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SUBJECT: Classification of Fusion Devices as Particle Accelerators; and Supplementing Common Defense & Security Discussions

Mr. Lynch,

Helion Energy, Inc. ("Helion") sincerely appreciates the work undertaken by the U.S. Nuclear Regulatory Commission ("NRC") staff to engage with the fusion community and public as it explores a regulatory path forward for commercial fusion energy devices.[1] We applaud the NRC staff's efforts to look at fusion from a fresh and open perspective, with an eagerness to learn about the technologies and seek input on regulatory options. We at Helion believe that applying an appropriate and risk-informed regulatory framework to commercial fusion can enable the timely deployment of this technology, as well as build public trust and acceptance.

The purpose of this letter is to: (i) provide additional information on the classification of fusion devices as particle accelerators ("accelerators"), a topic raised during recent public meetings; and (ii) summarize and provide supplementary research as to whether fusion triggers Atomic Energy Act ("AEA") common defense and security ("common defense") questions. We hope this additional information can aid the NRC's ongoing evaluation of this technology. Please let us know what additional questions we can address or additional information we can provide.

I. Summary

Particle Accelerator Classification: Fusion devices satisfy the NRC's definition of particle accelerators: fusion devices are the *only* energy technology to impart kinetic energy to subatomic particles through electromagnetic interactions, and fusion devices such as Helion's *Plasma Accelerator*[2] fall well within the diversity of particle accelerators currently in use around the world.

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[1] Helion understands that the NRC's evaluation concerns primarily *commercial fusion energy devices*. For simplicity, these are often referred to within as "commercial fusion devices" or just "fusion devices."
[2] Helion Energy, *Technology – Plasma Accelerator*. Note -- all undated websites in citations were last visited on or near the date of this letter.

Moreover, fusion devices have essentially identical safety cases to currently deployed particle accelerators—as documented in detail below—with similar radiological risk profiles addressed through similar safety approaches. The safety paradigm that exists for the thousands of particle accelerators in the United States today can form a strong long-term foundation for fusion regulation—and indeed this paradigm applies to many fusion devices already.

Classifying commercial fusion devices as particle accelerators will give the NRC sufficient authority to regulate their safe design and use. The AEA supports this classification, especially considering the NRC's broad authority on technical matters, and consistent NRC and state interpretation of many R&D and commercial fusion devices as particle accelerators. Crafting a framework for commercial fusion devices around the particle accelerator / byproduct materials regime would be a strong example of the NRC's Transformation to a risk-informed regulator, by enabling the agency to build an innovative framework for fusion from the ground up while still preserving flexibility for special circumstances. This approach will enable the safe and rapid deployment of fusion in the United States in time to fight climate change and ensure U.S. energy security, whereas a utilization facility-centric approach may pose an unnecessary, existential threat to the long-term deployment of this game-changing technology.

Common Defense Evaluation: Domestic licensing of fusion devices does not trigger common defense concerns sufficient to preclude Agreement States from partnering in licensing. This is because the AEA's common defense clause is closely tied to special nuclear materials proliferation, and specifically that equipment especially designed to process, use, or produce special nuclear material. Fusion devices do not fall within this scope, and indeed modification of a fusion device to accept or produce special nuclear material would be a major undertaking, transforming the essential nature of the device. This reading of the AEA is consistent with the Nuclear Non-Proliferation Act ("NNPA"), NRC practice, the Treaty on Non-Proliferation of Nuclear Weapons ("NPT"), and international guidance—the latter of which specifically excludes fusion from the key "Trigger Lists" that delineate those technologies of high proliferation concern. Instead, the limited nonproliferation concerns associated with fusion, which center around potential abuse of the underlying technology by rogue foreign state actors, are appropriately addressed through export controls (in line with Nuclear Suppliers Group Part 2 Guidance) and reforms to Part 37.

More about fusion's placement within the international nonproliferation framework is provided in an article that is planned to be published in the Journal of Fusion Energy, entitled *Nonproliferation and Fusion Power Plants.* A draft is available at https://arxiv.org/abs/2207.14348

II. Classification of Fusion Devices as Particle Accelerators

The Atomic Energy Act includes as a byproduct material any material that "has been made radioactive by use of a particle accelerator" for use in a commercial, medical, or research activity. *See* 42 USC 2014(e)(3)(B) (emphasis added). The classification of fusion devices as particle accelerators may be relevant for the NRC in evaluating framework options for fusion. Helion provided perspectives on this topic in its January 26, 2021 presentation to the NRC,[3] and in its

[3] ADAMS Access No. ML21026A315, at slides 75-78.

follow-on March 25, 2021 letter.[4] We wish to memorialize and expand upon those discussions herein to aid the NRC staff in preparation of its options paper.

A. Fusion devices satisfy the NRC's definition of particle accelerators.

i. NRC Definition in EPAct 2005 Rulemaking

The NRC has defined what a "particle accelerator" is in its regulatory filings. Per the NRC's rulemaking implementing aspects of the Energy Policy Act of 2005 ("EPAct 2005"), the agency defined an accelerator fundamentally to be:

> a "device that imparts kinetic energy to subatomic particles by increasing their speed through electromagnetic interactions."[5]

This aligns with other common definitions.[6] As described in our March 25, 2021 letter, all fusion devices meet these requirements:

- As far as Helion is aware, all fusion devices impart kinetic energy to (i.e., increase the speed[7] of) subatomic particles. Indeed, for fusion to occur, the plasma must reach "fusion conditions," which includes that the plasma temperature reaches approximately 10 keV or greater. Temperature is a measure of the average kinetic energy of a large group of particles, so increasing the temperature of a plasma is equivalent to increasing the kinetic energy of the subatomic particles in the plasma. Indeed, that is one reason why in plasma physics temperature is often described in a kinetic energy term—electron-Volts[8]—interchangeable with degrees.

- As far as Helion is aware, all fusion devices work with subatomic particles. All fusion involves a "plasma" which is essentially a collection of atoms separated into their subatomic components (ions and free electrons).

- As far as Helion is aware, all fusion devices use electromagnetic forces, such as magnetic fields or electromagnetic waves, to manipulate a plasma and increase the kinetic energy/speed of the subatomic particles. Fundamentally, all fusion always occurs between ionized atoms, and electromagnetic forces are the only practical means of increasing the kinetic energy of the subatomic particle ions to keV+ energies and manipulating them within a medium.

Helion is a perfect example of this tight relationship. Linear particle accelerators often use ring electromagnets to accelerate a consolidated group of charged particles or plasma (which could comprise hydrogen or other elements) towards a target, at which point reactions at the subatomic

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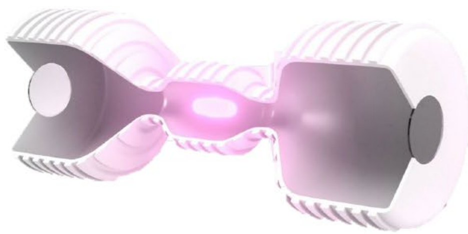
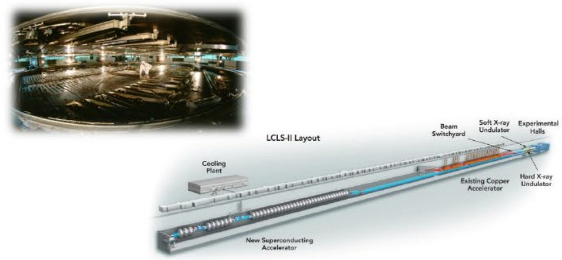
[4] ADAMS Access No. ML21085A477, at 5-6.
[5] Requirements for Expanded Definition of Byproduct Material, 72 Fed. Reg. 55,864, 55,868 (Oct. 1, 2007) ("EPAct 2005 Rulemaking") (emphasis added).
[6] *See, e.g.*, Merriam Webster Dictionary Online, *Accelerator* Definition ("an apparatus for imparting high velocities to charged particles (such as electrons)").
[7] Kinetic energy is directly related to speed/velocity (kinetic energy = 1/2 * mass * velocity^2).
[8] An electron-volt is equal to the kinetic energy an electron gains passing from a point of low potential to a point one volt higher in potential. Merriam Webster Dictionary Online, *Electron Volt* Definition; ScienceDirect, *Electron Volt Definition*.

level—including fusion—can occur due to the high kinetic energy of the accelerated particles. Helion's Plasma Accelerator likewise uses ring electromagnets to accelerate two plasmas towards each other into a target chamber, where the ions collide in the resultant medium. The now combined plasma has increased kinetic energy, which helps enable subatomic particle reactions (fusion) to occur.

Fusion Device



Accelerator (inc. Cyclotron)



Beyond these three core characteristics, accelerators can be quite varied devices, leaving substantial room for fusion to appropriately fit in as a sub-category. For example, particle accelerators have many different types of targets—it need not always be a fixed plate or foil. In synchrotrons, particularly, charged particle packets are steered towards each other to collide—similar in many ways to Helion's process where two plasmas are directed towards each other and collide.[9] The method of particle acceleration can also be quite varied, and include traditional ring magnets like Helion's approach, but also lasers or other methods. For example, "laser plasma wakefield accelerator[s]" are actively being explored, where a laser generates an electromagnetic "wake" that pushes a plasma towards a target.[10]

Moreover, many particle accelerators also directly do fusion-like reactions. For example, fluorine-18 for positron emission tomography is often produced by combining oxygen-18 and hydrogen-1 nuclei in a cyclotron or linear accelerator; this reaction also produces a neutron byproduct, like some deuterium-deuterium (D-D) and deuterium-tritium (D-T) reactions.[11] And D-D and D-T neutron generators are particle accelerators that generate neutrons via fusion for a commercial application (e.g., well-logging).[12] Despite performing fusion and emitting fusion neutrons, these devices have all been consistently classified as particle accelerators—because what remains constant is their use of electromagnetic interactions to drive subatomic particles to high kinetic energy levels.

At the same time, the fact that the "particle accelerator" definition captures fusion does not over-broaden its scope. It is important to recognize, for example, that particle accelerators do not encompass other *non-fusion* energy technologies. Nuclear fission reactors do not increase kinetic energy through electromagnetic interactions; instead, kinetic energy is added to the system only

[9] Symmetry Magazine, *A Primer on Particle Accelerators* (July 12, 2016).
[10] Physics World, *New Electron Accelerator Combines Laser and Plasma Wakefield Techniques* (June 25, 2021) (citing Nature Communications, *Demonstration of a Compact Plasma Accelerator Powered by Laser-Accelerated Electron Beams* (May 17, 2021)).
[11] As well, fusion of oxygen-16 and helium-3 is also used to generate fluorine-18. *See* NIH National Library of Medicine, *Radiosyntheses using Fluorine-18: the Art and Science of Late Stage Fluorination*, Sec. 1.2 (2014).
[12] SHINE, *Neutron Generators* (describing their device as an "accelerator-based system"); *see also* 10 CFR 39.55.

from nuclear reactions driven by neutron-induced chain reactions. And all other forms of energy generation (e.g., coal, gas, solar) do not work with subatomic particles as they rely on chemical or photoelectrical processes. The linkage between fusion devices and particle accelerators is distinct and unique.

ii. NRC Definition in 10 CFR 30.4

The NRC has also establish a definition of particle accelerators in 10 CFR 30.4, which is repeated in many state regulations (such as WAC 246-229-0010).

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

This regulatory definition in 10 CFR 30.4 does not conflict with the prior, more technical definition, but instead reflects an NRC choice to regulate a narrower band of particle accelerators and align with state regulatory practice. As stated by the Commission, "[t]he definition of Particle accelerator [in 10 CFR 30.4] has been used by State radiation control programs for many years. The lower limit of 1 MeV was chosen to avoid regulation of lower energy accelerators."[13]

Fusion devices also meet this definition, as they are all machines capable of—and designed to—"accelerat[e] electrons, protons, deuterons, or other charged particles in a vacuum and [discharge] the resultant particulate or other radiation into a medium." In the case of Helion, the medium is the center chamber of the Helion Plasma Accelerator shown above, where the opposing plasmas collide.

As well, the resultants of fusion also travel at energies in excess of 1 MeV (e.g., 14.1 MeV or 2.45 MeV neutrons), which aligns with the definition's 1 MeV threshold. Nonetheless, as noted by the term "usually" in the definition above, and regulatory history, the 1 MeV threshold was not added to distinguish what is or is not an accelerator, but to avoid unnecessary regulation of low-impact accelerators such as "cathode ray tube television sets."[14] Because fusion devices do have radiological consequences akin to industrial particle accelerators, Helion acknowledges that regulation at a similar level of stringency is appropriate.

Since the NRC 10 CFR 30.4 definition of particle accelerator originates from state use, how states have used the term is relevant. The current definition has been in circulation among state radiation control programs since at least the 1980s,[15] and the NRC adopted that language into its regulations to align with state practice.[16] To Helion's awareness, states frequently classify fusion devices as particle accelerators, and indeed Helion has a particle accelerator registration from the State of Washington for its 6th Generation fusion device "Trenta." It is likewise in the process of obtaining a particle accelerator registration for its 7th Generation "Polaris" research device. Consistent interpretation by states of a regulatory text they themselves developed should be given

[13] EPact 2005 Rulemaking, at 55,895.
[14] EPact 2005 Rulemaking, at 55,895.
[15] *See* Suggested Regulations for Control of Radiation, Vol. I - Ionizing Radiation (1982), at Appendix A4.
[16] EPact 2005 Rulemaking, at 55,895.

great weight. *See Entergy Corp. v. Riverkeeper, Inc.*, 556 U.S. 208, 224 (2009) (giving weight to an agency interpretation when it "has been proceeding in essentially this fashion for" many years); *Barnhart v. Walton,* 535 U.S. 212, 220 (2002) ("[T]his Court will normally accord particular deference to an agency interpretation of 'longstanding' duration." (citation omitted)); *N.L.R.B. v. Bell Aerospace Co. Div. of Textron*, 416 U.S. 267, 274-75 (1974) (A "court may accord great weight to the longstanding interpretation placed on a statute by an agency charged with its administration.").

B. Fusion devices are akin to accelerators from a technical perspective.

As discussed in our March 23, 2022 presentation to the NRC,[17] the radiological consequences from fusion devices such as Helion's are fundamentally similar to particle accelerators. Most important, the *types of risks* at issue are the same. This is summarized in the tables below.

<u>Radiological Issues During Operation</u>

<table>
<tr><td colspan="2">(1) Neutron and Photon Radiation. Both fusion devices and other particle accelerators emit neutrons or photons as the subatomic particles move within the device and upon particle collisions. Most x-ray emissions are shielded at the very first layer of material, and concrete or hydrogenous shielding can be used for neutrons.</td></tr>
<tr><td>• Other Particle Accelerators: Many cyclotrons can emit high levels of neutrons, (e.g., 10^{14} neutrons/second).[18] In particular, however, many particle accelerators can emit neutrons up to extremely high energy levels (e.g., cyclotrons can emit 250 MeV neutrons, and some particle accelerators discussed below can create GeV-particles). Common cyclotrons have up to 5 m of shielding to address high-energy emissions.</td><td>• Fusion devices: The neutron emission rate may be greater in the case of fusion, but at lower energy levels: 14.1 MeV in the case of D-T fusion, and only 2.45 MeV in the case of D-D fusion.[19] Helion projects that substantially less shielding than required for cyclotrons will be sufficient to meet regulatory limits for its 50 MW D-He-3 fusion device.</td></tr>
<tr><td colspan="2">(2) Radioactive Material Input/Output. Both fusion devices and other particle accelerators can require radioactive materials as input constituents or output radioactive materials. Post-device management of radioactive materials (e.g., tritium) produced from these devices tends to be a larger safety concern than radioactive materials used as inputs.</td></tr>
<tr><td>• Other Particle Accelerators: Most particle accelerators produce radioactive materials for commercial purposes, which can be substantial in quantity. For example, there are 1,200 cyclotrons worldwide producing many curies of radioisotopes.[20] Some particle accelerators may also use radioactive materials (such as tritium) in targets.[21]</td><td>• Fusion Devices: The vast majority of fusion approaches plan to produce tritium for commercial use—either directly through D-D fusion, or by capturing neutrons emitted from D-T fusion on lithium targets. Tritium is also used as an input in D-T fusion devices, although the plasma itself contains a very small quantity (<< 1 gram) and does not dramatically affect the safety case compared to other sources[22] & post-device handling.</td></tr>
</table>

[17] ADAMS Accession No. ML22081A057 ("March 2022 Presentations to NRC"), at slides 112-121.
[18] *E.g.,* Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, *Characterization of the Neutron Flux During Production of ^{18}F at a Medical Cyclotron and Evaluation of the Incidental Neutron Spectrum for Neutron Damage Studies* (December 2019); PETtrace 800 Cyclotron Series Data Sheet.
[19] The neutrons emitted associated from D-He-3 fusion originate from D-D side reactions. The D-He-3 fusion reaction itself is aneutronic.
[20] IAEA, *Increasing Radiopharmaceutical Production with Cyclotrons* (May 11, 2022).
[21] *E.g.,* Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, *The Characterization of D–T Neutron Generators in Precise Neutron Experiments* (July 1, 2022).
[22] March 2022 Presentations to NRC, at slide 119.

(3) **Incidental Activated Material.** Both fusion devices and other particle accelerators can irradiate shielding or other device components, activating the materials. These materials need to be managed for safety and decommissioning considerations.	
• **Other Particle Accelerators:** The very-high-energy neutrons from particle accelerators can activate substantial quantities of shielding or other device components, but all these components generally have established decommissioning and disposal pathway. Very high energy neutrons have many more activation pathways and reactions (e.g., spallation) as compared to neutrons of a few MeV.	• **Fusion Devices:** Neutrons from fusion devices can likewise activate shielding and other components, although the lower-energy 2.45 MeV neutrons anticipated from Helion's fusion approach activate fewer materials than the higher-energy neutrons from many particle accelerators. The activated materials from fusion devices likewise are expected to take advantage of decommissioning and disposal pathways that exist for other accelerators.

Radiological Issues During Off-Normal & Accident Scenarios

(1) **Release of In-Device Material & Dust.** Both fusion devices and other particle accelerators can have radioactive material within the device's operating medium (e.g., in targets or plasma), and radioactive dust on the walls (e.g., impinged from the plasma or created by neutron irradiation). Both of these can be released in some fraction in an accident scenario.	
• **Other Particle Accelerators:** Radioactive target material and dust inside the accelerator could be released in the case of an accident, although mitigating factors exist such as the vacuum vessel, incidental barriers (e.g., an outer building), and the fact that radionuclide production stops and the source term is fixed.	• **Fusion Devices:** The same risk exists in the case of fusion. In the Helion example, the tritium in gaseous form contributes to only micro-rem of dose; and even in extreme cases, activated material and tritium dust are estimated to total only a small percentage of annual background dose (and less than 100 mrem).[23]
(2) **Release of In-Process or Stored Generated Materials.** Both fusion devices and other particle accelerators have to manage the radioactive byproducts coming off the particle accelerator, such as medical radioisotopes or tritium. Licensees will need effective materials management practices in place.	
• **Other Particle Accelerators:** Radioisotopes produced from cyclotrons or other accelerators must be protected in accident scenarios—a well-established materials management issue.	• **Fusion Devices:** Operators of fusion devices will need to manage the tritium generated in or around the fusion device (often in systems or facilities separate from the fusion device). In the case of Helion, tritium will be independently stored after generation, far from the fusion device, because it is not needed for device operation thereafter.

As well, particle accelerators and fusion devices share the risks they both *avoid*. These include:

(i) *Criticality*—neither device can sustain a chain reaction (and Helion does not even reach ignition conditions). As a result, both particle accelerators and fusion devices turn off on demand, and passively deactivate in the event of any material abnormality.

(ii) *Inventory*—both fusion devices and particle accelerators have a low inventory of radioactive materials in the device at any time, whereas with a fission process the entire uranium core (years or more of fissionable material and fission products) is in the reactor vessel at all times.

In comparing fusion devices and other particle accelerators, the radiological hazards involved with many operating particle accelerators can exceed that expected for some or many fusion devices. For example, the Spallation Neutron Source at Oak Ridge National Laboratory can produce the

[23] March 2022 Presentations to NRC, at slide 70.

most intense neutron beam in the world,[24] and the Relativistic Heavy Ion Collider creates plasmas so intense that the hadrons decompose into a quark-gluon plasma.[25] Moreover, many such devices need to operate with researchers close by—sometimes *in* the beam path (protected by a beam stop)—manipulating experiments. These may be extreme examples, but the general truth is that every day 1,200 cyclotrons and thousands of other particle accelerators operate in hospitals and industrial parks globally without issue[26]—all safely managed under the current regulatory regimes in place. Fusion devices, which have the same fundamental risks (if not less), can be safely regulated under a similar regime.

Lastly, the technical comparison between fusion devices and particle accelerators can be driven home by a simple flip in circumstances. Many fusion devices can be used to produce radioisotopes with limited change in technology. For example, because it is such an effective particle accelerator, beyond creating electricity, Helion's fusion device can be used to generate substantial quantities of helium-3 and tritium for commercial use through D-D fusion.[27] Although changes would be required to accommodate the new mission (such as operational settings), the fundamental technology would remain the same. If Helion constructed a Plasma Accelerator solely for tritium and helium-3 generation through D-D fusion, it would fit clearly within the accelerator-produced byproduct materials framework. Why should use of a *less neutronic* fuel mix (D-He-3) to create electricity instead change this analysis?

C. The NRC has a clear path forward to classify fusion devices as accelerators.

i. An accelerator classification will give the NRC sufficient authority to regulate fusion's safe use.

As discussed above, fusion devices satisfy both the definitional and technical requirements to fall under the particle accelerator classification. Affirmatively classifying fusion devices as particle accelerators will bring fusion devices safely into the NRC materials framework without complicating regulation. Because nearly all planned fusion devices create radioactive material for a commercial purpose, all radioactive material—planned and incident—would fall under NRC byproduct materials regulation.[28] This is certainly anticipated to be true in the case of Helion, where the tritium that is produced is expected to be held until it decays into helium-3 (which is in turn an input for Helion's Plasma Accelerator).

In this environment, the states will continue to regulate the non-radiological aspects of fusion devices, such as electrical issues related to the power supplies, just as today states (and the U.S. Environmental Protection Agency) regulate water use and OSHA regulates personnel safety at nuclear facilities. However, the NRC would establish the regulatory framework for all core

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[24] Oak Ridge Natl. Laboratory, *SNS Completes Full Neutron Production Cycle at Record Power Level* (Aug. 9, 2018).
[25] Brookhaven Natl. Laboratory, *Relativistic Heavy Ion Collider, A New Area of Physics*.
[26] U.S. Department of Energy, *How Particle Accelerators Work* (June 18, 2014).
[27] D-D fusion directly produces helium-3 approximately 50% of the time, and tritium approximately 50% of the time. The tritium could be sold for commercial use or even stored until it decays into helium-3.
[28] "The NRC will regulate the radioactive material both intentionally and incidentally produced by all accelerators that are intentionally operated to produce a radioactive material for its radioactive properties." EPAct 2005 Rulemaking, at 55,868. *See also* NUREG-1556, Volume 21 Rev. 1 § 8.5 (requiring coverage of incidentally activated materials in a license application) (ADAMS Accession No. ML18143A670).

radiological aspects of fusion device and facility operation, giving the NRC sufficient authority to ensure the safe design and operation of these systems.

This approach has worked well for over a decade for accelerator-produced byproduct material, and there is no reason it could not work here. Indeed, the addition of accelerator-produced byproduct material to the NRC paradigm in 2005 showed how well new technologies can be incorporated into the byproduct materials framework. The phased transition set forth in EPAct 2005 for Agreement States to partner in licensing accelerators can also be repeated here as fusion technology and regulatory expertise progress.[29]

ii. An accelerator classification is justifiable under the Atomic Energy Act.

As described above, it is no coincidence that fusion devices meet the definitional requirements of particle accelerators. The definition of particle accelerator does not cover any other energy source, while at the same time its key elements (use of electromagnetic forces to increase kinetic energy of subatomic parties) are essential to all commercial fusion processes. As importantly, the safety cases closely align. On such a technical issue, which involves in-depth understanding of various complex technologies, the NRC has high levels of deference to interpret its organic statute and make appropriate classifications. "When examining this kind of scientific determination, as opposed to simple findings of fact," the NRC is given especially high deference. *Baltimore G. & E. Co. v. NRDC*, 462 U.S. 87, 103 (1983); *New Jersey Env't Fed'n v. NRC*, 645 F.3d 220, 228 (3d Cir. 2011).

In turn, the NRC is not tackling a "major question" by formally categorizing fusion devices as particle accelerators. This action would not give the NRC "unheralded power" to effect a "transformative expansion of its regulatory authority," nor would it fundamentally revise a major sector of the US economy. *See W. Virginia v. Env't Prot. Agency*, 142 S. Ct. 2587, 2610 (2022) (internal quotations omitted). Under any of the approaches the NRC is considering right now for regulating fusion, including under the byproduct materials framework as a particle accelerator, the NRC will remain the key federal entity establishing the regulatory framework for fusion, under the same Atomic Energy Act "adequate protection" standard that generally applies to all agency licensing actions.

Further, Congress has not declined to permit fusion to be regulated as a particle accelerator, nor has it objected to state regulation of fusion R&D devices as particle accelerators for years. Indeed, to the extent members of Congress have recently spoken on fusion, it has been to applaud the NRC for conducting a clean slate evaluation and to encourage it to adopt a right-sized regulatory approach based on the AEA's byproduct materials regime.[30] If anything, a choice instead to put fusion under a different, fission-centric framework would appear to conflict with recent instruction from Congress and could be a "major question" requiring Congressional involvement.

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[29] Section 651(e)(4) of EPAct 2005 (Pub. Law 109-58) established a transition process for interested states to take on regulation of accelerator-produced byproduct material. That process could easily be repeated here as necessary, potentially through regulatory or Congressional action.

[30] *See, e.g.,* Senate Env't and Public Works Committee, *Hearings on Nominations of Annie Caputo & Bradley R. Crowell*, at 1:42 through 1:44.

iii. The NRC does not need to classify fusion devices as utilization facilities.

Classifying fusion devices as particle accelerators does not conflict with the Atomic Energy Act's definition of utilization facility, nor does the NRC need to classify fusion devices as utilization facilities. A legal analysis is set forth in the Fusion Industry Association's June 2022 presentation to the NRC,[31] but we summarize and expand on some of the key points within.

The choice of what to place under the utilization facility framework is subject to substantial NRC discretion, and only occurs upon an affirmative Commission determination by notice-and-comment rulemaking. 42 USC 2014(cc). When Congress expressly yields to an agency the right to make certain regulatory determinations via rulemaking, agencies generally have substantial flexibility as to if and when to make such self-initiated determinations. In the case of the NRC, this flexibility is even more so. The AEA paradigm is "virtually unique in the degree to which broad responsibility is reposed in the administrative agency, free of close prescription in its charter as to how it shall proceed in achieving the statutory objectives." *Pub. Citizen v. NRC*, 573 F.3d 916, 918 (9th Cir. 2009) (quoting *Siegel v. AEC*, 400 F.2d 778, 783 (D.C. Cir.1968) (marks omitted)).

Moreover, in the case of fusion the agency's discretion is particularly high. The NRC is not determining whether to assert jurisdiction over commercial fusion, but simply the framework under which this jurisdiction will be asserted (byproduct materials framework versus utilization facility framework). And the choice as to how to proceed is in large part a technical determination as to the relationship between fusion devices and particle accelerators. Thus, the NRC's already broad flexibility "as to how it shall proceed in achieving [its] statutory objectives" is only heightened as it directly addresses an issue at the frontiers of science. *See Siegel*, 400 F.2d at 783; *Baltimore G. & E. Co.*, 462 U.S. at 103. The NRC should thus feel comfortable to conclude as the technical case warrants that fusion devices can be particle accelerators and need not be utilization facilities.

Such a determination would be consistent with historical practice. Over the decades, the NRC has declined to expand the scope of "utilization facilities" to include a broad range of potential uses of atomic energy. This has enabled broad swaths of the U.S. economy to use radioactive materials for substantial public benefit, safely regulated under a byproduct materials framework. For example, the Commission has consistently declined to treat radioisotope thermoelectric generators as utilization facilities despite their direct use of atomic energy for heat and electric processes. Commercial particle accelerators for decades have used atomic reactions to release energy (*e.g.,* x-rays, gamma rays) for research and development, medical diagnostics, and other purposes. D-D and D-T neutron generators are essentially fusion devices using the energy released for non-electricity applications such as well-logging—and these devices have been regulated under the materials framework for years.[32]

These devices have never been treated as utilization facilities—and without any disapprobation from Congress. Indeed, Congress inherently endorsed such discretion in the Energy Policy Act of 2005, by implicitly re-affirming the current paradigm for regulating particle accelerators while bringing in accelerator-produced material as byproduct material. In this light, maintaining the agency's historical discretion—as opposed to finding that the NRC *must* now include certain items

[31] ADAMS Accession No. ML22159A269 ("June 2022 Public Meeting Presentations"), at slides 36-39.
[32] *See* 10 CFR 39.55 (regulating D-T neutron generators used in well-logging).

as utilization facilities—is a justifiable path forward that would avoid unintentional "transformative expansion" of regulatory authority affecting major sectors of the U.S. economy. *See W. Virginia*, 142 S. Ct. at 2610.[33]

D. Classifying fusion devices as accelerators would enable the safe and rapid deployment of fusion.

Fusion has the potential to deliver incredible amounts of carbon-free energy to the world at extremely low cost and unprecedented levels of safety. In large part because they do not need special nuclear material, and are comprised largely of electronics, ceramic or metal plates, and magnets—as opposed to large pressure vessel structures—fusion devices can be small and mass manufactured. A 50 MW Helion generator and related power electronics are anticipated to be able to fit within a few shipping containers, which can be delivered to a facility similar to a commercial cyclotron being delivered to a medical center. Helion intends to construct a manufacturing base in the United States capable of producing fusion devices at the same scale as airplanes, enabling fusion to deploy in time to have a substantial impact in the fight against climate change. Furthermore, U.S. leadership in the global future energy economy, as well as our own energy security, depend upon getting the deployment of this technology right from the start.

In Helion's opinion, the materials framework, due to its statutory flexibility, is the ideal regime to host fusion. Under this framework fusion devices must still be held to the same "adequate protection" standard true across the AEA, but this regime is efficient at licensing a varied set of devices at scale, across ranges of technologies. This is evidenced perhaps best of all by the fact that there are nearly 18,000 materials licenses across the United States, covering dozens of very different applications.[34] Contrary to fission reactors, which regardless of size or type tend to work in similar ways and all use special nuclear material, fusion devices are highly differentiated in key engineering approaches but are all fundamentally limited to byproduct materials.[35]

Classified as particle accelerators, the NRC, public, and fusion developers would thus benefit from a flexible regime that excels at handling diversity, has experience evaluating similar technologies, and is capable of grading requirements to a technology's safety case. These stakeholders would also benefit from potentially up to 50 additional sets of hands to help license fusion devices under a standardized federal framework. Crafting a scalable framework for fusion from the ground-up within the particle accelerator / byproduct materials construct—as opposed to slotting fusion into an already-existing ill-fitting fission framework—strongly aligns with the NRC's Transformation goals and would showcase the NRC's role as a "modern risk-informed regulator that embraces innovative approaches.[36]

In turn, Helion has evaluated fusion's potential placement in the utilization facility statutory framework. In its opinion, this framework could pose an unwarranted *existential* threat to the

[33] This flexibility would still permit the NRC to classify certain fusion devices in special cases—such as hybrid devices that use special nuclear material—as utilization facilities on a case-by-case basis, such as with the SHINE facility in Wisconsin. *See* 10 CFR 50.2 (citing Docket No. 50–608).
[34] NRC Digest 2021-2022 (NUREG-1350, Vol. 33), at xiv.
[35] As discussed above, hybrid devices are excluded from this analysis, and may be appropriately regulated as utilization facilities on a case-by-case basis.
[36] NRC Transformation, *Strategy on a Page* (Feb. 6, 2019), at 1. Such a course would furthermore enable the NRC "to be prepared to regulate an industry that is innovative and has new technologies." NRC Website, *NRC's Transformation Journey*.

mass deployment of this critical climate technology. The construction permit requirement in particular—while potentially helpful to address limited fission-specific concerns[37]—would add an unnecessary but extremely costly step in the licensing process, complicating the mass production of fusion devices likely to the point of making it untenable. As well, the unnecessary inclusion of fusion into the Price Anderson regime,[38] and the inability for states to partner in deployment, all will work to prevent fusion from scaling. The NRC's Principles of Good Regulation call for efficiency[39] and clarity[40] in the regulatory process, and they alongside other broader policy considerations—such as the fight against climate change—can be factors to consider when deciding regulatory framework options for fusion.

III. Supplement to Common Defense & Security Analysis

In the June 22, 2022 public meeting, in response to stakeholder interest Helion presented its perspective on how the AEA's "common defense and security" prong applies in the case of commercial fusion. We summarize certain key points below, and also wish to provide citation to a draft journal article that dives deeper into this topic: *Nonproliferation and Fusion Power Plants* (https://arxiv.org/abs/2207.14348).

A. Summary of Common Defense & Security Discussion

The question of whether commercial fusion raises common defense concerns is relevant as to the role Agreement States can play in domestic licensing of fusion power plants. While the NRC can partner with Agreement States on regulating matters of public health and safety, the NRC generally cannot partner with Agreement States to regulate issues of common defense and security.[41]

It is worth noting at the outset that the mere presence of any potential common defense and security question does not eliminate Agreement State partnership in licensing. This is seen in the 2013 Part 37 rulemaking. There, the NRC identified that certain radioactive materials (Category 1 and Category 2 materials) could cause substantial harm if used in a terrorist attack and thus raise common defense concerns. However, the same attack also raises similar public health and safety concerns, which enabled the NRC to enact its Part 37 security regime under that authority

[37] The construction permit concept originated based off the approach taken to early radio station licensing. *See* Controlling the Atom – The Beginnings of Nuclear Regulation (NUREG-1610) (1945 - 1962), at 71. To the extent this extra licensing step offers a safety benefit, it is most applicable to fission. In fission reactors seismic or certain other events can lead to criticality accidents and rapidly growing source terms since the full fissile core is in the reactor vessel. Construction licensing and monitoring may help address some of this risk. In the case of fusion on the other hand, such events in fusion devices (i) tend to stop the fusion and fix the inventory, and (ii) cannot cause runaway chain reactions.

[38] Based on preliminary engagement with the insurance community Helion is confident that its fusion devices will be able to secure commercial insurance in sufficient levels to protect the public.

[39] "Regulatory activities should be consistent with the degree of risk reduction they achieve. Where several effective alternatives are available, the option which minimizes the use of resources should be adopted." NRC Website, *Values – Principles of Good Regulation*, Efficiency (last updated Apr. 11, 2022).

[40] "Regulations should be coherent, logical, and practical. There should be a clear nexus between regulations and agency goals and objectives whether explicitly or implicitly stated." NRC Website, *Values – Principles of Good Regulation*, Clarity (last updated Dec. 15, 2021).

[41] AEA § 274(b), (m). We focus herein on the connection between common defense and domestic licensing of fusion devices. Evaluation of common defense concerns in the context of fusion *exports* do not prohibit Agreement State involvement in domestic licensing. For example, although many exports of byproduct, source, and special nuclear materials are evaluated for common defense concerns pursuant to 10 CFR 110.42(c), states are still able to partner in domestic licensing of byproduct, source, and limited quantities of special nuclear materials.

instead.[42] For the purpose of this discussion then, common defense concerns are most relevant to the role Agreement States can play in licensing fusion when they are *unique*—i.e., distinct from public health and safety issues such that they mandate partial or complete federal-only licensing.[43]

Helion's evaluation, presented in its June 22, 2022 presentation, found that such *unique* common defense concerns arise in domestic licensing when the device being licensed is of "significance for nuclear explosive purposes." *See* NNPA § 204 (amending AEA § 126 and tying common defense closely to items of "significance for nuclear explosive purposes"). The NRC in turn has defined those devices and equipment that reach this "significance" threshold. Particularly, in a rulemaking amending 10 CFR Part 110 following the NNPA, the NRC found that "the Nuclear Suppliers' Group and IAEA Zangger Committee trigger lists [reflect] an international consensus on items considered to be significant for nuclear explosive uses."[44] These lists set forth equipment especially designed or prepared for the processing, use or production of special nuclear material.

It is thus salient—if not dispositive—that fusion devices are *explicitly* excluded from these Trigger Lists,[45] reflecting a long-standing determination by the international community that fusion devices in themselves are not "of significance to nuclear explosive purposes"—and thus that their domestic licensing do not raise unique common defense concerns under the NNPA/AEA. This aligns with the simple fact that commercial fusion devices (excluding fusion-fission hybrid devices, which are not subject to this analysis) cannot process, use, or produce source or special nuclear material. These devices would not have the requisite equipment and instead would have to undergo substantial modification to incorporate source or special nuclear material (both of which are already controlled) in any functional manner. A device such as Helion's Plasma Accelerator does not even have a breeding system, which has been opined as the likely potential pathway for introducing source material into a fusion device.[46] Moreover, beyond substantial physical changes, introduction of source material would have distinct chemical and radiological signatures that would be easily detected.[47]

The conclusion that domestic licensing of commercial fusion devices does not raise common defense concerns aligns with the NPT. The NPT—the parent of the modern nuclear nonproliferation regime—extends safeguards specifically to those items "especially designed" for processing, using, or producing special nuclear material.[48] The Trigger Lists mentioned above reflect the global determination as to what constitutes equipment "especially designed" for such

[42] Physical Protection of Byproduct Material, Final Rule, 78 Fed. Reg. 16,921, 16,927 (Mar. 19, 2013).
[43] Helion recognizes that certain fusion devices may contain a material amount of tritium on site. With the advent of fusion, tritium should be added to the Part 37 regime in line with IAEA recommendations to provide for appropriate physical security to protect against potential use of tritium in a radiological dispersion device. *See* June 2022 Public Meeting Presentations, at slide 57.
[44] Part 110-Export and Import of Nuclear Equipment and Material, Final Rule, 43 Fed. Reg. 21,641, 21,642 (May 19, 1978). The Zangger Committee Trigger List (INFCIRC/209/Rev.5) can be found at its website. The Nuclear Suppliers Group Trigger List (INFCIRC/254/Rev.14/Part 1) can be found at its website. Notably, only the Nuclear Suppliers Group Part 1 Guidelines constitute the Trigger List referenced in the NNPA. The Nuclear Suppliers Group Part 2 Guidelines (INFCIRC/254/Rev.11/Part 2) constitute a separate, dual use export controls list discussed further below. INFCIRC/539/Rev.7 provides additional context as to the origin and structure of the Nuclear Suppliers Group guidelines.
[45] *See* Zangger Committee Trigger List, Memorandum B, Annex § 1; Nuclear Suppliers Group Part 1 Guidelines, Annex B § 1 (both Trigger Lists stating that the nuclear reactor entry "does not control fusion reactors").
[46] A. Glaser, R.J. Goldston, *Proliferation Risks of Magnetic Fusion Energy: Clandestine Production, Covert Production and Breakout* (2012).
[47] *See* the preprint (https://arxiv.org/abs/2207.14348) for further discussion, including a discussion on environmental tritium sampling.
[48] NPT § III.2.

purposes,[49] and fusion devices, tritium, and other related materials and technologies are excluded from these Trigger Lists. Indeed, fusion-related material and equipment is instead located on a separate Nuclear Suppliers Group non-Trigger List guidance document ("Part 2 Guidance"), affirming that the decision to keep fusion off of the Trigger Lists was intentional and thought-through.

This conclusion also aligns with historical NRC practice, including that 10 CFR Parts 73-75 define "significance" in the context of special nuclear material and implement safeguards only for those facilities handling or creating source or special nuclear materials.[50] The Commission has routinely declined to read its common defense mandate more broadly, focusing instead on special nuclear material proliferation and deferring on broader economic or national security issues to the other arms of the U.S. government. *See, e.g.,* U.S. Department of Energy (Export of 93.35% Enriched Uranium), CLI-20-02, at 11 (Apr. 13, 2020) (finding that the "applicable statutory criteria governing the export"—which includes a common defense analysis—do not include "consideration of economic or market-based interests"); U.S. Department of Energy (Plutonium Export License), CLI-04-17, at 21 (stating that the NRC defers to the Executive Branch's "strategic judgements" regarding the common defense and security of the United States).

Our analysis instead concludes that while common defense concerns do not arise for domestic licensing of fusion devices, they could be relevant in *export* licensing of fusion devices. Although fusion devices themselves do not fall within the Trigger Lists, they—along with a variety of other dual-use technologies—could be manipulated by a foreign state actor to present a proliferation concern in the future. That is one reason why the Nuclear Suppliers Group has already placed many fusion-related technologies and materials—including tritium and neutron-generators—within its separate Part 2 Guidance on application of "dual use" export controls.[51] As export controls are a federally-managed process there is no question of sole federal jurisdiction in this area.

B. Additional Material for NRC Evaluation

Due to the close relationship between the AEA's common defense and security analysis and nonproliferation, we wish to make available for NRC review a draft article entitled "*Nonproliferation and Fusion Power Plants,"* which evaluates commercial fusion devices against the NPT and the modern nonproliferation regime that comes from it. This article provides additional background as to the global nonproliferation regime, and evaluates the various hypothesized risks associated with fusion. It likewise concludes that because fusion is not especially designed to process, use, or produce source or special nuclear material, it does not and should not fit within the global NPT safeguards regime.

However, because fusion technology could be manipulated by rogue foreign state actors, the article concludes that effective export controls present a path forward for enabling fusion while protecting again the limited proliferation concerns that do exist. The article also suggests a new

[49] "The [Zangger] Committee has been focusing on what is meant in Article III.2 of the Treaty by 'especially designed or prepared equipment or material for the processing, use or production of special fissionable material.'" Zangger Committee Website.
[50] *See, e.g.,* 10 CFR 73.1 & 75.2 (limiting the scope of these regimes to activities involving source and special nuclear material); 10 CFR 73.2 (defining "significance" in the context of quantities of special nuclear material).
[51] Nuclear Suppliers Group Part 2 Guidelines (INFCIRC/254/Rev.11/Part 2).

"controls by design" approach that could incentivize design changes over time to reduce the ability for a fusion device or technology to be misappropriated for negative uses.

The article is available at the following website: https://arxiv.org/abs/2207.14348

IV. Conclusion

Thank you for the opportunity to provide additional comments as the NRC evaluates the appropriate framework for fusion.

As discussed, fusion devices are legally and technically a category of particle accelerators, and continuing this classification by the NRC would provide the agency sufficient authority to safely regulate these devices. A particle accelerator approach for fusion enables a right-sized, innovative framework to be developed for this game-changing technology—fulfilling the NRC's Transformation into a risk-informed regulator, protecting the climate, and promoting U.S. energy leadership, all while falling within the bounds of the AEA and long-standing application of the particle accelerator framework to fusion R&D devices. As well, since fusion devices are not especially designed to process, use, or produce special nuclear material, the limited nonproliferation issues associated with this technology are appropriately addressed through export controls and need not preclude Agreement State partnership in domestic licensing.

Helion is excited to work with the NRC as it establishes a path forward for regulating fusion devices, including through guidance and/or eventual establishment of a new regulatory framework such as a new 10 CFR Part 38.[52] We look forward to continuing to work with you on this important topic. Please let us know if you have any questions.

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[52] *See* June 2022 Public Meeting Presentations at 73.