European Commission

BROADER APPROACH

CUTTING-EDGE **FUSION ENERGY** RESEARCH ACTIVITIES

Energy

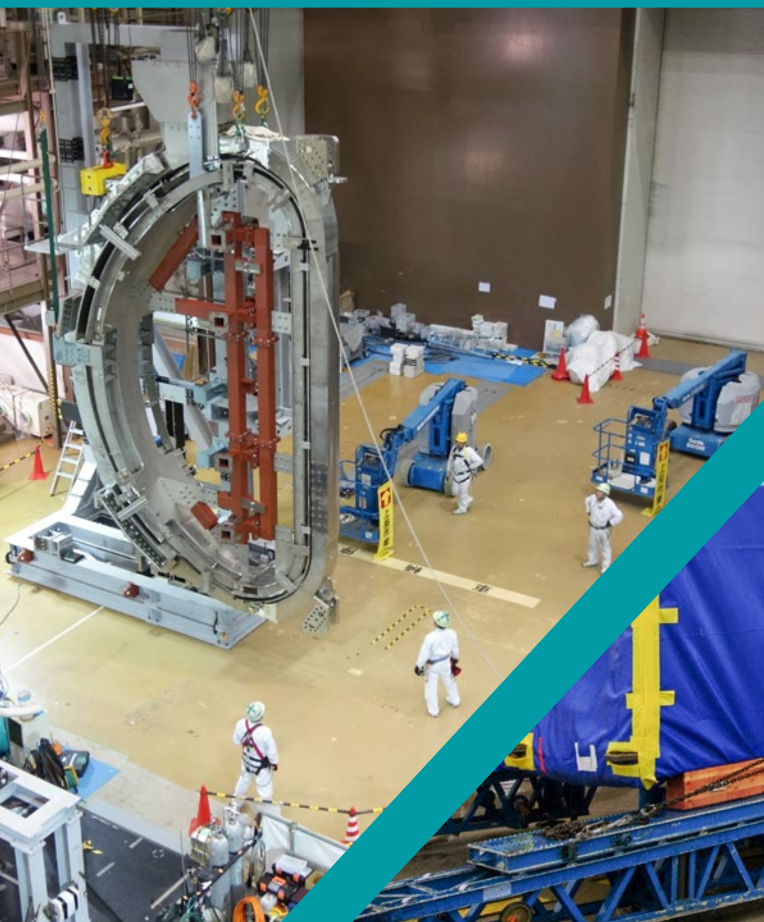
The Broader Approach – to ITER and beyond

Transitioning to a decarbonised, climate-friendly society is one of the key challenges of modern times. A major component is the creation of a diverse, secure and climate-friendly energy mix. Fusion research aims to help reach this goal by developing the promising technology of fusion energy as a clean, safe power source for the future. The key facility on the road to fusion power is the ITER Project, a major international collaboration under construction in Cadarache, France. Complementary to ITER, the European Atomic Energy Community (Euratom), represented by the European Commission, and the Government of Japan, represented by its Ministry of Education, Culture, Sports, Science and Techology (MEXT), are jointly investing in a project called the Broader Approach.

Established in 2007 through the signature of the Broader Approach Agreement by the two partners, the activities carried out under the Broader Approach aim to complement the ITER Project and to address the scientific and engineering challenges related to building a commercial fusion power plant. Thirteen years later, in 2020, Euratom and Japan are launching a new, second phase of activities, focused on exploiting the facilities that have already been built and on working closely with ITER as the latter enters its crucial assembly phase.

In practice, the work is carried out by the two "implementing agencies": Fusion for Energy (F4E) for Europe, and the National Institutes for Quantum and Radiological Science and Technology (QST) for Japan. Each organisation leads a "Home Team" and coordinates its respective contribution to the activities.

During the first phase of the activities, most of the European contribution came in the form of components and services provided to the Broader Approach from a few specific countries, called Voluntary Contributors. These countries – Belgium, France, Germany, Italy, Spain and, in the past, Switzerland, have provided about 80% of the European contribution to date through building facilities and components, and through providing technical and managerial staff to work on the projects. The remaining 20% of the European contribution was provided directly by Euratom through F4E. In the second phase of the project, EUROfusion, the European Consortium for Development of Fusion Energy, which supports and funds fusion research activities on behalf of Euratom, will also be closely involved in delivering the European contribution together with F4E and Euratom.



Thirteen Years of Collaboration

The Broader Approach activities consist of three projects, all located in Japan.

JT-60SA – the largest, most advanced tokamak in the world

The Satellite Tokamak Project, or JT-60SA, is a tokamak fusion device located in Naka, Ibaraki Prefecture. With its powerful heating systems able to inject targeted microwave energy and high-energy particles into the plasma, JT-60SA should reach plasma temperatures over 200 million °C, temperatures comparable to those that will be found in ITER. It also resembles ITER in its use of superconducting magnets, which will confine and control the plasma, and the liquid helium cooling system that will cool them to -269 °C. The major difference between the two machines is in their size; being about 12m across, JT-60SA is about half the size of ITER. Nevertheless, it will be the largest tokamak in the world before ITER begins operation.

The construction of this machine has been made easier by the fact that it is actually a major upgrade of a previous less advanced machine, JT-60U. In disassembling JT-60U and rebuilding a new machine in its place, Japanese and European engineers were able to use much of the existing site infrastructure, allowing them to reduce certain costs. Following the delivery of the base of the cryostat from Europe, assembly began in January 2013. The machine will be tested and commissioned throughout 2020, and the first time it will be switched on, its so-called First Plasma, will take place in the second half of 2020. This exciting milestone will mark the birth of a new leader in the field of fusion devices.

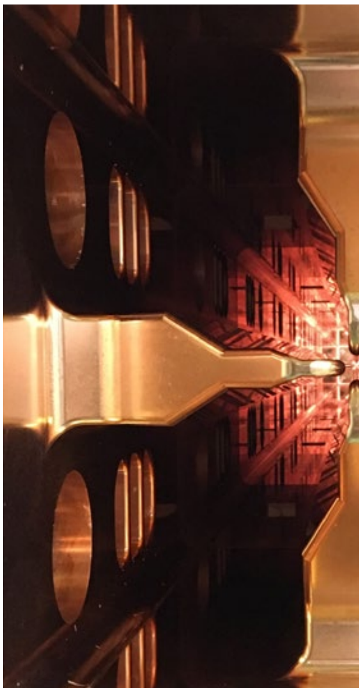
JT-60SA's operations will evolve over its lifespan according to the needs of the fusion community. In its first years, its primary function will be to support the assembly, commissioning and preliminary operation of ITER; even before it begins operation, scientists from the ITER Organization will collaborate with the JT-60SA Project Team to gain as much knowledge as possible about its assembly and commissioning. This knowledge and experience can then be brought back to ITER and used to help mitigate risks in this project. As the tokamak closest in design to ITER, JT-60SA will perform modelling to help scientists prepare as much as possible for the beginning of its operation. Once ITER is running, however, the focus of JT-60SA's research is likely to shift towards preparation for the following generation of fusion reactors focusing on the demonstration and optimisation of steady-state operation of advanced plasma configurations.

IFMIF/EVEDA – prototyping essential materials research and validation

Conditions inside the fusion devices of the future, and indeed inside the fusion devices of today, are demanding for the materials that face the plasma. This is partly due to the neutrons produced by the fusion reaction – very fast-moving neutral particles bombarding the inside of the device throughout operation. This so-called flux of neutrons on the walls of the chamber that holds the plasma allows the machine to extract energy from the fusion reaction, and can also produce tritium, one of the fuels needed to create fusion. However, this flux, together with the high temperatures and strong magnetic fields, creates a severe environment, and so the components of the machine that are closest to the plasma need to be extremely strong and resilient.

Understanding the effects of high neutron flux and minimising the mechanical degradation that follows is a key element in constructing efficient and viable fusion power plants in the future. This will be the task of the International Fusion Materials Irradiation Facility (IFMIF), which will test and qualify advanced materials for the plasma-facing components of fusion devices.

The design, prototyping and testing of the key components needed for such a facility is carried out as part of the Broader Approach under the name IFMIF/EVEDA. This work centres on the construction of the Linear IFMIF Prototype Accelerator (LIPAc), a machine that accelerates deuterium nuclei to very high speed, and creates a neutron flux similar to what is found in fusion devices. The IFMIF/EVEDA Project Team aims to finalise the assembly and work on the reliability of LIPAc with the goal of eventually using it to test materials. The work carried out at IFMIF/EVEDA will feed into the design and construction of new fusion materials irradiation facilities, which would aim to test materials under conditions similar to those in the commercial fusion power plants of the future. Preliminary studies are ongoing, notably in Europe regarding a facility in Spain called IFMIF-DONES, and in Japan a facility called A-FNS.

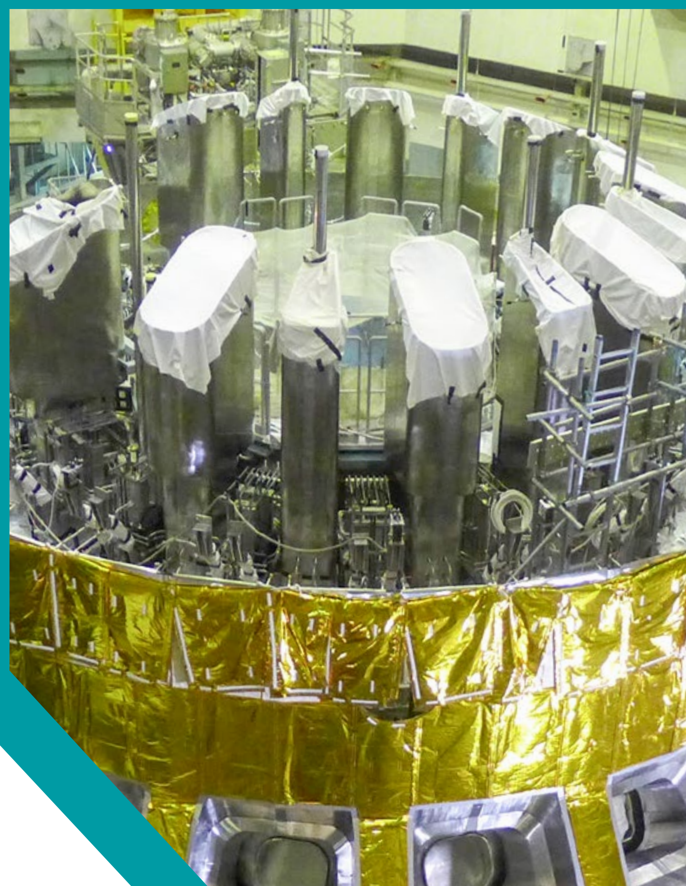


IFERC – looking to the future

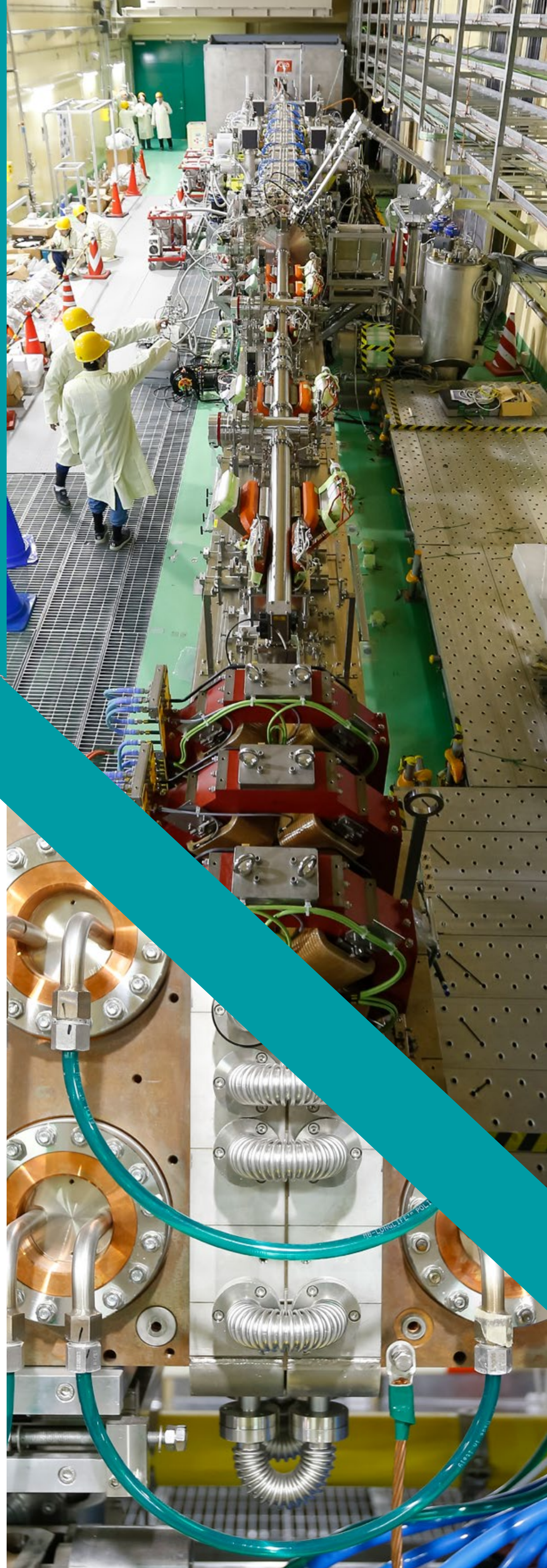
The International Fusion Energy Research Centre (IFERC), itself one of the three Broader Approach Activities, coordinates three main sub-activities.

The **Computational Simulation Centre (CSC)** focuses on the role of ultra-fast supercomputing in fusion research. It aims to provide state-of-the-art supercomputing facilities that can perform high-definition simulations of fusion plasmas, analyse experimental data from existing machines, model ITER's operation, and contribute to the design of the next-generation fusion device after ITER (the DEMO Demonstration Reactor). This target was successfully achieved through the installation of the "Helios" supercomputer, which operated continuously at full capacity at the CSC between 2012 and 2016, and was one of the most powerful supercomputers in the world. During its operation, work carried out in Helios contributed to over 600 peer-reviewed papers spanning the breadth of fusion and plasma physics. Helios was decommissioned in 2017, but a new joint supercomputer is planned to take its place in the second phase of the Broader Approach.

The IFERC project also hosts the **Remote Experimentation Centre (REC)**. The objective of the REC is to allow scientists to participate remotely in fusion experiments from its control room in Japan. The participation could extend to almost every aspect of the experimentation, including the preparation of the experiments, the visualisation of data and the plant status in real time, and detailed analysis of the results. In November 2018, scientists in the REC successfully ran an experiment in the WEST tokamak in southern France, over a distance of almost 10,000 km. Fusion research is a highly international field, and the remote participation technology that the REC is pioneering is essential to allow fusion scientists all over the world to accelerate the development of fusion power through sharing knowledge and experience. In the coming years, the REC will continue its development work, including running experiments in ITER when operational.



The **DEMO Design and R&D Coordination Centre** plays an important role in coordinating scientific and technological activities necessary for the DEMO fusion reactor, which will follow ITER and have the main objective of producing electricity from fusion. Pre-conceptual design activities for DEMO have already begun, as well as technology research and development on key issues of common interest. In addition, IFERC hosts a facility for handling radioisotopes (radioactive elements), where preliminary materials research for DEMO is being carried out. The centre's coordination work also includes regular joint Broader Approach workshops where this materials research is shared and discussed together with similar research carried out in Europe. The work carried out in this centre is building a strong base, not just of knowledge, but in an international community, to ensure that the world is ready for the challenge of building a commercial-scale fusion reactor.

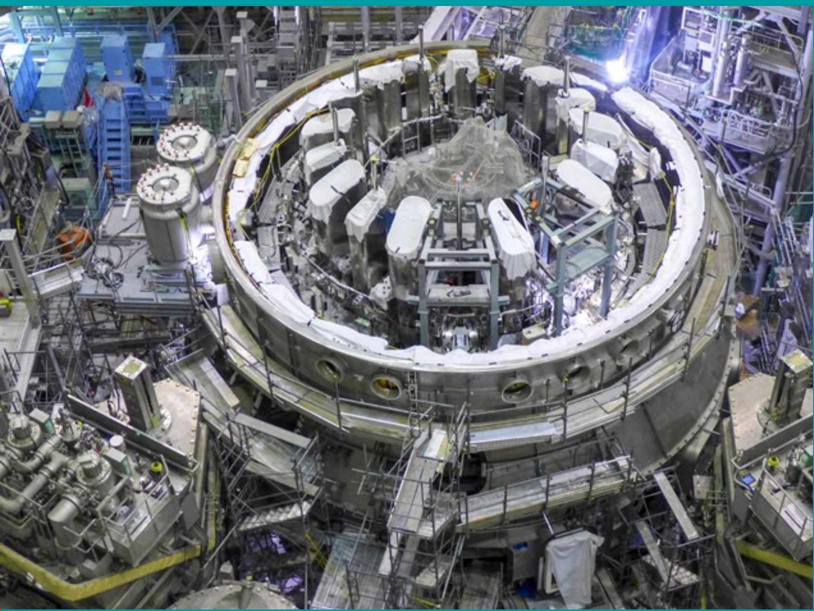


The Next Step

The Broader Approach represents a highly successful collaboration between two major players in the global landscape of fusion research. Europe and Japan have taken stock of the progress made so far and reaffirmed their commitment to continuing the activities.

From 2020, the Broader Approach will focus on operating and exploiting the facilities that have already been set up, for the benefit of both parties. As ITER is approaching its own First Plasma and the beginning of its operation, teams working on the Broader Approach will work ever more closely with ITER to ensure that it moves forward as smoothly as possible.

The other benefit of the Broader Approach Activities will be to consolidate knowledge and expertise among the global fusion community, with the objective of creating as solid a base as possible on which to build the commercial fusion reactors of the future. Only through sincere cooperation and sharing of research, as exemplified in this joint project, can fusion technology accelerate to meet the world's changing energy needs.



FOR FURTHER INFORMATION

Fusion for Energy (F4E)

www.f4e.europa.eu

QST

http://www.fusion.qst.go.jp/rokkasyo/en/about/about_ba.html

Project websites

www.ba-fusion.org

www.jt60sa.org

www.ifmif.org

www.iferc.org

Images Courtesy of National Institutes for Quantum and Radiological Science and Technology (Japan)

Printed by the Publications Office of the European Union in Luxembourg

Luxembourg: Publications Office of the European Union, 2020

Publications Office
of the European Union

Print	ISBN 978-92-76-16660-3	doi:10.2833/62030	MJ-03-20-115-EN-C
PDF	ISBN 978-92-76-16659-7	doi:10.2833/57707	MJ-03-20-115-EN-N