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SUMMARY

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Todd Kuiken
Analyst in Science and Technology Policy

Toward Commercial Fusion Energy: Considerations for Congress

While there has been considerable U.S. public and private investment in developing fusion energy, scientific and technological hurdles remain for commercial viability. Congress may have an interest in U.S. strategic positioning in regard to fusion energy technology as countries around the world, including China, are competing to be the first to achieve commercialized fusion energy.

Nuclear fusion is a process in which the nuclei of two lightweight atoms join, or *fuse*, to form a heavier nucleus, releasing energy. Achieving fusion requires three conditions: (1) heating a small quantity of fuel above its ignition point, (2) maintaining the reaction long enough for the release of fusion energy to exceed the energy input, and (3) converting the energy released to a useful form of energy (e.g., electricity). As of the date of this report, just one project claims to have successfully achieved the first condition and partially achieved the second. Once all three are achieved, electricity generated by a fusion reaction would then need to be integrated into the electric grid, which may introduce additional engineering and technical challenges. Different designs and technologies are being explored to achieve commercial fusion energy.

Federally funded fusion energy research and development (R&D) is primarily supported by the Department of Energy's (DOE's) Office of Science through its Fusion Energy Sciences (FES) program. In FY2025, the FES program budget was $790 million. According to the U.S. Government Accountability Office (GAO), from FY2020 to FY2023, about 70% of FES's budget supported three projects, including two DOE user facilities and an international fusion project called ITER, formerly the International Thermonuclear Experimental Reactor, which accounted for about 30% of the total FES budget. DOE also supports fusion energy research directed toward weapons activities and improved stewardship of the U.S. nuclear weapons stockpile. This latter work includes inertial confinement, an approach used in the National Ignition Facility (NIF) at the DOE Lawrence Livermore National Laboratory to initiate fusion reactions. In 2022, NIF became the first facility to achieve "ignition," when the energy released by the fusion reaction is greater than the energy directly expended to create the reaction, an event that has increased interest in inertial confinement designs for future power plants. In 2024, DOE released its Fusion Energy Strategy, which focuses on three pillars: (1) resolving the scientific and technological gaps to a fusion pilot plant, (2) paving the way for commercial fusion deployment, and (3) cultivating and expanding partnerships. As part of the strategy, DOE developed a science and technology roadmap composed of targeted actions and metric-driven milestones to guide DOE investments in order to support a competitive U.S. fusion energy industry.

The number of private fusion companies has increased significantly in the past few years. According to a recent survey of private fusion companies, they raised $2.2 billion in private funding in 2025, with total private investment reaching nearly $9 billion between 2021 and 2025. The survey also shows that a majority of these companies believe there will be a commercially viable fusion plant by 2035, with some responding that it will be before 2030. However, the timing of commercial fusion energy may be difficult to predict.

Congress may have a continued interest in shaping the broader U.S. fusion R&D strategy to achieve commercially viable fusion energy. Congress may consider whether current federal funding levels, R&D priorities, supply chains, workforce pipelines, levels of international collaboration, and public engagement programs are appropriate to achieve the first commercial fusion power plant and establish a fusion energy industry in the United States. Congress may also choose to investigate the strategic positioning of the United States as it relates to China and other countries, such as Japan, Germany, and the United Kingdom, all of which have strategies to develop fusion energy.

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Introduction

Fusion is the opposite of fission: Instead of splitting heavy atoms to generate energy, fusion attempts to "fuse" light atoms together.[1] While there has been considerable U.S. public and private investment toward commercializing fusion energy, scientific and technological hurdles remain. Congress may have an interest in U.S. strategic positioning in regard to fusion energy technology as countries around the world, including China, are competing to be the first to achieve commercialized fusion energy.

This report provides an overview of fusion energy and the fusion research and development (R&D) landscape, including technology approaches being explored, federal R&D programs and investments, the state of the private fusion industry and potential timelines toward commercialization of fusion energy, impacts of artificial intelligence (AI), regulations and permitting of fusion reactors, and considerations for Congress.

Basics of Fusion Energy

Nuclear fusion is a process in which the nuclei of two lightweight atoms (such as hydrogen) join, or *fuse*, to form a heavier nucleus, releasing energy (see **Figure 1**). Fusion reactions take place in a hot, dense, ionized gas (i.e., one in which the electrons have separated) called *plasma* (the fourth state of matter). Plasmas that generate a predefined ratio of energy from the ongoing nuclear fusion reaction relative to the added external energy from the experimental apparatus are deemed *burning plasmas*. Under the right conditions, burning plasmas can approach or exceed the point at which the reaction achieves ignition, where the energy resulting from the reaction is greater than the energy directly needed to enable the reaction. The Sun is an example of a self-sustaining[2] burning plasma that has reached ignition.

Creating and maintaining a fusion reaction requires fuel. Various types of fuels have been proposed for fusion reactor[3] technologies, including isotopes of hydrogen, such as deuterium and tritium,[4] or heavier elements, such as boron. According to a report from the U.S. Government Accountability Office (GAO), "the deuterium-tritium reaction is the easiest to achieve, so it is highly studied and the likely basis for the first fusion energy systems."[5] When deuterium and tritium fuse, they produce helium, and excess energy is released because the remaining potential energy is lower than when the deuterium and tritium were separate (see **Figure 1**). According to

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[1] For additional information on nuclear fission, see CRS Report R42853, *Nuclear Energy: Overview of Congressional Issues*, by Mark Holt.

[2] A self-sustaining fusion reaction is dependent on a constant source of fuel. For example, ignition is achieved in an inertial confinement fusion device when lasers are directed onto a fuel "pellet," which creates the fusion reaction. Once the fusion reaction occurs, energy is released, and the reaction ends. The process starts over with each new pellet that is added to the device.

[3] A reactor is the device in which the reaction will take place. The term *nuclear reactor* is typically related to a nuclear fission reactor. For fusion, these types of devices are often referred to as "fusion machines" (see "Regulation and Permitting for Commercial Fusion Energy").

[4] "Deuterium is a stable isotope of hydrogen, which, unlike 'normal' hydrogen atoms, or protium, also contains a neutron. The isotope deuterium has one proton, one neutron and one electron" (Puja Daya, "What Is Deuterium?," International Atomic Energy Agency [IAEA], January 13, 2023, https://www.iaea.org/newscenter/news/what-is-deuterium). Tritium "is a hydrogen atom that has two neutrons in the nucleus and one proton" (Environmental Protection Agency, "Radionuclide Basics: Tritium," January 22, 2026, https://www.epa.gov/radiation/radionuclide-basics-tritium).

[5] U.S. Government Accountability Office (GAO), *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO-23-105813, March 2023, p. 4, https://www.gao.gov/products/gao-23-105813.

one fusion expert, "Everything in the universe aspires to be iron—so light things fuse and heavy things split to move toward the middle of the periodic table (i.e., iron). At the light end of the scale, deuterium and tritium are the furthest away from iron, so they have the greatest aspirations."[6]

Achieving practical fusion energy requires three things: (1) heating a small quantity of fuel above its ignition point (about 100 million degrees Celsius), (2) maintaining the reaction long enough for the release of fusion energy to exceed the total energy input, and (3) converting the energy released to a useful form of energy (e.g., electricity).[7] To date, these three conditions have not reportedly been achieved. One project claims to have successfully achieved the first condition and partially achieved the second.[8] If all three are achieved, electricity generated by a fusion reaction would then need to be integrated into the electric grid, which may introduce additional engineering and technical hurdles.[9]

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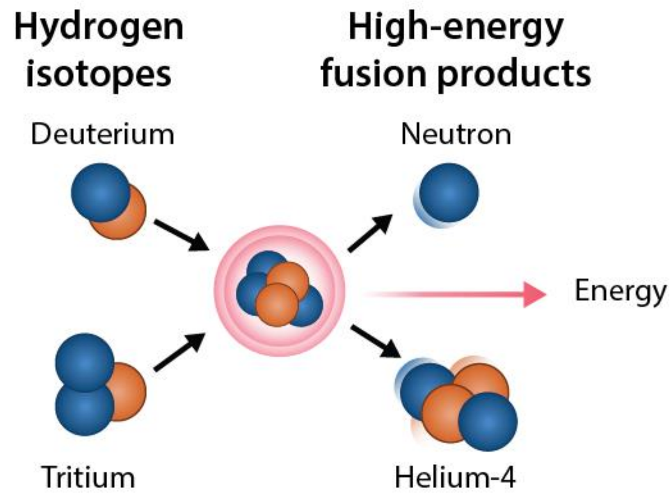
[6] Piers Letcher, "The Magic Cocktail of Deuterium and Tritium," ITER, February 6, 2023, https://www.iter.org/node/20687/magic-cocktail-deuterium-and-tritium.

[7] Richard F. Post, "Fusion Power: The Uncertain Certainty," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024). Originally published in 1971 by *Bulletin of the Atomic Scientists*.

[8] The National Ignition Facility (NIF), which operates on a different concept than the magnetic confinement described in this memorandum, reports it "produced more energy from fusion than the laser energy used to drive it." U.S. Department of Energy (DOE), "DOE National Laboratory Makes History by Achieving Fusion Ignition," press release, December 13, 2022, https://www.energy.gov/articles/doe-national-laboratory-makes-history-achieving-fusion-ignition. The fusion was of short duration, less than one nanosecond, impractical for use in electricity applications. A. L. Kritcher et al., "Design of an Inertial Fusion Experiment Exceeding the Lawson Criterion for Ignition," *Physical Review E*, vol. 106 (August 8, 2022), article 025201, https://doi.org/10.1103/PhysRevE.106.025201. Although it achieved ignition, the energy produced from the NIF fusion reaction exceeded only the laser energy directed onto the fuel. The energy calculations did not include the energy needed to operate the lasers themselves. For example, see Dina Genkina, "Fusion 'Breakthrough' Won't Lead to Practical Fusion Energy," *IEEE Spectrum*, April 16, 2024, https://spectrum.ieee.org/national-ignition-facility-impractical.

[9] GAO, *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO-23-105813, March 2023, p. 5, https://www.gao.gov/products/gao-23-105813.

Figure 1. Fusion of Hydrogen Isotopes



Source: CRS, adapted from U.S. Government Accountability Office, *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO-23-105813, March 2023, p. 4, https://www.gao.gov/products/gao-23-105813.

Notes: The orange circles represent protons; the blue circles represent neutrons. When deuterium and tritium fuse together the result is a helium-4 atom (two protons, two neutrons, and two electrons [not shown]), along with the release of a neutron and energy. "Deuterium is a stable isotope of hydrogen, which, unlike 'normal' hydrogen atoms, or protium, also contains a neutron. The isotope deuterium has one proton, one neutron and one electron" (Puja Daya, "What Is Deuterium?," International Atomic Energy Agency, January 13, 2023, https://www.iaea.org/newscenter/news/what-is-deuterium). Tritium "is a hydrogen atom that has two neutrons in the nucleus and one proton" (Environmental Protection Agency, "Radionuclide Basics: Tritium," January 22, 2026, https://www.epa.gov/radiation/radionuclide-basics-tritium).

Fusion Technology Approaches

A key challenge for maintaining a fusion reaction is confining the fuel. The plasma fuel for the reaction must be confined to keep it hot and dense so the reaction can continue. The plasma, which can reach temperatures up to 150 million degrees, requires specialized containment devices that can withstand such high temperatures and pressures. Different designs and technologies are being explored to achieve commercial fusion energy.[10]

Two main strategies have been developed for fusion energy: magnetic confinement and inertial confinement, each of which can have different design concepts (examples discussed below). One analysis showed that global private investment has pursued magnetic confinement designs at a rate nearly 10 times greater than it has pursued inertial confinement and other concepts.[11]

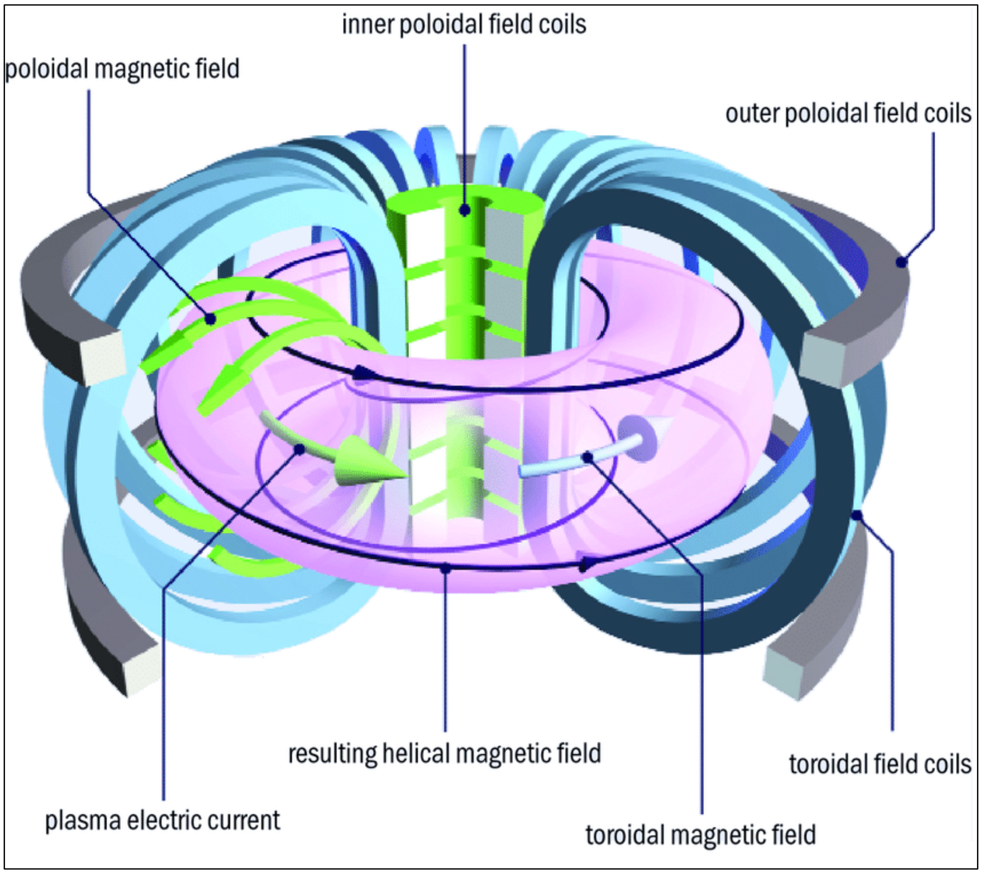
[10] For examples and schematical drawings of different types of fusion reactor designs being developed around the world, see IAEA, *IAEA World Fusion Outlook 2025*, 2025, pp. 16-31, https://www.iaea.org/publications/15935/iaea-world-fusion-outlook-2025.

[11] Fusion for Energy, *Global Investment in the Private Fusion Sector*, 2nd ed. (2025), p. 16, https://fusionforenergy.europa.eu/wp-content/uploads/2025/11/F4E_Observatory_2025_digital.pdf.

Magnetic Confinement

In magnetic confinement, the plasma is held in place using magnetic fields. This is the most common choice both for current research reactors and for some planned power plant designs. A widely used configuration known as a *tokamak* uses powerful magnets to confine the plasma within a toroidal (doughnut-shaped) reaction vessel to create the conditions for fusion (see **Figure 2**). An electric field drives a current through the plasma, which generates a poloidal magnetic field that bends the plasma current into a circle. The other magnetic field goes around the length of the doughnut.[12] The combination of these two fields keeps the plasma away from the walls of the vessel to prevent damage to the walls and unintended cooling of the plasma.[13] A spherical tokamak has a more rounded shape (i.e., a cored apple) than the toroidal tokamak. It inherits the basic stability and confinement properties of the tokamak in a potentially more compact system.[14]

Figure 2. Schematic of a Tokamak Reactor



Source: Francesco Romanelli, "Fusion Energy," *EPJ Web of Conferences*, vol. 246 (2020), article 00013, https://doi.org/10.1051/epjconf/202024600013.

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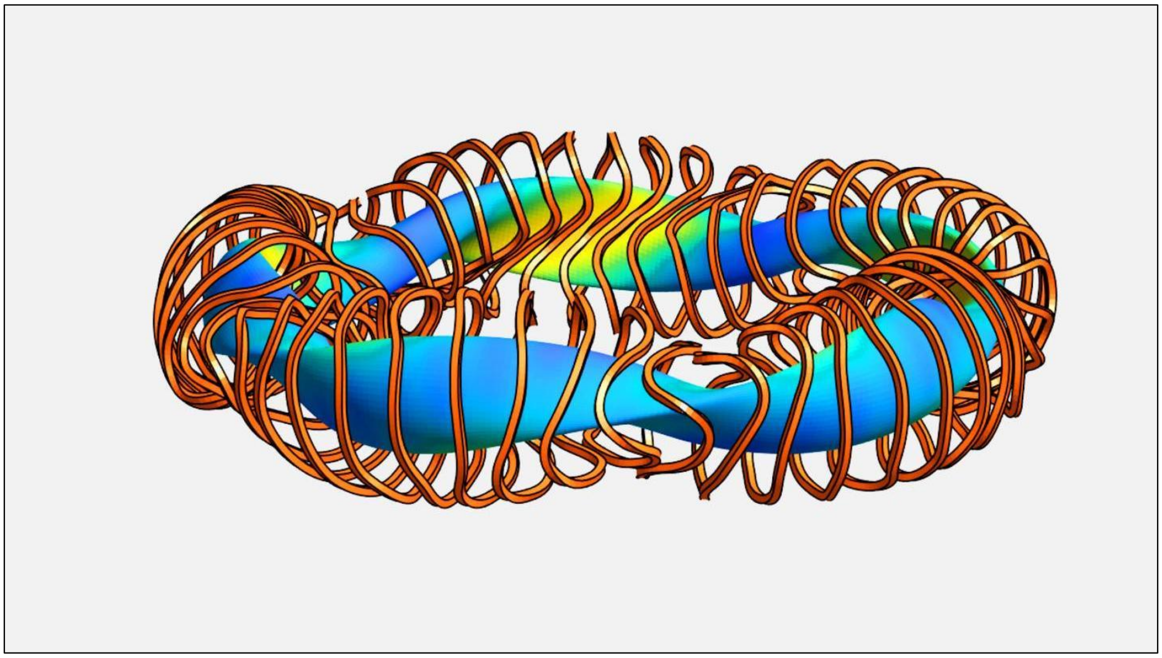
[12] Wolfgang Picot, *Magnetic Fusion Confinement with Tokamaks and Stellarators*, *IAEA Bulletin*, vol. 62, no. 2 (2021), https://www.iaea.org/bulletin/magnetic-fusion-confinement-with-tokamaks-and-stellarators.

[13] Robert J. Goldston, "An Overview of the Fusion Landscape," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024); Francesco Romanelli, "Fusion Energy," *EPJ Web of Conferences*, vol. 246 (2020), article 00013, https://doi.org/10.1051/epjconf/202024600013.

[14] Robert J. Goldston, "An Overview of the Fusion Landscape," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024).

In a *stellarator*, a version of a tokamak, the coils that form the magnetic fields are twisted or tilted in such a way as to direct the magnetic field lines around the torus (the doughnut-shaped area of the reactor where the plasma is contained) (see **Figure 3**).[15] Typically, the magnetic field in a stellarator is created using electromagnetic coils.[16] The twisting magnetic field design is more complex than the design of a tokamak, but the plasma may be more stable in comparison.

Figure 3. Schematic of a Stellarator



Source: John Greenwald, "PPPL Researcher's Work Yields a Breakthrough For a Promising Fusion-Energy Device," Princeton Plasma Physics Laboratory, March 3, 2022, https://research.princeton.edu/news/pppl-researchers-work-yields-breakthrough-promising-fusion-energy-device.

Notes: The blue mass represents plasma, and the bronze-colored coils represent magnets, which are twisted in such a way as to direct the magnetic field lines around the stellarator's torus (the doughnut-shaped area of the reactor where the plasma is contained).

Example of Other Magnetic Confinement Concepts

In a zeta pinch, or Z-pinch, fusion device, magnets are not needed for confinement. An electrical current is driven from one electrode to another, and if this current is strong enough, it can create a magnetic field to contain the plasma. The resistance of the current through the electrodes also heats the plasma to create the conditions necessary for a fusion reaction to occur.[17]

Zap Energy, a fusion company utilizing a Z-pinch configuration for its fusion device, describes the technology as follows:

> As every physics student learns, electric currents also create magnetic fields. Point your right thumb in the direction of a current [i.e., a straight line] and curl your fingers inward, and they will reveal the direction of the associated magnetic field (the "right hand rule"

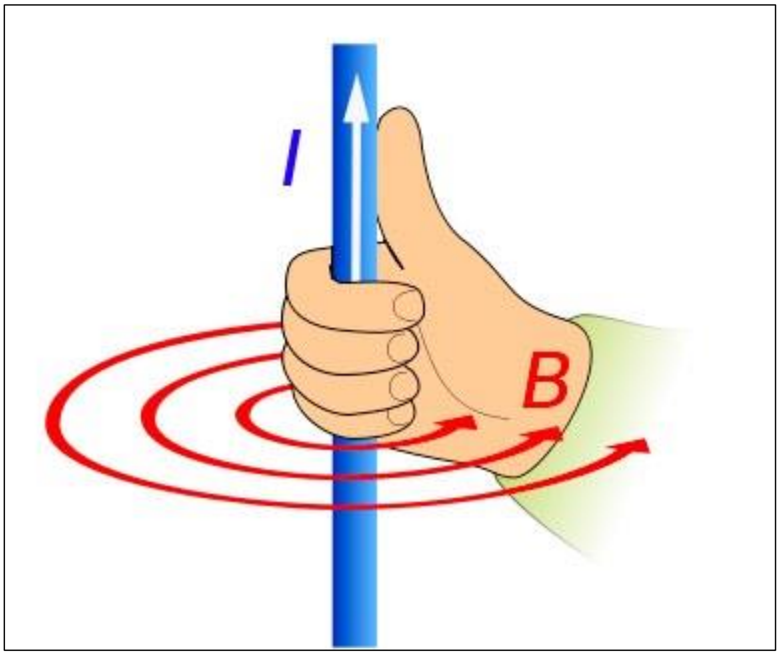
[15] Robert J. Goldston, "An Overview of the Fusion Landscape," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024).

[16] University of Maryland Stellarator Group, "Stellarators," https://terpconnect.umd.edu/~mattland/projects/1_stellarators/.

[17] Robert J. Goldston, "An Overview of the Fusion Landscape," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024).

[see **Figure 4**]). A pinch happens when charged particles flow across those magnetic fields, for example when you run a current through a bundle of electric wires. Squeezed by these magnetic fields, the wires constrict like [a] crumpled lightning rod. The same thing happens if you run a current through a column of plasma, a state of matter packed with charged particles. This special kind of pinch is called a Z pinch, and the stronger the electric current, the more powerful its pinch becomes. With a powerful enough pinch, the plasma will get so hot and dense that the elements in the plasma fuse into entirely new elements.[18]

Figure 4. Determining the Direction of Magnetic Fields with the Right-Hand Rule



Source: Kawsar Ahmed, "Why Does the Right Hand Rule Work for Determining the Direction of Magnetic Field Around a Straight Current Carrying Wire?," *Physics Stack Exchange* (blog), 2017, https://physics.stackexchange.com/q/343192.

Notes: "I" indicates the direction of the current; "B" indicates the direction of the magnetic field.

Inertial Confinement

In inertial confinement, pulsed sources of energy directed toward small fuel targets create rapid fusion reactions in short bursts, with each reaction completing before the plasma fuel has time to disperse. Lasers are the most developed technology for this purpose. The lasers cause the fuel to compress when the capsule containing the target fuel burns off, or *ablates*.[19] This approach is used, for example, in the National Ignition Facility (NIF) at the Department of Energy (DOE) Lawrence Livermore National Laboratory.[20] While the NIF is intended primarily for research to improve stewardship of the U.S. nuclear weapons stockpile (see "DOE Weapons Programs Research Related to Fusion"), it has also demonstrated fusion ignition several times, beginning in

[18] Zap Energy, "How It Works," 2025, https://www.zapenergy.com/how-it-works.

[19] National Academies of Sciences, Engineering, and Medicine, *Interim Report—Status of the Study "An Assessment of the Prospects for Inertial Fusion Energy"* (National Academies Press, 2012), p. 16, https://www.nationalacademies.org/read/13371/chapter/1.

[20] Lawrence Livermore National Laboratory, "National Ignition Facility & Photon Science," 2025, https://lasers.llnl.gov/.

December 2022.[21] Although each ignition lasted for less than one nanosecond, these demonstrations have increased interest in inertial confinement designs for future power plants.[22] According to some experts, for lasers to be used in a commercial power plant, they would need to be more efficient and have higher repetition rates than current models. In addition, the targets, or fuel, would need to be manufactured precisely and then positioned, compressed, and heated to fusion temperatures as often as 10 times per second. Other concepts are also being researched to deliver the pulsed power needed for inertial confinement fusion, such as electrical currents.[23]

Federal Programs for Fusion Research and Development (R&D)

Public investment in fusion R&D can take different forms, including basic plasma physics research, engineering concepts underlying different types of fusion reactors, and weapons-related activities. According to GAO, the United States began to fund magnetic confinement[24] fusion research at national laboratories in 1951.[25] In 1971, the United States invested approximately $30 million ($180.4 million adjusted for inflation in 2024 dollars)[26] in fusion research efforts, representing about 25% of the global investment in fusion R&D. At that time, about 50% of the total global investment in fusion came from Russia.[27]

Discussed below are fusion-related R&D programs from DOE and the National Science Foundation (NSF). Other federal agencies may be engaged in additional fusion-related activities, including the Department of Defense, which is "using a secondary Department of War designation" under Executive Order 14347 of September 5, 2025.[28]

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[21] National Ignition Facility and Photon Science, "Achieving Fusion Ignition," https://lasers.llnl.gov/science/achieving-fusion-ignition.

[22] DOE, "DOE National Laboratory Makes History by Achieving Fusion Ignition," press release, December 13, 2022, https://www.energy.gov/articles/doe-national-laboratory-makes-history-achieving-fusion-ignition.

[23] Robert J. Goldston, "An Overview of the Fusion Landscape," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024).

[24] In magnetic confinement, the plasma is held in place using magnetic fields. This is the most common choice both for current research reactors and for planned power plant designs. A widely used configuration known as a "tokamak" uses powerful magnets to confine the plasma within a toroidal (doughnut-shaped) reaction vessel, with the magnetic fields keeping the plasma away from the walls of the vessel to prevent damage and unintended cooling of the plasma.

[25] GAO, *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO-23-105813, March 2023, p. 7, https://www.gao.gov/products/gao-23-105813.

[26] Inflation-adjusted values based on Table 10.1 - Gross Domestic Product and Deflators Used in the Historical Tables: 1940-2024, https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.whitehouse.gov%2Fwp-content%2Fuploads%2F2025%2F06%2FBUDGET-2026-HIST.xlsx&wdOrigin=BROWSELINK.

[27] Richard F. Post, "Fusion Power: The Uncertain Certainty," *Bulletin of the Atomic Scientists,* vol. 80, no. 6 (2024). Originally published in 1971 by *Bulletin of the Atomic Scientists*. For a historical perspective on U.S. fusion research and development and DOE-specific fusion programs and offices, see Stephen O. Dean, "Historical Perspective on the United States Fusion Program," paper presented at the American Nuclear Society 16th Topical Meeting on the Technology of Fusion Energy, Madison, WI, September 14-16, 2004, https://fire.pppl.gov/Dean_US_fusion_TOFE_2004.pdf.

[28] Executive Order 14347 of September 25, 2025, "Restoring the United States Department of War," 90 *Federal Register* 43893, September 10, 2025, https://www.federalregister.gov/documents/2025/09/10/2025-17508/restoring-the-united-states-department-of-war.

DOE Fusion R&D

Federal funding for fusion energy R&D is primarily awarded by DOE's Office of Science[29] through its Fusion Energy Sciences (FES) program.[30] According to DOE, the mission of the FES program is "to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source."[31] On November 20, 2025, DOE announced an organizational realignment that made several changes to the offices overseen by the Under Secretary for Science, which may impact FES.[32] The new organizational chart established an Office of Fusion within the responsibilities of the Under Secretary for Science.[33] CRS has been unable to determine whether the Office of Fusion will take over all responsibilities pertaining to FES, which previously had been under the Office of Science.

DOE Fusion Strategy

According to DOE, the mission of its FES program is to "expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source."[34] FES has four stated strategic goals:

> 1. Advance the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source;
>
> 2. Support the development of the scientific understanding required to design and deploy the materials needed to support a burning plasma environment;
>
> 3. Pursue scientific opportunities and grand challenges in high energy density plasma science to better understand our universe, and to enhance national security and economic competitiveness;
>
> 4. Increase the fundamental understanding of basic plasma science, including both burning plasma and low temperature plasma science and engineering, to enhance economic [competitiveness] and to create opportunities for a broader range of science-based applications.[35]

In 2020, the DOE Fusion Energy Sciences Advisory Committee (FESAC)[36] published a long-range plan to deliver fusion energy and to advance plasma science. In the report, FESAC

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[29] The Office of Science was created in FY1999 in P.L. 105-245, the Energy and Water Development Appropriations Act, 1999. Previously, the Office of Energy Research administered basic science programs, starting in 1977 with the creation of DOE in P.L. 95-91, the Department of Energy Organization Act. See also CRS In Focus IF12692, *Department of Energy (DOE) Office of Science*, by Todd Kuiken.

[30] DOE, "Fusion Energy Sciences," https://www.energy.gov/science/fes/fusion-energy-sciences.

[31] DOE, "Mission," 2025, https://science.osti.gov/fes/About.

[32] DOE, "Energy Department Announces Organizational Realignment to Strengthen Efficiency and Unleash American Energy," press release, November 20, 2025, https://www.energy.gov/articles/energy-department-announces-organizational-realignment-strengthen-efficiency-and-unleash.

[33] For DOE's November 25, 2025, organizational chart, see https://www.energy.gov/sites/default/files/2025-11/Organization-Chart-11.20.2025-2.pdf.

[34] DOE, "Mission," 2025, https://science.osti.gov/fes/About.

[35] DOE, "Fusion Energy Sciences (FES)," 2025, https://science.osti.gov/fes.

[36] FESAC has been chartered pursuant to Section 14(a)(2)(A) of P.L. 92-463, the Federal Advisory Committee Act, and Title 41, Section 101-6.1015 of the *Code of Federal Regulations*. The committee provides independent advice to the DOE Director of the Office of Science on complex scientific and technological issues that arise in the planning, implementation, and management of the FES program. The current charter is in effect until August 2025.

recommended that DOE focus on establishing the scientific and technical basis for a fusion pilot plant by the 2040s, to include the following:

- "Build the science and technology required to confine and sustain a burning plasma.
- "Develop the materials required to withstand the extreme environment of a fusion reactor.
- "Engineer the technologies required to breed fusion fuel and to generate electricity in a fusion pilot plant by the 2040s."[37]

In 2021, the National Academies of Sciences, Engineering, and Medicine reported that the United States was positioned to begin planning its first fusion pilot plant; however, the report concluded that

> successful operation of a pilot plant in the 2035-2040 timeframe requires urgent investments by DOE and private industry—both to resolve the remaining technical and scientific issues and to design, construct, and commission a pilot plant.[38]

In 2024, DOE released its Fusion Energy Strategy (strategic plan), which focuses on three pillars: (1) resolving the scientific and technological gaps to creating a fusion pilot plant, (2) paving the way for commercial fusion deployment, and (3) cultivating and expanding partnerships.[39]

According to the strategic plan, the budgets of the FES program were to be realigned to focus on closing the science and technology (S&T) gaps needed to realize commercial fusion energy in three areas: "sustain a burning plasma, engineer for extreme conditions, and harness fusion power."[40] In particular, the strategic plan, if implemented, would shift research toward fusion materials and technology. As part of the strategic plan, DOE developed and implemented an S&T roadmap, which was released in October 2025.[41] The strategic plan and roadmap are intended to enable a partnership and dialogue with the private fusion industry.

DOE Fusion Science and Technology Roadmap

The Fusion Science & Technology Roadmap (S&T roadmap) proposes a series of targeted actions and metric-driven milestones to help guide DOE investments in order to support a "competitive U.S. fusion energy industry" that is aligned with the 2020 FESAC long-range plan.[42] One expert from the DOE noted in 2023 that "the largest new fusion experiments in the U.S. are now being built by the private sector."[43] Recognizing the increased private investment in fusion energy, DOE

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[37] FESAC, *Powering the Future: Fusion & Plasmas*, 2020, p. iv, https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC_Report_2020_Powering_the_Future.pdf.

[38] National Academies of Sciences, Engineering, and Medicine, *Bringing Fusion to the U.S. Grid* (National Academies Press, 2021), pp. 93-94, https://nap.nationalacademies.org/catalog/25991/bringing-fusion-to-the-us-grid.

[39] DOE, *Fusion Energy Strategy 2024*, 2024, https://www.energy.gov/sites/default/files/2024-06/fusion-energy-strategy-2024.pdf.

[40] DOE, *Fusion Energy Strategy 2024*, 2024, p. 4, https://www.energy.gov/sites/default/files/2024-06/fusion-energy-strategy-2024.pdf (capitalization altered). These three areas of research were identified in FESAC, *Powering the Future: Fusion & Plasmas*, 2020, https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC_Report_2020_Powering_the_Future.pdf.

[41] DOE, *Fusion Science & Technology Roadmap*, 2025, https://www.energy.gov/sites/default/files/2025-10/fusion-s%26t-roadmap-101625.pdf.

[42] DOE, *Fusion Science & Technology Roadmap*, 2025, p. 5, https://www.energy.gov/sites/default/files/2025-10/fusion-s%26t-roadmap-101625.pdf.

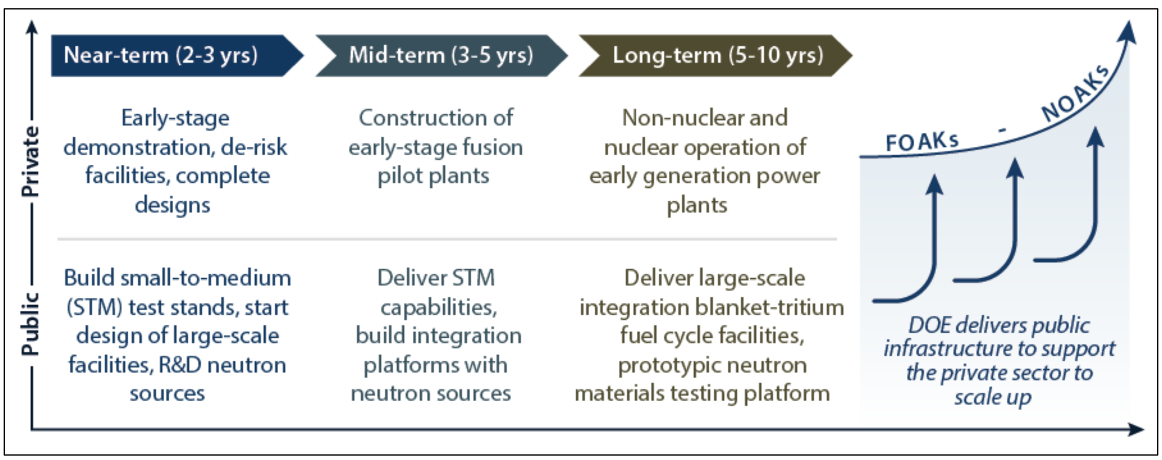
[43] Scott C. Hsu, "U.S. Fusion Energy Development Via Public-Private Partnerships," *Journal of Fusion Energy*, vol. 42 (2023), article 12.

developed the S&T roadmap to work in conjunction with private industry to achieve commercial fusion energy.

According to the S&T roadmap, 10 key actions are to be "executed in the near-term (next 2-3 years), mid-term (3-5 years) and long-term (5-10 years)" in order to "deliver the public infrastructure that supports the fusion private sector scale-up in the 2030s" (see **Figure 5**).[44] These are the 10 key actions:

1. Deliver Fusion Science and Technology Infrastructure
2. Build the AI-Fusion Digital Convergence Platform
3. Pursue Innovative and Transformative Research
4. Advance Toward Cost-Competitive Fusion Power Plants
5. Expand Public-Private Partnership Programs
6. Seed Fusion Supply Chains
7. Foster Talent by Enabling Fusion Workforce Pathways
8. Leverage Advanced Nuclear R&D and Deployment
9. Support a Practical Path to Fusion Energy Adoption
10. Provide a Path to Commercialization

Figure 5. Department of Energy (DOE) R&D Investment Timeline Toward Commercialized Fusion Energy



Source: DOE, *Fusion Science & Technology Roadmap*, 2025, p. 9, https://www.energy.gov/sites/default/files/2025-10/fusion-s%26t-roadmap-101625.pdf.

Notes: FOAK = first-of-a-kind power plant; NOAK = *n*th-of-a-kind power plant; R&D = research and development. The "blanket" is the material that surrounds the plasma and covers the inner walls of a tokamak fusion device, which helps protect the outer walls and overall structure from the heat and high energy from the fusion reaction. The heat and energy generated by the fusion reaction and absorbed by the blanket can then be converted into a usable form of electricity. The blanket is also intended to "breed" (i.e., produce) tritium fuel, resulting from the emitted neutrons and their reaction with the blanket, which contains lithium. See ITER, "The Machine Blanket," 2026, https://www.iter.org/machine/blanket.

The S&T roadmap is intended to guide DOE's public investment in order to support the private sector's development of demonstration plants and eventual full-scale commercial fusion power

[44] DOE, *Fusion Science & Technology Roadmap*, 2025, p. 5, https://www.energy.gov/sites/default/files/2025-10/fusion-s%26t-roadmap-101625.pdf.

plants. Per the S&T roadmap, DOE will focus on six core S&T challenge areas identified as common across the fusion industry:[45]

> **Structural Materials Science & Technology**
>
> The design, development and qualification of materials, structures and systems that can withstand the high neutron flux, thermal loads and environmental stresses of a fusion power plant.
>
> **Plasma-Facing Components and Plasma-Materials Interactions**
>
> The design and testing of materials, structures and systems that can withstand the high neutron flux, thermal loads and environmental stresses[[46]] of a fusion power plant.
>
> **Advancing Confinement Approaches**
>
> The physics and engineering of creating, sustaining and controlling high-performance burning plasmas.
>
> **Fuel Cycle and Tritium Processing**
>
> The technologies and processes needed to produce, handle and recycle fusion fuels in a closed loop.
>
> **Blanket Science & Technology[[47]]**
>
> The development of blanket concepts (e.g., solid, liquid, molten salt), materials compatibility studies, thermal hydraulics, tritium transport modeling and integrated testing to validate performance and maintainability.
>
> **Fusion Plant Engineering & System Integration**
>
> The design and integration of the entire plant system, beyond the fusion engine.

DOE Fusion R&D Funding

In FY2025, the FES program budget was $790 million (see **Figure 6**).[48] According to GAO, from FY2020 to FY2023, about 70% of FES's budget supported three projects: two DOE user facilities (see "DOE Fusion Energy User Facilities") and ITER (see "ITER (International Thermonuclear Experimental Reactor)"), the latter accounting for about 30% of the total FES budget.[49] Under P.L. 119-74, the Commerce, Justice, Science; Energy and Water Development; and Interior and Environment Appropriations Act, 2026, the budget for FES is $806 million, about 21% of which is directed toward ITER.[50]

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[45] DOE, *Fusion Science & Technology Roadmap*, 2025, p. 34, https://www.energy.gov/sites/default/files/2025-10/fusion-s%26t-roadmap-101625.pdf.

[46] "Environmental stresses" refer to the environment created within the fusion device itself.

[47] The "blanket" is the material that surrounds the plasma and covers the inner walls of a tokamak fusion device, which helps protect the outer walls and overall structure from the heat and high energy from the fusion reaction. The heat and energy generated by the fusion reaction and absorbed by the blanket can then be converted into a usable form of electricity. The blanket is also intended to "breed" (i.e., produce) tritium fuel, resulting from the emitted neutrons and their reaction with the blanket, which contains lithium. See ITER, "The Machine Blanket," 2026, https://www.iter.org/machine/blanket.

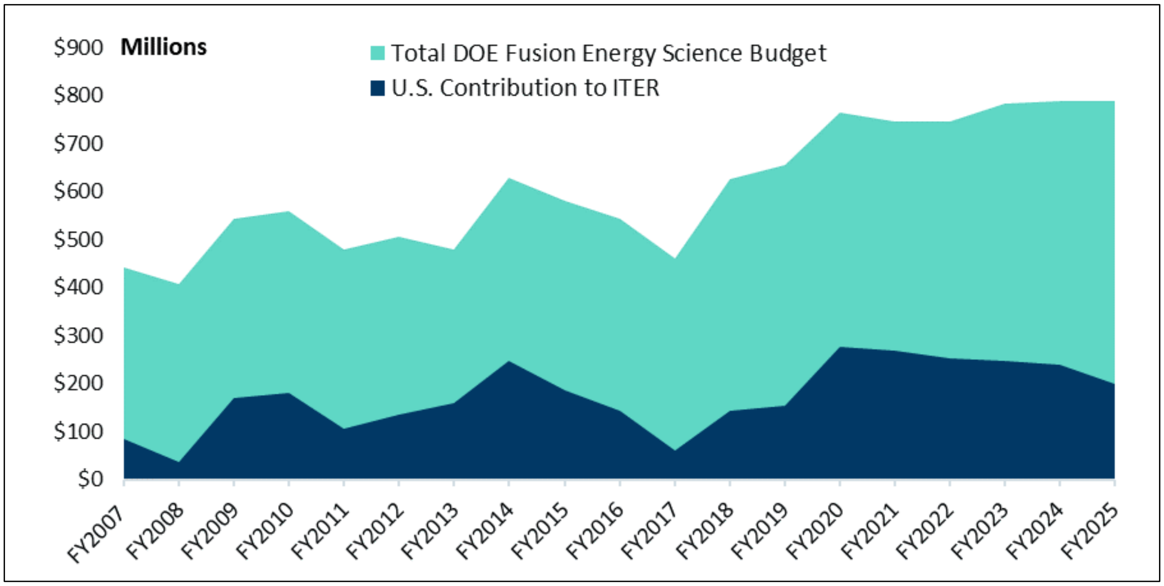
[48] For DOE budget justifications and supporting documents from FY2007 through FY2026, see https://www.energy.gov/budget-performance.

[49] GAO, *Fusion Energy: Additional Planning Would Strengthen DOE's Efforts to Facilitate Commercialization*, GAO-25-107037, January 2025, p. 15, https://www.gao.gov/products/gao-25-107037.

[50] See H.R. 6938, the Commerce, Justice, Science; Energy and Water Development; and Interior and Environment (continued...)

Figure 6. Total U.S. Department of Energy (DOE) Fusion Energy Science Budget and the Portion for U.S. ITER Contribution

FY2007-FY2025 Adjusted for Inflation



Source: Department of Energy, *Budget Justification (Science Volumes), FY2007-FY2026*, https://www.energy.gov/cfo/listings/budget-justification-supporting-documents.

Notes: Budget amounts adjusted to 2024 dollars based on Bureau of Economic Analysis, Line 16, "Federal Research and Development," in "Table 3.9.4. Price Indexes for Government Consumption Expenditures and Gross Investment," accessed July 30, 2025, https://apps.bea.gov/iTable/?reqid=19&step=3&isuri=1&1921=survey&1903=97.

In January 2025, DOE announced $107 million in funding for six projects in the Fusion Innovation Research Engine (FIRE) Collaboratives.[51] In the same announcement, DOE reported that several privately funded fusion companies have completed early critical-path S&T milestones in the Milestone-Based Fusion Development Program.[52] According to DOE, companies in the Milestone-Based Fusion Development Program work toward scientific, technological, and commercialization milestones negotiated with DOE and receive federal payments after DOE verifies completion of each milestone.

In September 2025, DOE announced $134 million in funding for two programs in FES—the FIRE program and the Innovation Network for Fusion Energy (INFUSE) program. These programs are "designed to secure U.S. leadership in emerging fusion technologies and innovation." According to the DOE press release, part of this investment is intended to bridge the

Appropriations Act, 2026; budget tables are available at https://www.appropriations.senate.gov/download/fy26-ewd-jes.

[51] The Fusion Innovation Research Engine (FIRE) is "structured as a framework [composed] of Collaboratives with the purpose of bridging the gap between foundational science and practical application. These Collaboratives are envisioned as dynamic hubs of innovation, driving advancements in fusion energy research in collaboration with both public and private entities." See DOE, Office of Science, Fusion Energy Sciences, *Fusion Innovation Research Engine (FIRE) Collaboratives*, Funding Opportunity Announcement DE-FOA-0003361, May 22, 2024, p. 1, https://science.osti.gov/-/media/grants/pdf/foas/2024/DE-FOA-0003361.pdf.

[52] DOE, "U.S. Department of Energy Announces Selectees for $107 Million Fusion Innovation Research Engine Collaboratives, and Progress in Milestone Program Inspired by NASA," press release, January 16, 2025, https://www.energy.gov/articles/us-department-energy-announces-selectees-107-million-fusion-innovation-research-engine.

FES program's basic science research programs and the growing fusion industries. DOE says it has awarded grants to 20 projects to date with the goal of accelerating "private-sector fusion energy development by reducing barriers to collaboration between businesses and national laboratories or universities."[53]

There may be additional funding for fusion research incorporated into other DOE budgetary lines. For example, the DOE Advanced Research Projects Agency–Energy (ARPA-E) also supports some fusion energy projects,[54] along with other projects across the full range of energy technologies.

Additional DOE funding for fusion research outside the present-day Office of Science is directed toward weapons activities (see "DOE Weapons Programs Research Related to Fusion"), including inertial confinement.[55] In FY2025, the DOE inertial confinement fusion budget was approximately $700 million (see **Figure 7**).[56] As noted above, in 2022, the NIF at the DOE Lawrence Livermore National Laboratory became the first lab to use a fusion device to achieve "scientific energy breakeven"—when the energy released by the fusion reaction is greater than the energy added directly to the plasma.[57] While this work is intended primarily for research to improve stewardship of the U.S. nuclear weapons stockpile, its demonstration of fusion ignition, though lasting less than a nanosecond,[58] has increased interest in inertial confinement designs for future power plants.

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[53] DOE, "Energy Department Announces $134 Million to Advance U.S. Fusion Leadership Through Targeted Research," press release, September 10, 2025, https://www.energy.gov/articles/energy-department-announces-134-million-advance-us-fusion-leadership-through-targeted.

[54] Advanced Research Projects Agency–Energy (ARPA-E), *Power Generation: Nuclear Fusion*, 2025, https://arpa-e.energy.gov/programs-and-initiatives/search-all-projects/complexion-engineered-nanocrystalline-tungsten-alloy-plasma-facing-materials-long-pulse-tokamak-operation.

[55] In inertial confinement, powerful lasers create rapid fusion reactions in short bursts, with each reaction completing before the plasma fuel has time to disperse.

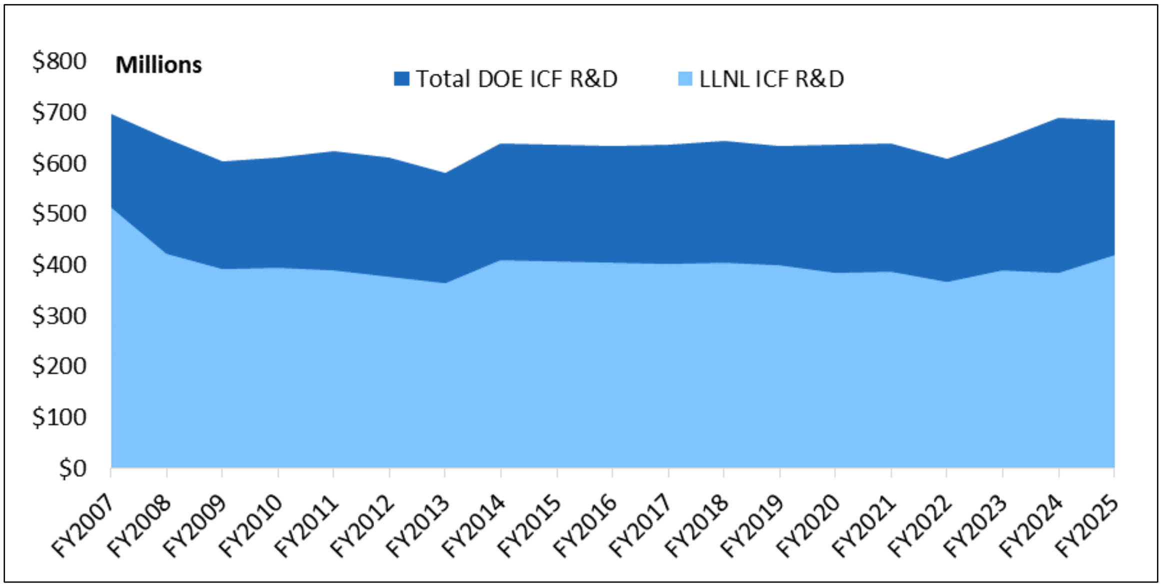
[56] For DOE budget justifications and supporting documents from FY2007 through FY2026, see https://www.energy.gov/budget-performance.

[57] DOE, "DOE National Laboratory Makes History by Achieving Fusion Ignition," press release, December 13, 2022, https://www.energy.gov/articles/doe-national-laboratory-makes-history-achieving-fusion-ignition. In a process known as "indirect drive," the NIF lasers impinge on a *hohlraum* (container for fuel) that in turn heats the fuel capsule, which then ablates and drives the inner fuel core to higher densities according to Newton's third law. During this process, the energy of the hohlraum approximates a Planck (i.e., thermal) distribution that emits corresponding X-rays. A. B. Zylstra et al., "Burning Plasma Achieved in Inertial Fusion," *Nature*, vol. 601 (2022), pp. 542-548.

[58] Lawrence Livermore National Laboratory, National Ignition Facility and Photon Science, "FAQs," https://lasers.llnl.gov/about/faqs.

Figure 7. Total U.S. Department of Energy (DOE) Inertial Confinement Fusion Program Budget Compared with Lawrence Livermore National Laboratory (LLNL) Apportionment of That Budget

FY2007-FY2025 Adjusted for Inflation



Source: Department of Energy, *Budget Justification (Volume 1), FY2007-FY2026*, https://www.energy.gov/cfo/listings/budget-justification-supporting-documents.

Notes: The DOE Inertial Confinement Fusion (ICF) Program is operated under the National Nuclear Security Administration; it previously was referred to as the Inertial Confinement Fusion Ignition and High Yield Campaign program. Budget amounts adjusted to 2024 dollars based on Bureau of Economic Analysis, Line 16, "Federal Research and Development," in "Table 3.9.4. Price Indexes for Government Consumption Expenditures and Gross Investment," accessed July 30, 2025, https://apps.bea.gov/iTable/?reqid=19&step=3&isuri=1&1921=survey&1903=97. R&D = research and development.

DOE Fusion Energy User Facilities

DOE operates two fusion energy user facilities, the DIII-D National Fusion Facility and the National Spherical Torus Experiment-Upgrade (NSTX-U).

DIII-D National Fusion Facility

DIII-D, located in San Diego, CA, "is a tokamak confinement device with significant engineering flexibility to explore the optimization of the advanced tokamak approach to fusion energy production."[59] DIII-D is a federally sponsored facility available for researchers outside DOE to conduct research aligned with the three current research groups described below. In addition, the DIII-D facility is a training facility, with dedicated time for student-run projects, a mentorship program, and other programs to provide work opportunities in the fusion research fields.[60]

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[59] DOE, "DIII-D National Fusion Facility (DIII-D)," 2025, https://science.osti.gov/fes/Facilities/User-Facilities/DIII-D.

[60] R. J. Buttery et al., "DIII-D's Role As a National User Facility in Enabling the Commercialization of Fusion Energy," *Physics of Plasmas*, vol. 30, no. 12 (2023), article 120603, https://doi.org/10.1063/5.0176729.

Currently, there are three research groups operating in the DIII-D user facility:

- the Plasma-Interacting Technology group, which provides an "experimental test bed for technology development and validation in a fusion reactor-relevant plasma environment to mature [fusion pilot plant] technology";
- the Fusion Pilot Plant Research group addresses "the gaps in physics knowledge presenting challenges to the development of a commercially viable fusion pilot plant"; and
- the ITER Research (see "ITER (International Thermonuclear Experimental Reactor)") group focuses on establishing "operating procedures and necessary physics knowledge required for ITER to achieve its research goals."[61]

National Spherical Torus Experiment-Upgrade (NSTX-U)

The NSTX-U is a magnetic confinement fusion user facility located at Princeton Plasma Physics Laboratory (PPPL) in Princeton, NJ, that utilizes "a spherical torus confinement configuration to explore the potential stability and confinement advantages" of a compact tokamak reactor.[62] The original National Spherical Torus Experiment (NSTX) was in operation from 1999 to 2010, when it was shut down for a major upgrade. The upgraded facility (NSTX-U) restarted in 2016 for 10 weeks until one of the plasma-shaping magnetic field coils failed, and it was shut down again.[63] Since then, the NSTX-U Recovery Project has been working to return the NSTX-U to full operations.[64] In a recent presentation, the director of PPPL reported that NSTX-U is 94% complete, and PPPL anticipates generating a first plasma in summer 2026 and is aiming for a fusion pilot plant design by 2031 and operation by 2035.[65] The pilot plant is not meant to be a commercial reactor but is designed for testing.

ITER (International Thermonuclear Experimental Reactor)

ITER, previously referred to as the International Thermonuclear Experimental Reactor, is a multibillion-dollar collaboration among the United States, the European Union (host), China, India, Japan, Russia, and South Korea.[66] This international collaboration intends to build a tokamak "that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy."[67] The key goal of the consortium is to operate ITER at or near the ignition point of burning plasma, a critical step toward self-sustaining nuclear fusion. ITER's planned capabilities also include extensive instrumentation for advancing the scientific understanding of plasmas, as well as opportunities for testing specialized materials for use in fusion applications. ITER is primarily an exploratory science initiative and is not designed or intended to produce

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[61] DOE, "About the DIII-D National Fusion Facility," 2025, https://d3dfusion.org/about-diii-d/.

[62] DOE, "National Spherical Torus Experiment – Upgrade (NSTX-U)," 2025, https://science.osti.gov/fes/Facilities/User-Facilities/NSTX-U.

[63] Jack Moore, "NSTX-U Prepares to Re-Enter the Fusion Energy Conversation," ITER, January 29, 2024, https://www.iter.org/node/20687/nstx-u-prepares-re-enter-fusion-energy-conversation.

[64] S. P. Gerhardt, "Overview of the NSTX-U Recovery Project Physics and Engineering Design," Princeton Plasma Physics Laboratory (PPPL), https://nstx.pppl.gov/DragNDrop/Scientific_Conferences/IAEA/IAEA_2018/Papers/Gerhardt_FIP-P3-63.pdf.

[65] Comments from Steve Cowley, Director, PPPL, at the U.S. DOE Fusion Power Associates (FPA) 46th Annual Meeting and Symposium, December 9, 2025.

[66] For additional information related to ITER, see CRS Report R48362, *ITER—An International Nuclear Fusion Research and Development Facility*, coordinated by Todd Kuiken.

[67] ITER, "In a Few Lines," 2024, https://www.iter.org/few-lines.

electricity. However, ITER is designed to help develop the technology for a future fusion demonstration power plant.

The United States is a party to the multilateral "Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project," which entered into force on October 24, 2007.[68] The agreement initiated a 35-year partnership for the seven participating members and established the ITER Organization to lead the project. Congress authorized U.S. participation in ITER in the Energy Policy Act of 2005 (P.L. 109-58) and reaffirmed this participation in the Energy Act of 2020 (Division Z of P.L. 116-260, the Consolidated Appropriations Act, 2021).

Oak Ridge National Laboratory, in partnership with two other DOE laboratories—Savannah River National Laboratory and PPPL—manages the U.S. portion of ITER (US ITER)[69] for DOE. According to DOE, the United States "contributes in-kind hardware components" and funding that goes toward the ITER Organization's management and overhead costs "(e.g., design integration, nuclear licensing, quality control, safety, overall project management, and installation and assembly of the components provided by the U.S. and other Members)."[70]

From 2007 through 2023, the United States contributed more than $2.9 billion (adjusted for inflation) to ITER through research, hardware design, and manufacturing for 12 different ITER systems. This contribution represents about 9% of the total international cost. In FY2025, Congress appropriated $200 million to DOE for the U.S. contribution to ITER, representing about 30% of the total appropriation for the FES program in the DOE Office of Science. This proportion of the overall FES budget for ITER has been relatively consistent since 2007 (see **Figure 6**). Given the current plan, US ITER anticipates that hardware construction will be completed in December 2035, and U.S. financial contributions to ITER construction and operation will be completed in 2040. After ITER construction is complete, the United States has agreed to pay a 13% cost share during the operation phase.[71]

Initial projections suggested that ITER construction would be completed in 2016, with the first experiments beginning in 2020, at a total cost of $10 billion (adjusted for inflation).[72] In 2016, the construction schedule was extended to 2025, with full operation expected by 2035, adding an additional $5.2 billion (adjusted for inflation) to the total cost.

In July 2024, ITER announced that the facility would not be fully operational (with burning plasma) until 2039 and would cost an additional $5.2 billion (i.e., $10.4 billion more than the initial estimate).[73] Given the delays in ITER's construction and projected operational readiness, some fusion science researchers have raised concerns about whether future investments are justified given the progress being made in other public and private research endeavors.[74]

[68] U.S. Department of State, Office of Treaty Affairs, "Multilateral (07-1024) – Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project," October 24, 2007, https://www.state.gov/07-1024.

[69] For more information on US ITER, see https://usiter.ornl.gov/.

[70] DOE, *FY 2025 Congressional Justification, Volume 5: Science*, March 2024, p. 196, https://www.energy.gov/sites/default/files/2024-03/doe-fy-2025-budget-vol-5-v2.pdf.

[71] Letter from Anne White, Chair, Fusion Energy Sciences Advisory Committee (FESAC), to Dr. Harriet Kung, Acting Director, Office of Science, DOE, May 10, 2024, https://www.osti.gov/servlets/purl/2476326.

[72] ITER, "FAQs," https://www.iter.org/faqs. Dollar values were converted from euros.

[73] ITER, "New Baseline to Prioritize Robust Start to Exploitation," press release, July 3, 2024, https://www.iter.org/node/20687/new-baseline-prioritize-robust-start-exploitation.

[74] Daniel Clery, "Giant Fusion Project in Big Trouble," *Science*, vol. 385, no. 6704 (2024), pp. 10-11.

DOE Weapons Programs Research Related to Fusion

DOE conducts R&D related to fusion under its weapons activities program operated by the National Nuclear Security Administration. The Inertial Confinement Fusion (ICF) Program, previously known as the Inertial Confinement Fusion Ignition and High Yield Campaign, is focused on the use of fusion science to improve stewardship of the U.S. nuclear weapons stockpile. In FY2025, the budget for ICF was $683 million, with a majority of that funding going to the DOE Lawrence Livermore National Laboratory (see **Figure 7**).

NSF's Fusion R&D Programs and Funding

NSF's Plasma Physics program supports research in fundamental plasma physics, the focus of which is "to generate an understanding of the fundamental principles governing the physical behavior of a plasma via collective interactions of large ensembles of free charged particles, as well as to improve the basic understanding of the plasma state as needed for other areas of science and engineering."[75]

This research, according to NSF, is "bringing society closer to conquering one of its biggest science and engineering challenges,"[76] which could enable R&D toward commercialized fusion energy. A search of grants funded within the Plasma Physics program revealed 121 projects from August 2016 through December 2025 with total anticipated funding of $77.4 million.[77] Other programs within NSF may also support fusion-energy-related research.

Examples of NSF-Sponsored Research Facilities

Prominent NSF-sponsored research facilities are located at the University of California, Los Angeles (UCLA); Florida State University; the University of Florida; and the University of Michigan.

The UCLA Basic Plasma Science Facility is sponsored by both NSF and DOE and contains the Large Plasma Device, which enables researchers to study magnetized plasma and how plasmas might behave in a fusion reactor with magnetic confinement.[78]

The National High Magnetic Field Laboratory (MagLab) is jointly funded by NSF and the state of Florida. It claims to be the largest and highest-powered magnet lab in the world. As a user facility, MagLab provides research opportunities to scientists and engineers from universities, national labs, and industry investigating the use of magnets in producing fusion energy.[79]

The NSF Zettawatt-Equivalent Ultrashort Pulse Laser System (NSF ZEUS) is an NSF-funded user facility located at the University of Michigan. According to NSF, NSF ZEUS is the highest-

[75] National Science Foundation (NSF), "Plasma Physics," 2025, https://www.nsf.gov/funding/opportunities/plasma-physics.

[76] Ariela Haber, "Fusion Energy: Pathway to Abundant Power," NSF, April 9, 2025, https://www.nsf.gov/science-matters/fusion-energy-pathway-abundant-power.

[77] Compiled from search of awards on NSF's website, which yielded the results found here: https://www.nsf.gov/awardsearch/search-results/?ProgEleCode=124200&BooleanElement=Any&BooleanRef=Any&ActiveAwards=true#results. Certain grants are active grants in which funding has been obligated for work to be completed.

[78] University of California, Los Angeles (UCLA), "UCLA Basic Plasma Science Facility," 2025, https://plasma.physics.ucla.edu/.

[79] For more information about the National High Magnetic Field Laboratory, see https://nationalmaglab.org/.

powered laser system in the United States, enabling researchers to study laser-plasma interactions, which can be used in the development of inertial confinement fusion devices.[80]

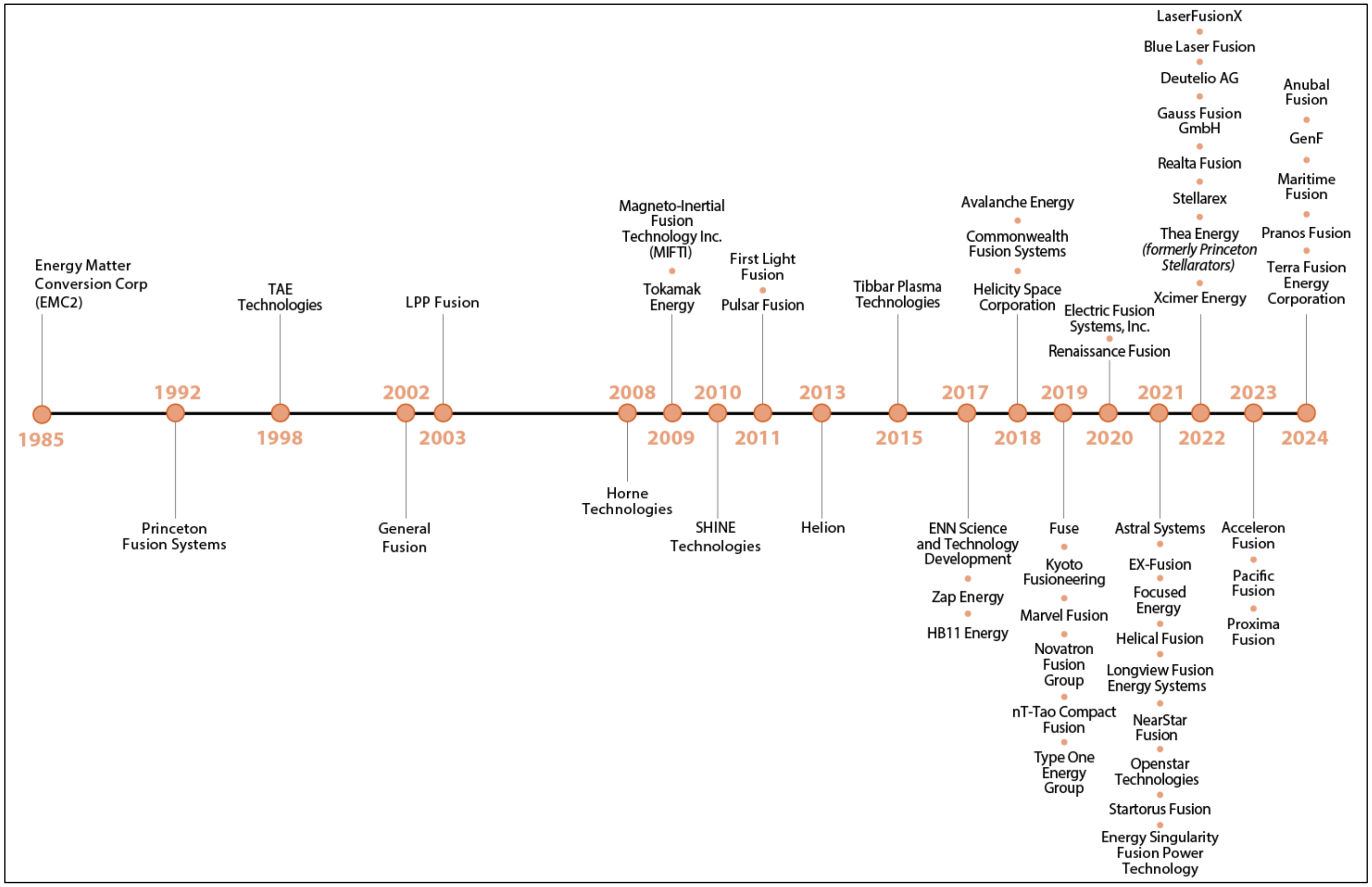
Private-Sector Fusion

The number of private fusion companies has increased significantly in the past few years (see **Figure 8**). These companies are researching and developing a variety of fusion technology approaches to achieve economically viable fusion power that could be delivered to the electric grid.

[80] University of Michigan, "NSF ZEUS User Facility," 2026, https://zeus.engin.umich.edu/.

Figure 8. Timeline of Fusion Companies Founded

1985-2025



Source: CRS, adapted from Fusion Industry Association, *The Global Fusion Industry in 2025: Fusion Companies Surveyed by the Fusion Industry Association*, 2025, https://www.fusionindustryassociation.org/fusion-industry-reports/.

Notes: Figure should not be considered comprehensive and represents only companies that responded to the Fusion Industry Association's 2025 survey.

Private Investment

As noted earlier, one DOE expert noted in 2023 that "the largest new fusion experiments in the U.S. are now being built by the private sector."[81] According to the Fusion Industry Association (FIA), which surveyed fusion companies in 2025, respondents (53 companies) raised $2.2 billion in private funding in 2025, nearly 3 times the total FES budget in 2025. Total private investment reached nearly $9 billion between 2021 and 2025.[82] A separate report from Fusion for Energy (F4E), the European Union organization that manages Europe's contribution to ITER, suggests that there has been approximately $15 billion in global fusion private investment from 2020 to 2025.[83]

Estimated Timelines Toward Commercially Viable Fusion Energy

A 2021 National Academies of Sciences, Engineering, and Medicine report concluded that in order for the United States to achieve an operational fusion pilot plant in the 2035-2040 timeframe, "urgent investments by DOE and private industry—both to resolve the remaining technical and scientific issues and to design, construct, and commission a pilot plant"—would be needed.[84] A separate analysis came to a similar conclusion, stating that "commercial deployment of fusion energy will require equal focus on resolving the remaining S&T issues/challenges and preparing the path to commercialization."[85] According to DOE, scientific and technical advancements are needed before fusion energy may become commercially viable.[86] For example, to be profitable, a power plant will likely need to both achieve and maintain a fusion reaction that produces more energy than was required to create the reaction. While the NIF achieved fusion ignition for the first time in December 2022, it was not maintained, lasting less than one nanosecond, and as of October 2025, ignition has not reportedly been replicated in any fusion facility outside the NIF.[87]

Predicting the timing of commercially viable fusion energy has been challenging. For example, in 1971, physicist Richard F. Post predicted that the first applications of fusion power would emerge in the 1980s and that fusion power would be economically viable by 1990.[88] These predictions turned out to be inaccurate. DOE, in its 2025 S&T roadmap, states that its goal is to "deliver the public infrastructure that supports the fusion private sector scale-up in the 2030s."[89] In 2020,

[81] Scott C. Hsu, "U.S. Fusion Energy Development Via Public-Private Partnerships," *Journal of Fusion Energy*, vol. 42 (2023), article 12.

[82] Fusion Industry Association, *The Global Fusion Industry in 2025: Fusion Companies Surveyed by the Fusion Industry Association*, 2025, https://www.fusionindustryassociation.org/fusion-industry-reports/.

[83] Fusion for Energy, *Global Investment in the Private Fusion Sector*, 2nd ed. (2025), https://fusionforenergy.europa.eu/news/f4e-fusion-observatory-investment-private-sector/.

[84] National Academies of Sciences, Engineering, and Medicine, *Bringing Fusion to the U.S. Grid* (National Academies Press, 2021), p. 3, https://nap.nationalacademies.org/catalog/25991/bringing-fusion-to-the-us-grid.

[85] Scott C. Hsu, "U.S. Fusion Energy Development Via Public-Private Partnerships," *Journal of Fusion Energy*, vol. 42 (2023), article 12.

[86] DOE, *Fusion Science & Technology Roadmap*, 2025, p. 5, https://www.energy.gov/sites/default/files/2025-10/fusion-s%26t-roadmap-101625.pdf.

[87] Commission on the Scaling of Fusion Energy, *Fusion Forward: Powering America's Future*, October 2025, p. 11, https://www.scsp.ai/wp-content/uploads/2025/10/Fusion-Commission-Fall-2025-Report-Draft.pdf.

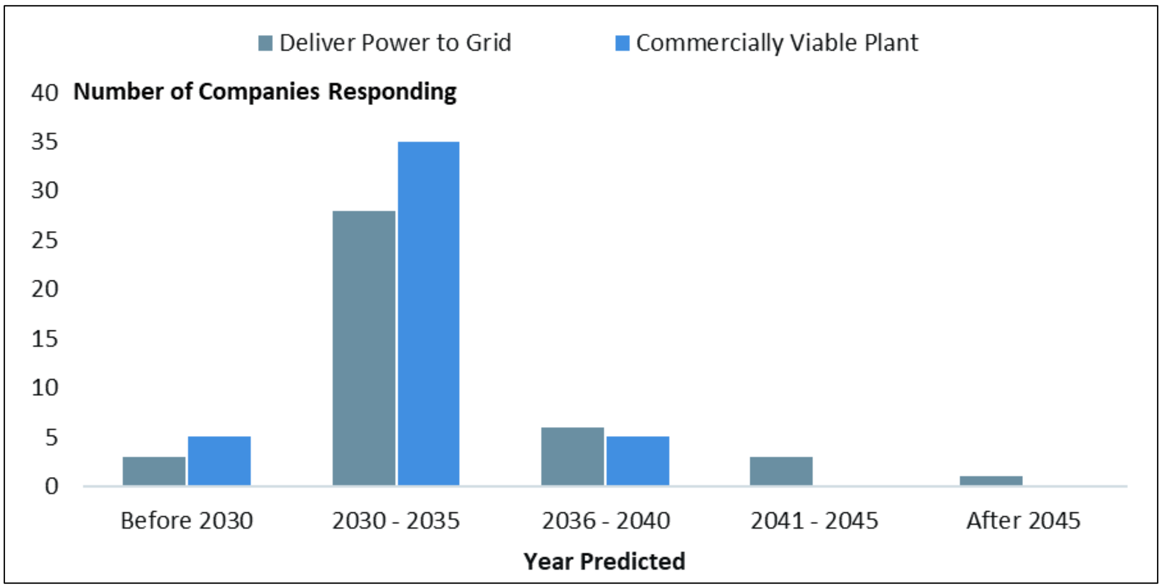
[88] Richard F. Post, "Fusion Power: The Uncertain Certainty," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024). Originally published in 1971 by *Bulletin of the Atomic Scientists*.

[89] DOE, *Fusion Science & Technology Roadmap*, 2025, p. 5, https://www.energy.gov/sites/default/files/2025-10/fusion-s%26t-roadmap-101625.pdf.

FESAC, which advises DOE, described a timeline to make fusion economically viable by the mid-2040s.[90] In 2023, GAO reported varying predictions by fusion companies and other stakeholders asked to project when fusion energy will become technically feasible as an energy source. Some companies suggested that fusion energy would be added to the electricity grid in about 10 years, other stakeholders and experts expected this to occur in 10 to 20 years, and still others said it would take more than 20 years.[91] The FIA's more recent study shows that a majority of the private fusion companies surveyed believe there will be a commercially viable fusion plant by 2035, with some responding it will be before 2030 (see **Figure 9**).[92] However, others in the survey projected longer timeframes.

Figure 9. Estimated Year When Fusion Power Plant Will Be Commercially Viable and Deliver Electricity to the Grid

According to companies surveyed by the Fusion Industry Association in 2025



Source: Fusion Industry Association, *The Global Fusion Industry in 2025: Fusion Companies Surveyed by the Fusion Industry Association*, 2025, https://www.fusionindustryassociation.org/fusion-industry-reports/.

Progress Toward Commercial Viability

In testimony to the Energy Subcommittee of the House Committee on Science, Space, and Technology, the CEO of Commonwealth Fusion Systems (CFS)[93] testified that the company is aiming to achieve net fusion energy in 2027. He also testified that they have secured a site in Chesterfield County, VA, to build their 400-megawatt (MW) ARC[94] commercial power plant and that Google has agreed to purchase power from CFS if and when fusion energy is produced and

[90] FESAC, *Powering the Future: Fusion & Plasmas*, 2020, https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC_Report_2020_Powering_the_Future.pdf.

[91] GAO, *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO-23-105813, March 2023, p. 4, https://www.gao.gov/products/gao-23-105813.

[92] Fusion Industry Association, *The Global Fusion Industry in 2025: Fusion Companies Surveyed by the Fusion Industry Association*, 2025, https://www.fusionindustryassociation.org/fusion-industry-reports/.

[93] For more information about Commonwealth Fusion Systems, see https://cfs.energy/.

[94] For a description of the ARC fusion reactor, see Commonwealth Fusion Systems, "ARC: Putting Fusion Energy on the Grid," https://cfs.energy/technology/arc.

enters the grid.[95] At the same hearing, the president of Pacific Fusion[96] testified that his company plans to build the world's first demonstration plant, which would produce *net facility gain* (i.e., produce more energy than the amount of energy needed to create the fusion reaction), by 2030 and to deliver commercial power plants by "no later than the mid-2030s."[97]

In May 2023, Helion Energy[98] announced an agreement to provide power to Microsoft from its fusion power plant in 2028.[99] As recently as December 2025, Helion continued to report that it was making progress "towards our goal of putting fusion energy on the grid in 2028."[100]

Intersection of AI and Fusion Energy

The proliferation of AI technology may impact fusion energy in two distinct ways: (1) serving as an R&D tool to develop fusion energy and (2) driving the development of fusion energy sources to supply the AI industry with its energy needs.

One expert suggests that "fusion—and AI—are the two most disruptive technologies of this century. Because one totally changes how you work and exchange information, and the other changes how you get access to the root stock of what you need, which is energy."[101] Certain AI industry leaders have suggested that energy is a key bottleneck for AI and the data centers needed for computation.[102]

U.S. data center annual energy use in 2023 (not accounting for cryptocurrency) was approximately 176 terawatt-hours (TWh), approximately 4.4% of U.S. annual electricity consumption that year.[103] Some projections show that data center energy consumption could double or triple by 2028, accounting for up to 12% of U.S. electricity use.[104] For additional information on U.S. data center energy use, see CRS Report R48646, *Data Centers and Their Energy Consumption: Frequently Asked Questions*.

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[95] Testimony of Dr. Bob Mumgaard, Commonwealth Fusion Systems, in U.S. Congress, House Committee on Science, Space, and Technology, Subcommittee on Energy, *Igniting America's Energy Future: The Promise and Progress of Fusion Power*, 119th Cong., 1st sess., September 18, 2025, https://republicans-science.house.gov/index.cfm?a=Files.Serve&File_id=4D6001F3-7C82-48C5-9EBB-B6D2DFEC76AD.

[96] For information about Pacific Fusion, see https://www.pacificfusion.com/.

[97] Testimony of Dr. Will Regan, Pacific Fusion, in U.S. Congress, House Committee on Science, Space, and Technology, Subcommittee on Energy, *Igniting America's Energy Future: The Promise and Progress of Fusion Power*, 119th Cong., 1st sess., September 18, 2025, https://republicans-science.house.gov/index.cfm?a=Files.Serve&File_id=46D3BAB8-CC54-4AB6-A61E-0EAAA8E39D45.

[98] For information about Helion Energy, see https://www.helionenergy.com/.

[99] Helion Energy, "Announcing Helion's Fusion Power Purchase Agreement with Microsoft," press release, May 10, 2023, https://www.helionenergy.com/articles/announcing-helion-fusion-ppa-with-microsoft-constellation/.

[100] Helion Energy, "2025 at Helion," press release, December 31, 2025, https://mailchi.mp/helionenergy/2025-at-helion?e=ea7341b1ff.

[101] Dan Drollette Jr., "After ITER: What China and Others Are Doing in Fusion. Interview with MIT's Dennis Whyte," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024), pp. 371-376.

[102] Harry Booth, "Why the AI Industry Is Betting on a Fusion Energy Breakthrough," *Time*, October 29, 2025, https://time.com/7328213/nuclear-fusion-energy-ai/.

[103] Arman Shehabi et al., *2024 United States Data Center Energy Usage Report*, Lawrence Berkeley National Laboratory (LBNL), LBNL-2001637, December 2024, p. 5, https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf. While cryptocurrency is one type of service supported by data centers, not all studies of energy consumption of data centers touch upon energy usage related to cryptocurrency. The report noted that its calculations assumed that data centers would operate consistently with how they were commissioned and designed but that results may differ.

[104] Shehabi et al., *2024 United States Data Center Energy Usage Report*, p. 6.

According to one report, numerous companies that own, operate, or utilize data centers, including Google, Nvidia, Japan's SoftBank, Japan's NTT, and the Gates Frontier, have invested in fusion energy companies.[105] As discussed previously, Microsoft and Google have both signed purchase agreements with fusion companies to supply power to their data centers if and when they are able to produce electric power.

Genesis Mission

AI is also being utilized in research to address the scientific and engineering challenges related to fusion energy. DOE's Genesis Mission, launched in 2025, is "a national initiative to build the world's most powerful scientific platform to accelerate discovery science, strengthen national security, and drive energy innovation" by developing "an integrated platform that connects the world's best supercomputers, experimental facilities, AI systems, and unique datasets across every major scientific domain to double the productivity and impact of American research and innovation within a decade."[106]

The mission is focused on three overarching challenge areas: energy dominance, scientific discovery, and national security. DOE selected fusion as one of the technology areas that the Genesis Mission will initially focus on. Fusion activities will concentrate on supporting the S&T roadmap by building an AI-fusion digital convergence platform intended to accelerate timelines to achieve a sustained burning plasma, aid in materials discovery, and help close the fusion fuel loop, leading toward the ability to harness fusion power.[107]

The extreme temperatures and energy produced within a fusion device cause the materials within the device to degrade. It has been suggested that AI may aid in determining how certain classes of materials degrade over time under fusion conditions by simulating the conditions within a fusion device. Certain components of the fusion reactor (e.g., the blanket) are intended to breed, or produce, fuel (i.e., tritium) from the fusion reaction.[108] This fuel can then be fed back into the device to enable the fusion reaction to continue. AI is proposed to help simulate the conditions within a fusion reactor to study this breeding potential and what materials are best suited for this process.

One recently announced project under the Genesis Mission is AI-Driven Evaluation of Power Plant Technologies for Fusion (ADEPT-Fusion), being led by PPPL and Oak Ridge National Laboratory.[109]

Regulation and Permitting for Commercial Fusion Energy

The Atomic Energy Act (AEA) of 1954 (P.L. 83-703), as amended in P.L. 118-67, gave authority to regulate special nuclear material, source material, and byproduct material used for civilian

[105] Mark Halper, "AI Datacenters Need Nuclear Fusion," *Communications of the ACM*, September 30, 2025, https://cacm.acm.org/news/ai-datacenters-need-nuclear-fusion/.

[106] DOE, "Genesis Mission," 2025, https://genesis.energy.gov/.

[107] Shantenu Jha et al., "The Genesis Mission and Fusion Energy," AI4Fusion Colloquium Series, December 2025, https://www.pppl.gov/events/2025/genesis-mission-and-fusion-energy.

[108] See footnote 47.

[109] Shantenu Jha et al., "The Genesis Mission and Fusion Energy," AI4Fusion Colloquium Series, December 2025, https://www.pppl.gov/events/2025/genesis-mission-and-fusion-energy.

purposes to the Atomic Energy Commission (AEC), among other authorities.[110] Subsequent actions transferred AEA authorities to other agencies, including in 1970 to the U.S. Environmental Protection Agency and, upon dissolution of the AEC in 1974, to successor agencies.[111] Today, these AEA authorities have been transferred to the Nuclear Regulatory Commission (NRC). Division B of P.L. 118-67, the Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy Act, or ADVANCE Act, of 2024, amended the AEA to affirm that this authority extends to radioactive material produced by fusion machines. DOE, among other responsibilities, currently regulates nuclear defense applications (i.e., fusion- and fission-related weapons) and environmental cleanups. The AEA distinguishes between byproduct material resulting from nuclear fission[112] and that from fusion machines and other "particle accelerators."[113] P.L. 118-67, Division B, defined *fusion machine* as a device "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."[114] The AEA relies on this definition to determine whether radioactive material produced by the device constitutes byproduct material within the NRC's AEA authority, requiring an NRC-issued license to "manufacture, produce, transfer, receive, acquire, own, possess, or use [the] byproduct material" (10 C.F.R. §30.3).[115]

In 2019, P.L. 115-439, the Nuclear Energy Innovation and Modernization Act (NEIMA), required the NRC to develop the regulatory infrastructure to support the development and commercialization of advanced nuclear reactors, including both nuclear fission reactors and fusion machines. Section 103 of NEIMA requires the NRC to complete a rulemaking to establish a technology-inclusive regulatory framework for optional use by applicants for new commercial advanced nuclear reactor licenses by December 31, 2027 (commercial advanced nuclear reactors include fusion machines).[116] The NRC released its proposed rule in December 2024, which had an estimated date of publication in November 2025. On February 26, 2026, the NRC published the *Regulatory Framework for Fusion Machines* in the *Federal Register*; this included the proposed rule, draft guidance for the implementation of the proposed rule, and a request for public comment.[117]

According to the NRC, "The proposed rule is not intended to address speculative, fusion technologies significantly different from those being researched, developed, piloted, and deployed today (for example, today's design types include tokamak, stellarator, z-pinch, field

[110] 42 U.S.C. §§2011-2259. For a description of each type of material, see DOE, "Atomic Energy Act and Related Legislation," https://www.energy.gov/ehss/atomic-energy-act-and-related-legislation. The Atomic Energy Commission itself was established by P.L. 79-585, the Atomic Energy Act of 1946.

[111] See Reorganization Plan No. 3 of 1970 (U.S. Congress, House Committee on Government Operations, *Reorganization Plans Nos. 3 and 4 of 1970*, message from the President of the United States, 91st Cong., 2nd sess., July 8, 1970) and the Energy Reorganization Act of 1974 (P.L. 93-438). In 1977, the Department of Energy Organization Act (P.L. 95-91) created and consolidated agencies and again delegated various Atomic Energy Act authorities.

[112] For an overview of nuclear fission, see CRS Report R42853, *Nuclear Energy: Overview of Congressional Issues*, by Mark Holt.

[113] 42 U.S.C. §2014.

[114] 42 U.S.C. §2014.

[115] U.S. Nuclear Regulatory Commission (NRC), *Regulatory Framework for Fusion Machines*, October 17, 2024, https://www.nrc.gov/docs/ML2401/ML24019A065.pdf.

[116] U.S. NRC, *Regulatory Framework for Fusion Machines*, October 17, 2024, https://www.nrc.gov/docs/ML2401/ML24019A065.pdf. The rule is "technology inclusive" in NRC's description since it departs from past regulations that primarily applied to one type of nuclear reactor or machine.

[117] U.S. NRC, "Regulatory Framework for Fusion Machines," 91 *Federal Register* 9476, February 26, 2026. For the current status of the rulemaking process, see U.S. NRC, "Fusion Machine Rulemaking Status," January 15, 2026 (accessed by CRS February 26, 2026), https://www.nrc.gov/materials/fusion/rulemaking-status.html.

reverse, and configurations with fuels that include deuterium-tritium, deuterium-helium-3, and proton-boron-11)."[118] This statement may imply that the NRC may revisit any finalized rule to address differences if and when newly developed fusion technologies emerge.

The NRC can delegate some of its authority to the states. The NRC has entered into an effective regulatory discontinuance agreement with 39 states under Subsection 274b of the AEA.[119] The role of these states, known as "Agreement States," is to regulate most types of radioactive material in accordance with the compatibility requirements of the AEA.

Agreement States issue radioactive material licenses, promulgate regulations, and enforce those regulations under the authority of each individual state's laws. Each Agreement State exercises licensing and enforcement actions under the direction of its governor in a manner compatible with the licensing and enforcement programs of the NRC.[120] Fusion machines, while often referred to as "reactors," nonetheless do not require the particular type of license required of nuclear fission reactors (10 C.F.R. Part 50), per the ADVANCE Act (Division B of P.L. 118-67). To the extent that facilities with fusion machines would require only a radioactive materials license and are not fission reactors or fuel-cycle facilities, such fusion facilities may be regulated by Agreement States and not by the NRC.[121] This could reduce the overall time and costs associated with acquiring permits to build and operate a fusion power plant compared with a nuclear fission plant.[122]

Three companies have been in consultation with Agreement States to build or operate fusion power plants and devices,[123] which perhaps indicates progress toward commercialization of fusion energy in the United States. Commonwealth Fusion Systems (CFS) is developing a tokomak in Massachusetts and plans to build a grid-scale fusion power plant in Virginia. In August 2025, the Chesterfield Planning Commission in Virginia approved CFS's application for a conditional use permit to build a fusion power plant in Chesterfield County, VA.[124] Type One Energy, headquartered in Knoxville, TN, has plans to construct its fusion devices at Tennessee Valley Authority's former Bull Run coal plant.[125] Helion Energy has received approval from the Washington State Department of Health to operate its Polaris[126] fusion machine in Malaga, WA.[127]

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118 U.S. NRC, *Regulatory Framework for Fusion Machines*, October 17, 2024, p. 19, https://www.nrc.gov/docs/ML2401/ML24019A065.pdf.

119 U.S. NRC, "Agreement State Program," https://www.nrc.gov/about-nrc/state-tribal/agreement-states.

120 Organization of Agreement States (OAS), "About OAS," 2025, https://www.agreementstates.org/about.html.

121 U.S. NRC, "Fusion Activities in Agreement States," November 3, 2025, https://www.nrc.gov/materials/fusion/fusion-activities-agreement-states.html.

122 For an overview of the permitting process for nuclear fission power plants, see CRS Report RL33558, *Nuclear Energy Policy*, by Mark Holt.

123 U.S. NRC, "Fusion Activities in Agreement States," November 3, 2025, https://www.nrc.gov/materials/fusion/fusion-activities-agreement-states.html.

124 Billy Shields, "Chesterfield Planning Commission Greenlights Nuclear Fusion Plant," *VPM News*, August 21, 2025, https://www.vpm.org/news/2025-08-21/chesterfield-nuclear-plant-commonwealth-fusion-systems-tokamak-byboth.

125 Type One Energy, "Type One Energy Issues First Realistic, Unified Fusion Power Plant Design Basis," press release, March 27, 2025, https://typeoneenergy.com/type-one-energy-issues-first-realistic-unified-fusion-power-plant-design-basis/.

126 Helion, "Polaris," 2025, https://www.helionenergy.com/polaris/.

127 Helion, "Helion Secures Land and Begins Building on the Site of World's First Fusion Power Plant," July 30, 2025, https://www.helionenergy.com/articles/helion-secures-land-and-begins-building-site-of-worlds-first-fusion-power-plant/.

Potential Congressional Considerations

While there has been considerable U.S. public and private investment in developing fusion energy, the technology is not yet commercially viable. Congress may have an interest in U.S. strategic positioning in regard to fusion energy as countries around the world, including China, are competing to be the first to achieve commercialized fusion energy. Congress may also have a continued interest in conducting oversight and shaping the broader U.S. fusion R&D strategy.

Research Priorities and Federal Investment

A 2023 GAO report found that public- and private-sector misalignments around research priorities is impeding fusion energy development in the United States. Whereas federal research funding is focused on basic science, commercializing fusion energy will require increased focus of federal investments on technology development and engineering research. GAO described a series of policy options related to fusion energy development in the United States, including keeping the status quo, aligning public and private research efforts, building shareable assets for the fusion energy research community (including workforce development), and engaging the public in decisionmaking.[128] P.L. 119-60, the National Defense Authorization Act for Fiscal Year 2026, authorized the Office of Strategic Capital within the Department of Defense to issue loan guarantees to support nuclear fission and fusion energy technologies. Congress may choose to evaluate how these loan guarantees might affect GAO's findings. Additionally, Congress may request information from DOE and other federal agencies on how they have responded to GAO's analysis.

In particular, Congress may choose to conduct oversight of DOE's implementation of its strategic plan and S&T roadmap, whether DOE is meeting its planned metrics and goals, and whether these goals and metrics align with congressional priorities. The explanatory statement accompanying Division B of H.R. 6938, the Energy and Water Development and Related Agencies Appropriations Act, 2026 (P.L. 119-74), directs DOE to "provide a brief to the Committees on a resource informed Fusion Energy Sciences strategy, with clear milestones and deliverables, not later than 30 days after the date of enactment of this Act."[129]

In addition, Congress may have an interest in how the newly established Office of Fusion at DOE is organized and what, if any, role it has in implementing the strategic plan and S&T roadmap.[130] This may have implications on any congressional debate pertaining to the Office of Fusion Act of 2025 (S. 3437/H.R. 6709), introduced in the 119th Congress, which would direct the Secretary of Energy to establish an Office of Fusion.

The Commission on the Scaling of Fusion Energy[131] made a series of recommendations in order for the United States to achieve a goal to start building the "world's first commercial fusion

[128] GAO, *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO-23-105813, March 2023, https://www.gao.gov/products/gao-23-105813.

[129] "Proceedings and Debate of the 119th Congress, Second Session," remarks in the House, *Congressional Record*, vol. 172, no. 5 (January 8, 2026), p. H396, https://www.congress.gov/119/crec/2026/01/08/172/5/CREC-2026-01-08-bk3.pdf.

[130] DOE, "Energy Department Announces Organizational Realignment to Strengthen Efficiency and Unleash American Energy," press release, November 20, 2025, https://www.energy.gov/articles/energy-department-announces-organizational-realignment-strengthen-efficiency-and-unleash. For DOE's November 25, 2025, organizational chart, see https://www.energy.gov/sites/default/files/2025-11/Organization-Chart-11.20.2025-2.pdf.

[131] The Commission on the Scaling of Fusion Energy, convened by the Special Competitive Studies Project, was "a 12-
(continued...)

power plant" by 2030.[132] These recommendations included having the federal government declare fusion a national security priority, establish fusion leadership within the DOE to drive commercialization, and increase federal funding, including a $10 billion one-time investment.[133] The DOE strategic plan and S&T roadmap calls for shifting federal investments from more basic R&D on fusion toward commercialization efforts. Through its oversight authorities, Congress may evaluate whether the DOE's fusion efforts are effectively making progress toward commercialization, how other federal investments (e.g., NSF's fusion R&D programs) are contributing toward fusion energy, and whether additional appropriations, priority setting, or both would be required to enable the United States to be the first country to achieve commercially viable fusion.

U.S. Participation in ITER

Congress may wish to examine the role of continued U.S. investment and participation in ITER and how it relates to DOE's strategic plan and S&T roadmap, including whether levels of funding are appropriate compared with the overall budget for FES. Congress may choose to explore what options to consider if there are additional ITER project delays and how this could impact the United States' fusion R&D strategy given the current allocations of the FES budget toward ITER.

Through its appropriations and oversight authorities, Congress could examine how DOE implements its S&T roadmap and what impacts potential scientific and engineering advances from the academic and private fusion industry have on ITER's R&D goals and timelines.[134] For example, to what extent, if any, should these potential advances change U.S. participation in ITER?

Congress may also choose to investigate the state of fusion energy R&D, the fusion energy industry in other nations, and to what extent, if any, U.S. participation in ITER provides a strategic advantage to future economic competitiveness for the United States and for private U.S. companies.

Public Engagement Pertaining to Commercial Fusion Energy

As part of its study, documented in *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO held three focus groups in the United States regarding fusion energy. According to GAO, participants in the focus group said they "would want sufficient regulatory oversight before they would be comfortable with fusion energy plants in their communities." Individual participants raised concerns about radioactivity and living in proximity to a fusion plant. These proximity concerns, however, were not specific to fusion energy plants and included coal-burning plants. Other issues raised by participants included environmental impacts (both positive and negative), costs associated with developing fusion energy, and how fusion energy would impact their lives, including jobs and whether a power plant would "affect the aesthetics of their community." Participants also said they would want

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month effort to align government, academia, and industry around a shared vision for the deployment of fusion energy to secure America's position in the energy transition." Special Competitive Studies Project, "Commission on the Scaling of Fusion Energy," https://www.scsp.ai/fusion/.

[132] Commission on the Scaling of Fusion Energy, *Fusion Power: Enabling 21st Century American Dominance*, 2025, p. 5, https://fusion.scsp.ai/posts/fusion-power-enabling-21st-century-american-dominance.

[133] Commission on the Scaling of Fusion Energy, *Fusion Power: Enabling 21st Century American Dominance*, 2025, https://fusion.scsp.ai/posts/fusion-power-enabling-21st-century-american-dominance.

[134] ITER, "What Will ITER Do?," 2026, https://www.iter.org/fusion-energy/what-will-iter-do.

government and industry to "engage with communities where fusion energy facilities might be sited."[135]

It is not clear whether any of the funding within DOE's FES program or NSF is focused on public engagement related to the U.S. public's views about commercial fusion. Congress may consider whether such investments are necessary to achieve commercialized fusion in the United States and, if so, what levels of funding are needed and which federal agencies are best suited to conduct such research. Additionally, Congress may consider GAO's recommendation that policymakers engage with the public in decisionmaking around fusion energy.[136] This could include congressional field hearings, public engagement activities, and other oversight activates focused on decision frameworks related to risk-benefit analysis, public investments in fusion R&D, and federal permitting of fusion reactors (including when permitting authority is delegated to Agreement States), among other factors. If such activities were deemed necessary, Congress could also, through legislation, direct NSF, DOE, or other relevant agencies to conduct public engagement pertaining to fusion energy.

U.S. Strategic Competition with China

According to *The Wall Street Journal*, in 2018, China began building a fusion research and technology campus, formed the state-owned Chinese National Nuclear Corporation, and built at least two tokamaks.[137] A separate study suggests that China is investing heavily in large-scale infrastructure projects, including a fusion research facility similar to the NIF, which could provide a competitive advantage against the United States in terms of reaching commercialized fusion.[138] According to some experts, China's stated goal is to be the first country to achieve commercial fusion.[139]

According to the Special Competitive Studies Project (SCSP), China has invested at least $6.5 billion toward fusion R&D since 2023. These investments represent a mix of central government funding (52%), regional government funding (26%), and private capital (21%).[140] If those estimates are accurate, total Chinese government funding ($5.07 billion) would represent about twice as much as FES budgets during the same time period (see **Figure 6**).

[135] GAO, *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO-23-105813, March 2023, pp. 27, 28, https://www.gao.gov/products/gao-23-105813.

[136] GAO, *Fusion Energy: Potentially Transformative Technology Still Faces Fundamental Challenges*, GAO-23-105813, March 2023, p. 35, https://www.gao.gov/products/gao-23-105813.

[137] Jennifer Hiller and Sha Hua, "China Outspends the U.S. on Fusion in the Race for Energy's Holy Grail," *Wall Street Journal*, July 8, 2024.

[138] Commission on the Scaling of Fusion Energy, *Fusion Forward: Powering America's Future*, October 2025, pp. 15-18, https://www.scsp.ai/wp-content/uploads/2025/10/Fusion-Commission-Fall-2025-Report-Draft.pdf.

[139] Dan Drollette Jr., "After ITER: What China and Others Are Doing in Fusion. Interview with MIT's Dennis Whyte," *Bulletin of the Atomic Scientists*, vol. 80, no. 6 (2024).

[140] Caleb Barnes et al., "Cash, Scale, and Speed: Why China's $6.5 Billion Fusion Buildout Should Shock the World," Special Competitive Studies Project (blog), September 15, 2025, https://scsp222.substack.com/p/cash-scale-and-speed-why-chinas-65. The authors describe $6.5 billion as a conservative estimate "in a range that could be as high as $10 [billion] or $13 billion [and that] the true picture is obscured by the blending of state and private capital in China's ecosystem, gaps in data availability, and the challenges in making apples-to-apples comparisons with U.S. counterparts." See also Commission on the Scaling of Fusion Energy, *Fusion Forward: Powering America's Future*, October 2025, p. 19, https://www.scsp.ai/wp-content/uploads/2025/10/Fusion-Commission-Fall-2025-Report-Draft.pdf.

Separate reporting in 2024 suggested that China spent about $1.5 billion a year on fusion research and was following DOE's strategic plan.[141] *The New York Times* reported that in the summer of 2025, a Chinese state-owned fusion company received $2.1 billion from the Chinese government and private investors.[142] This would represent nearly three times the entire FES budget in 2025. However, a separate analysis of global private investment suggests that the United States leads China in overall investment.[143]

In terms of education and workforce development, China is reportedly producing 10 times as many fusion PhD graduates than the United States.[144] H.R. 4999, the Fusion Workforce Act, would direct NSF to award grants supporting fusion education and related skilled technical workforce activities.

Additionally, the Commission on the Scaling of Fusion Energy contends that "the United States government has not prioritized developing or securing the fusion supply chain, leaving the nascent industry vulnerable as China aggressively captures control over the critical materials and specialized components essential for fusion deployment."[145]

What would be the economic and national security implications for the United States if China were to become the first nation to commercialize fusion energy? Through its oversight and appropriations authorities, Congress may choose to investigate the strategic positioning of the United States' progress toward fusion energy compared with that of China and other countries such as Japan, Germany, and the United Kingdom, all of which have strategies to develop fusion energy.

Author Information

Todd Kuiken
Analyst in Science and Technology Policy

[141] Jennifer Hiller and Sha Hua, "China Outspends the U.S. on Fusion in the Race for Energy's Holy Grail," *Wall Street Journal*, July 8, 2024; National Academies of Sciences, Engineering, and Medicine, *Final Report of the Committee on a Strategic Plan for U.S. Burning Plasma Research* (National Academies Press, 2019), https://nap.nationalacademies.org/catalog/25331/final-report-of-the-committee-on-a-strategic-plan-for-us-burning-plasma-research.

[142] Raymond Zhong, "Clean, Limitless Energy Exists. China Is Going Big in the Race to Harness It," *New York Times*, December 20, 2025, https://www.nytimes.com/2025/12/13/climate/china-us-fusion-energy.html.

[143] Fusion for Energy, *Global Investment in the Private Fusion Sector*, 2nd ed. (2025), https://fusionforenergy.europa.eu/news/f4e-fusion-observatory-investment-private-sector/.

[144] Commission on the Scaling of Fusion Energy, *Fusion Forward: Powering America's Future*, October 2025, p. 14, https://www.scsp.ai/wp-content/uploads/2025/10/Fusion-Commission-Fall-2025-Report-Draft.pdf.

[145] Commission on the Scaling of Fusion Energy, *Fusion Forward: Powering America's Future*, October 2025, p. 22, https://www.scsp.ai/wp-content/uploads/2025/10/Fusion-Commission-Fall-2025-Report-Draft.pdf.

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