

Fusion: The Fire Some Time



Fusion is the gaudiest of hopes, the fire of the stars in the human hearth. Produced when two atoms fuse into one, fusion energy could satisfy huge chunks of future demand. The fuel would last millennia. Fusion would produce no long-lived radioactive waste and nothing for terrorists or governments to turn into weapons. It also requires some of the most complex machinery on Earth.

A few scientists have claimed that cold fusion, which promises energy from a simple jar instead of a high-tech crucible, might work. The verdict so far: No such luck. Hot fusion is more likely to succeed, but it will be a decades-long quest costing billions of dollars.

Hot fusion is tough because the fuel—a kind of hydrogen—has to be heated to a hundred million degrees Celsius or so before the atoms start fusing. At those temperatures the hydrogen forms a roiling, unruly vapor of electrically charged particles, called plasma. "Plasma is the most common state of matter in the universe," says one physicist, "but it's also the most chaotic and the least easily controlled." Creating and containing plasma is so challenging that no fusion experiment has yet returned more than 65 percent of the energy it took to start the reaction.

Now scientists in Europe, Japan, and the U.S. are refining the process, learning better ways to control plasma and trying to push up the energy output. They hope that a six-billion-dollar test reactor called ITER will get the fusion bonfire blazing—what physicists call "igniting the plasma." The next step would be a demonstration plant to actually generate power, followed by commercial plants in 50 years or so.

"I am 100 percent sure we can ignite the plasma," says Jerome Pamela, the project manager of a fusion machine called the Joint European Torus, or JET, at Britain's Culham Science Center. "The biggest challenge is the transition between the plasma and the outside world." He means finding the right materials for the lining of the ITER plasma chamber, where they will have to withstand a bombardment of neutrons and transfer heat to electric generators.

At Culham I saw an experiment in a tokamak, a device that cages plasma in a magnetic field shaped like a doughnut—the standard design for most fusion efforts, including ITER. The physicists sent a huge electrical charge into the gas-filled container, a scaled-down version of JET. It raised the temperature to about ten million degrees Celsius, not enough to start fusion but enough to create plasma.

The experiment lasted a quarter of a second. A video camera shooting 2,250 frames a second captured it. As it played back, a faint glow blossomed in the chamber, wavered, grew into a haze visible only on its cooling edges, and vanished.

It was—well, disappointing. I had expected the plasma to look like a movie shot of an exploding automobile. This was more like a ghost in an English paneled library.

But this phantom was energy incarnate: the universal but elusive magic that all our varied technologies—solar, wind, biomass, fission, fusion, and many others large or small, mainstream or crazy—seek to wrestle into our service.

Taming that ghost is not just a scientific challenge. The ITER project has been held up by a seemingly simple problem. Since 2003 the participating countries—including much of the developed world—have been deadlocked over where to build the machine. The choice has come down to two sites, one in France and one in Japan.