# Nuclear Fusion: How Stars on Earth Could Change the Human Race

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## We Need Energy

Our Sun powers the solar system, including our home planet, using its internal fusion reaction. To power Earth's biosphere, as it has done for billions of years, the Sun has to produce a lot of energy. To be more precise, according to the Einstein exhibit in the American Museum of Natural History, the Sun produces $4 \times 10^{26}$ Joules per second; that number has 26 zeros! On Earth, humans have pioneered several methods of energy production, from fire and steam, to windmills and hydropower. We have even adopted solar panels to directly tap into the energy of our Sun. Why then are scientists and engineers trying to replicate nuclear fusion on Earth? The answer is that we will never stop needing energy and that need is growing exponentially.

Developed countries continue to consume energy to charge phones, run air conditioners, heat water, light up rooms, wash and dry clothes, play video games, and the list continues. To power households full of modern conveniences across the globe, we need new energy sources that will sustain our consumption. Wind and solar energy are clean, renewable resources that will continue to help us move away from dirty and non-renewable fossil fuels. However, these methods of energy production are not capable of powering the future colossal energy demand of the human species. In fact, according to Isaac Arthur, futurist and president of the American National Space Society, engineers need to work towards nuclear fusion reactors with a power to mass ratio even greater than that of our own Sun. Rather, we need to reach for the power to mass ratios of the blue and white giants.

**A Tale of Two Cities**

In a village in Madagascar, people are now staying out past 6:00 p.m., thanks to solar streetlights. Kids can go to the movies for the first time because of mini-power grids. Life for the villagers is changing because of the efforts of Africa GreenTec Madagascar, according to UN News. Developing nations, such as those in sub-Saharan Africa, are new and increasing consumers of energy, and the goal is to provide clean energy. However, the rapid growth of technology in these areas will eventually require more energy than current clean sources can give. Meanwhile, in Marietta, Georgia, students at Lassiter High School are using artificial intelligence (AI) tools like ChatGPT to enhance their education. They must use it ethically to avoid cheating but still find it helpful for studying or for advice on questions like how to choose a college. AI puts a heavy load on data centers. According to the World Economic Forum, “the computational power needed for sustaining AI’s growth is doubling roughly every 100 days.” These “cities” are two of thousands that will continue to consume more energy in the quest for improved quality of life. We must seek new energy sources - ones that are safe yet powerful and can propel human progress into a new age. We need nuclear fusion.

**Meet Nuclear Fusion**

A fusion history timeline from euro-fusion.org shows that British astrophysicist Arthur Eddington suggested that stars draw their energy from the fusion of hydrogen into helium in the 1920s. Futurists, scientists, and engineers since then have moved this theory along to a point where we can reach for the practical application of this energy source. A fusion reactor that could efficiently harness this energy would have the potential to power a large city or even a small nation. Nuclear fusion could help to solve many of the problems that currently ail the human

race, including a lack of clean water, insufficient food supplies, and the destructive divide between the haves and have-nots. We could meet not only the basic needs of each human, but also provide the technological advances to encourage every person to realize, develop, and contribute their talents, work, and creativity to advance the human race. Nuclear fusion could even enable us to terraform other planets, eventually.

**How Does Nuclear Fusion Compare?**

How does nuclear fusion compare to other types of energy production? Fission, nuclear fusion's opposite, is currently used to generate electricity, and, according to the International Atomic Energy Agency (IAEA), is about a million times more effective than burning oil or coal. However, fusion "could generate four times more energy per kilogram of fuel than fission," and with just a few grams of reactants "it is possible to produce a terajoule of energy… the energy one person… needs over sixty years" (IAEA). Fusion is a much cleaner energy source when compared to fission and fossil fuels. The burning of fossil fuels still produces most of the energy that humans use, with the number at 84% of total U.S. energy production in 2023, according to U.S. Energy Information Administration. Unlike fossil fuels which produce greenhouse gases such as $CO_2$ and other harmful byproducts, fusion does not produce any such chemicals. The hydrogen isotopes used in fusion are abundantly available, and there are minimal amounts of radioactive wastes produced from fusion. Radioactive waste from fusion has a half-life of 50-100 years, which is tiny compared to fission's wastes which can last for thousands of years and pose a much higher health risk to the ecosystem. Fission involves a chain reaction of particles splitting each other apart. The chain part of the reaction is what makes fission dangerous. During a meltdown, such as the events of Chernobyl and Three Mile Island, the chain reaction becomes out of control and powers itself to continue despite the reactor failing, leading the reactor fuel

temperatures to increase until they melt. Unlike fission, fusion does not involve a chain reaction, and if there were to be a mistake in the machining of a fusion reactor, no meltdowns would occur. The reaction would naturally terminate and lose its energy before causing any damage. There would be no danger of an explosion or excessive exposure to radiation in a complete fusion reactor. For its fuel efficiency, cleanliness, and inherent safety features, nuclear fusion is worth chasing despite challenges.

**Challenges to Overcome**

There are significant challenges to implement nuclear fusion energy as a power source. Satisfying the aforementioned prerequisites that allow fusion reactions to occur requires extremes. Reaching the heat and pressure needed to make the deuterium and tritium plasma reactive is exceedingly hard to achieve and maintain. Additionally, to contain the reaction, advanced magnetic technology is essential, and pioneers hope to create new materials to withstand the monstrous conditions of fusion in a reactor and contain it better. On December 5th, 2022, scientists at the National Ignition Facility (NIF) in California achieved the first every artificial fusion reaction on Earth. This was a milestone achievement, one which required countless discoveries and innovations over 60 years of researching fusion technology. An article from the Lawrence Livermore National Laboratory stated that at the NIF, ”192 of the world’s highest-energy lasers converge on a target the size of a peppercorn filled with hydrogen atoms” in order to meet the pressure and heat needed. However, the success of the NIF is not yet efficient. In later tests the NIF was able to break even with the production of energy from fusion and the energy debt used to power their lasers. More recently, according to the World Economic Forum, the Korea Superconducting Tomak Advanced Research (KSTAR) reactor broke its previous record of 31 seconds by superheating a plasma loop to 100 million degrees Celsius for

48 seconds in February of 2024. Despite these exciting milestones, we cannot yet efficiently maintain fusion reactions to produce energy for commercial and industrial use. These scientific and engineering challenges of nuclear fusion require astronomical monetary investment but also human creativity and perseverance.

**Fusion, The Next Big Breakthrough**

Fusion is difficult and achieving even an inefficient reaction has been an arduous trial. However, clearing the hurdles of nuclear fusion will drive the scientists and engineers of today and generations to come to work even harder, regardless of whether they will see commercially viable nuclear fusion reactors in their lifetimes. Fusion can power streetlights, movie theaters, AI, every basic need and also every convenience to all rather than only some. Kids everywhere should attend schools equipped with ultramodern classrooms, filled with the ambition of making the fantastical become the everyday. With nuclear fusion, what was once only science fiction will become reality. This energy source will help humanity to reach the next frontier in science, technology, and civilization, to create a highly advanced and eco-friendly society capable of powering human ingenuity and technology to its full potential on Earth and beyond.

**Sources**

Arthur, I. (2015, November 21). *The Impact of Nuclear Fusion*. YouTube. https://www.youtube.com/watch?v=8Pmgr6FtYcY

Arthur, I. (2024, November 10). *Nuclear Fusion: Updates & Impacts*. YouTube. https://www.youtube.com/watch?v=_n3punkST2s

History of fusion. EUROfusion. (2024, June 7). https://euro-fusion.org/fusion/history-of-fusion/

How nif works. National Ignition Facility & Photon Science. (n.d.-a). https://lasers.llnl.gov/about/how-nif-works

How the sun works | amnh. (n.d.). https://www.amnh.org/exhibitions/einstein/educator-resources/how-the-sun-works

IAEA. (2016, October 12). *Fusion - frequently asked questions*. https://www.iaea.org/topics/energy/fusion/faqs

Kemene, E., Valkhof, B., & Tladi, T. (2024, July 22). *AI and energy: Will AI reduce emissions or increase demand?*. World Economic Forum. https://www.weforum.org/stories/2024/07/generative-ai-energy-emissions/

Libretexts. (2023, February 13). *6.1.6: The collision theory*. Chemistry LibreTexts. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Kinetics/06%3A_M

odeling_Reaction_Kinetics/6.01%3A_Collision_Theory/6.1.06%3A_The_Collision_Theory

U.S. Energy Information Administration. (2024, July 15). *U.S. Energy Information Administration - EIA - independent statistics and analysis*. U.S. energy facts explained - consumption and production - U.S. Energy Information Administration (EIA). https://www.eia.gov/energyexplained/us-energy-facts/

United Nations. (2024, January 25). *Will developing countries benefit from the renewables boom? | | UN news*. United Nations. https://news.un.org/en/interview/2024/01/1145922

Valich, Lindsey. "What Is Fusion, and Why Is It so Difficult to Create?" Rochester.Edu, newscenter, 28 Feb. 2024, www.rochester.edu/newscenter/what-is-fusion-and-why-is-it-so-difficult-to-create-342732/