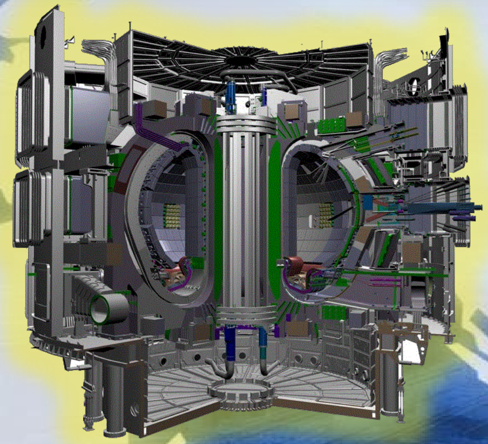
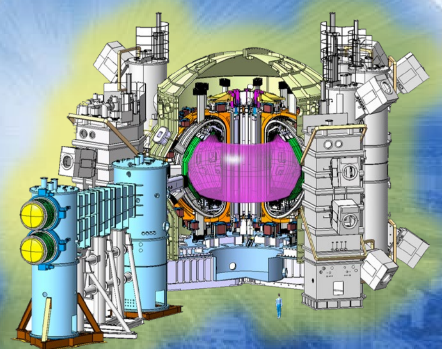
30th IAEA Fusion Energy Conference
18th October 2025

Fusion Research and Development Strategy for JA DEMO investigated in QST



ITER Project



BA Activities

IFMIF-DONES

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M. Hanada and S. Higashijima

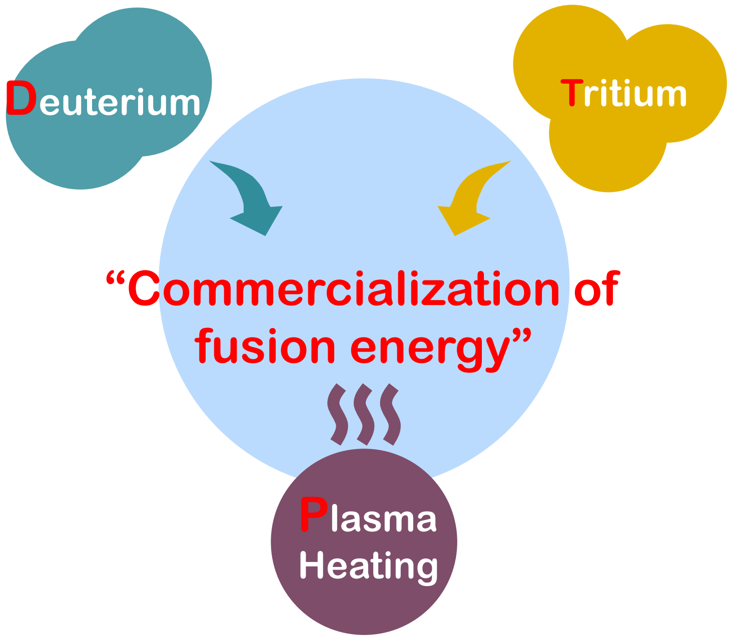
National Institutes for Quantum Science and Technology (QST)

Fusion Energy Innovation Strategy

The "Fusion Energy Innovation Strategy" was formulated in the Cabinet Office as Japan's first national strategy for fusion energy in April 2023. This strategy was revised in June 2025 aiming to demonstrate electricity generation in the 2030s and to establish the fusion industry ecosystem.

Developing the Fusion industry

- Collaboration with J-Fusion.
- Ensuring safety that is scientifically appropriate and internationally coordinated.
- Establishing a Task Force toward promotion of social implementation.
  Definition of electricity generation demonstration, TRL, implementing entity and way of proceeding site selection.



Developing Fusion Technology

- Acceleration of R&D to establish technical basis toward DEMO.
- Strengthening R&D capabilities in both the public and private sectors including start-up companies.
- Acquisition of core technologies through ITER project and BA activities.

Framework for Promoting Fusion Energy Innovation Strategy

- Advancing the strategy with the Cabinet Office as the "control tower" together with relevant ministries and agencies.
- Establishing the fusion technology innovation hubs in QST, NIFS and ILE etc.
- Establishing a programme for systematic human resource development through inter-university and international collaborations. Defining development goals.
- Environmental development for fostering public understanding through risk communication.

Three stages for realization of Fusion Energy

Physics/ Engineering Basis for ITER

Test device

JT-60U

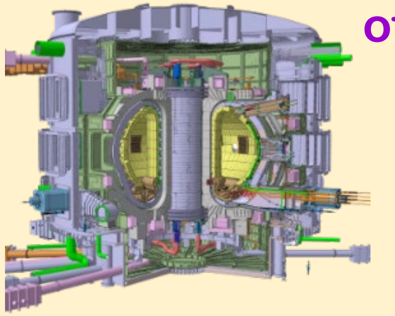
Corresponding Fusion Power of ~10 MW

Fusion Energy Production

Experimental reactor

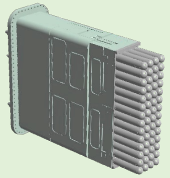
ITER

【France】



Fusion Power of 500 MW

TBM



Electricity Generation

DEMO reactor

JA DEMO

Electric Power of >100 MW

Support ITER

Establish Engineering Basis for DEMO

Broader Approach (BA) activities

【Ibaraki Naka】

Satellite Tokamak (JT-60SA)

【Aomori Rokkasho】

IFERC

DEMO Design/R&D
CSC
ITER REC

IFMIF/EVEDA

Development of prototype accelerator

Fusion neutron source and Full-scale R&D facilities

Domestic Activities

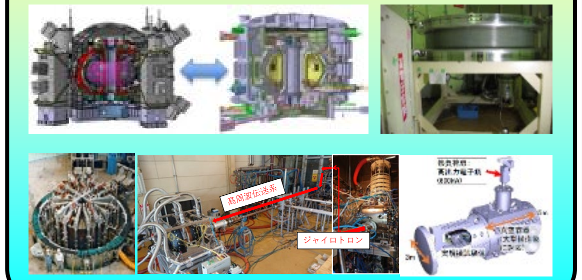
Strengthen of collaboration with industries

- **Fusion technology innovation hub**
  - Fostering fusion industries by open innovation
  - Fostering young leaders

Open platform at Rokkasho

Technical coordinator
joint research, use of facilities, intellectual property strategy

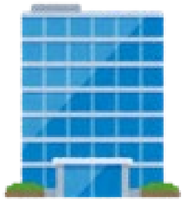
Open platform at Naka



- Provision of technologies and feedback

Collaboration / Cooperation

- Gathering wisdom
- Human resource development
- Promoting brain circulation

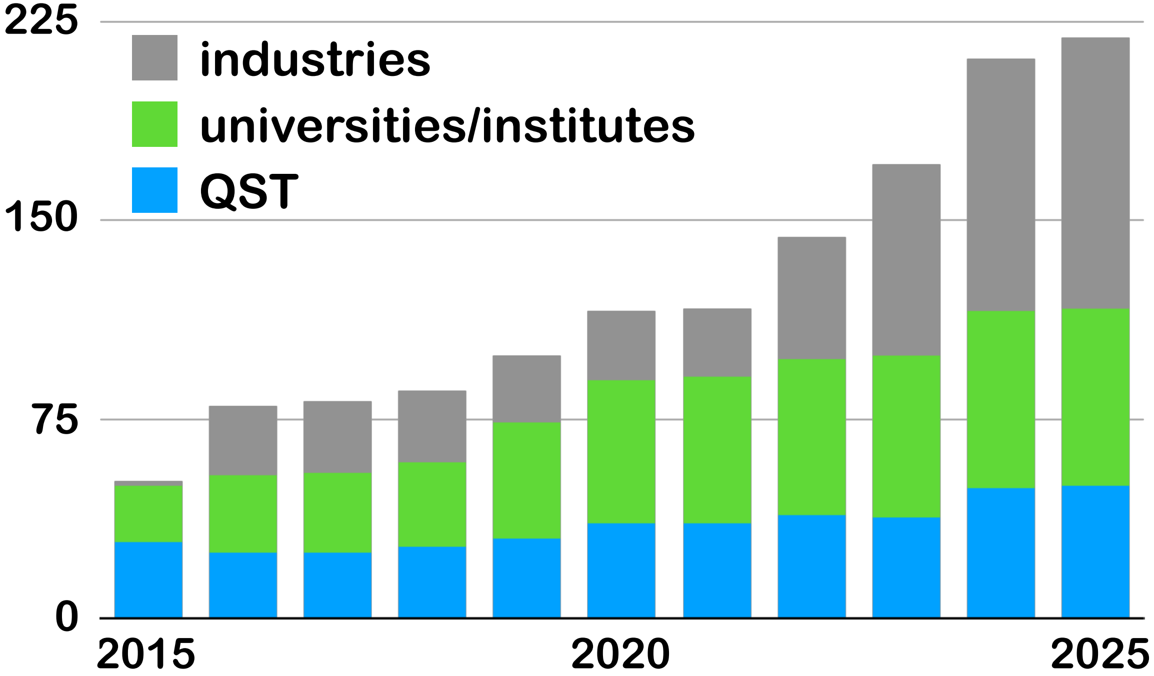


Industries
J-Fusion

Institutes

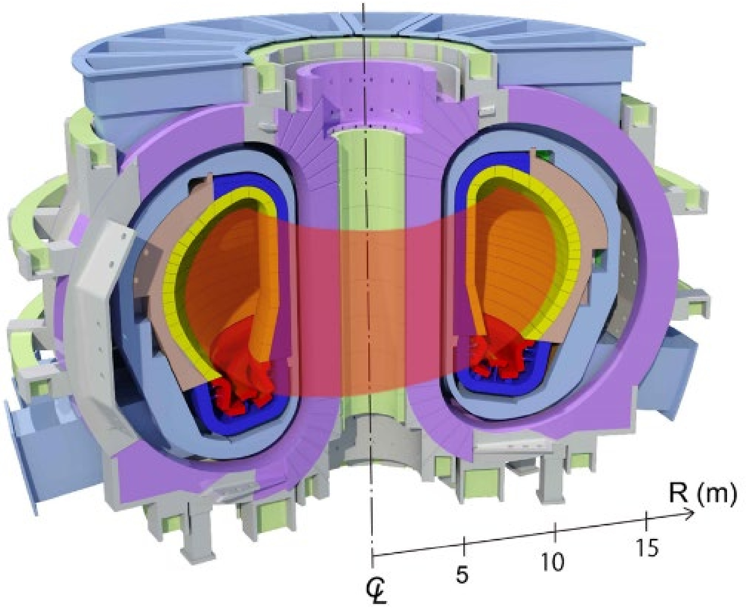
Universities

- **Joint Special Design Team for Fusion DEMO**
  - The number of members from industry recently increased.



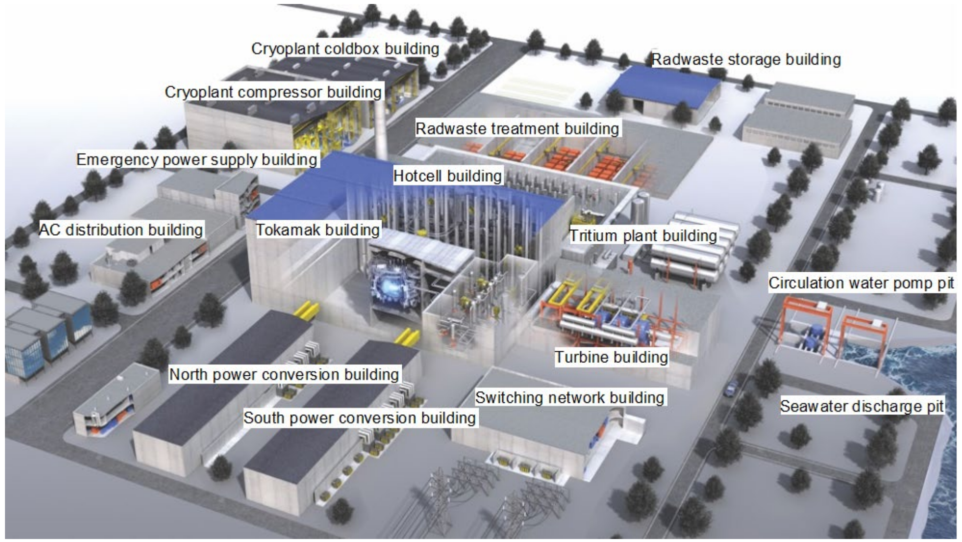
Original JA DEMO Design

- A Conceptual Design of JA DEMO has been developed based on the ITER technologies and the industry experiences.



R_p	8.5m	n_e/n_{GW}	1.2
a_p	2.42m	HH_{98y2}	1.3
B_{T0}	6T	Cooling	PWR condition
I_p	12.3MA	Availability	~70%
P_{aux}	<100MW	Operation	Steady-State
β_N	3.4	TBR	1.05

JA DEMO objectives
- electric power of several 100 MW
- availability sufficient for commercialization
- self-sufficiency of fuel



Fusion Output	1,500 MW
Effective Heat Output	1,870 MW
Gross Electric Power	640 MW
Electric Power used in site	390 MW
Net Electric Power	250 MW

Acceleration of JA DEMO Program

- QST concluded that the manufacturing of original JA DEMO TFC needs much time and cost based on the discussing with industries considering the experience of the ITER TFC manufacturing.

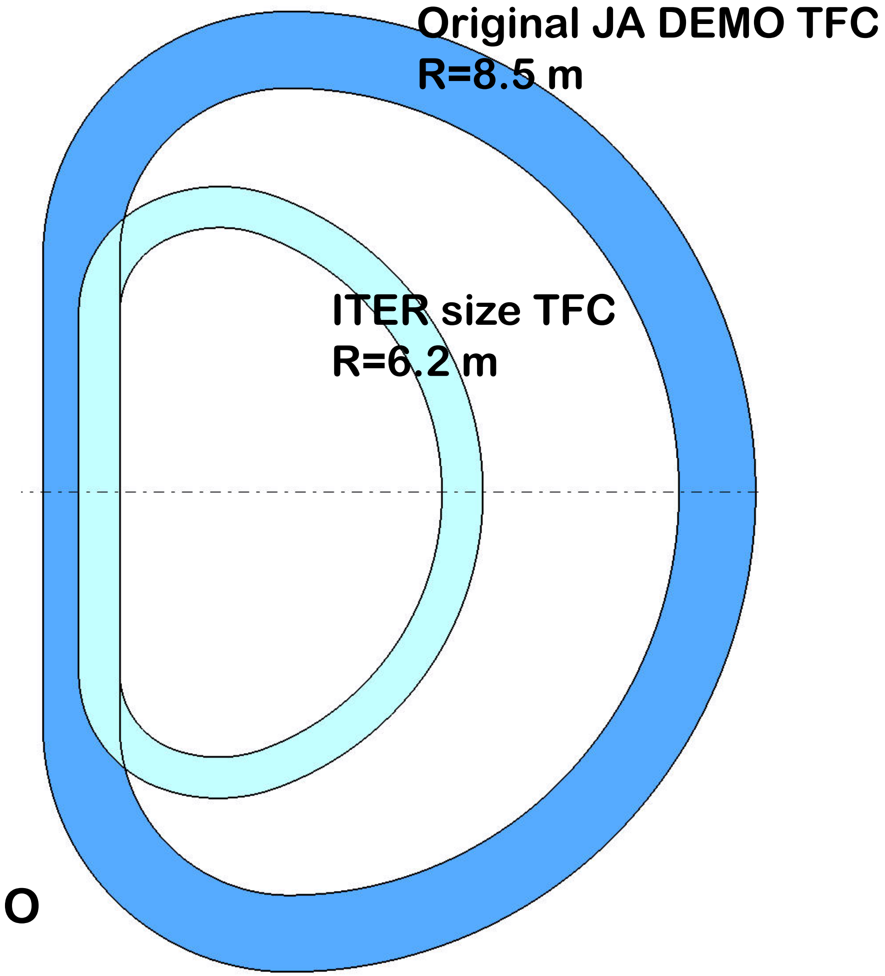
- QST started to investigate acceleration scenario of JA DEMO having a scientific and technical significance for leading to social implementation.
  - Burning plasma with significant self-regulation (self heating dominated)
  - Demonstration of net electric power

➡ $Q \gtrsim 10$

- Experience of ITER construction
- Plasma operation scenario well elaborated for ITER

➡ **ITER size JA DEMO**

for minimizing the path to the construction of JA DEMO

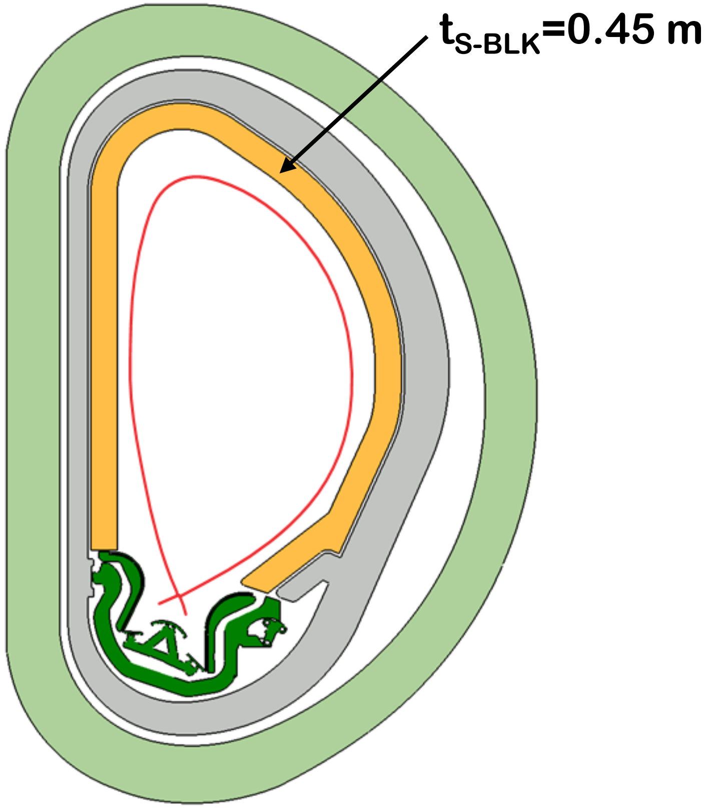


Phased approach strategy of JA DEMO

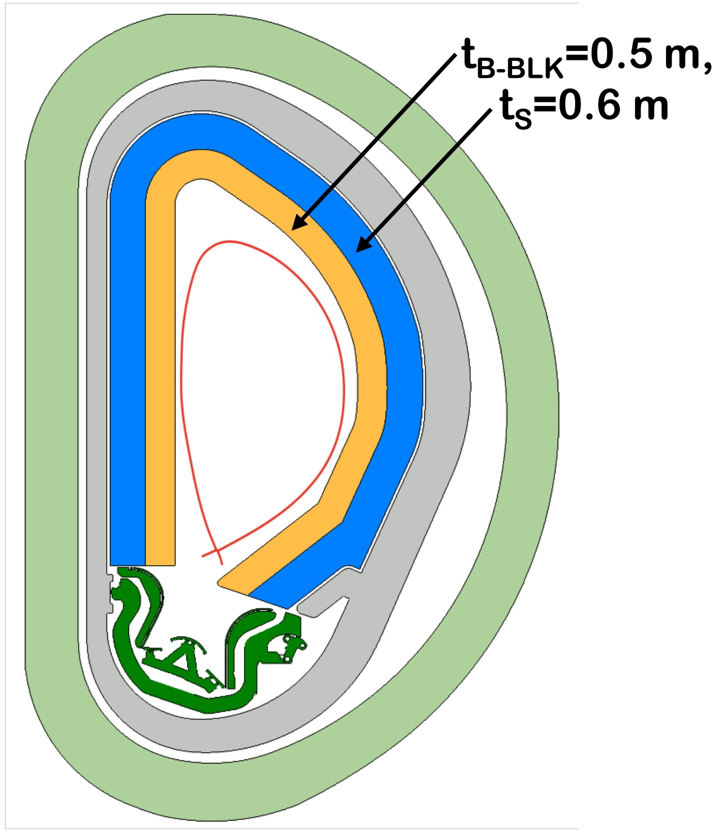
- Phase I : Demonstration of electricity generation with $P_{net} \gtrsim 0$
- Phase II : Demonstration of tritium breeding
- Phase III : Demonstration of steady-state operation with P_{net}~100 MW level

ITER shielding blanket

Phase I

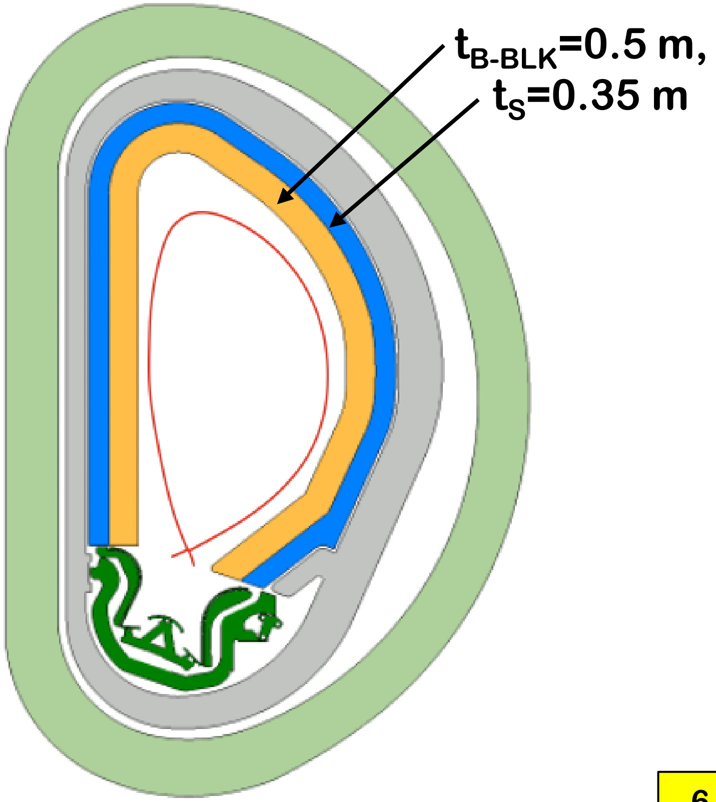


Breeding blanket and shielding those are the same thickness as the original JA DEMO



Breeding blanket and thin shielding

Phase II and III



Phased approach strategy of JA DEMO

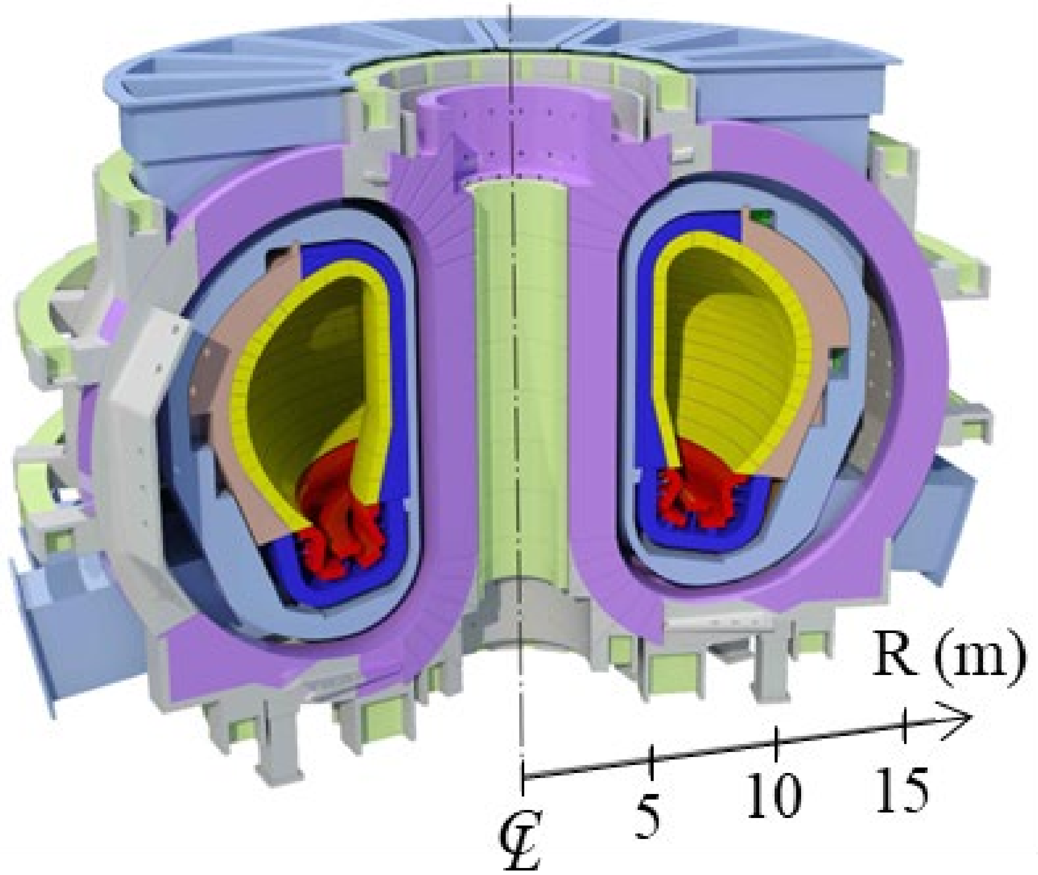
- **Phase I** : Install blankets specialized for electricity generation and shielding to secure a plasma volume comparable to ITER and demonstrate $P_{net} \gtrsim 0$ in short pulse operation.
- **Phase II** : Replace with breeding blankets and thin shielding, and demonstrate fuel breeding and $P_{net} \gtrsim 0$ in high β long pulse operation.
- **Phase III** : Improve the efficiency of heating and current drive devices, and enhance plasma performance in steady-state operation.

	Phase I : Demonstration of electricity generation	Phase II : Demonstration of tritium breeding	Phase III : Demonstration of steady-state operation
Obj.	• Short pulse (several min.) • P_{gross} > ~180 MW • $P_{net} \gtrsim 0$	• Long pulse (several hours) • $P_{net} \gtrsim 0$ • Self-sufficiency of fuel	• Steady-state operation • $P_{net} > 0$ (~100MW) • Self-sufficiency of fuel
Spec.	• ITER baseline scenario ✓ Fusion output: 500 MW ✓ Q value: 10 ✓ Pulse length: ~400 s • Electricity generation and shielding blanket ✓ Same size as ITER shielding blanket ($t_{E\&S\text{-}BLK}$=0.45 m)	• Original JA DEMO baseline scenario ✓ Fusion output: >500 MW ✓ Q value: 10 ✓ High β_N: 3.4 ✓ High HH_{98y2}:1.41 • Tritium breeding blanket ✓ Original JA DEMO breeding blanket ($t_{B\text{-}BLK}$=0.5 m) ✓ Thin shielding (t_S=0.35 m)	• JT-60SA scenario (High β & High confinement) ✓ Fusion output ~1 GW ✓ High efficiency heating and current drive • Tritium breeding blanket ✓ Original JA DEMO breeding blanket ($t_{B\text{-}BLK}$=0.5 m) ✓ Thin shielding (t_S=0.35 m)

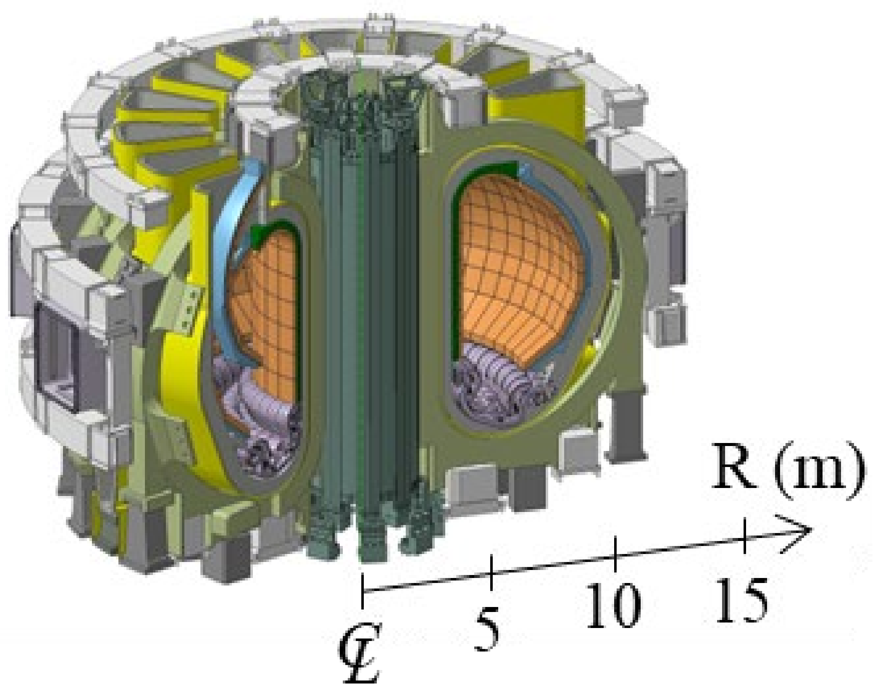
ITER size JA DEMO

- For the phased approach strategy, the integration of manufacturing and engineering technologies as well as plasma physics, being developed in ITER and JT-60SA will be a key.
- Further optimization of the specifications should be investigated considering the entire system including remote maintenance scenario in future work.

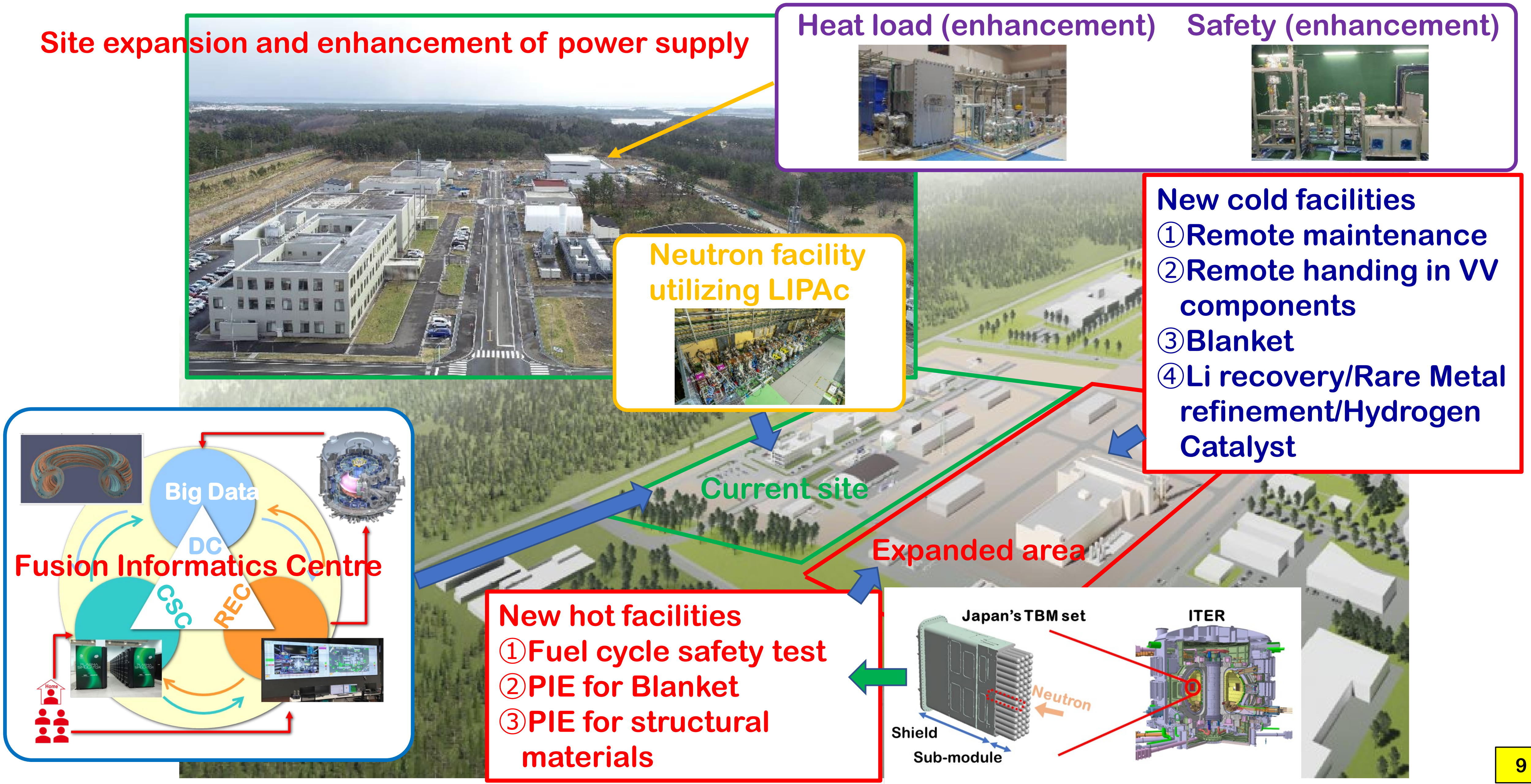
Original JA DEMO



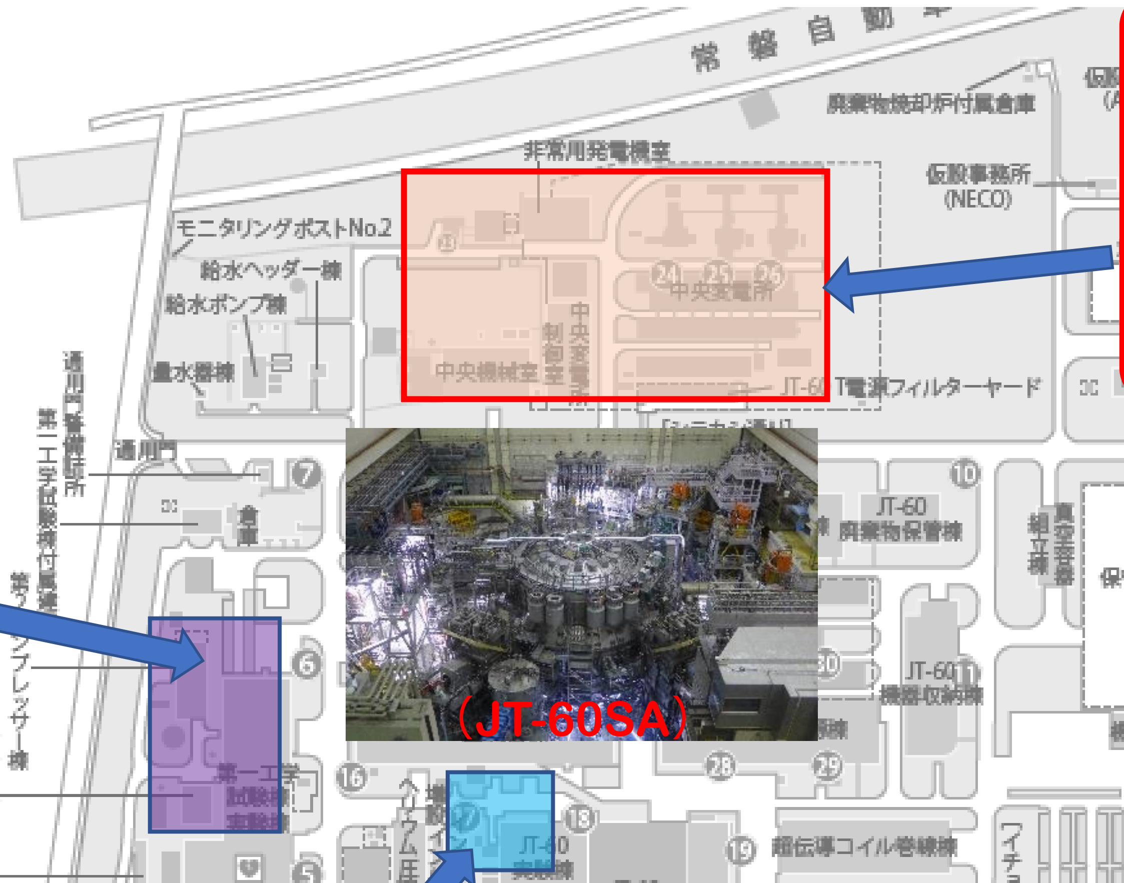
ITER-size JA DEMO



Proposal of enhancement of facility in Rokkasho Institute

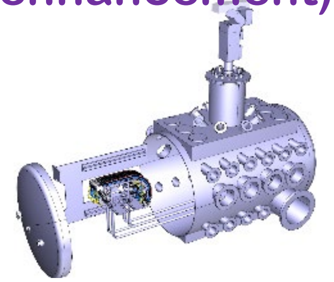


Proposal of enhancement of facility in Naka Institute



Superconductor (enhancement &new)

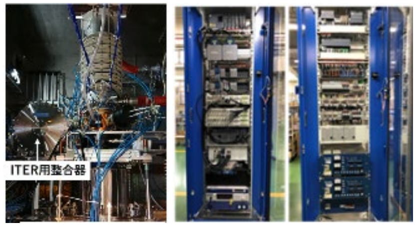
Divertor (enhancement)



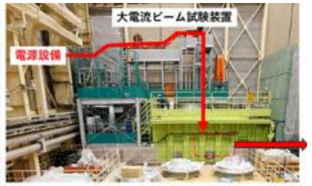
Infrastructure (renewal)

Diagnostics (enhancement)

RF heating (enhancement)



NB (new)



Collaborative build. (new)

Fusion Neutron Source

- Japan has joined the IFMIF-DONES Programme which will construct the neutron source based on the IFMIF/EVEDA project at Granada, Spain.
- QST has been designated as the Implementing Agency.
- QST will contribute to the construction of DONES and will obtain the neutron irradiation data up to 10 and 20 dpa for structural materials.

Ensuring safety

- QST contributed to publish the initial recommendations from Agile Nations working group on fusion energy regulation. The Working group recommended the development of a regulatory framework for fusion energy that maintains appropriate protections for people and the environment, proportionate to the hazards of fusion energy while remaining transparent and pro-innovation.

- QST led the discussion of ideas on ensuring safety in Atomic Energy Society of Japan.

- QST has contributed to the task force in the Cabinet Office.

  Basic ideas on ensuring safety for fusion energy

  - Scientific and reasonable approach: Application of agile regulations that respond to new findings and technological advancements and the graded approach (regulation according to the magnitude of specific risks).

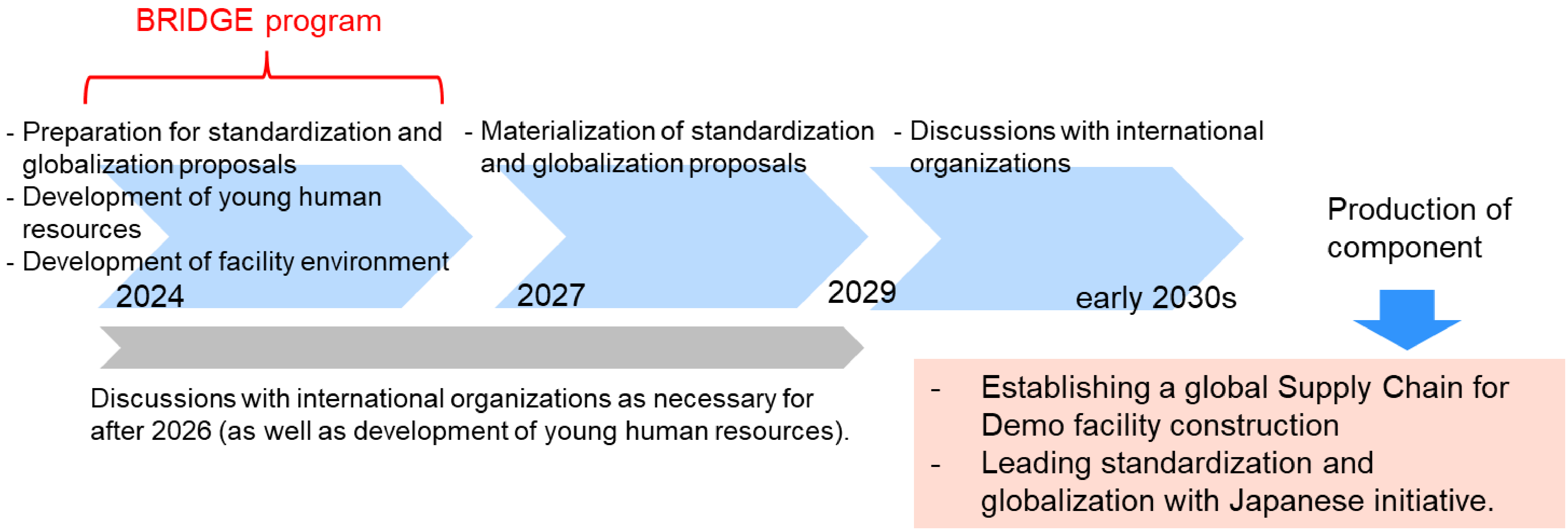
  Issues to be considered in the future

  - Legal Framework: It is appropriate to regulate fusion devices as subjects of the RI Law within the scope of the risks currently anticipated.

- Nuclear Regulation Authority (NRA) accepted to start the dialogue with business operators such as QST and fusion start-ups.

Standardization

- QST is discussing **standardization with academic societies** such as the Japan Society of Mechanical Engineers (JSME) and the Japan Society of Maintenology.
- In the BRIDGE Program promoted by the Cabinet Office, QST has started **the activities for international standardization** in fusion energy system.



JSME and ASME collaboration is being organized for international standardization.

Fusion Startups from Rokkasho Institute

- Start-up companies have been established as QST venture for industrialization of fusion technologies.
- QST is aiming at a fusion technology spin-off through these start-up companies and feedback of these technologies matured in the market to the DEMO project.

Refining technology of beryllium (Be)

Low energy consumption process of Be and rare metal with alkali and RF power

MiRESSO

Company	■ MiRESSO Co. Ltd. Mineral Refining and Recycling System Society
Business Outline	■ Production and sales of Be ■ Technical support for energy saving of refinement and recycling processes with high temperatures
Mission	■ Contribution of fusion realization by providing a stable supply of be

Recovery technology of lithium (Li)

Very simple process on Li with Li ionic conductor

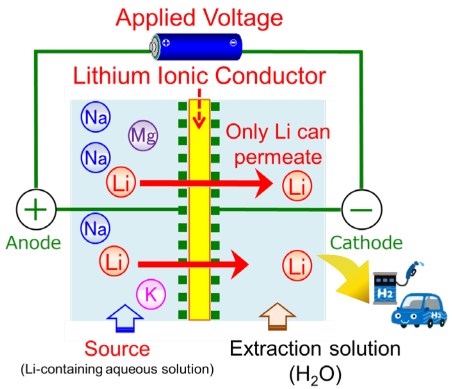
LiSTie

LiSTie Inc.

Li ＝Lithium
S ＝Sustainable
Tie

Aiming to be a bridge company that connects a decarbonized society to the next generation.

Li Separation Method by Ionic Conductor : LiSMIC



Li extraction device

Future actions

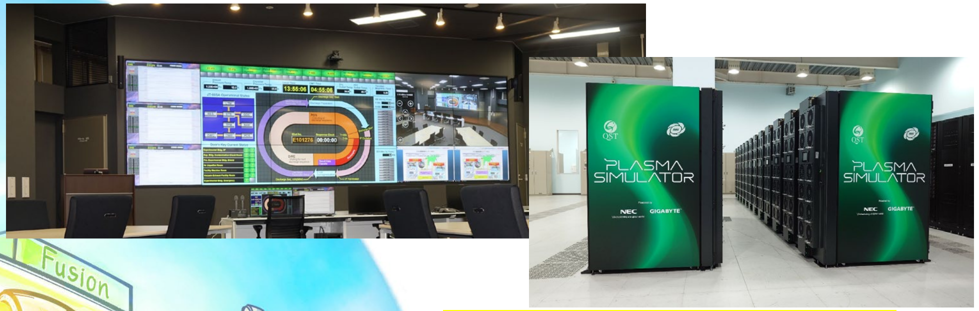
- Task force toward promotion of social implementation
  - Discussion for the definition of electricity generation demonstration leading to social implementation.
  - Hearing from QST and fusion start-ups.
- Cabinet Office and MEXT (and related ministries)
  - Objective and cross-sectional evaluation of TRL of the DEMO reactor project and/or the electricity generation project proposed by start-ups.
  - Development of a roadmap based on back-casting from the electricity generation demonstration leading to social implementation in the 2030s.
- NRA
  - Opinion exchange with business operators promoting R&D for fusion devices.
  - Hearing from start-ups about the development status, safety assurance concepts, future outlook etc. as information gathering for future considerations.
- QST
  - Conceptual design of the ITER size JA DEMO considering the status of the discussion described above.

Fusion Industry and Future Society

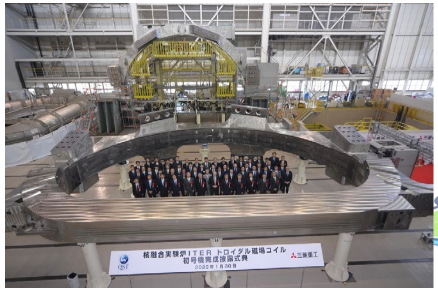
Neutron Forest
(Neutron Industry)

Net Zero Society

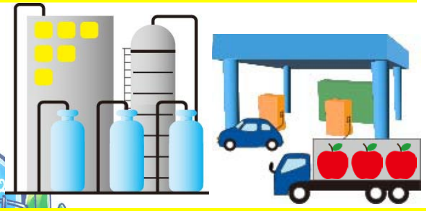
Fusion Informatics Centre



Factory of Fusion Device



Hydrogen Station



Food preservatives

Fusion Reactor

Lithium Recovery /
Factory of Li Battery Recycle

Rare Metal Refinement /
Recycle Plant