ENERGY: NUCLEAR FUSION

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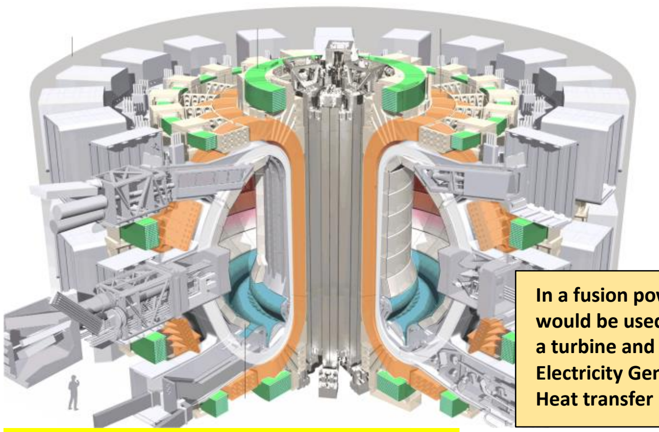
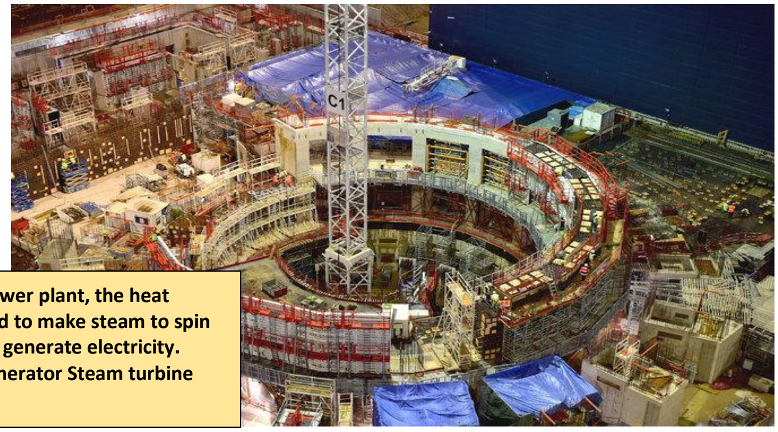
A Dream of Clean Energy at a Very High Price



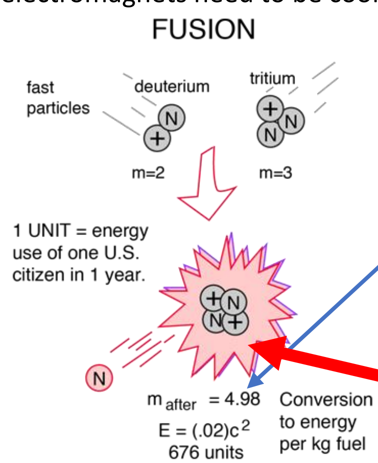


In a fusion power plant, the heat would be used to make steam to spin a turbine and generate electricity. Electricity Generator Steam turbine Heat transfer

SAINT-PAUL-LEZ-DURANCE, France — At a dusty construction site here amid the limestone ridges of Provence, workers scurry around immense slabs of concrete arranged in a ring like a modern-day Stonehenge.

It looks like the beginnings of a large commercial power plant, but it is not. The project, called ITER, is an enormous, and enormously complex and costly, physics experiment. But if it succeeds, it could determine the power plants of the future and make an invaluable contribution to reducing planet-warming emissions.

ITER, short for International Thermonuclear Experimental Reactor (and pronounced EAT-er), is being built to test a long-held dream: that nuclear fusion, the atomic reaction that takes place in the sun and in hydrogen bombs, can be controlled to generate power. ITER will produce heat, not electricity. But if it works — **if it produces more energy than it consumes.**.To fuse, atomic nuclei must move very fast — they must be extremely hot — to overcome natural repulsive forces and collide. In the sun, the extreme gravitational field does much of the work. **Nuclei need to be at a temperature of about 15 million degrees Celsius**. In a tokamak, without such a strong gravitational pull, the atoms need to be about 10 times hotter. So enormous amounts of energy are required to heat the plasma, using pulsating magnetic fields and other sources like microwaves. Just a few feet away, on the other hand, the windings of the superconducting electromagnets need to be cooled to a few degrees above absolute zero



INTRODUCTION: Energy obtained from fusion and fission reactions is based on differences in the nuclear binding energy. The mass of the products of a fusion reaction is smaller than the mass of its reactants. **The difference or "missing mass" is converted into energy in accordance with Einstein's equation $E=mc^2$.** Because c is very large, a small amount of missing mass turns into a large amount of energy. The main fuels used in nuclear fusion devises are deuterium and tritium, both heavy isotopes of hydrogen. The **Deuterium (D) – Tritium (T) reaction** has the largest cross section (in other words, the probability of a reaction to take place) and also the largest Q-value (the released energy of a reaction) of all varieties of fusion reactions. **It produces an alpha particle (or Helium-4 nucleus) and a neutron, and releases 17.6 megaelectron volt (MeV) of energy in the form of (((kinetic energy of the products)))(3.5 MeV to alpha particle and 14.1 MeV to neutron).**

QUESTIONS: **(a) Convert the 3.5 Mev of kinetic energy alpha particle to Joules of energy?, (b) Convert the 14.1 Mev of kinetic energy of neutron to Joule units of energy? , (c) Convert total kinetic energy of both particles 17.6 Mev to Joule units of energy?**

HINTS: **1.602×10^{-19} J/ev , ev = electron volt**

ANSWERS: **(a) 5.607×10^{-13} J , (b) 22.59×10^{-13} J , (c) 28.1952×10^{-13} J**