# 10 Facts About Fusion Energy via Magnetic Confinement



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Nuclear fusion has enormous promise as a global energy source. The fuel is nearly inexhaustible and the waste products have less environmental impact than the wastes associated with fossil fuels and nuclear fission.

**Want to learn more?**

The Andlinger Center for Energy and the Environment at Princeton University recently released a publication, “Fusion Energy via Magnetic Confinement,” which is the center’s latest Energy Technology Distillate, one of a series of informative reports on emerging energy technologies that have the promise of meeting the world’s growing need for power while mitigating the effects of climate change. These Distillates provide concise yet thorough information on various solutions – with technological, political, and economic considerations – for researchers, policymakers, business leaders, educators, students, and the larger public.

This Distillate specifically looks at fusion energy in a magnetic confinement fusion reactor, which uses strong magnetic fields in its design. Although the Distillate’s authors consulted several fusion experts at the Princeton Plasma Physics Laboratory (PPPL) – a major national fusion research facility– this report was written independently of PPPL and has not been approved by PPPL.

Here are 10 facts about fusion energy via magnetic confinement. More details can be found in the report at acee.princeton.edu/distillates

**The Facts**

1. **It’s Star Power.** Fusion energy is what powers our Sun and the stars. A burst of fusion energy is released when two light nuclei smash together and rearrange into other nuclei. These reactions happen at the core of the Sun, nature’s fusion reactor, where temperatures reach 15 million degrees Celsius. To make fusion on Earth, temperatures in reactors need to be even higher – 200 million degrees Celsius.
2. **It’s Clean.** A fusion reactor would be a low-carbon energy source. It would not contribute to global warming because it produces energy without emitting damaging greenhouse gases such as carbon dioxide and methane. Radioactivity is less prominent than in nuclear fission reactors.

3. **Controlling Plasma is the Key.** Fusion reactions occur in the state of matter called a plasma, where the nuclei and electrons of atoms have separated. Controlling plasmas on Earth at very high temperatures is key to fusion becoming a global energy source. In a fusion reactor that uses magnetic confinement, strong magnets are used to control the plasma. Tokamaks and stellarators are two types of magnetic confinement fusion reactors being developed today.
4. **Goal: The Burning Plasma.** Scientists now want to create a "burning plasma" in a fusion reactor, which will reveal how a plasma behaves when fusion reactions within the plasma produce significant amounts of energy. Understanding the burning plasma is a stepping stone to commercial fusion power.
5. **The Fuel is Almost Limitless.** The best fuels for a burning plasma are deuterium and tritium (heavy isotopes of hydrogen). Deuterium is present in all water. Tritium is very rare but can be produced in fusion and fission reactors. Lithium, a necessary ingredient for making tritium, is plentiful in the Earth's crust.
6. **ITER: A Massive Experiment in France.** To reach a burning plasma, the European Union and six countries, including the United States, are building the International Thermonuclear Experimental Reactor (ITER), a tokamak that is billed to be the largest nuclear fusion device in the world once completed. ITER should produce 500 megawatts of fusion power for 400 seconds with only 50 megawatts of input power.
7. **ITER is Expensive.** The ITER project is expected to begin operating in 2026 at a cost of more than $20 billion. It is possible that ITER will not be finished if its members lose patience with repeated delays and rising costs. It is also possible that ITER's technical goals will not be realized if the burning plasma reveals intrinsic complications.
8. **Fusion Costs Depend on Component Durability.** Internal structural components are subject to intense neutron bombardment that can shorten their useful life. Looming over fusion is the concern that component replacements will not be straightforward and will require costly plant shutdown for months at a time. Burning plasmas may also turn out to have severe instabilities that drive the hot plasma into a wall and lead the reactor to shut itself down automatically.
9. **Fusion's Competitiveness is Uncertain.** Fusion's future depends on several external factors such as climate policy and the costs faced by its competitors, including fission. Fusion would have a greater share of the global energy market if there is a tough climate policy in place, fission is expensive, and other low-carbon solutions such as carbon sequestration are limited.
10. **Fusion and Fission.** In general, the risks from fusion power are smaller than the risks from fission power. But will quantitative differences be seen as qualitative differences? There is little chance that a fusion reactor or its fuel could be used to make nuclear weapons. And a nuclear meltdown, which is a risk at fission plants, is not possible with a fusion reactor. However, accidents are possible that could release radioactive structural material and tritium (which is also radioactive). Also, reactor parts that have become radioactive would need to be disposed of properly.

*To read the Energy Technology Distillates, go to acee.princeton.edu/distillates*

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