The future Iter nuclear reactor: a titanic and energy-intensive project

reporterre.net/Le-futur-reacteur-nucleaire-Iter-un-projet-titanesque-et-energivore

Investigation - Energy

[1/3] The future Iter nuclear fusion reactor, in Bouches-du-Rhône, will consume as much energy as it produces. This huge project is also much more expensive than expected: 44 billion euros.

[1/3 Iter, the reality behind the promises of nuclear fusion] *Iter, the future international reactor, wants to be the showcase of nuclear fusion, whose qualities, according to its promoters, surpass those of fission, in use in conventional power stations. Investigation at the heart of a disproportionate project, with disastrous health and environmental consequences.*

• **Part 2:** Behind the Iter project, mountains of toxic metals and radioactive waste

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Saint-Paul-lez-Durance (Bouches-du-Rhône), report

In Cadarache, in the Bouches-du-Rhône, several thousand people are working on one of the largest construction sites in the world. The complex where we enter with our guide, which will house the future Iter nuclear fusion reactor (*“ International Thermonuclear Experimental Reactor ”*), weighs 440,000 tonnes , or more than forty Eiffel Towers. Men in construction *helmets - " red helmets for the bosses, white for the workers "*, explains the guide - all equally tiny in this space, contemplate a colossal piece of metal weighing 440 tons. It was shipped from China by boat, transported from Fos-sur-Mer on a barge specially built on the Etang de Berre, then transported by night convoy on 104 kilometers of fortified road aboard a giant truck equipped with 352 wheels. .

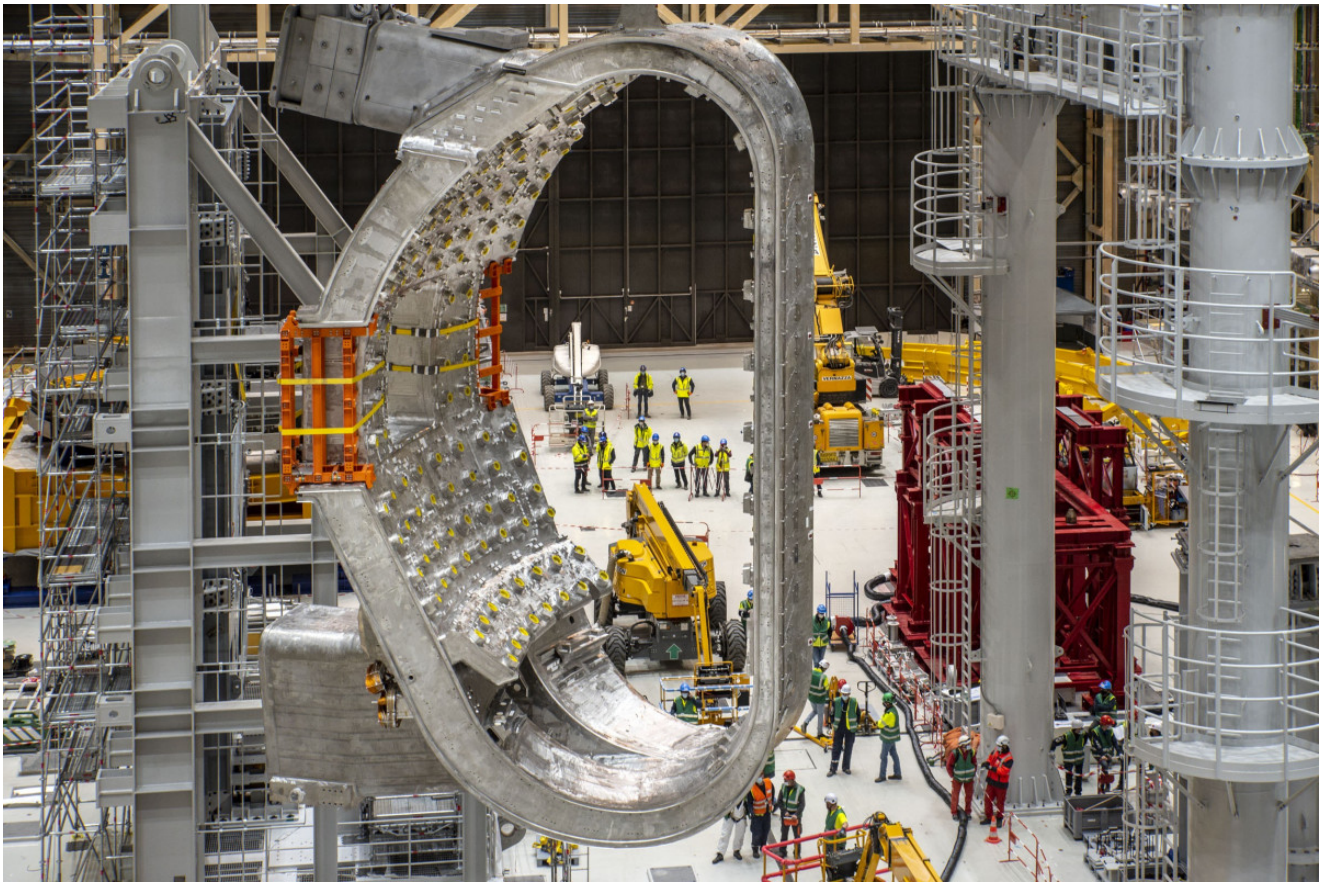
If members of an unknown tribe arrived in Iter and observed the titanic resources mobilized for this project, they would probably conclude that a temple is being built here for the worship of a god. They might not be wrong. The name of this deity appears in large letters on the first page of the Iter Organization's website : *“ Inexhaustible energy. "*

Home page of the Iter Organization. *Screenshot / Iter.org*

Nuclear power plants built from the 1960s already promised to answer this prayer, but by means of fission : triggering a chain reaction releasing neutrons by breaking uranium nuclei. But in Iter, we tell you bluntly: nuclear fission is a dead end. Uranium must be extracted to fuel reactors, manage tens of thousands of tonnes of radioactive waste for thousands of years, and control the chain reaction which, for lack of cooling, gets carried away, as in Fukushima . *" We no longer want all that, "* says Joëlle Elbez-Uzan, responsible for safety and the environment at Iter.

With nuclear fusion , we are assured, all these problems would be overcome: very little fuel, very little waste, no risk of runaway. With deuterium (extracted from seawater) and only a few kilograms of radioactive tritium , heated to between 150 and 200 million degrees Celsius (ten times the temperature of the center of the sun), we can create a plasma resulting from the fusion atoms and produce enormous heat [1] . *" Fusion can generate four times more*

energy per kilogram of fuel than fission, and nearly 4 million times more energy than burning oil or coal, " promises the International Atomic Energy Agency (IAEA) on the front page of its bulletin published in May 2021 .

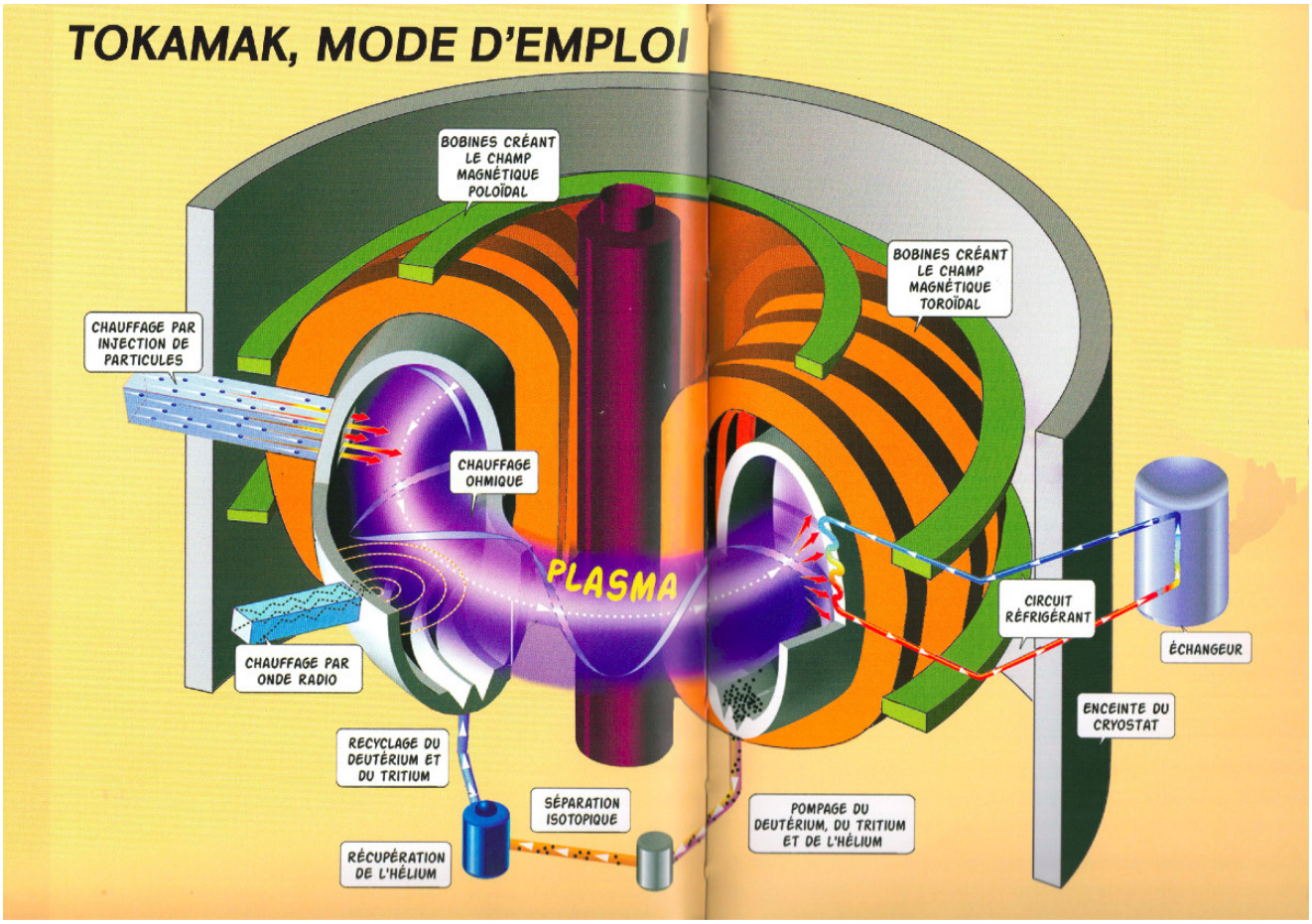


One of the sectors of the Iter tokamak vacuum chamber. © *Iter Organization*

Increase energy tenfold ... Really ?

So far, nothing new: it is the principle of the thermonuclear bomb (or H bomb). As physicists explained in 1957, shortly after the international *" Atoms for Peace "* conference , which initiated this research, the purpose of a thermonuclear fusion reactor is to *" harness the energy of the H-bomb "* [2] .

Instead of giving free rein to the destructive heat of the neutrons, we will try to confine this plasma in gigantic magnetic fields. Locked in this tokamak , a sort of magnetic bottle invented by Russian physicists, the plasma, brought to a very high temperature as previously explained, would produce helium nuclei, and the fusion reaction would be self-sustaining by releasing heat. We could then recover the excess heat created by the reaction and convert it into electric current.

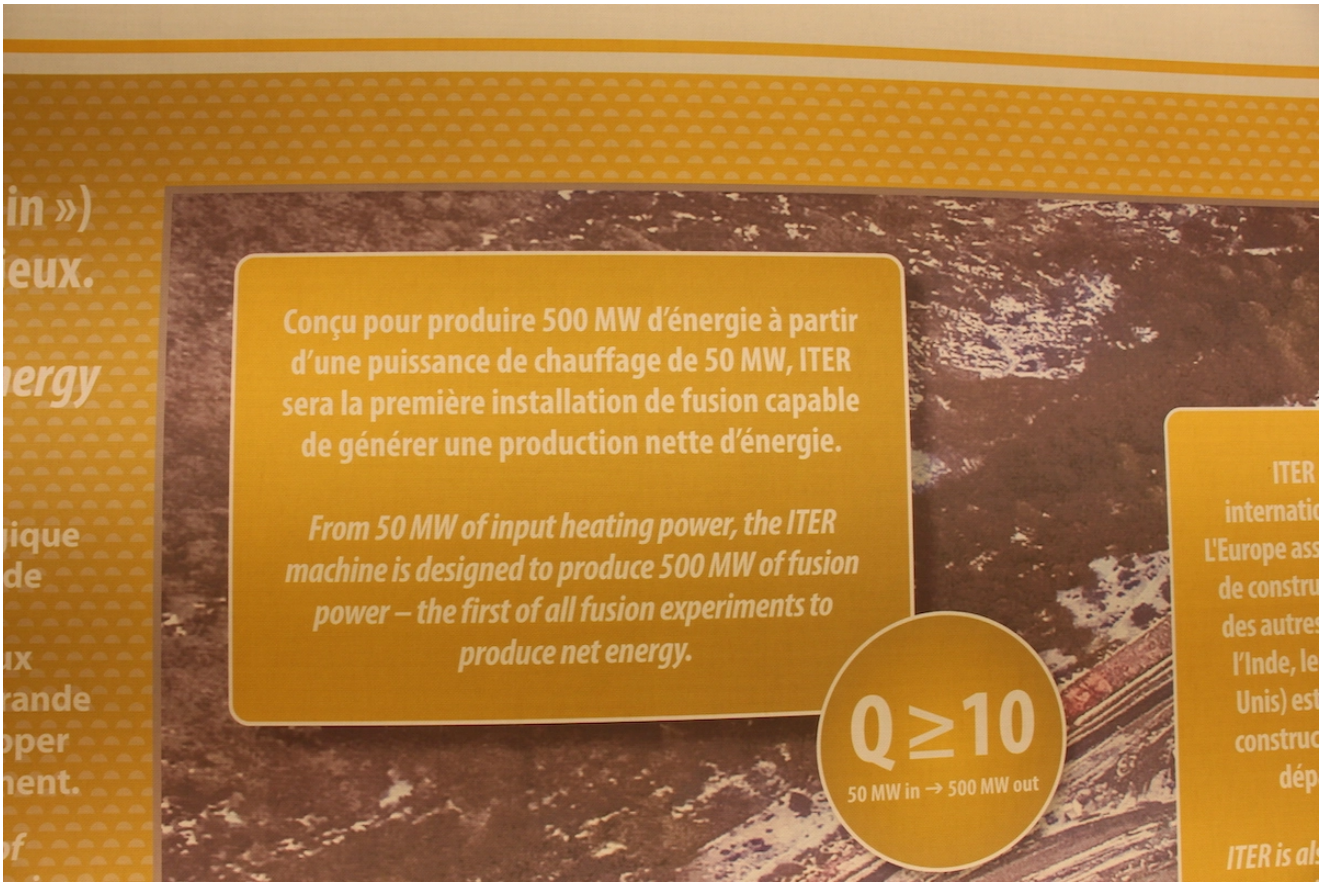


Instructions for use of the tokamak, with the vacuum chamber, the gray circular tunnel, surrounded by the coils generating the magnetic field. *CEA , taken from Iter: the path to the stars ? , J. Jacquinot, R. Arnoux, Edisud, 2006.*

So far, nuclear fusion has only been able to be carried out for a few seconds, due to the lack of a tokamak large enough to contain the energy [3] . As no country could have assumed alone the costs of such a construction, the experiment conducted at Cadarache brings together thirty-five countries (European Union, United States, China, Russia, Switzerland, England, Japan, India and South Korea. South), who all contribute to its financing. After fifteen years of work and research, the assembly of the Iter tokamak - a gigantic metal enclosure 73 meters high - began in the summer of 2020. The objective is to succeed in confining a plasma for four minutes in order to check whether the helium nuclei manage to maintain the nuclear fusion reaction.

Because of its experimental vocation, Iter is not connected to turbo-alternators and will not produce electricity. The first plasma firing with deuterium and tritium will not begin until 2035, once the machine has been assembled, its stability and tightness tested. A prototype reactor, Demo , would be built around 2050 , then a whole nuclear fusion sector *" by 2070 "* , estimates Joëlle Elbez-Uzan cautiously. But Iter already intends to demonstrate that with its self-sustaining plasma, the reactor will generate *" the first net energy production in the history of fusion "* by creating *"amplification by a factor of 10: ie 50 megawatts (MW) at*

the input and 500 megawatts at the output " . This is the first thing we teach you about Iter. With very little fuel and waste, we will increase the energy tenfold: we inject 50 MW , we obtain 500 MW .



In Cadarache, information panel on Iter. © *Celia Izoard / Reporterre*

Zero energy balance

The problem is, it is wrong. Or, at least, this is only very partially true. Steven B. Krivit, American scientific journalist, specialist in nuclear fusion, devoted an investigation to it, then a film . At the time of the plasma firing, he explains, to produce these 50 MW of heat that will be injected into the tokamak, taking into account all the infrastructures present on the site, the heating systems and the energy losses, Iter will consume between 300 and 500 MW. Almost as much as the energy it is supposed to produce. And that without counting the embodied energy of the reactor, that is to say the energy necessary for the production of all these components, their routing, etc., we are talking here simply of the electrical power that Iter will take from the RTE network .

" This reactor is made to produce fusion [neutron] *particles that have ten times the power injected into the particles* ," says Steven B. Krivit, " *not to produce ten times the energy it will consume. "* If the experiment conducted at Iter working, and it was connected to the grid, the energy balance would be zero. A *" strategic omission ",* according to Krivit, which considerably removes the prospect of producing electricity by nuclear fusion.

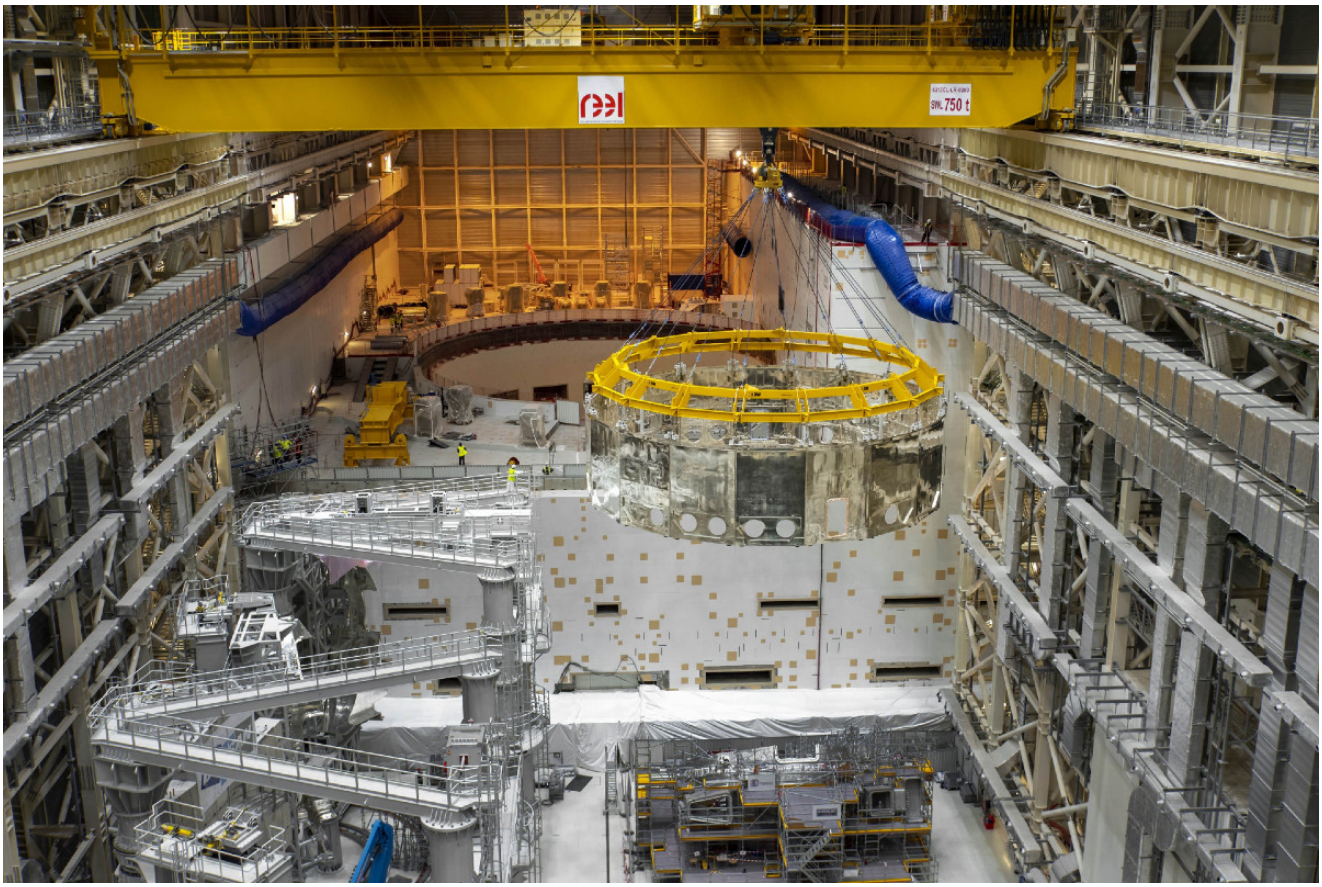
Inside the Iter site. © *Celia Izoard / Reporterre*

This subtle distinction between the amount of energy consumed to initiate the reaction and the amount of energy consumed by the reactor (like its giant cryogenic plant) is never explained to the public or even, presumably, to Iter's staff. When we corrected Joëlle Elbez-Uzan during our interview on the fact that the amplification factor by ten concerns only the reaction, and not the total energy injected into Iter, the director of safety exclaimed, perplexed: *" Are you playing a joke on me ?" "*

Asked the same day about Iter's total power consumption, Laban Coblentz, communications director, replied that he did not know. After a written request, fifteen days of waiting and several reminders, orders of magnitude confirming those of Steven B. Krivit were provided, but accompanied by a long dissertation on the need to *" place these responses in the context of the mission. of Iter "* . Its energy consumption must be weighed against *" the enormous potential of fusion to eliminate more than a century of geopolitical tensions and conflicts linked to access to fossil resources "* . Part of the power consumed by Iter is due *"the large number of diagnostic tools aimed at an exhaustive analysis of the plasma and serving to optimize the design of future machines "* . And anyway, it is impossible to precisely estimate the power consumption because *" it will depend on the precise configuration of the systems used for each experiment "* .

> " A small group of physicists [...] misinformed the public in order to ensure the maintenance of its public funding. "

This admission of ignorance is all the more surprising since at the time of the public debate on Iter in 2006, the team seemed perfectly capable of providing an estimate. The report of the meeting organized in Salon-de-Provence by the National Commission for Public Debate indicates: *" When the machine is in standby mode, it will consume 120 megawatts in order to supply the auxiliaries. During the experiments, the power consumed [...] will then reach 620 MW in order to heat the plasma, then will drop to 450 MW during the main phase of the experiment (370 seconds), and will be restored to 120 MW . At peak power of 620 MW, compensation systems will limit Iter's impact on the regional electricity grid [4] . "* And for good reason! 620 MW represents colossal power, since the entire Toulouse metropolitan area uses power of nearly 500 MW . Year-round, we learn in one of the notebooks intended for public debate , Iter will consume 600 GWh [5] , which corresponds to the supply of a city of 145,000 inhabitants, such as Aix-en-Provence or Le Mans.



The first element of the cryostat heat shield transferred to the tokamak pit on January 14, 2021 © *Iter Organization*

From 4.5 billion to 44 billion euros

Obviously, the leaders of the Iter Organization carefully avoid mentioning it, for fear of dampening the enthusiasm of the political leaders who finance this colossal instrumentation. *" A small group of physicists representing the scientific community of nuclear fusion researchers has misinformed the public in order to ensure the maintenance of its public*

funding " , summarizes the journalist Steven B. Krivit. To convince the political leaders, it was necessary at least to promise an energy miracle worthy of the multiplication of the loaves. *" This is the massive argument,"* quips with *Reporterre* Thiéry Pierre, physicist of fusion plasmas at the CNRS., himself very skeptical about the possibility of confining a thermonuclear plasma. *Imagine scientists, crowned with the prestige of theoretical physics, explaining to Jacques Chirac that energy can be multiplied by ten: he writes the check right away ! "*

Today, those involved in mergers have all the less interest in disappointing their interlocutors as the amounts keep doubling. In 2000, Iter was to cost 4.5 billion euros . In 2006, the year in which the Iter Agreement was ratified by Jacques Chirac , the total cost (construction, operation and dismantling) was estimated at 10 billion euros . The Iter Organization announces today 22 billion euros but, admits Laban Coblentz, *" this excludes operating costs and dismantling "* .

Moreover, it is all the more false to quantify the cost of the project at 22 billion euros since, according to the Iter Agreement, the European Union contributes to the project up to 45.6 % of the total amount, yet it allocated it 20 billion euros until 2035 . According to this agreement, the other six partner countries contribute the rest of the cost through in-kind contributions: the supply of all these unique very high-tech components, always from public funds. The construction cost would therefore be around, according to Thiéry Pierre, *" 44 billion euros "* , which led the physicist to send an information note to the management of the National Center for Scientific Research (CNRS), asking to put an end to this disinformation *" which risks casting permanent discredit on plasma physics "* .

Finally, by adding the billions needed to run the experiments and deal with a colossal volume of dismantling waste, the US Department of Energy may have been more realistic in estimating the total cost of Iter at 65 billion dollars (approximately 54 billion euros). Apart from the International Space Station, it is the most expensive scientific experiment in human history.

The rest of the investigation tomorrow .

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Notes

(1) The fusion sought at Iter is called " *thermonuclear* " : it consists, by heating them, in accelerating the nuclei so as to make them cross the force of electrostatic repulsion and to merge them, which emits very energetic neutrons. Heating takes place in different stages. 1. Gaseous fuel is introduced into the tokamak, electricity passes through the large central magnet, which itself sends a current through the gas. It is ohmic heating, which works on the principle of a resistance and which allows to reach the temperature of 20 million degrees Celsius. 2. Two complementary heating techniques are introduced to reach 150 million degrees: neutral particles are injected into the plasma, giving it energy and two sources of high frequency electromagnetic waves are activated.

(2) *" Nuclear fusion: energy in abundance "*, The scientific method, France Culture, June 12, 2019.

(3) For example, in the JET tokamak in England and the West tokamak at the CEA in Cadarache. And more recent announcements from Korea (KSTAR) and China (East).

(4) *Report of the public debate on Iter in Provence* , National Commission for Public Debate, 2006, p. 43.

(5) *Iter en Provence* , National Commission for Public Debate, Cahier 1, 2006, p. 23.

Details

Source: Celia Izoard for *Reporterre*

Photos:

. Chapô: Overview of the Iter site, in November 2020 © Iter Organization / EJF Riche

. One of the nine sectors of the Iter tokamak vacuum chamber. © Iter Organization

. Instructions for use of the tokamak, with the vacuum chamber in orange. CEA , taken from *Iter: the path to the stars ?* J. Jacquinot, R. Arnoux Edisud, 2006

. Inside the Iter site. © Celia Izoard / *Reporterre*

. The first element of the cryostat heat shield transferred to the tokamak pit on January 14, 2021 © Iter Organization

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Updates:

• June 16 at 4:11 pm: clarification of the legend of the vacuum chamber diagram.

• June 16 at 4:46 pm: clarification in a quote from Krivit: " *fusion particles* "are " *neutrons* ".