

**HEADING 1A: Competitiveness for growth and jobs****International Thermonuclear Experimental Reactor (ITER)**

Lead DG: ENER

**I. Overview*****What the programme is about?***

ITER is a large-scale scientific experiment intended to prove the viability of fusion as an energy source. ITER is currently under construction in Saint-Paul-lez-Durance 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 take fusion energy to the threshold of industrial exploitation. ITER will not produce electricity, but it will resolve critical scientific and technical issues and thereby take fusion to the point where industrial applications can be designed. As the first fusion device in the world to produce and sustain a plasma that outputs more power than is put into it, ITER will be the proof of principle for magnetically-confined burning plasmas that will open the way to the next step: a demonstration fusion power plant.

The programme covers the European contribution to the ITER Organization (IO) for the construction of the ITER facility, which includes the procurement of equipment, installation, general technical and administrative support for the construction phase, and participation in commissioning and operations. It also covers other ITER-related activities, such as the Broader Approach activities with Japan. These European contributions are delivered through Fusion for Energy (F4E), the European Domestic Agency located in Barcelona (Spain). F4E was set up in 2007 as a European Joint Undertaking by a Council Decision under the Euratom Treaty

***EU added value of the programme***

ITER will achieve what no single country can do on its own. The risk, costs, and long-term nature of a large research project such as ITER puts it beyond the reach of individual EU Member States and even of the EU itself. Thus, the establishment of a global framework through an international agreement between Euratom and six other Parties was essential to undertake this large-scale scientific experiment. Construction started in 2007 and Euratom, as the Host Party of the project, is responsible for 45 % of the construction phase. Euratom's obligations to the project are fully discharged through the Joint Undertaking Fusion for Energy (F4E)

Europe's support to ITER and ITER-related activities such as the Broader Approach activities with Japan contributes to the strategic agenda of the European Union for clean and secure energy. In particular, it supports the first objective of the Commission's political agenda: *'boosting growth, jobs and investment in future high potential technologies'*. Supporting European businesses and research organisations to work on ITER represents an investment in the high-tech and advanced civil engineering industries. To date, F4E has awarded over 700 contracts and grants to companies, including SMEs, in 24 countries, for a value of almost EUR 5 billion.

Fusion has enormous potential and net present value as an environmentally friendly and virtually unlimited source of energy. Therefore, its development as a future energy technology contributes to the Research & Innovation pillar of the Energy Union. Thanks to its leadership in fusion research and the construction of ITER, Europe will be in a privileged position to reap the benefits of constructing and operating the first generation of fusion power plants in the future.

***Implementation mode***

The Directorate-General for Energy (DG ENER) is the lead DG for the implementation of the European contribution to ITER. The programme is managed under the indirect management mode through the Joint Undertaking Fusion for Energy (F4E).

**II. Programme Implementation Update*****Implementation status (2017-2019)***

In 2015, the ITER Council approved an action plan prepared by the ITER Organization (IO) to address the challenges faced by the project related to schedule, cost and governance. One of the main actions was the revision of the baseline (long-term schedule, cost and scope) in 2016. The updated schedule follows the *'staged approach'* which first prioritises the construction of the components essential to achieving First Plasma (FP, the beginning of operation) in 2025, followed by a series of installation and testing phases before starting the full performance phase (Deuterium-Tritium operation) in 2035.

ITER continues to move towards its assembly phase. As of the end of November 2019, the work up to First Plasma is 65.9 % completed. This progress corresponds to an average rate of 0.68 % per month over the last 21 months. To reach the First Plasma milestone, all components from the ITER members need to be available and delivered on time to the ITER Organization (IO), and assembled and installed in the Tokamak Complex.

Although the machine will begin preliminary operations in 2025, ITER construction will nevertheless continue until 2035, when testing will end and experimental operation will begin. The percentage completion up to the end of all construction activities in 2035 is now 51.8 %. The European in-kind contribution to the ITER project has progressed over the course of 2019 from ca. 34 % (December 2018) to almost 42 % (December 2019) against a planned target of almost 48 %. The European cash contribution to IO by the end of 2019 amounts to about EUR 1 140 million (committed amount) for an equivalent value of about one third of the overall cash contribution for the construction phase.

**Key achievements**

In terms of governance, since 2015 the goal has been to address the issues in management and project culture that caused, along with other factors, the project's delays and cost overruns. At European level, changes made to improve the functioning of Fusion for Energy (F4E). New management with industrial experience was appointed at F4E, and new monitoring systems and indicators were introduced along with strategies to streamline the governance of the project. The effects of these efforts are becoming visible, with the construction progressing in accordance with the 2016 baseline, renewed confidence in the project among the stakeholders, and coverage in the media reporting on the project's 'turnaround'.

A full series of key performance indicators dedicated to the specific monitoring of the schedule and cost performance have been recently introduced to better monitor the progress and the efficiency of F4E in delivering the Euratom contribution to the ITER project. A dashboard report based on these indicators is submitted regularly to the Governing Board. It includes metrics based on an Earned Value Management system.

For what concerns the progress at the ITER site, in November 2019 the walls & floors of the Tokamak building were finished, that marked the successful completion of an important construction milestone, about 5 years from the first pouring of concrete for the basemat slab. This first-of-a-kind infrastructure for a fusion device was a new territory for all involved and needed to comply with the extremely strict standards set by France's Nuclear Safety Authority. For its construction, approximately 10 types of concrete were developed to be used in different parts of the edifice. The building counts more than 80 000 embedded plates, anchored deep into the concrete, and positioned with accuracy to match the location of the ITER equipment that will be installed. Moreover, 18 of the 46 heavy doors weighing 70 tons each have been installed, to keep inside the radiation resulting from the fusion reaction.

Construction is well advanced on the Crane Hall, which will enlarge the Tokamak building to accommodate the cranes that will move the components during assembly. The first and second modules of its roof were lifted into place by Fusion for Energy (F4E) on 4 December 2019.

**Evaluations/studies conducted**

The Mid-term progress report in accordance with Article 5b of the Council Decision establishing the European Joint Undertaking for ITER and the Development of Fusion Energy and conferring advantages upon it has been adopted on 21 March 2019 (COM(2019)147 final <sup>(1)</sup>). The evaluation states that following the overhaul in management, the project is now on track within its current (2016) baseline, and early indicators show positive effects of the change. However, ITER's construction and management are still under improvement; in such a long-term project, it will be important to monitor whether these positive effects continue and grow over the next few years. Regarding ITER's place in energy policy and decarbonisation, the project remains an important part of EU energy and innovation policy, and although it does not contribute directly to energy and climate targets in the short- to medium-term, its potential role in the decarbonisation of the energy landscape post-2050 is very significant.

Three external studies were conducted in 2018 and 2019. The key findings of these studies were presented in the Programme Statements 2020.

**Forthcoming implementation**

In 2020, the European in-kind contribution to the ITER project should progress by ca. 10 % with the following main deliverables by F4E:

- Magnets: several components will be completed (all 10 Toroidal Field Coil Winding Packs) and handed over to IO (the 9 Pre-Compression Rings, the first 2 out of 10 Toroidal Field Coils, 2 out of 5 Poloidal Field Coils).
- Main Vacuum Vessel: the full production for all sectors will continue, heading towards final assembly of sectors 5 and 4.
- Blanket System: signature of the various contracts for the series manufacturing of the EU share of First Wall panels, the first batch of Beryllium tiles and the CopperCromeZirconium alloy raw material.
- Divertor: the main activities will be the follow-up of the on-going manufacture of the full-scale prototypes of the divertor inner vertical target by the additional suppliers and of the on-going manufacture of the two contracts for Stage I of the series production of the divertor cassette body.
- Remote Handling: the main activities will focus on the continuation of preliminary design activities and starting, in some areas, the final design activities, accompanied by complementary prototyping and qualification activities.
- Vacuum Pumping: The contract for Leak Detection systems will be signed. Manufacturing of the Torus and Cryostat Cryopumping System will be initiated. Megavolt ITER Injector & Concept Advancement (MITICA) contracts will focus on manufacturing and assembly. As for the Front-end Cryopump Distribution System, final design will be completed and all components will be in the manufacturing stage. Work for the Warm Regenerationlines will be completed.
- Tritium Plant and ITER Radiological & Environmental Monitoring Systems (REMS): First activities will start in support of the Hydrogen Isotope Separation system. As for Radiation and Environmental Monitoring Systems, the tendering process for 1st plasma activities will be on-going.
- Cryoplant: End of installation for Liquid Nitrogen Plant and Auxiliary Systems components will take place.

<sup>(1)</sup> <https://ec.europa.eu/transparency/regdoc/rep/1/2019/EN/COM-2019-147-F1-EN-MAIN-PART-1.PDF>

- RadioFrequency Heating & Current-Drive: The Electron Cyclotron (EC) system (Upper Launchers and ex-vessel waveguide systems) procurement activities will focus on the fabrication of the blanket shield module and material, in parallel to final design/prototype and testing activities related to the ex-vessel systems. For the EC Plant Control system, the main activity will be the delivery, installation and commissioning of the ECPC Stage 2 in ITER-IO.
- Electron Cyclotron Gyrotrons, Power Sources and Power Supplies (PS): the manufacturing and testing of the last units of the Main and Body High Voltage Power Supplies will continue, the first sets will be delivered to ITER Cadarache and the preparation of the EU Gyrotrons tendering procedure will be initiated.
- Neutral Beam (NB) Heating & Current Drive (non FP): As for the Neutral Beam (NB) Test Facility at RFX-Padua, for MITICA, the activities in the test bed will continue with commissioning and testing of vessel and power supplies. The contract for MITICA Cryoplant will be completed. The contracts for MITICA diagnostics, MITICA Beam Source, MITICA Beam line components will proceed. As for the NB at ITER-Cadarache, detailed design and manufacturing design consolidation for Neutral Beam power supplies systems of the ITER units will be developed.
- Diagnostics (partly FP): Several diagnostics systems will finalize either the preliminary design phase or the final design phase. Procurement activities will encompass manufacturing contracts- as for the electrical auxiliary components – and design contracts as for the core plasma Thomson scattering system.
- Test Blanket Systems (TBS – non-FP): The activities, performed in collaboration with EUROfusion, will be mainly focused on the Preliminary Design and Safety Analyses.
- Site, Buildings and Power supply: completion of the civil works in the Tokamak Complex and erection of the Tokamak Building steel structure in order to grant crane access from the Assembly Building to the Tokamak Pit to allow installation of the Cryostat Base by IO. Alongside this, there will be deliveries of building services equipment for the Tokamak Complex, deliveries related to electrical networks and load centres and the completion of the Cryoplant and Building Services auxiliary buildings.
- The cash contribution to IO for 2021 of about 250M€ will be committed.
- Broader Approach (BA): The activities in 2020 will focus on the delivery of the remaining EU contributions within the frame of BA Phase I, and the preparation for BA Phase II.

F4E plans to commit more than EUR 550 million for procurement contracts.

**In 2021**, the European in-kind contribution to the ITER project is expected to progress by ca 9 %. The main deliverables by F4E in relation to ITER will be the following:

- Magnets: three Toroidal Field Coils and one Poloidal Field Coil.
- Main Vacuum Vessel: the first Sector deliveries.
- Blanket System: F4E will award contracts for the procurement completing the need for the Beryllium and CuCrZr materials in relation to the series production. High heat flux testing will be carried out on First Wall panel full-scale prototypes to assess the performance of the selected manufacturing routes. F4E will award the contract for the first 30 degree sector pipe bundles of blanket cooling manifold.
- Divertor Systems: F4E will sign with IO the Procurement Arrangement (PA) for the Divertor rails project as well as the contract for Stage 2 of the Cassette Body Series Production. High heat flux testing will also be carried out on full-scale prototypes of the divertor inner vertical target.
- Remote Handling: Divertor Remote Handling systems will further develop the final design by already running task orders and new contracts, supported in some areas by laboratory tests. Cask & Plug RH systems will continue final design development of FP components and gradually moving from preliminary design to final design of non-FP cask systems with existing and new contracts. Neutral Beam Remote Handling systems FP components will continue final design development and prototyping of FP components. In-Vessel Viewing systems will focus on final design activities, validated by prototyping.
- Cryoplant (FP), Vacuum Pumping and Fuel Cycle: F4E will sign a contract for manufacturing and testing of the NB Front End Cryodistribution System as well as for the cryostat leak detection and localization. In the area of Fuel Cycle, F4E will sign a specific contract for the Waste Management Systems Preliminary Design.
- Antennas and Plasma Engineering: The main contract for Manufacturing, Assembling & Testing of the EC Upper Launcher Port Plug will be awarded.
- Neutral Beam Heating and EC Power Supplies and Sources: F4E will sign specific contracts for the Padua Research on ITER Megavolt Accelerator (PRIMA) assembly as well as for MITICA control system. F4E plans that the contract for NBI-1&2 Drift Duct will be signed. Sets of HV power supplies for the EC will be delivered during the year and installation and commissioning on ITER site completed for the first sets.
- Diagnostics: Manufacturing activities for several Diagnostic components and systems, most of them essential for first plasma will continue and some first plasma (FP) components of the Magnetics diagnostic and the Tokamak electrical services will be delivered in 2021. F4E will launch or sign additional contracts for the manufacturing of electrical feedthroughs, front-end components (waveguides, mirrors and horns) for the collective Thomson scattering system, supporting platforms for the in-

vessel bolometer cameras, and different components (in-port and ex-port) for the wide-angle viewing system, among others. F4E plans to sign a framework contract for the design of the core plasma Thomson scattering system.

- Test Blanket Systems (TBS): The preliminary design phase will continue for Test Blanket Module (TBM) Sets, Ancillary Systems, Safety and Accidental Analyse and TBM Set Fabrication Development and Manufacturing studies. The collaboration with EUROfusion will continue.
- Site, Buildings and Power Supplies: F4E will make the remaining areas of the Tokamak building not delivered in 2020 (Level L3, L4 and L5) ready for IO contractors to work (RFIOC) as well as levels B2, B1 and L1 of the Tritium building to enable IO contractors to continue assembly activities. The contracts for Architect Engineer Design as well as Support to the Owner for Buildings 21, 23, 24 (Hot Cell Complex), will be signed.

Cash contributions to the ITER organization for the year 2022: ca. EUR 300 million (forecast).

### Outlook for the 2021-2027 period

The proposal for the future ITER programme is included in the 2021-2027 MFF Heading 1 ‘Single Market, Innovation and Digital’ under the name ‘International Thermonuclear Experimental Reactor (ITER)’.

## III. Programme key facts and performance framework

### 1. Financial programming

Legal Basis	Period of application	Reference Amount (EUR million)
2013/791/Euratom: Council Decision of 13 December 2013 amending Decision 2007/198/Euratom establishing the European Joint Undertaking for ITER and the Development of Fusion Energy and conferring advantages upon it	2019 – 2020	

	Financial Programming (EUR million)							
	2014	2015	2016	2017	2018	2019	2020	Total Programme
Administrative support	8,9	9,7	6,6	7,3	6,4	6,5	6,4	51,8
Joint undertaking	720,9	382,2	323,3	315,2	369,9	402,6	358,4	2 872,5
<b>Total</b>	<b>729,8</b>	<b>391,9</b>	<b>329,9</b>	<b>322,5</b>	<b>376,4</b>	<b>409,1</b>	<b>364,8</b>	<b>2 924,3</b>

### 2. Implementation rates

	2019				2020			
	CA	Impl. Rate	PA	Impl. Rate	CA	Impl. Rate	PA	Impl. Rate
Voted appropriations	409,116	99,99 %	361,254	99,79 %	364,775	99,84 %	445,466	27,27 %
Authorised appropriations (*)	427,669	99,69 %	380,020	99,41 %	366,092	99,84 %	447,189	27,23 %

(\*) Authorised appropriations include voted appropriations, appropriations originating from assigned revenues (internal and external) as well as carried-over and reconstituted appropriations; the execution rate is calculated on 15 April 2020

### 3. Performance information

#### Programme performance

The ITER project/programmes is performing well. The deficiencies (immaturity of the design and the manufacturing challenges, management deficiencies and a lack of cooperation between the Domestic Agencies and the ITER Organization, schedule and cost estimate thus perceived to be unreliable) identified in the beginning of the 2014-2020 MFF period have been addressed, which improved the overall effectiveness of the project and thus allows moving to the reactor’s assembly phase. In practical terms, the ITER Parties launched in 2015 a major overhaul of the project, which included the appointment of a new senior management in the ITER Organization (IO) with an Action Plan under the leadership of a new Director-General. The action plan envisaged a complete re-organisation of the ITER Organization, a close cooperation with the Domestic Agencies the freezing of the design to allow the construction of buildings and other components and the establishment of a Reserve Fund as incentive for the ITER Organization to minimize changes as much as possible. A new reliable baseline was approved in November 2016, achieved a stabilization of the project and provides a realistic basis for its completion.

Changes in the management and organization of Fusion for Energy (F4E), that acts as EU’s Domestic Agency delivering the European contribution to IO, took place in parallel to those in IO and entailed the change of the Director (in early 2016) and the majority of the top management and its organization (in 2016 and 2017).

Against this background and due to the stringent supervision and proactive management by the Commission in line with the adopted supervision strategy (nominations of the prominent experts for the management and the decision-making bodies of the IO, rigorous follow-up of the implementation of the recommendations of the annual management assessment reports, etc) as of the end of November 2019 the work up to First Plasma (first important project milestone due at the end of 2025) is 65.9 % completed. This

progress corresponds to an average rate of 0.68 % per month over the last 21 months. To reach the First Plasma milestone, all components from the ITER members need to be available and delivered on time to the ITER Organization (IO), and assembled and installed in the Tokamak Complex.

**General objectives**

**General Objective 1:** development of fusion as a potentially limitless, safe, sustainable, environmentally responsible and economically competitive source of energy

**Indicator 1:** Reduction of greenhouse gas emissions at EU level compared to 1990

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
	Milestones foreseen							2020
18 %	20 %	20 %	20 %	20 %	20 %	21 %	21 %	21 %
	Actual results							
	23 %	22 %	22 %					

Source: <https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2015>. The study is updated every June; the latest update in June 2018 added the data for 2016.

**Specific objectives**

**Specific Objective 1:** to provide the Euratom contribution to ITER and to the ITER related activities

**Indicator 1:** Percentage of Euratom’s obligations discharged by the ITER Organization (IO) through the Joint Undertaking F4E

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
	Milestones foreseen							2020
6 %	13 %	19 %	27 %	36 %	46 %	57 %	63 %	63 %
	Actual results							
	13 %	17 %	24 %	31 %	35 %	41 %		

Source: Eurostat [https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse\\_gas\\_emission\\_statistics#Trends\\_in\\_greenhouse\\_gas\\_emissions](https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics#Trends_in_greenhouse_gas_emissions)  
The study is updated every June; the latest update in June 2018 added the data for 2016.

**4. Contribution to Europe 2020 Strategy and mainstreaming of policies**

Not applicable

**5. Programme contribution to the Sustainable Development Goals**

**SDG7 Ensure access to affordable, reliable, sustainable and modern energy for all**

The United Nations’ Sustainable Development Goals are targets to be achieved by 2030. Through these Goals, the EU has set ambitious targets to reduce greenhouse gas emissions, improve energy efficiency and increase the share of renewable energy. ITER and fusion development in general are on a longer timescale than this framework, but already contribute to several of these Goals at a later stage. For example, they will contribute to a clean energy transition while boosting jobs and growth in the area of energy and climate under Sustainable Development **Goal 7** (‘Ensure access to affordable, reliable, sustainable and modern energy for all’) and Sustainable Development **Goal 13** (‘Take urgent action to combat climate change and its impacts’).

ITER also falls under the category of Research and Innovation, both of which underpin the implementation of virtually all Sustainable Development Goals and in particular Sustainable Development **Goal 9** (‘Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation’)

Finally, ITER is also an example of a global partnership for Sustainable Development **Goal 17** (‘Strengthen Means of Implementation and revitalise the global partnership for sustainable development’).

**SDG 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation**

**SDG 13 Take urgent action to combat climate change and its impacts**

**SDG 17 Strengthen the means of implementation and revitalize the global partnership**

**6. Information about financial instrument(s) and trust fund(s) financed by the Programme**

Not applicable

**7. Programme related additional information**

Since its launch, the ITER project has faced many challenges in terms of schedule, risk of cost increase and management. Many of these are linked to the inherent nature of the project, which goes beyond the current state-of-the-art of fusion technology. Some are a consequence of the complex international nature of the project, with seven international Partners (and seven Domestic Agencies responsible for procurement). Radical decisions were taken in 2015, in particular at the extraordinary ITER Council of March 2015, to put the project back on track. One of the most important decisions was the appointment of a new Director-General of the ITER Organization and the approval of an action plan for the sound and effective management of ITER.