

Road to Commercialization: Japan

- a new trend of fusion development and the role of startups -



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Japan's Policy on DEMO Reactor

The Science and Technology Committee on Fusion Energy of MEXT published the strategies for the development of DEMO reactor.

December 2017

Japanese Official Policy

➤ **Promotion of R&D for DEMO reactor**

➤ **Action Plan towards DEMO reactor**

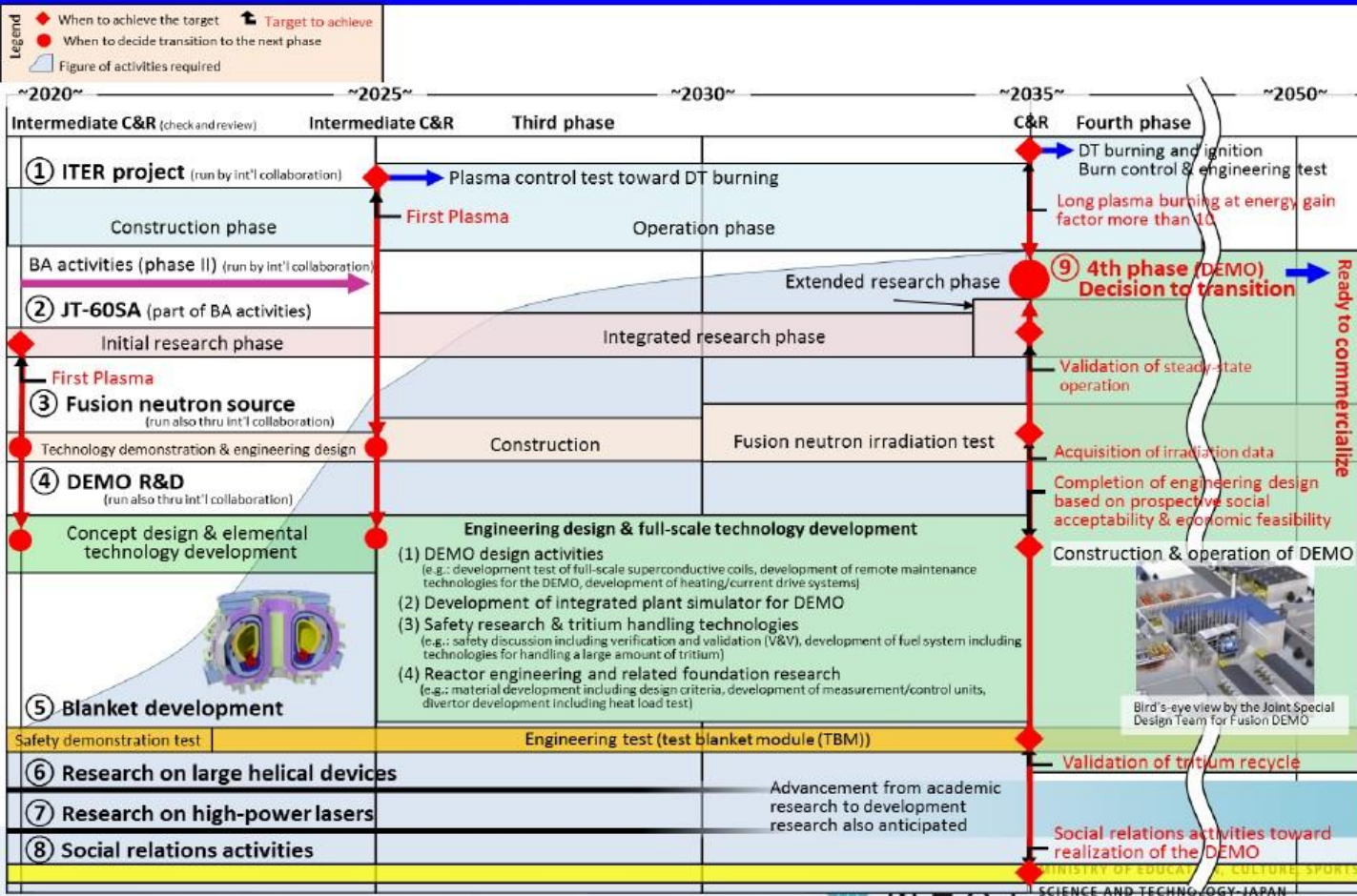
July 2018

➤ **Roadmap toward DEMO reactor (first report)**

Phased Approach toward DEMO reactor

- ✓ Current : Pre-conceptual Design Phase
- ✓ 2021 : 1st Intermediate Check and Review (C&R)
- ✓ Conceptual Design Phase
- ✓ Within a few years after 2025 : 2nd Intermediate C&R
- ✓ Engineering Design Phase
- ✓ In the 2030s : Final C&R
- ✓ Construction Phase

Roadmap toward DEMO Reactor



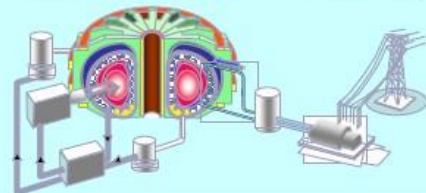
Broader Approach for Realization of Fusion

- 1) Taking Initiative of Fusion Research
- 2) Development of Fundamental Fusion Technology
- 3) Human Resource Development

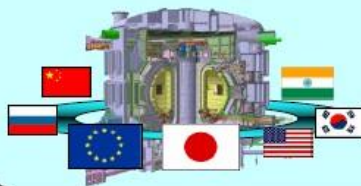
BA Activities

DEMO

*Demonstration of
Fusion Power Plant*



**ITER : Demonstration of Scientific
and Technological Feasibility
of Fusion Energy**

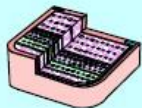


$Q = 10$
DT Burning 300-500s



JT-60

$Q = 1.25$
 $T_i(0) = 45\text{keV}$



Fusion Technology

*Material
Blanket
R&D (Coils, VV, Heating)*

Broader Approach Activities



Rokkasho, Aomori

IFERC

IFMIF/EVEDA



Naka, Ibaraki

Satellite Tokamak

1. ITER

- for the burning plasma experiments
- for technology development
- Blanket program by TBM

2. Broader Approach

- JT60SA, IFMIF, Fusion technology

3. DEMO design team activity

- with small scale collaboration with university and industry

No commercialization considered by policy yet.

Japan is not ready for commercialization yet.

- Still in research phase
- Industry completing ITER ; no following sales
- Blanket program by TBM

Commercialization requires..

- Entity that launch the project with firm decision
- Finance and
- Industry that can make it with workforce
- Supply chain
- Technology and Innovation



Kyoto Fusionneering Ltd. (KF) has been founded in 2019
for the commercial fusion business from Kyoto University.

This company contributes world fusion industrialization.

Role and methodology of private fusion companies are
Significantly different from public fusion programs.

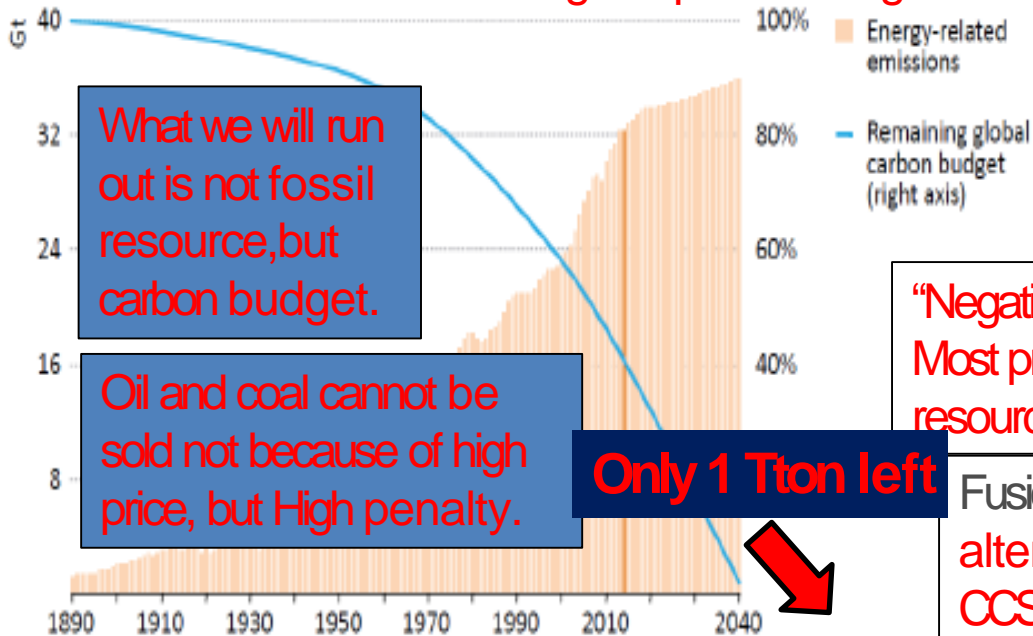
Competition of fusion business has already started!

Ex-fusion and Helical Fusion followed as startups.

Carbon Budget (by IEA)

Carbon budget and CO2 emissions

Carbon budget of post-Paris agreement runs out after 2040



What we will run out is not fossil resource, but carbon budget.

Oil and coal cannot be sold not because of high price, but High penalty.

Only 1 Tton left

CCS resource is more critical

"Negative Carbon" will be Most precious energy resource beyond 2040.

Fusion can provide alternative CCS technology

Source: IEA (2015). Global energy-related CO₂ emissions extrapolating from current national emissions pledges under the UNFCCC, compared to remaining carbon budget for a less than 50% chance of keeping to 2°C.

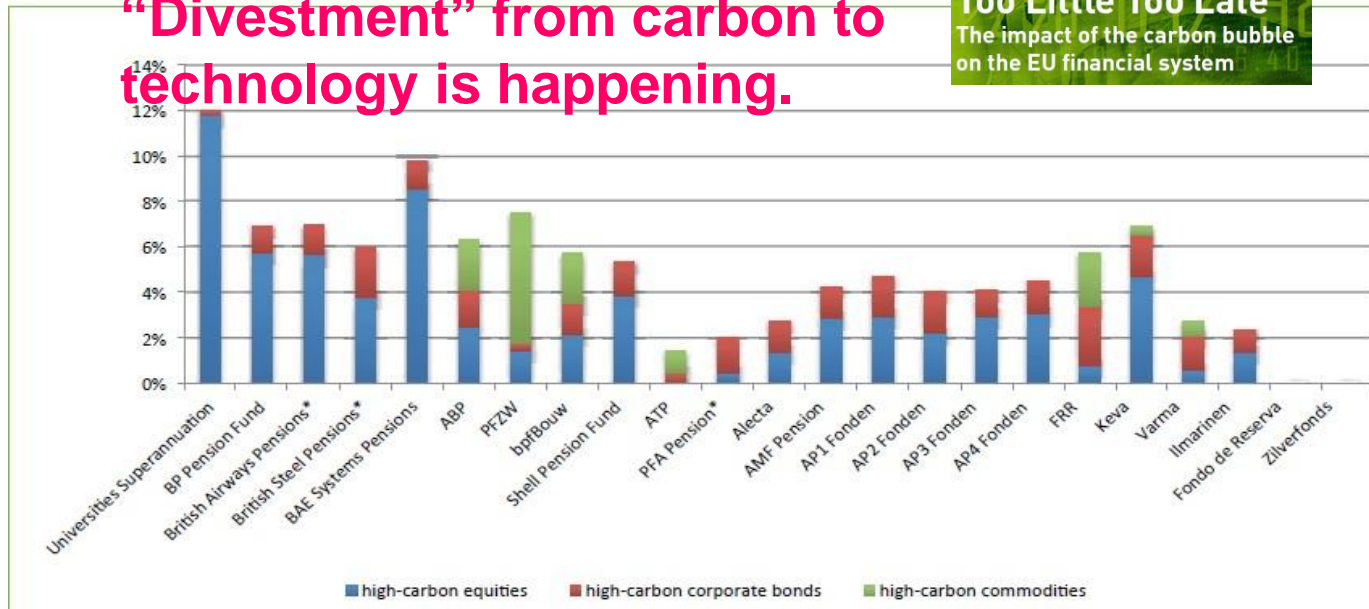
Stranded Assets

Fusion Power Associates 40th annual meeting 2019

Figure 4: Share of high-carbon investments in total assets

“Divestment” from carbon to technology is happening.

The Price of Doing Too Little Too Late
The impact of the carbon bubble on the EU financial system



- Fossil resources become “stranded” because they cannot be sold
- Many of the large scale long term investment (bond) in the world, particularly pension fund is highly dependent on fossil assets
- Value of the fossil assets drops under low carbon economy

Current situation of fusion

Current situation

Ventures into big science field (e.g., SpaceX)

Traditional research results and new enabling technologies

Paris Agreement -> Carbon neutrality
COVID-19 -> Green New Deal

Drastic Change

nuclear fusion as their ESG investment and divestment

Bright outlook on practical use of fusion reactors

Governments are willing to create a fusion industry in their country

Path to
accelerate
fusion
electricity



2040

In 20 years



2035

In 15 years



In 8 years

We accelerate the development of **high performance, commercially viable fusion plant components** associated with **power generation and fuel cycle**.

Locations	Tokyo, Japan Kyoto, Japan Reading, UK TBA, US (in 2022)
No. of Staff	50 (full and temporary)
Funding to Date	17 million USD
Foundation	2019



KF Mission

To accelerate development of high performance, commercially viable reactor technologies

- associated with power generation and fuel cycle*
- for the rapid expansion of the budding fusion industry*

Particular emphasis on:

- plant technology**
 - fuel cycle and supply chain**
 - energy conversion, alternative fuel and**
- CARBON SEQUESTRATION**

Company itself is the product

- Shared will by investors and company members accomplishes the objective.
 - **Growth** \Rightarrow Return of the Investment
 - Gather and organize the human resources, materials, technology and knowledge
 - Establish a body entity to build a fusion plant
 - **Innovation** \Rightarrow Research, Development, Test, Failure, Improvement...
- \Rightarrow This process makes the value of company
- \Rightarrow **Return of Investment**

Innovation

- Original, Innovative idea
 - Test, fail and improve with fast cycle
 - Cutting edge technology with high risks
 - To take risk and control is the mission
- ⇔ Public program and Big company do not take risks

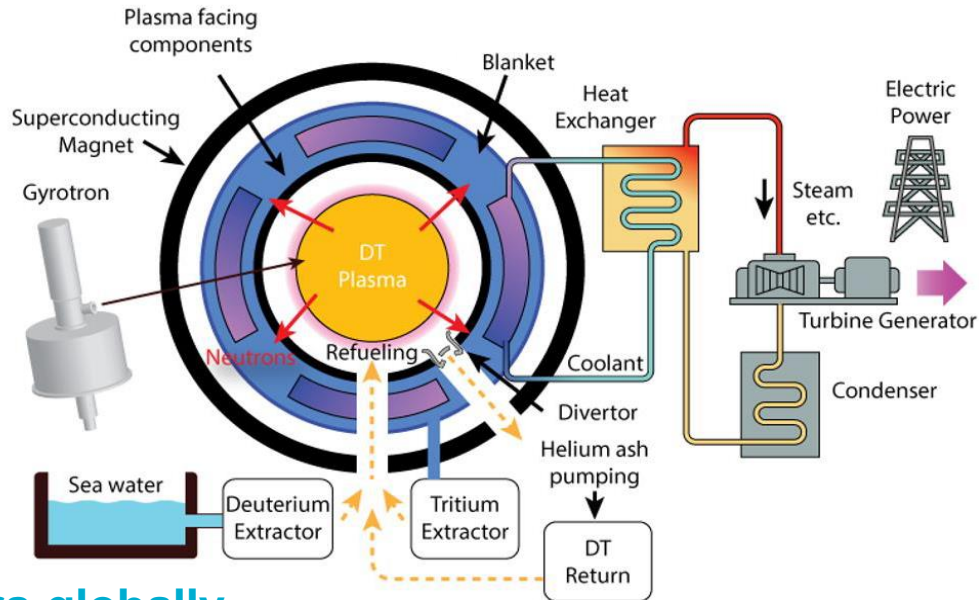
Large projects are usually conservative and slow to move

Modern industry expects startups to try challenging technology (many may fail ...)

KF provides technology for fusion energy

- Blanket
- Conversion
- Application
- Fuel cycle
- Device

Some comes from
Japanese industry



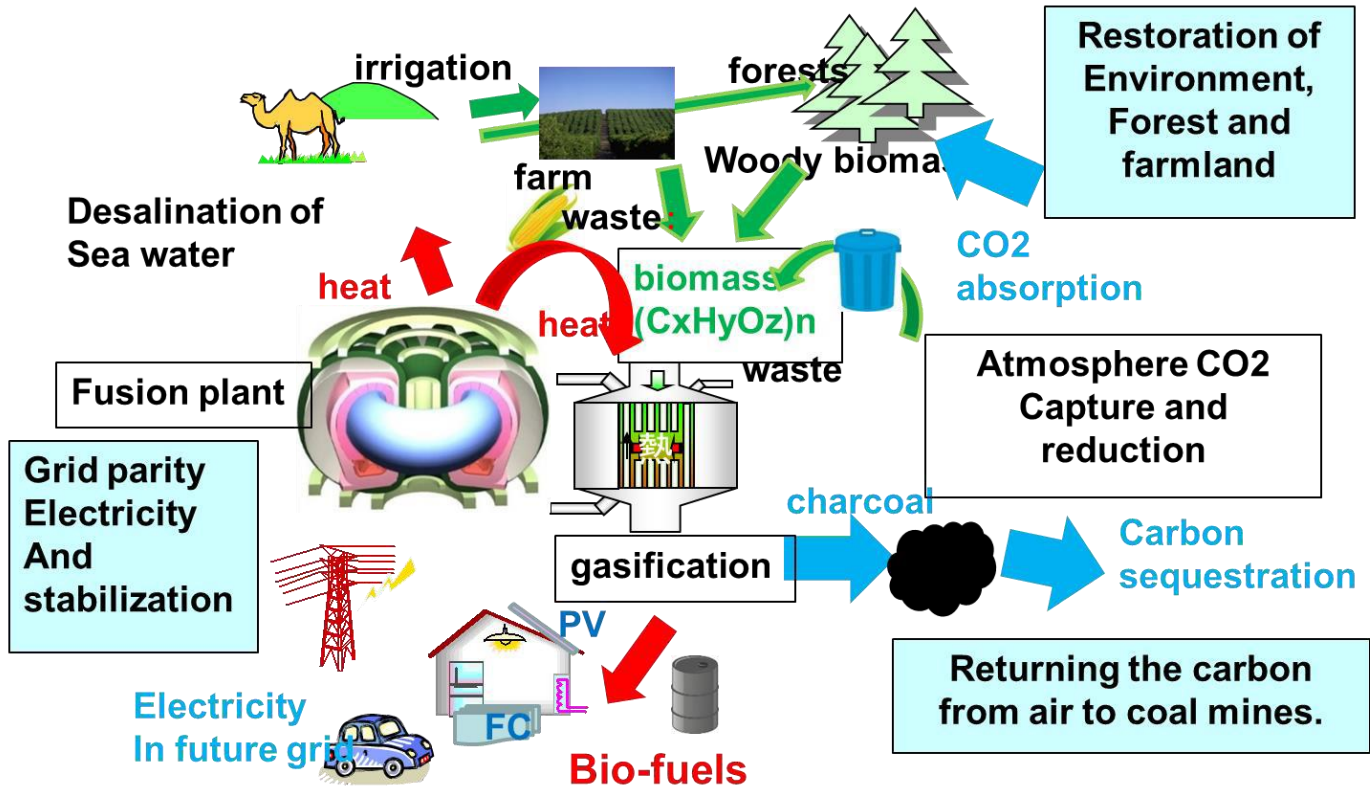
**Fusion developers globally
are working on power-
producing plasmas &
related tech.**

**Kyoto Fusioneering is focused on
key reactor technologies and
engineering.**

Plasma, device, plant and consumer

- A number of “Big” fusion companies encompass Fusion reaction
- Many small companies sell devices (only)
- **Kyoto Fusionneering** provides **energy** conversion and fuel cycle technology
 - Unique in fusion industry
- Fusion businesses will have to respond to
 - questions to **return investments** to sponsors
 - **expectation of public** how fusion would provide energy products and reduce carbon emission

Sustainable energy system with fusion-biomass



What makes fusion Real?

- Rapidly growing team of workforce
- Collect investment
- Organizing Technology and industries
- Knowledge, skill, experience, and business network
- Exchanging human resource, migration from different industry area
- Strong, flexible and fast decision making

Organize the social expectation for fusion

KF's R&D domain

		2021 TRL ¹⁾	2026 TRL	Market size in 2026
Turbine	Lithium Lead Droplet Thermal			\$1B
	Tritium Recovery	4	7	
Fuel Handling	Liquid Metal Diffusion Pump	7	9	\$1B
	Hydrogen Isotope Separation Pump	3	7	
Blanket	SCYLLA© Blanket	3	6	\$500M
	Solid Propagation Material & H Permeation Properties	3	6	
	Li-Pb Impurity control	3	7	
	Li-Pb ▪ Low activation ferritic steel coexistence	3	7	\$1B
	Li-Pb Simulation of Tritium production	5	9	
	SiC-Hydrogen isotope permeation diffusion behaviour	3	7	
	Li-Pb-Hydrogen isotope behaviour	4	7	
Plasma Heating				
	Gyrotron	7	10	

1) TRL= Technology Readiness

Fusion requires **Social challenge**

- Ultimate objective is shared: Sustainable energy. Now public and private collaborate.
- Human resource for fusion is the key .
- Science and social activity (business) found another path for rapid development.
 - **Industrialization** requires startup companies.
 - **Fusion business has** already launched in the world, and Japan is about to be aware.

TAURO concept
Giancarli et al., 1998

Thank you!

FUSION for the FUTURE

