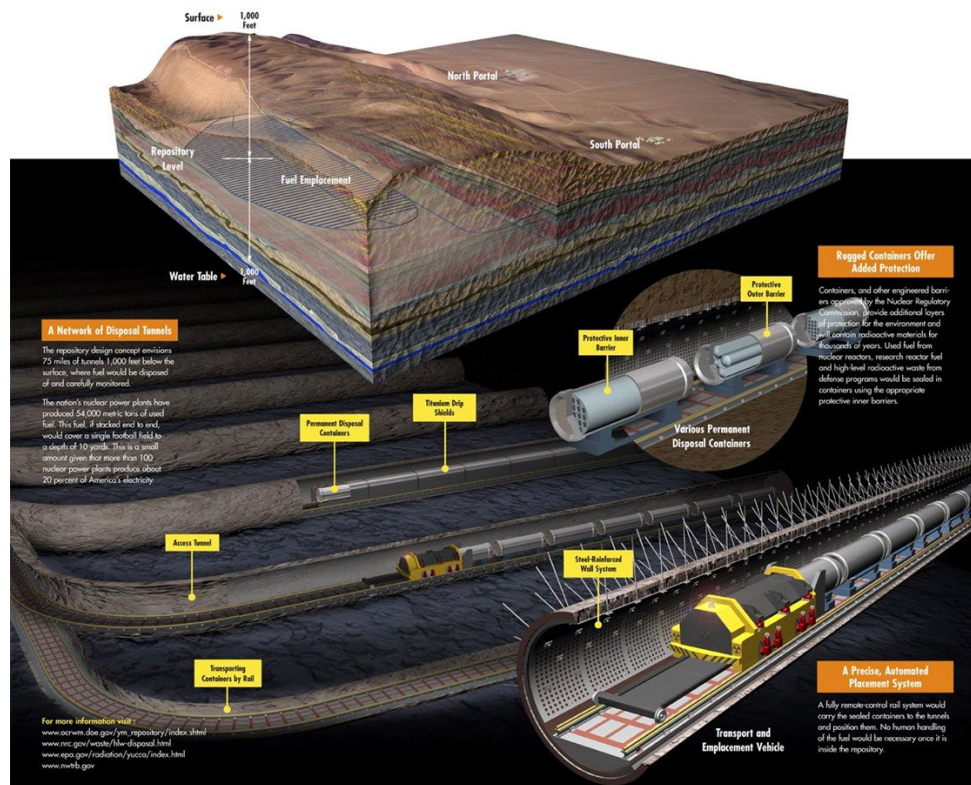
Indian Point Nuclear Power Plant

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

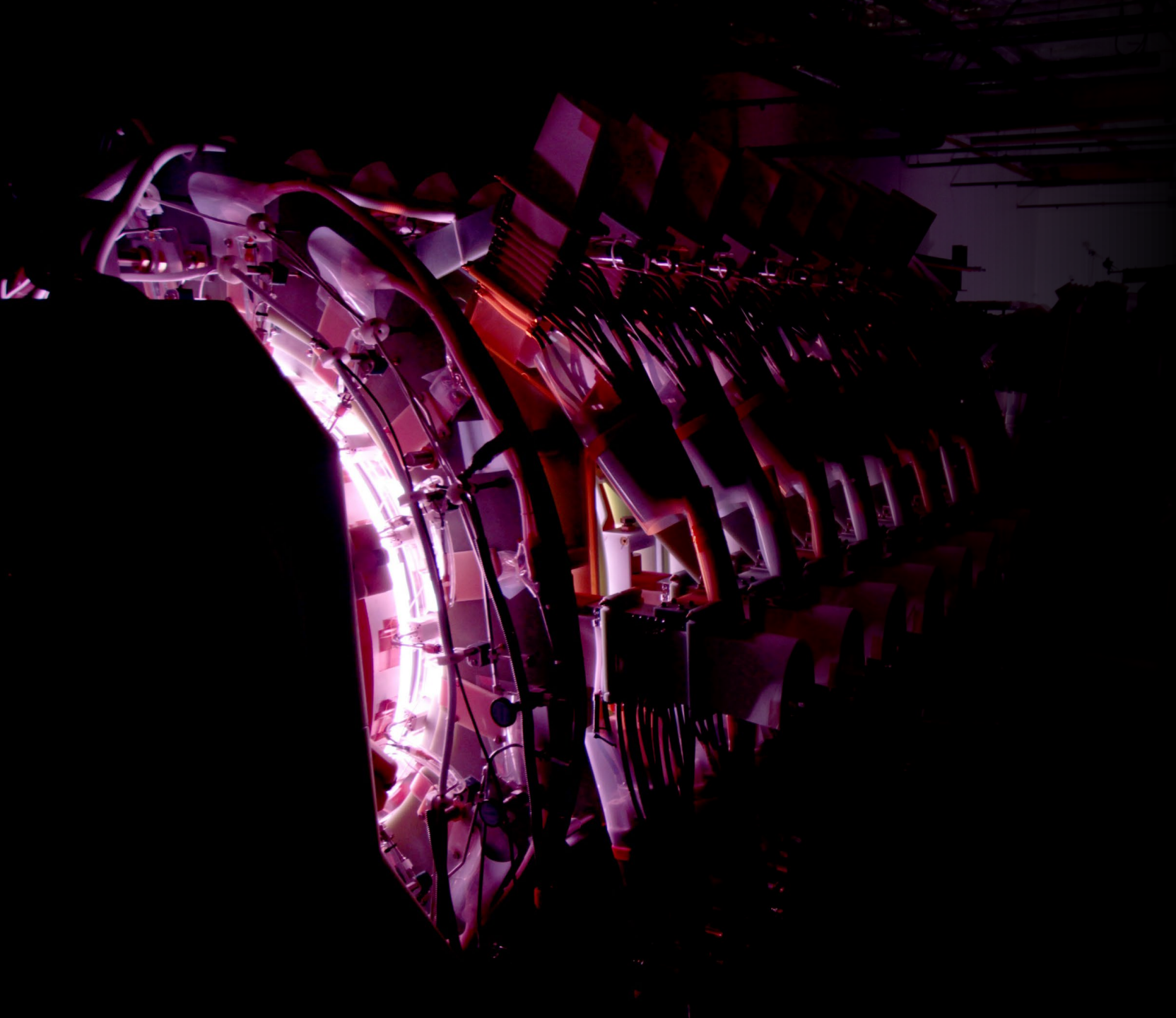
A two-way **process** that opens expertise to new questions and perspectives:¹

- More than "education," public relations, or "letting the public see the experts at work"²
- 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 activity³
- Acts as a form of peer review that generally improves outcomes for proponents and society⁴

Far more than a legal license or permit⁵: successful examples see regulatory compliance as only a starting point for social acceptance⁶

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. Otlinger, 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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