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Star power

France has just been chosen as the host site for the experimental ITER nuclear fusion reactor, a multi-billion-dollar project designed to emulate the power of the Sun. Richard Ingham looks at the potential benefits of the reactor – and its problems.

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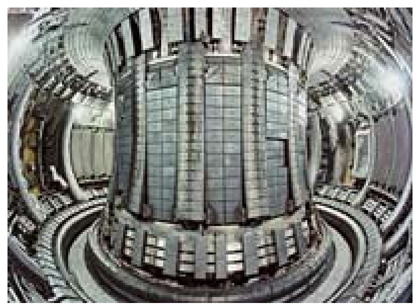
In today's world, most energy sources are expensive, dirty, dangerous and finite.


The world's most expensive doughnut, the tokamak

The vision behind ITER (International Thermonuclear Experimental Reactor), the 10-billion-dollar scheme which cleared its last political hurdle on Tuesday, is of a world where energy will be cheap, clean, safe and almost infinite.

Instead of splitting the atom -- the principle behind the 1940s Manhattan Project that built the atomic bomb and led to civilian nuclear plants -- ITER seeks to harness nuclear fusion: the power of the Sun and the stars.

Emulating the Sun

Under fusion, the nuclei of light atomic elements are forced together to make heavier elements and, as they do this, huge amounts of energy are released.

A huge jolt of heat to nearly 100 million C would kickstart the process.

In the Sun, mighty gravitational forces ram hydrogen atoms together to produce helium, with solar energy the by-product.

On Earth, the fusion would take place in a reactor fuelled by two isotopes of hydrogen -- deuterium and tritium -- with helium as the waste product in addition to the energy.

A huge jolt of heat (to nearly 100 million C, 180 million F) would kickstart the process, fusing the nuclei in a charged gas called a plasma.

Plasma has some of the qualities of a gas, but conducts electricity and responds to magnetism.

Unlike oil, gas and coal, the sources of deuterium are almost infinite, for it is present in seawater. Tritium is a man-made isotope derived by irradiating the plentiful element lithium in the fusion vessel.

The world's largest doughnut

ITER was conceived at an international summit in 1985 as a test bench to see whether fusion can be taken out of the lab and help meet the world's energy needs from the middle of the 21st century.

It will build on encouraging results from lower-powered machines known as tokamaks -- doughnut-shaped vessels lined with superconductive magnets to hold the plasma in place.

ITER will be the largest tokamak in the world, capable of holding plasma volume of 800 cubic metres, 10 times more than the largest tokamak in existence today, the Joint European Torus (JET) in Culham, England.

Nobel Prize winner Masatoshi Koshiba is sceptical about the reactor

A tough challenge

Among the many problems facing its researchers are how to efficiently confine the plasma cloud in the magnetic field so that charged particles do not slip out.

Then there is the big energy equation -- the cost in energy it takes to pump up the plasma to such high temperatures in comparison with the yield this brings.

Fusion enthusiasts insist the process will be far safer than fission, with no risk of a repetition of the 1986 Chernobyl disaster.

So far, despite steady improvements, no one has achieved a self-sustaining fusion event longer than a few minutes and input/yield ratios remain low.

That compares with ITER's goal of producing sustained pulses of 400-500 megawatts of electricity from 40 MW of heating power.

Among the sceptics is Masatoshi Koshiba, a Japanese scientist who won the Nobel Prize for Physics in 2002.

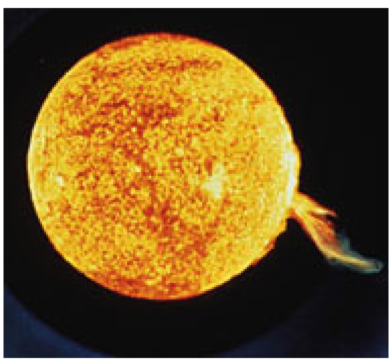
In an interview earlier this year, Koshiba warned ITER did not meet "a certain number of conditions, namely safety and economic costs" for it to be considered the dream energy of the future.

He said no-one had experience with producing or handling high-energy masses of neutrons, reaching 14 megaelectronvolts (14 MeV). It could become inordinately expensive to build walls and absorbers as a safety buffer for this seething pulse, with the possible need to replace them every six months, said Koshiba.

A long-term vision

After several years of wrangling, the experimental reactor is now set to be built at Cadarache, southern France, under the decision announced by the six ITER partners in Moscow on Tuesday.

After the construction programme, experiments would start around the middle of the next decade and continue for some 20 years, testing ITER for technological feasibility, safety, health and waste management. The reactor would then be decommissioned.



The reactor will recreate the processes fuelling the Sun's energy

If this experimental machine is successful, a demo fusion power plant would be built in the mid-2030s, and -- if all goes well -- the first commercial fusion plant would be born in the middle of the century to assess economic feasibility.

As for safety, fusion enthusiasts insist the process will be far safer than fission, with no risk of a repetition of the 1986 Chernobyl disaster that wrecked the last glittering vision to be espoused by the nuclear industry.

Unlike fission, where fuel rods and other heavily radioactive materials have to be stored underground for hundreds of years after use, irradiated materials from nuclear fusion could be stored above ground as low-level waste for less than a century, physicists predict.

Green groups argue that the money being ploughed into ITER would be better spent on research to improve familiar sources of renewable energy such wind, solar and wave power.

ITER's cost is shared among the European Union (EU), Japan, the United States, Russia, South Korea and China. Canada pulled out in early 2004.

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Subject: ITER, Cadarache, nuclear fusion, electricity generation

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