Frequently Asked Questions

In this section, we provide answers to the most frequently asked questions about the ITER Project.

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Fusion and the ITER Project

What is ITER?

ITER (the Latin word for "The Way") is a large-scale scientific experiment intended to prove the viability of fusion as an energy source. ITER is currently under construction in the south of France. In an unprecedented international effort, seven partners—China, the European Union, India, Japan, Korea, Russia and the United States—have pooled their financial and scientific resources to build the biggest fusion reactor in history. ITER will not produce electricity, but it will resolve critical scientific and technical issues in order to take fusion to the point where industrial applications can be designed. By producing 500 MW of fusion power from 50 MW of power injected in the systems that heat the plasma—a "gain factor" of 10—ITER will open the way to the next step: a demonstration fusion power plant.

On-site construction of the scientific facility began in 2010. As the buildings rise at the ITER site in southern France, the fabrication of large-scale mockups and components is underway in the factories of the seven ITER Members. The shipment of the first completed components began in 2014 and will continue into the 2020s. Machine assembly will begin as soon as the giant Tokamak Complex is ready for occupation. First Plasma is planned for December 2025.

ITER is one of the most complex scientific and engineering projects in the world today. The complexity of the ITER design has already pushed a whole range of leading-edge technologies to new levels of performance. However, further science and technology are needed to bridge the gap to the commercialization of fusion energy.

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What questions will be answered by ITER that have not already been answered by research to date?

ITER is the experimental step between today's fusion machines, focused on plasma physics studies, and tomorrow's fusion power plants.

The plasma physics community will have access, in ITER, to a one-of-a-kind device capable of plasma pulses of a much longer duration than those achieved in other fusion machines. ITER will be twice as large as the largest tokamak fusion experiment currently operating (JET in the UK), with ten times the plasma volume. This unique experimental machine has been designed to:

- produce 500 MW of fusion power ($Q \geq 10$) from 50 MW of heating input power
- confine a deuterium-tritium plasma in which alpha-particle heating dominates
- demonstrate the integrated operation of technologies for a fusion power plant
- test components required for a fusion power plant
- test concepts for a tritium breeding module
- demonstrate the safety characteristics of a fusion device

Today, fusion research is at the threshold of exploring a "burning plasma," in which sufficient heat from the fusion reaction is retained within the plasma and sustains the reaction for a long duration. Such exploration is a necessary step toward the realization of a fusion energy source. Scientists are confident that the larger ITER plasmas will not only produce much more fusion power, but will remain stable for long periods of time. The scale of ITER is necessary to break new ground in fusion science.

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Is there consensus in the scientific community about the ITER Project?

In a project of this unprecedented scale, involving worldwide cooperation and billions of euros of expenditure, it would be naïve to believe that there could be unanimity in the scientific community on the aims and the scientific and technical basis of the project. A scientific consensus may be possible while discussions remain at the abstract level, but in a world of intense competition for research funding it is inevitable that scientists from various fields will criticize the decision to spend money on a large project, arguing that they would prefer to spend the money elsewhere.

What can be said about ITER is that for the scientific community working in the energy field, this project is considered by a strong majority as a major step that may provide a future energy alternative for all humankind. The present political and scientific approach to this project has not suddenly appeared out of lobbying by a few influential individuals. It is the result of decades of painstaking, step-by-step research by fusion scientists all over the world as well as intense discussions in the scientific administrations of involved governments who debated the options, the costs and the risks before deciding that ITER was a worthwhile investment in our common energy future. The proportion of papers directly concerned with ITER presented at leading international scientific conferences on fusion as well as in fusion journals has been steadily increasing for a number of years. The fact that research aimed at ITER is now such a dominant topic in these papers demonstrates how essential the project is to the advancement of fusion towards energy production.

Fusion research, and the role of ITER, has been subject to serious scrutiny by panels of independent experts established by funding agencies in Europe and most of the other ITER partners. The results of these investigations provide the most reliable measure of consensus in the scientific community. A few examples:

• In 2004 during the early stages of ITER negotiations, a high-level panel chaired by Sir David King (Chief Scientific Advisor to the UK government) concluded that the time was right to press ahead with ITER and recommended funding a "fast track" approach to fusion energy. In 2013 the European Fusion Development Agreement (EFDA, now **EUROfusion**) published a **roadmap** to the realization of fusion energy by 2050.
• The French Academy of Sciences organized a detailed review of the state-of-the-art and the remaining challenges of fusion both by magnetic confinement (including ITER) and using laser-driven systems. The review was published in a book in 2007 which emphasized the arguments supporting the construction of ITER.
• The United States went through a long process to decide to re-enter the ITER collaboration, after leaving it in the late 1990s. The US National Academy of Sciences convened a panel which included both fusion scientists and senior scientists from related fields such as nuclear fission power, high-energy physics and

astrophysics. The non-fusion scientists were empowered to make the key recommendations. The panel strongly endorsed the renewed membership of the US in the ITER Project as the best path forward to fusion energy.
• China announced in 2011 that it is planning to train 2,000 skilled experts over 10 years to carry out research and development in fusion.
• In 2016, the US Department of Energy made **a report** to the US Congress in which it recommends that the US remain a partner in ITER, through a re-assessment in 2018. Noting that "the management of the ITER Organization and the performance of the project have improved substantially," the report concludes that despite accumulated delays, "ITER remains the fastest path for the study of burning plasma."
• In June 2017 the European Commission produced the 14-page document "**EU Contribution to a Reformed ITER Project**" expressing confidence that the project was back on track.
• In December 2017, the US National Academy of Sciences issued the first part of a two-phase study on the state and potential of magnetic fusion research in the US. In it, US policy makers were urged to continue to participate in the ITER Project and to develop a long-term strategy for fusion energy demonstration. (*The report is available **here**.)*
• In April 2018 the European Council of Ministers issued a statement mandating Commission to approve the new ITER Baseline (cost, schedule, scope). One month later, the European Commission issued its 2021-2017 budget proposal with unequivocal support for the ITER Project.
• In December 2018 the US National Academy of Sciences published its final report (available **here**), recommending not only that the US remain a partner in ITER "as the most cost-effective way to gain experience with a burning plasma at the scale of a power plant," but also that it start a "national program of accompanying research and technology leading to the construction of a compact pilot plant."

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What has been accomplished in 60 years of tokamak research?
What are the advantages of ITER compared to the alternative approaches under development such as the Wendelstein 7-X stellarator in Germany, and the inertial fusion programs in the US and France?
What is the ITER model for collaboration and cooperation?

ITER schedule

When will ITER be operational?
When will the first giant ITER components travel along the ITER Itinerary?
Is ITER running behind schedule?
What are the Members doing to address the project's difficulties/schedule delays?
We hear the project is delayed. Are the ITER Members prepared to contribute additional budget?
Is there any danger that ITER will experience start-up difficulties as, for example, the LHC had with its array of magnets?

ITER cost

How is ITER financed?
How much is France contributing as Host?
Why have ITER costs risen?
Do we really know how much ITER will cost?
Is it worth spending billions on fusion or would the money be better spent in improving renewables like solar, wind and geothermal?
Are there risks of further cost increase?

Economic Benefits

Has ITER resulted in any positive economic benefits locally? Is ITER creating jobs?

ITER power amplification

I read that ITER's goal is $Q \geq 10$? What does that mean?
Is $Q \geq 10$ significant?
What is a burning plasma?
Will ITER be the first burning plasma device in the world?
How did the ITER designers choose the specific value of $Q \geq 10$?
And a related question: Why not design ITER to produce electricity?
What is the difference between plasma energy breakeven and engineering breakeven?

What is the status of construction workers?

Some say that ITER construction will rely on migrant workers who are poorly paid and precariously housed. Is this true?
Doesn't ITER have a specific legal status ?
What hiring regimes apply?
How are the construction companies chosen?
How many levels of subcontractors are permitted?
How many workers are expected on the ITER worksite in the years to come? What percentage will come from outside of France?
I've heard that foreign workers on the ITER site are only paid EUR 300 per month. Is this true?
What controls are carried out by the French authorities on site working conditions?
Several construction companies have reported the late payment of invoices. What is the situation?
What are the plans for housing thousands of people involved with ITER construction and assembly works?
Will infrastructure modifications be necessary to absorb the increase in traffic flow around the ITER site?

ITER licensing procedure

Becoming an "Installation Nucléaire de Base" in France
What regulatory steps remain?

ITER and the environment

What kind of nuclear waste will be produced by ITER, and in what quantity?
What arrangements are foreseen for radioactive waste generated by ITER during operation and decommissioning?
What effect will ITER operation have on local electricity and water supplies?

ITER safety

Is the energy stored in a 100-million-degree plasma dangerously large?
What would be the danger of an earthquake occurring near ITER, or a double disaster like earthquake and flooding?
What about malevolent acts?
Could ITER explode?
Could a Fukushima-type catastrophe occur at ITER?
What about the issue of nuclear decay heat that was so serious at Fukushima?
ITER will be built near a site with other nuclear installations. What is the additional risk due to the presence of more than one installation?
What will be the total amount of tritium stored on site? What are the procedures foreseen to confine and control the stock?
Where do all the neutrons go?
What procedures are foreseen to avoid any loss of tritium, mostly during the first tests (incomplete fusion)?

What would be the effect on the population near ITER of potential accidental radioactive releases in the environment, including tritium?
Can you declare fusion is really safe, while it uses huge amount of tritium, generates strong neutrons, and brings about huge amount of radiological waste?
Is there any possibility that fusion opens a new way for the production of mass destruction weapons?
What measures are in place for occupational safety?

Disruptions : Everything you wanted to know

What are disruptions?
What are the consequences of disruptions?
Will ITER be able to withstand disruptions?
What disruption mitigation system is planned for ITER?

Fusion as a sustainable energy source

Why has fusion science developed much more slowly than fission science, which provided commercial reactors just a few years after its inception?
Will commercial fusion be available early enough to contribute to the energy transition needed to fight climate change and to replace fossil fuels?
If successful, when would fusion be able to add power to the grid? What steps would be required after ITER?
How much power would a fusion reactor be able to deliver and at what cost? Would it be competitive?
Will fusion run out of fuel?
Is the concept of tritium breeding sufficiently robust to start the ITER Project?
I recently read that there was a shortage of helium in the world and this was unlikely to improve as stocks are used up. How will this affect plans for the fusion superconducting magnets?
What are the benefits of pursuing fusion as compared to next-generation nuclear fission reactors?

Reliability of materials

Is it really possible to find materials which can cope with strong fusion neutrons?
How often will the ITER first wall need to be replaced during operation?
What are the procedures to dispose of the irradiated material contained in the first wall? Have safety risks been taken into account?
Is there any risk of damage in case of loss of superconductivity in the ITER superconducting magnets?