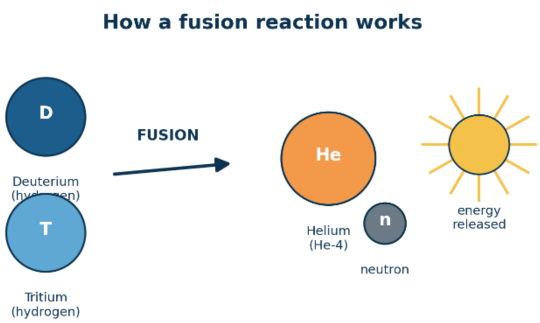
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF RADIOLOGICAL HEALTH

Division of Radiological Health: Fast Fusion Fact Sheet

What is fusion?

Nuclear fusion occurs when two atomic nuclei combine to create one heavier nucleus, releasing a large amount of energy in the process. The most well-known example of this reaction is found in the Sun, but once commercially replicated on Earth, fusion technologies may be able to generate large amounts of energy using less fuel than fission.

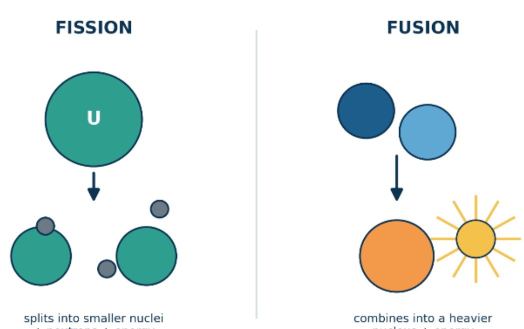


There are several approaches currently being explored for commercial use, including magnetic confinement (such as in tokamaks and stellarators) and inertial confinement (using lasers or particle beams). These methods aim to recreate extreme conditions like those found on the sun to sustain fusion and deliver practical energy output.

What is the difference between fusion and fission?

Fission and fusion both release energy through nuclear reactions, however; this is accomplished in fundamentally different ways. Fission occurs when an atomic nucleus, such as uranium or plutonium, splits into smaller nuclei, releasing energy and the additional neutrons sustain a chain reaction. This process is used in traditional nuclear power plants, including the Tennessee Valley Authority (TVA)'s Sequoyah and Watts Bar nuclear plants. Fission produces long-lived low-level radioactive waste and high-level waste in the form of used fuel.

Fusion, on the other hand, involves combining two atomic nuclei, typically hydrogen isotopes like deuterium (H-2) and tritium (H-3), to form a heavier nucleus, such as helium (He-4), and neutrons. This reaction releases significantly more energy than fission and, when used for power production, is expected to produce minimal long-lived low-level radioactive waste.



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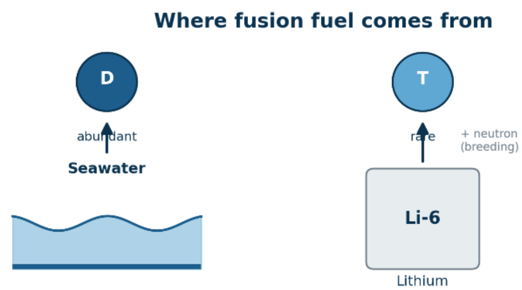
What is the fuel source for fusion?

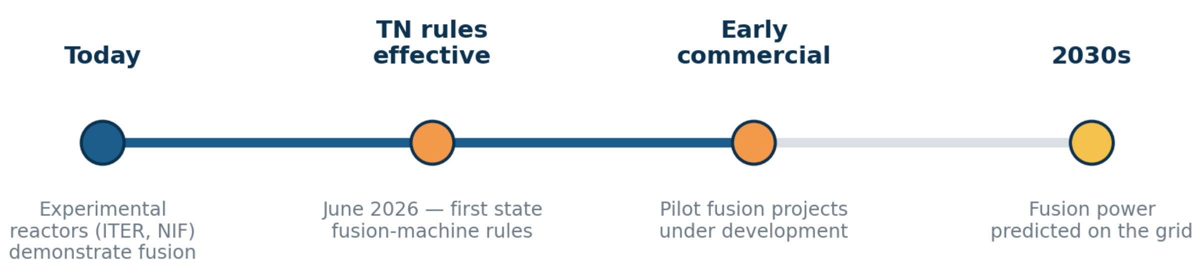


The primary fuel for fusion technologies currently under development is hydrogen isotopes, specifically deuterium and tritium. Deuterium is abundant in seawater, while tritium is rare. Most commercially available tritium today is produced in certain kinds of fission reactors, and some commercial fusion technologies are expected to rely on creating or “breeding” tritium using lithium (Li-6), which can produce tritium after absorbing neutrons.

Researchers are exploring other fusion reactions for future applications. All fuels currently under consideration are highly efficient, and fusion machines using them would produce minimal long-lived radioactive waste, making fusion a promising energy solution.

What is the timeline for the commercialization of fusion energy?

The fusion industry predicts that fusion power will be available and on the grid by the 2030s. Both the Nuclear Regulatory Commission (NRC) and TDEC’s focus is in making sure that the operation of these machines is done safely with the fusion regulatory framework.



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Are companies or research organizations generating fusion energy now?

Currently there are no fusion machines that are commercially operational in the United States producing electricity, but there are more 20 companies working toward this goal, including here in Tennessee.

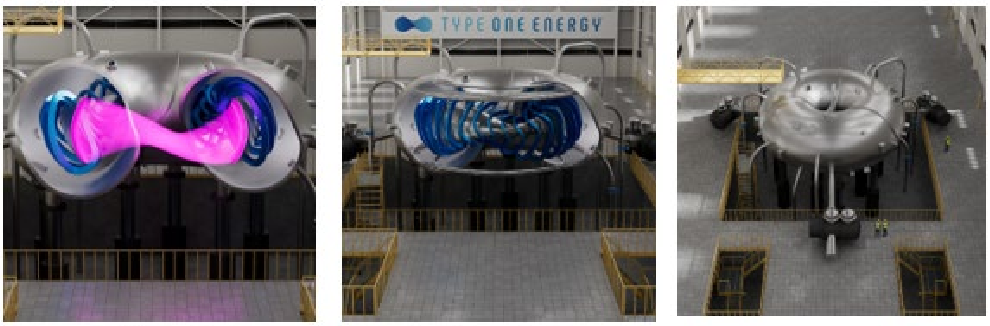

Image courtesy of Type One Energy

Laboratories such as the International Thermonuclear Experimental Reactor (ITER), the National Ignition Facility (NIF), and private ventures have successfully achieved fusion reactions, with some experiments demonstrating net energy gain. ITER, an international collaboration in France, is the world's largest fusion experiment, designed to demonstrate the feasibility of sustained fusion energy using magnetic confinement.

What is a fusion machine and how is it regulated?

Tennessee is the first state in the nation to create its own regulations for fusion machines further solidifying its reputation as the global epicenter of nuclear energy.

Tennessee promulgated rules which were effective as of June 9, 2026 defining fusion machines as any machine that is capable of (a) Transforming atomic nuclei, through fusion processes, into different elements, isotopes, or other particles through processes of fusion; and (b) Directly capturing and using the resultant elements, isotopes, particles, products, including particles, heat, or other electromagnetic radiation.

The Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy or ADVANCE Act, signed into law on July 9, 2024, also added the term "fusion

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machine" to the Atomic Energy Act of 1954, as amended. The amendment defines fusion machines as "a machine that is capable of (1) transforming atomic nuclei, through fusion processes, into different elements, isotopes, or other particles; and (2) directly capturing and using the resultant products, including particles, heat, or other electromagnetic radiation."

These definitions are purposefully technology-neutral to recognize there are many different ways to achieve fusion. The definitions also require the fusion machines directly capture and use the resultant products of the fusion process.

Unlike traditional fission nuclear plants which are regulated by the NRC, TDEC will be the main regulatory entity involved in the licensing and oversight of fusion machines.

Fusion machine-produced radioactive material is regulated under the byproduct material framework. Nationally this is Title 10 of the *Code of Federal Regulations* (10 CFR), Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material."

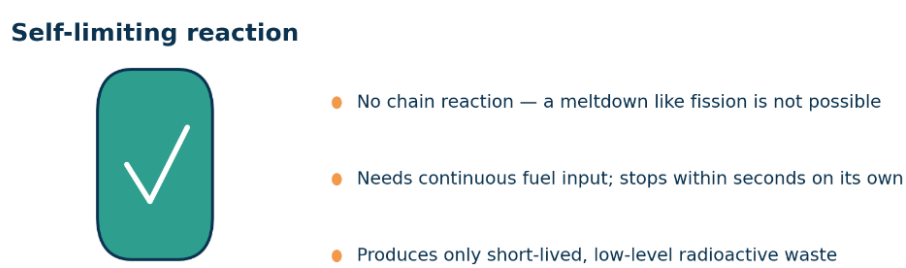
What are the safety concerns surrounding fusion machines?

While both fission and fusion reactions produce energy by modifying atoms, their fundamental differences have broad implications for safety.

The conditions required to start and maintain a fusion reaction make a fission-type accident or nuclear meltdown based on a chain reaction impossible. The extreme conditions required to allow for nuclear fusion— temperatures exceeding 100 million degrees Celsius to achieve enough particle density long enough for the reaction to take place— make a 'runaway' chain reaction impossible.

Fusion reactions depend on the continuous input of fuel, and the process is highly sensitive to any variation in working conditions. Given that a fusion reaction could come to a halt within seconds, the process is inherently safe. The fusion reaction becomes a self-limiting process by switching itself off if the reaction cannot be controlled.

Furthermore, fusion does not produce high level nuclear waste. Activated components or contaminated items such as protective clothing or cleaning supplies are low level radioactive waste that can be handled safely with existing infrastructure.



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