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The Fusion Myth

Sebastien Balibar

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France is now rushing to construct the International Thermonuclear Experimental Reactor, (ITER), which is supposed to show that nuclear fusion can be used to power nuclear power stations. ITER is often presented as the long-term solution to the problem of global warming, because nuclear fusion can provide an infinite and clean source of energy. But ITER will do nothing of the sort.

In the fission reactions that nuclear power generation relies on today, heavy elements such as uranium break into smaller ones, while in nuclear fusion small elements such as hydrogen stick together and form heavier elements (helium). Both fission and fusion produce a lot of energy.

Some political leaders explain that nuclear fusion is at work in the sun, and that, thanks to ITER, we will harness it. They often add that, since fusion burns hydrogen, which can be found in seawater, it is an infinite source of energy.

Unfortunately, political leaders know little about the scientific issues involved. That nuclear fusion is a source of energy has been known since the invention of the hydrogen bomb. But its control is still a fundamental challenge for research institutes, not some minor technical difficulty that can be easily overcome.

Confining a little sun inside a box is an extremely difficult task for three main reasons. First, the nuclear fuel is not seawater, but a mixture of the two heavy isotopes of hydrogen, deuterium and tritium, a radioactive element that has been produced in small quantities for hydrogen bombs. Any development of fusion reactors would require producing tritium with industrial methods that have yet to be invented.

Second, the deuterium-tritium fusion reaction starts at around 100 million degrees. To achieve this requires using a magnet to accelerate a plasma that is a big flame of deuterium and tritium nuclei. This must be done in a ultra-high vacuum in a large chamber. ITER is not designed to produce electricity, but to study the stability of the flame in the magnet. Since the fusion reactions produce alpha particles, which pollute the plasma, one has to insert a "divertor" inside the flame at 100 million degrees in order to clean it. Nobody has ever accomplished this, but ITER may be able to try around 2030 – that is, if it solves the previous problem.

Third, fusion also emits neutrons that will produce helium gas bubbles inside the wall material, which tends to explode. The supporters of ITER explain that if the walls are porous, the bubbles can escape. But nothing can be both leak-proof and porous, and ITER is not designed to study this contradiction. In the future, a "blanket" should be inserted between the plasma and the walls, with two objectives: to protect the outer

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walls and to produce tritium from nuclear reactions within a circulating fluid containing lithium. This might work, but the first wall of the blanket will need to be not only leak-proof and porous, but also sufficiently permeable to neutrons, which have to hit the lithium atoms beyond it.

The problem of materials is an entire research field in itself. In order to study it, it has been decided to build the International Fusion Materials Irradiation Facility (IFMIF) in Japan. Some scientists have argued that the neutron irradiation in IFMIF won't be the same as in fusion reactors, but it should be noted that its cost, at one billion euros, will be one-tenth that of ITER.

So why can't we wait for IFMIF's results before building ITER? It all depends on one's budget. If ITER could really solve the planet's energy problem, €10 billion would be a negligible investment – less than the net profit of the oil company TOTAL (€13 billion in 2006) and equivalent to ten days of waging the war in Iraq.

But if fusion is ever to work in industrial power stations, it will take many decades. Even if ITER is successful, and if one solves the tritium and material problems, everything would need to be tested in real size, and only then could a first prototype of an industrial reactor be built. A drastic reduction of CO2 emissions is an urgent priority, but fusion is unlikely to produce sufficient energy to achieve that goal before the twenty-second century.

In fact, ITER is a big instrument for fundamental research, so its €500 million Euros annual cost needs to be compared with similar scientific initiatives, such as the European Organization for Nuclear Research (CERN), which costs one billion Swiss francs per year. In my opinion, searching for the fundamental structure of particles is far more important than studying the stability of a plasma.

In France, the contribution to ITER is more than all the available funding for research projects in all our physics laboratories. So the danger is that ITER will squeeze out funding for other vital research. We already have the bad example of the International Space Station, a waste of $100 billion that has produced no scientific results.

ITER will not solve our energy problem. Although it has some scientific interest in plasma physics, the participating countries should clearly state that funding it won't affect the rest of their research efforts. At the same time, the international community should support research on energy saving and storage, and accelerate the development of fourth-generation nuclear reactors, which will use fission and be both clean and durable.

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