MEXT MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

Symposium 2019 on the ITER/BA Activities
Fusion Energy Forum of Japan

Research and Development Policy on Fusion Energy in Japan

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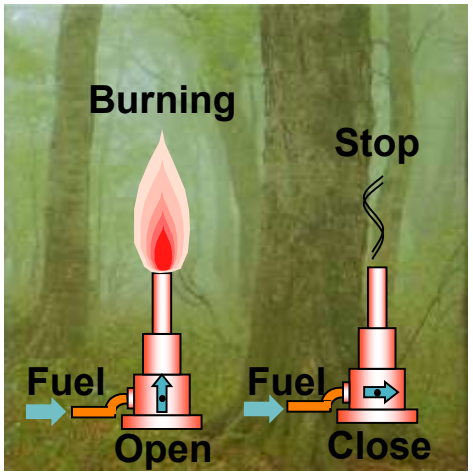
International Nuclear Cooperation and

Fusion Energy Affairs Division, MEXT

December 19, 2019
Fusion Energy Forum of JAPAN
Symposium for 2019 ITER/BA Activities
at ITO Hall (Tokyo Univ.)

Fusion as Future Energy

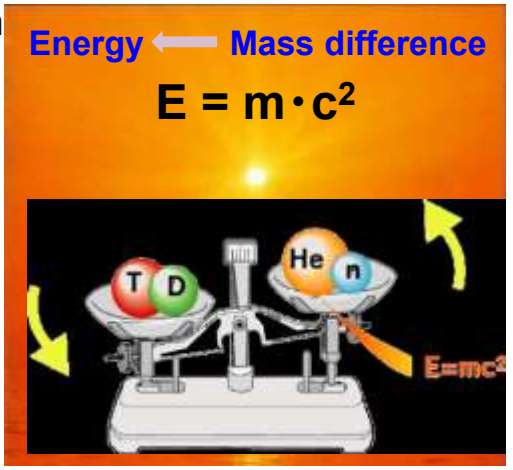
Safe & Eco-friendly



- ✓ Automatic shut-off of burning by stopping of fuel supply
- ✓ Free from high-level radioactive wastes

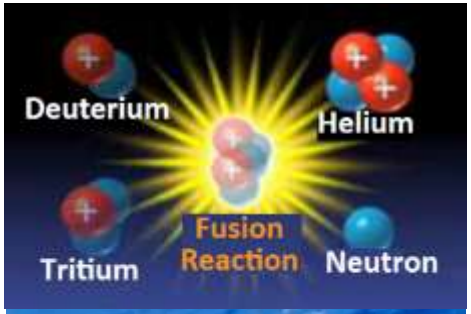
Highly efficient energy

Energy produced by 1 gram of fuel (Deuterium (D) and Tritium (T)) is equivalent to that by 8 tons of oil



7 AFFORDABLE AND CLEAN ENERGY

The fundamental solution for energy and environmental issues



Self-production of fuel Tritium by reaction between Lithium and Neutron

Abundant fuel

Inexhaustible fuel in sea water;
<Fuel/Sea water>
Deuterium 33 gram/ton
Lithium 0.2 gram/ton

A cluster of advanced technologies for future;
Superconductivity (MRI, Quantum computer, etc.), Robotics, etc.

Cutting edge technologies

(Copyright: National Institutes for Quantum and Radiological Science and Technology)

R&D Steps for Realization of Fusion Energy

- Through confirmation of scientific and technical feasibility in the ITER project and BA activities, we will make a decision to shift to a DEMO reactor.
- MEXT promotes fusion R&D with Check&Review the progress of technological development required for the DEMO reactor.

Scientific Feasibility

-To achieve break-even plasma condition

JT-60
(JAEA)

Scientific & Technological Feasibility

-To realize burning plasma and long-duration burning
-To establish physical and technological basis for DEMO

(Cadarache, France)

JT-60SA（Naka, Japan）

International Fusion Energy Research Center(IFERC)
(Rokkasho, Japan)

ITER Project ← BA Activities

Technological Demonstration & Economic Feasibility

-To demonstrate electric power generation
-To Improve economic efficiency

DEMO Reactor

Academic Research

LHD（NIFS）

FIREX-I
(Osaka Univ.)

Fusion Science in National Policy

5th Science and Technology Basic Plan （Cabinet Decision in January 2016）

◇Chapter 3 Addressing economic and social issues

・・・Furthermore, we will work on R&D aimed at establishing important energy technologies for the future, such as innovative nuclear fusion and nuclear fuel cycle technologies.

◇Chapter 4 Reinforcing the “fundamentals” for science, technology, and innovation

・・・ As a nation, we are making advances in such areas as planning the use and operation of facilities in Japan and overseas for big science projects such as nuclear fusion, particle acceleration, and space development and utilization, as well as constructing mechanisms to stimulate international joint research with a variety of overseas partners.

5th Strategic Energy Plan
（ Cabinet Decision in July 2018 ）

◇Chapter 2 Basic Policies and Measures towards 2030

・・・The ITER project, which uses the tokamak and is being implemented through international cooperation and the Broader Approach Activities aimed at realizing energy from nuclear fusion, there has been progress in on-site construction and the production of the equipment. GOJ will continue to steadily promote these activities from the long-term viewpoint. It will also promote parallel research on the helical and laser types as well as innovative concepts from the perspective of securing technological diversity.

The Long-term Strategy under the Paris Agreement （Cabinet decision, June 11, 2019）

◇Chapter 3: Cross-sectoral Measures to be Focused

・・・On nuclear fusion energy, in parallel with steady implementation of the ITER project, which uses the tokamak and the Broader Approach Activities, Japan will promote the research on helical and other types based on unique Japanese ideas, aims at establishing scientific and technological feasibility.

Policy on DEMO Development

October 2005

- **Future Fusion Research and Development Strategy**

December 2017

- **Japan's Policy to promote R&D for a fusion DEMO reactor**
- **Action Plan towards DEMO (revised ver.)**

July 2018

- **A Roadmap toward Fusion DEMO Reactor (first report)**

October 2019

- **The direction of the development and promotion of fusion research towards the 6th Science and Technology Basic Plan**

Policy on DEMO Development

New Policy on DEMO Development has just been compiled in Dec. 2017 as the revision of the policy set by Atomic Energy Commission in 2005. Summary of the New Policy is as follows.

Development Strategy

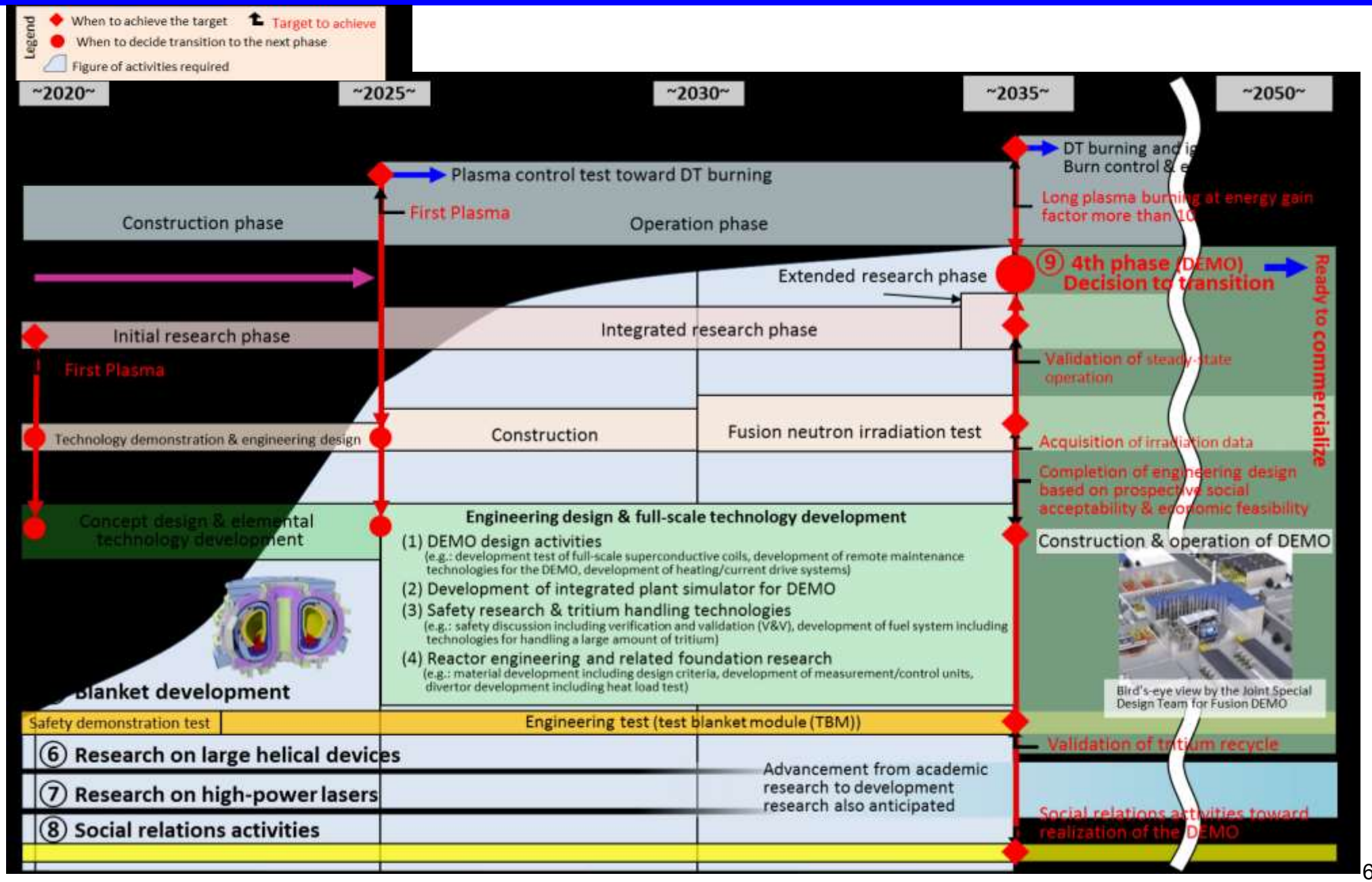
- ✓ Common target for entire community is to achieve technological solution for DEMO with tokamak.
- ✓ Promote balanced research on helical and laser fusion as alternative or complimentary option in parallel.

Approach for Transitioning to the DEMO Phase

- ✓ The decision to transition to the DEMO phase will be taken in the 2030s when fusion operation (DT) of ITER is expected.
- ✓ The economic feasibility of a commercial reactor is foreseeable when transitioning to the DEMO phase.
- ✓ The intermediate check and review(C&R) will be reexamined and implemented in two parts.

1 C&R: When JT-60SA is expected to begin operations in around 2020
2 C&R: Within a few years of 2025 when ITER's FP is scheduled

A Roadmap toward Fusion DEMO Rector

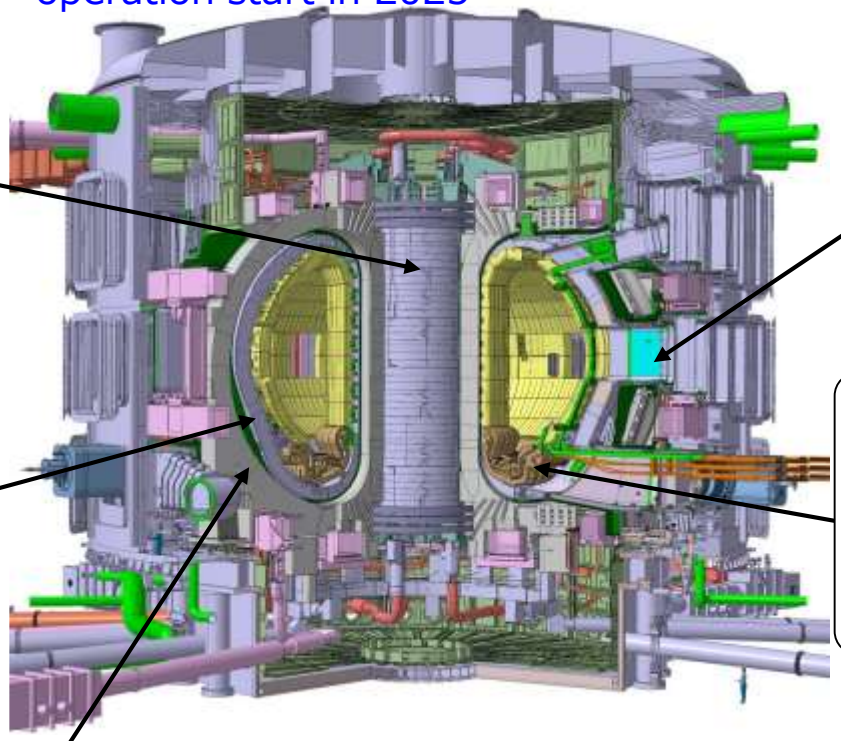


ITER Components Manufactured in Japan

FP →Components needed for the operation start in 2025

Center Solenoid (CS) Superconducting Coil (JA,US) FP

Vacuum Vessel (EU,KO,IN,RF) FP



Remote Handling Equipment (JA, EU)

Divertor (JA,EU,RF)

※Each member manufactures components and delvers to ITER site

Installation and Assembly (ITER Organization)

Heating Equipment
- Ion Cyclotron (ICRH) (EU,US,IN)
- Radio Frequency (ECRH) (JA,EU,US,IN,RF) FP
- Neutral Beam Injection(NBI) (JA,EU,IN)

Poloidal Field (PF) Coil (EU,RF,CN) FP

Cryogenic System (EU,US,IN) FP

Vacuum Pumping System (EU, US,CN) FP

Toroidal Field (TF) Superconducting Coil (JA,EU,US,RF,CN,KO) FP

Building (EU) FP

Blanket System (EU,RF,CN,KO)

Tritium Plant (JA,EU,US,KO)

Diagnostics (ALL)

Progress and Future Schedule of ITER

Oct. 2019 → **Spring 2020** → **Dec. 2025**

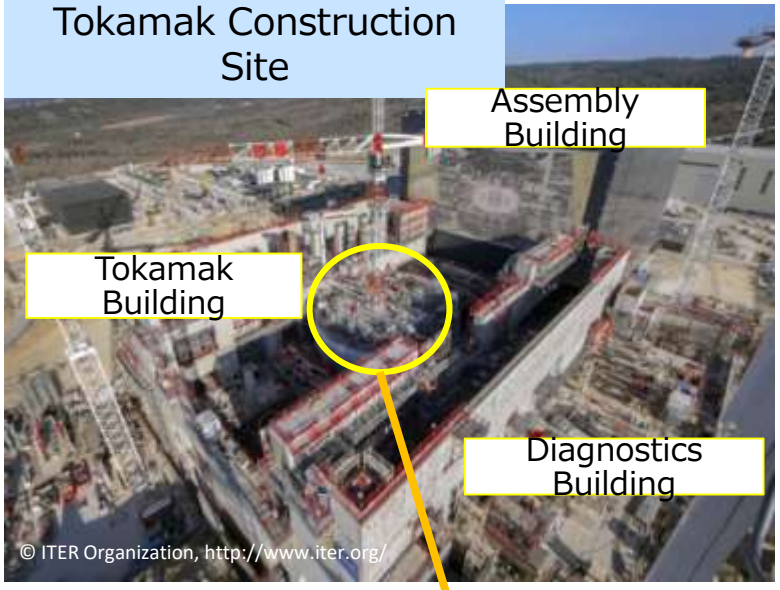
Start of operation (first plasma)

Manufacturing of components in each Member State
Building construction at the site

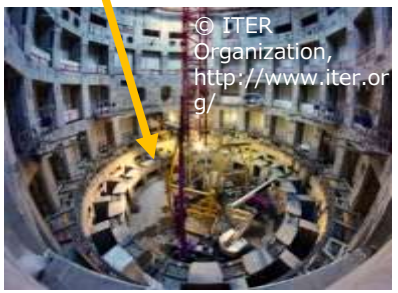
More than 65% Complete to the start of operation (first plasma)

Delivery of components procured in each member state to the site, ITER assembly and installation are fully in progress.

Tokamak Construction Site

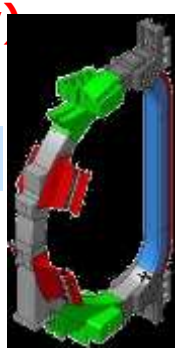


Tokamak Pit

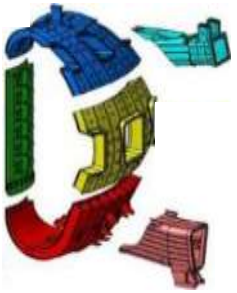


Delivery of Japan's first TF coil and Korea's first vacuum vessel to the ITER site **(Start of sector assembly)**

TF Coil



Vacuum Vessel



Operations of cranes connecting the assembly building and Tokamak building commenced **(Tokamak Assembly Begins)**

Crane

© ITER Organization, http://www.iter.org/

Progress of ITER Construction

➠ Steady progress of construction towards the first plasma in 2025

Assembly Hall (Oct.

(Oct. 2016)

Tokamak Building (Dec.

(Oct. 2019)

Progress in Japan

TF Coil:
Resin impregnation into the coil case (1st coil) has completed. (Sep. 2019)

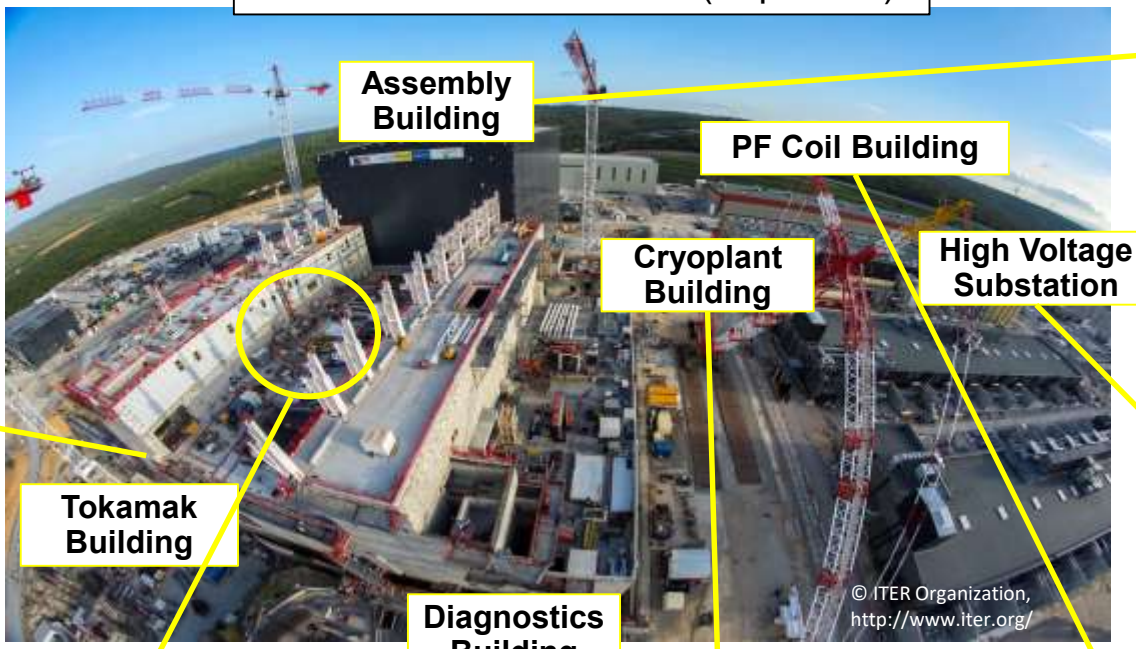
Neutral Beam Injector:
High voltage test of 1MV power supply system of NBTF (Italy) has been completed (Nov. 2019)

Radio Frequency Heating:
Four of eight gyrotrons have been fabricated (Aug. 2019)

Progress of ITER Construction #2

Installation of Drain Tank

Tokamak Installation Site (Sep. 2019)

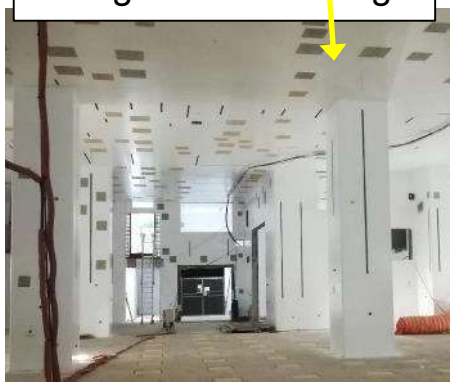


Assembly Hall

High Voltage Substation

Tokamak Pit

Diagnostics Building



Cryoplant Building

PF Coil Winding

Progress in BA Activities

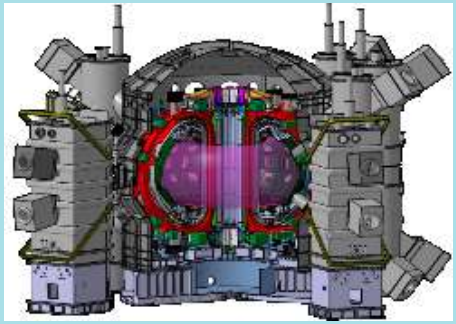
- To support the early realization of fusion energy, JA & EU are jointly implementing 3 projects.
- Phase I(June 2007 – March 2020) : Completed the development of major research environment necessary for the BA activities.
- Phase II(April 2020–) : Produce research results which contribute and supplement to the ITER project by using the research facilities developed in Phase I as well as by improving the performance of the equipment toward the goal.

Naka Site

Satellite Tokamak programme(JT-60SA)

Support for the ITER project

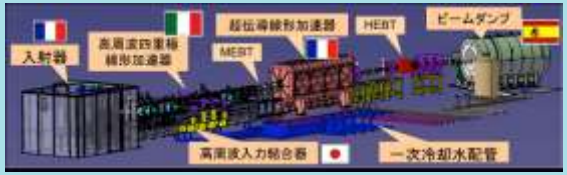
Challenging R&D For DEMO



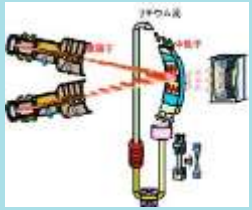
Rokkasho Site

IFMIF/EVEDA Project

Engineering Validation of Elemental Technologies



Engineering Design of IFMIF



IFERC Project

DEMO Design and R&D Coordination Center

ITER Remote Experimentation Center(REC)

Fusion Computer Simulation Center(CSC)

Major achievements of BA Phase Ⅰ
Key objectives of BA Phase Ⅱ

	JT-60SA	IFMIF/EVEDA	IFERC
Ⅰ	■ Construction of the world's leading superconducting TOKAMAK "JT-60SA" will be completed.	■ Linear IFMIF Prototype Accelerator (LIPAc), which is under construction for the part of the development of IFMIF, successfully achieved the acceleration of deuterium beam at 5MeV, 125 mA (previous record; 2 MeV, 45 mA).	■ The International Fusion Energy Research Centre (IFERC) was established as the Fusion Energy R&D site, and produces steady progress. ✓ Succeeded in the remote experiment participation from REC (Rokkasho) to WEST (CEA in France). ✓ Completed the pre-conceptual design for DEMO.
Ⅱ	• Contribute to the commissioning for ITER first plasma (FP) by achieving the FP of JT-60SA. • Contribute to the development of H mode operation scenario for ITER by developing the heating devices.	• Complete the construction of LIPAc and improve its performance for the continuous working up to several hundreds of seconds. • R&D for the purification system for the target facility. • Design activities necessary for the neutron source facility.	• DEMO Design and R&D activities • Development of simulation codes for ITER experiment and DEMO design. • Integration of technical elements for the ITER Remote Experiment.

Key Points of the BA Phase II Pre-Evaluation

■ prior-evaluation

The Science and Technology Committee on Fusion Energy of MEXT conducted interviews with the implementation agency, QST, on Project Plans, etc. from the standpoint of necessity, effectiveness, and efficiency, and conducted a third-party evaluation.

Dicided by the Subdivision on R&D Planning and Evaluation, council for Science & Technology, MEXT

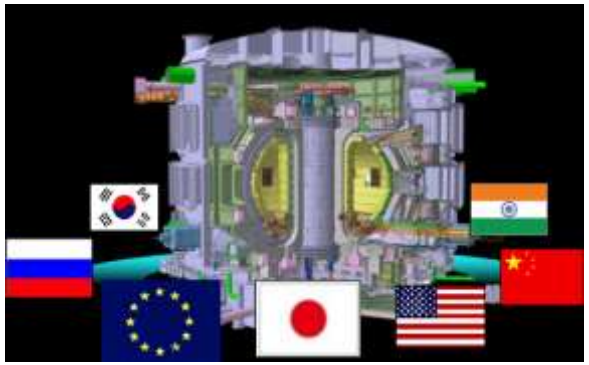
【Results of the prior-evaluation】

- ✓ BA activities constitute a unique project in which research facilities have been established in Japan under the budgets of JA&EU, and JA&EU have been cooperating to promote research and development, and the benefits for Japan as the host are huge.
- ✓ In Phase I, the main research facilities are scheduled to be completed, these research facilities will be utilized and advanced through cooperation between JA&EU to achieve research results, and their activities should be promoted by the government.
- ✓ While bearing in mind the trends affecting fusion science and technology in Japan and other countries, ensure constant coordination with Europe and consider collaboration with other countries and industries in order to seek out the implementation of effective and efficient research.
- ✓ Fusion Science in National Policy such as the 5th Science and Technology Basic Plan and the 5th Strategic Energy Plan refers to the importance of securing energy and strengthening the knowledge base, and can be evaluated as contributing to the steps towards DEMO, including human resource development.

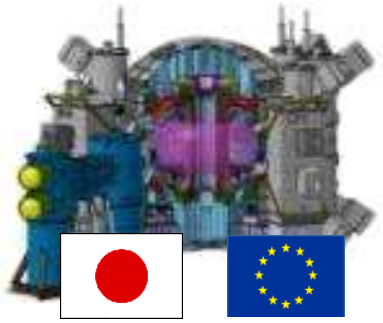
Cooperation between ITER and JT-60SA

- At the BASC-24 in Apr. 2019, JA and EU confirmed to proceed with the scientific cooperation between ITER project and BA activities. The cooperation arrangement was concluded among ITER organization and BA Implementing Agencies at the margin of ITER Council in Nov. 2019.

ITER



JT-60SA



Recent policy reviews

The direction of the development and promotion of fusion research towards the 6th Science and Technology Basic Plan

The Science and Technology Committee on Fusion Energy of MEXT
Excerpt from the "Thinking of the Science and Technology Committee on Fusion Energy towards the 6th Science and Technology Basic Plan".

<Matters to be particularly addressed in the field of fusion energy related to R&D systems>

- Regarding the ITER Project and BA activities, promote projects that take into account the perspective of demonstrating the value of large-scale international collaborative research conducted through cooperation between countries and organizations, engaging in effective and efficient research and development and human resource development, inviting overseas human resources and investment and reinforcing the "strengths" while compensating for "weaknesses"
- Enhance research and development productivity by integrating emerging fields in line with the times, such as information science and technology, and contribute to the acceptance of human resources including industries that utilize information science and technology
- Proactive use of external funds, including proactive use of R&D investment through ESG investments and venture capital investments to realize the SDGs
- Promote investment in fusion energy-related technologies from industries by proactively promoting spin-offs to other fields, and develop and diversify the supply chains to maintain human resources and technologies
- Promote understanding of spending taxes on long-term big projects

All-Japan framework for Fusion DEMO

Science and Technology Committee on Fusion Energy

Discuss and decide the policy on fusion R&D, including Road-map

Review

Draw up/Formulate an Action Plan

Task Force on DEMO comprehensive strategy

-grasp the situation of elemental technologies as a whole
-Optimize the overall strategy

Show the policy

Sharing information etc.

Propose/approve theme of joint research

DEMO Concept Design

"Joint Special Design Team for Fusion DEMO" of Rokkasho Fusion Research Center

-Plan and implement R&D to address issues
- Organize Work Shops

QST,NIFS,Univ.,Industry

Joint research toward DEMO

WG for Joint Research

TF, QST, NIFS, Univ., Joint Special Design Team

-Close Relations with Universities to Strengthen the DEMO R&D Framework
- Carry out Joint Research by universities
- Human development through research

Recent progress of the Joint Special Design Team for Fusion DEMO

Clarification of basic concept of DEMO for fusion energy generation

- Aiming to realize DEMO in the mid-21st century towards a decarbonized society -

QST press release on 27th November 2019

＜Main Points＞

- **Basic concept of the Japanese fusion DEMO, which is expected to be realized in the mid-21st century, has been clarified based on technologies for ITER together with incorporation of technologies and operation experience of industrial power plant.**
- **Overall picture of the fusion power plant has been shown by the above DEMO concept which is well beyond the former concepts focusing on reactor core design.**

Overview of the fusion DEMO plant

New Framework Of Collaborative Research For Universities

FY2020 New Subjects for Applications

NIFS collaborative research

Mid-term subjects in Action Plan. They are conducted autonomously and independently with contributions to human develop

There is a category for young researcher

Designated subjects 3 years・Max. 15 MY

Category in Action Plan	Subject (Number of adoption)
3. Divertor	Development of soundness evaluation technology for divertor devices (1)
7. Fueling system	Development of manufacture/test technology for DT pellet for DEMO (1)

Proposal-based subjects One year・Max. 1 MYen

In order to proceed Action Plan, new approach is expected with collaboration with innovative and transdisciplinary research field.

QST collaborative research

R&D subjects in order to conduct Action Plan directly

Designated subjects 3 years typically (Max. 5 years) Max. 1 MYen/year

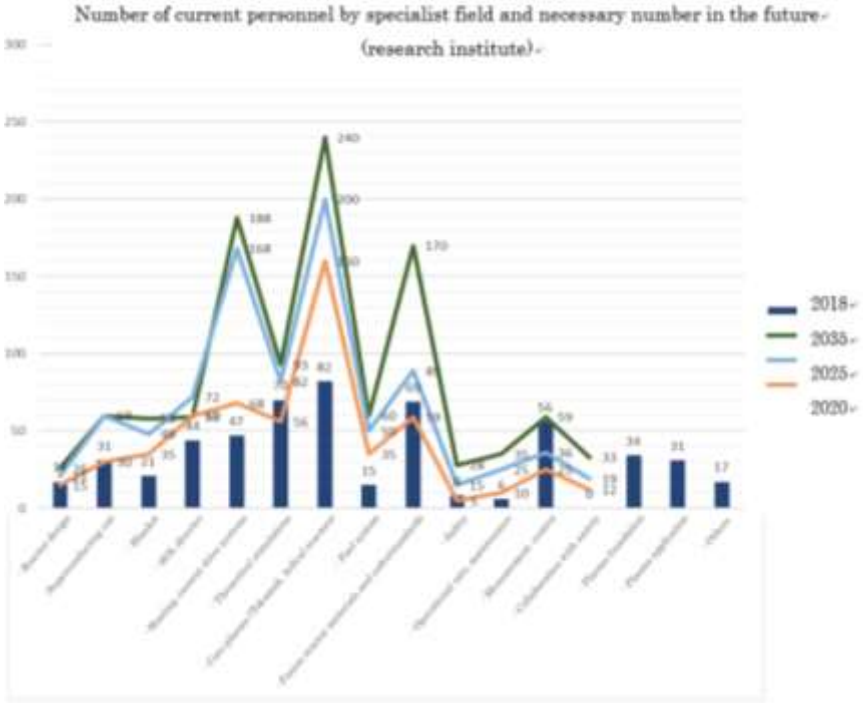
Category in Action Plan	No. of adoption	Category in Action Plan	No. of adoption
0. Reactor design	1	6. Core plasma	1
2. Blanket	2	7. Fuel system	1
3. Divertor	2	8. Fusion materials and standards	8
4. Heating & current drive system	1	10. Maintenance	1
5. Theory/ Simulation	3	11. Diagnostics/ control	2

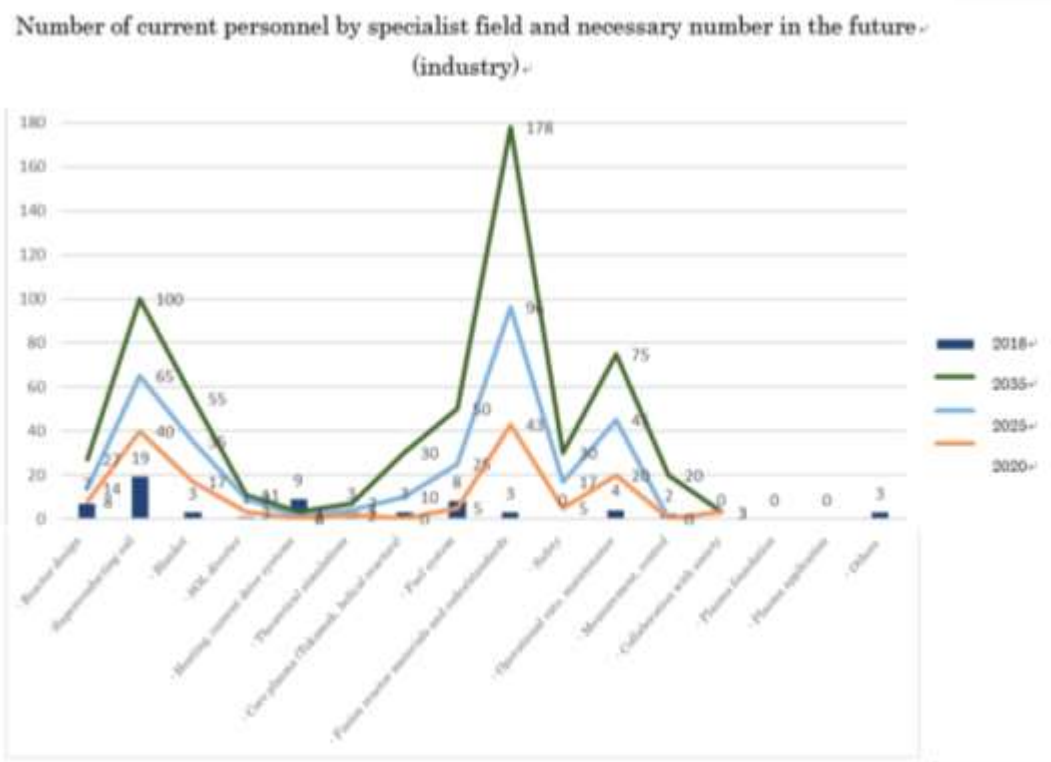
Application started at the beginning of December. Now open for application.

★Detailed information (research period, budget request, qualification, etc.) is shown in each HP.

Current Situation Surrounding Fostering of Human Resources

- Large disparity between number of personnel needed in the future and current number of personnel currently engaged in mainly fusion development.





Training and securing of personnel for the promotion of fusion energy developments

Consistent, long-term R&D will be needed to achieve fusion energy, necessitating the training and finding of personnel who will be able to stay working on such a project for the long haul. We propose sorting out the challenges and taking specific, urgent, and long-term actions.

Graduate school education

We need to promote academic research, maintain and bolster an environment for basic research in order to increase the number of doctoral candidates.

- Building an educational program to teach a broad and varied range of specialization; and bringing together industry and academia in order to gain experience with manufacturing and system integration

Personnel mobility

We need to partner domestic R&D with ITER project and BA activities; and to develop such partnerships as a system for knowledge circulation.

- Creating broad personnel mobility among industry and academia, including the ITER Organization and establishing appealing career paths

Outreach

We need to promote mutual understanding on and inspire interest in fusion R&D among all ages, including children.

- Social partnership work, including outreach, incorporating the need to recruit work-ready personnel and to secure future personnel, and promoting public acceptance

Japanese Staff in ITER Organization

○Japanese Staff in ITER Organization; 31 (3.4%) (the end of Aug 2019)

EU	CN	IN	JA	KO	RF	US	total
621	84	30	31	48	44	49	906
68.5%	9.3%	3.3%	3.4%	5.3%	4.9%	5.4%	100%

○For increasing the number of Japanese staff, QST established the section in April 2017. The section has worked with staff recruitment company and enforced measures.

ITER Project Associates（IPA）

1. Over View

IPA is the framework that workers engage in tasks about ITER as a seconded employee of QST.

The chance to experience state-of-the-art technology and have a relationship with a variety of engineers and market. In addition, the chance to experience international negotiation and management in the multicultural environment.

- Skills：Plant engineering, HR, PR, Procurement, Legal, IP
- Period：Less than 4 years
- Support from IO：Installation allowance,
  Access to the local international school in Manosque (EIPACA)
- Support from QST：salary, support to application and stay

2. Application method

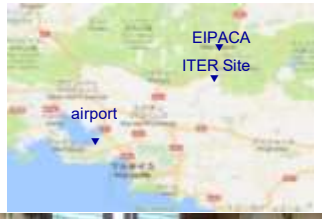
Contact to ITER Japan(QST) with resume

※(ITER Japan) E-mail：jada-recruiting@iter.jp TEL：029-270-7739

3. Ecole Internationale de PACA (EIPACA)

Over view：EIPACA is the international school FR established based on ITER agreement for children from ITER Members.

- FR public school (fees are free)
- Nursery, Elementary, Junior high, High
- 1 Sep～31 Aug
- French + Japanese



Students in Japanese section（in Sep 2018）

	Nursery（3～5）	Elementary（6～10）	Junior high（11～14）	High（15～18）	Total
students	4	8	6	0	18

Outreach Activities

set up an outreach headquarters

■Objective

It is necessary to integrate outreach activities, which have conventionally been conducted individually by universities and research institutes, and establish an outreach headquarters. The headquarter conducts outreach activities related to the entire fusion research and development and drafts an activity promotion plan.

■Members

- Science and Technology Committee on Fusion Energy
- Task Force on DEMO comprehensive strategy
- MEXT
- QST
- NIFS
- University etc.

Activities

■NEW Fusion Energy Website

scan the QR code

■ITER internship for university students

■ITER site tour for high school students