Progress on reactor system technology in the FaCT project toward the commercialization of fast reactor cycle system

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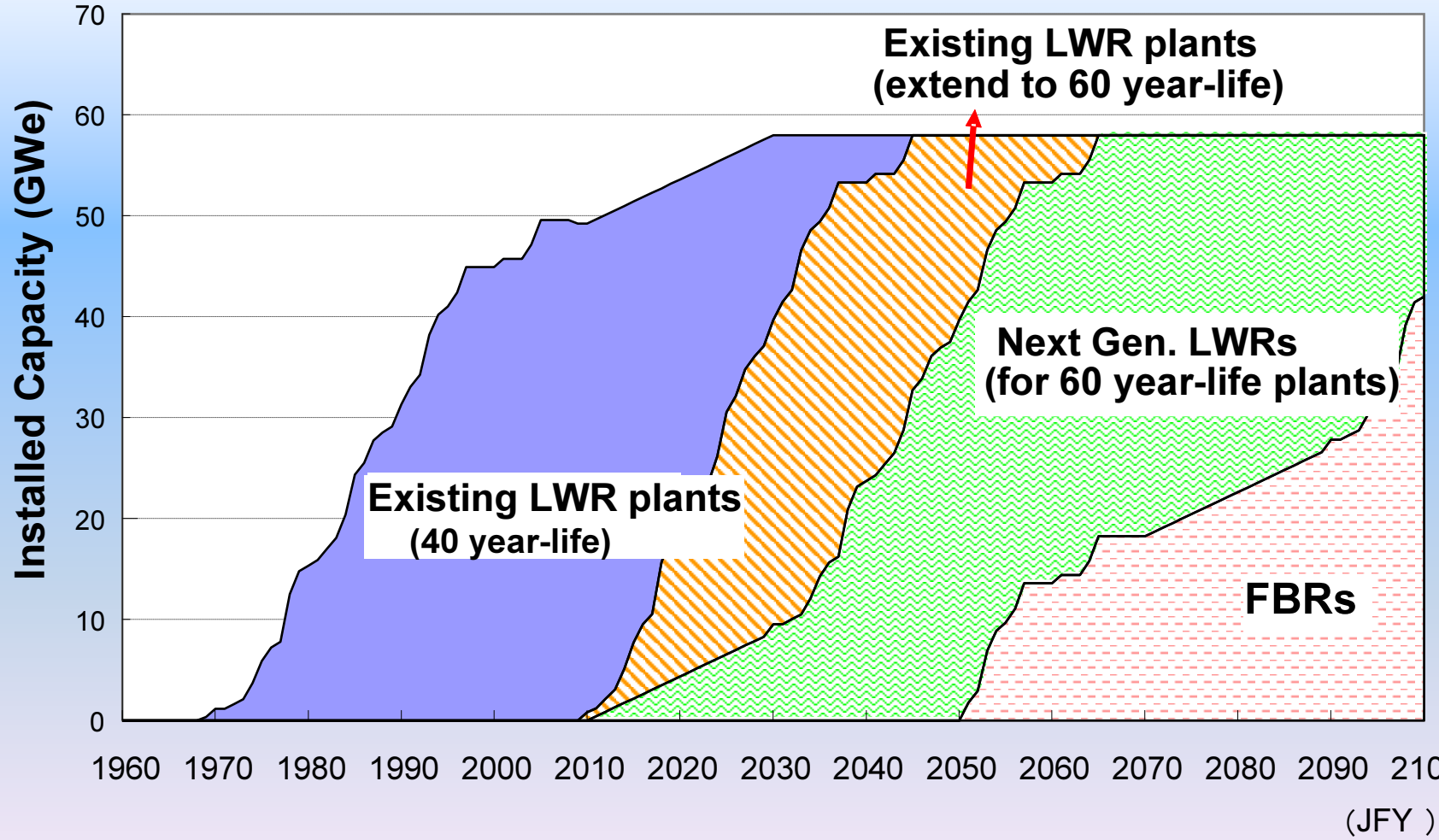
Table of Contents

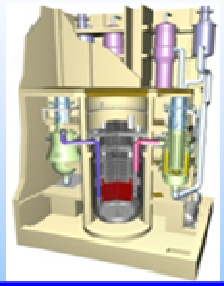
Long Term Forecast of Nuclear Energy in Japan



*** The installed capacity is assumed to reach saturation at 58GW, for illustrative purpose.**

History of Fast Reactor Development in Japan

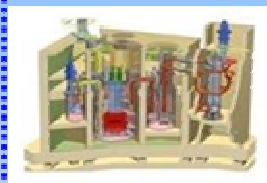
JSFR
- 2025 *Demonstration /*
- 2050 *Commercialization*



*1 : study performed
*2 : initial criticality attained

Innovative Technology for Economics and Reliability

1990s*1
DFBR
Design for Demonstration



- **Design Study of Demonstration Reactor**
- **Development of Element Technologies**

Power : 1,600MWt / 660MWe
Temperature : 550ºC

1994*2
Monju
Prototype

- **Demonstration of Reliable Operation**
- **Establishment of Sodium Handling**

Power : 714MWt / 280MWe
Temperature : 529ºC

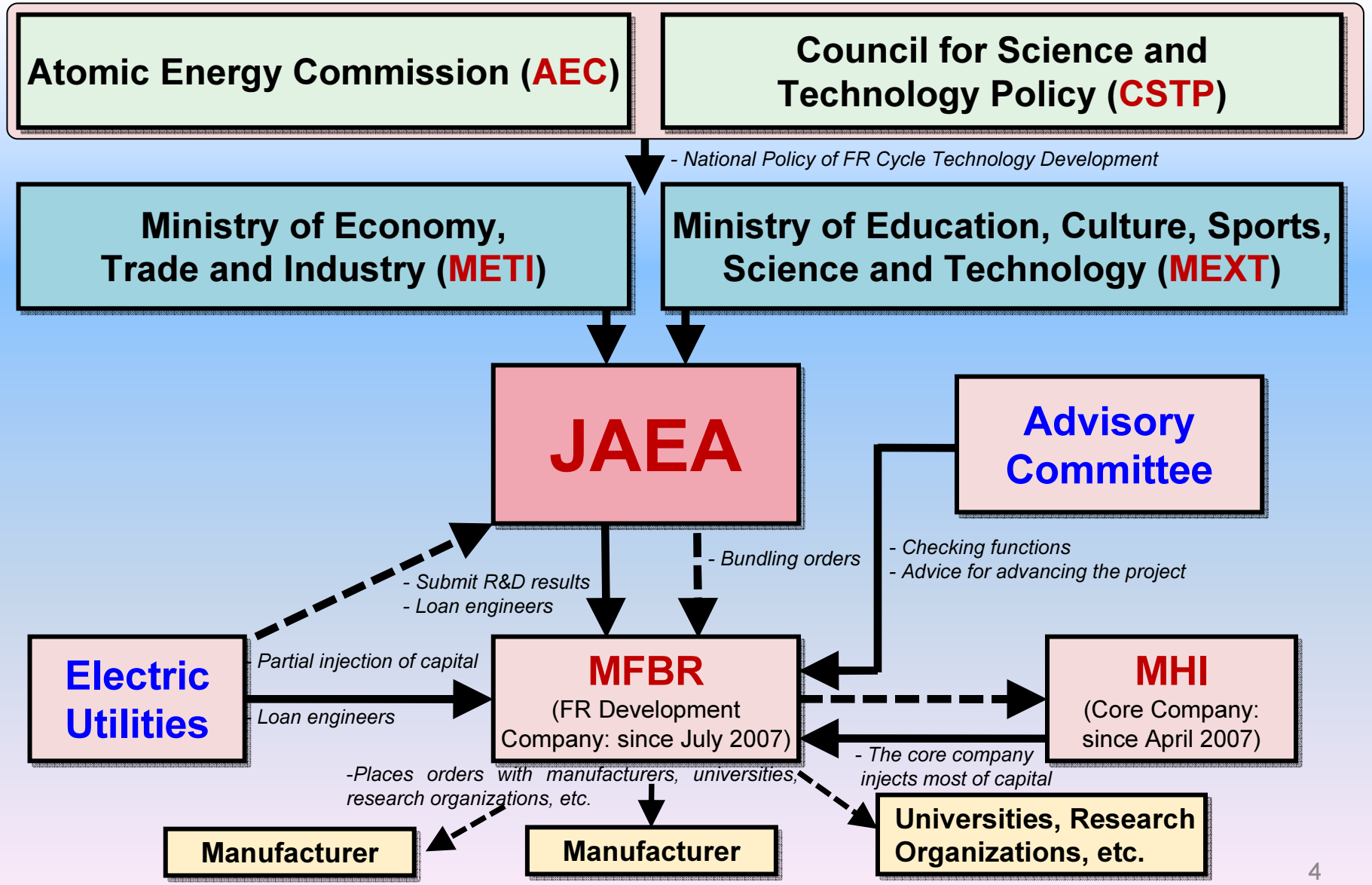
1977*2
Joyo
Experi-mental

- **Confirmation of FR Basic Technologies**
- **Verification of Safe and Stable Operation**

Power : 50MWt → 100MWt → 140MWt (Mk-III Core)
Temperature : 435ºC → 500ºC → 500ºC

System Development as Electricity Generation

Framework of Promoting the FaCT Project



Development Targets for FaCT Project

Safety and Reliability

SR-1	Ensuring safety equal to future LWR and related fuel cycle facilities
SR-2	Ensuring reliability equal to future LWR and related fuel cycle facilities

Sustainability

Environment Protection

EP-1	Radioactive influence through normal operation no more than future LWR cycle
EP-2	Emission control of environment transfer substances which can restrict in safety limits

Waste Management

WM-1	Reduction of an amount of radioactive waste compared with future LWR cycle
WM-2	Improvement of waste manageability equal to or more than future LWR cycle
WM-3	Reduction of radio-toxicity compared with future LWR cycle

Efficient Utilization of Nuclear Fuel Resources

UR-1	Breeding performance to enable transition to fast reactor, and its flexibility

Economic Competitiveness

EC-1	Electric generation cost which can compete with other power plants
EC-2	Investment risks no more than future LWR cycle
EC-3	External costs no more than future LWR cycle

Nuclear Non-Proliferation

NP-1	Adoption of institutional measures and application of technical features which can enhance non-proliferation
NP-2	System design of physical protection and its development to prevent theft of nuclear materials and sabotage

Innovative Technologies for JSFR

Economic Competitiveness

○ **Reduction of Mass & Volume**

①Shortened piping with high chromium steel

② 2 loop cooling system

③ Integrated pump-IHX component

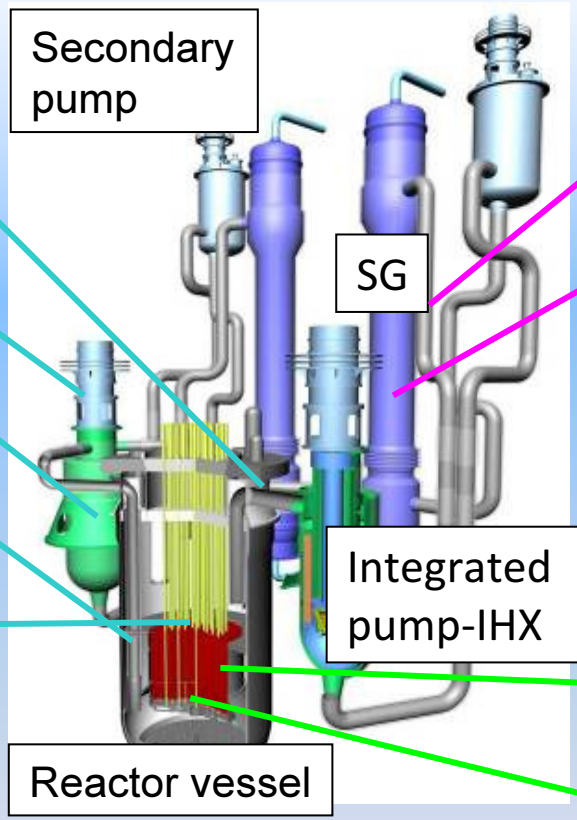
④ Compact reactor vessel

⑤ Simplified fuel handling system

⑥ CV with steel plate reinforced concrete building

○ **Long operation by high burn-up fuel**

⑦ Advanced fuel material



⑭Plant design study (D-FR/C-FR)

⑮ Large-scale sodium tests

Enhanced reliability

○ **Sodium technology**

⑧Sodium leak tightness with double-walled piping

⑨Higher reliable SG with double-walled tube

⑩ Higher inspection ability inside of sodium boundary

Enhanced safety

○ **Core safety**

⑪Passive shutdown and decay heat removal

⑫Re-criticality free core

○ **Seismic reliability**

⑬Seismic reliability in core assemblies

(1)Thermal Hydraulic of Compact RV

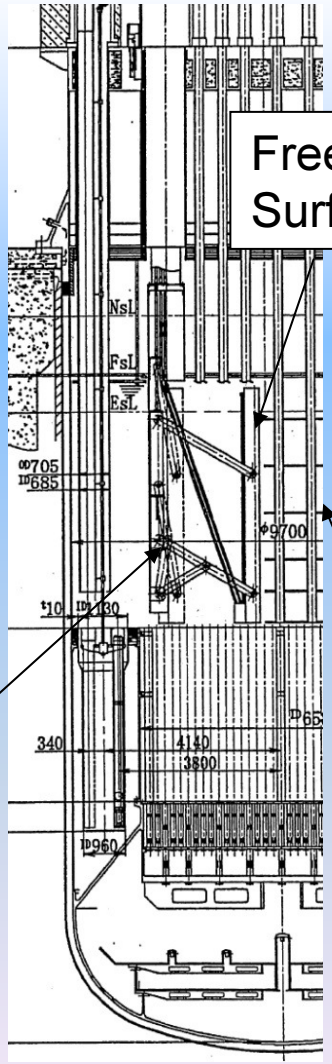
Investigation on

***Gas Entrainment**

***Thermal Stratification**

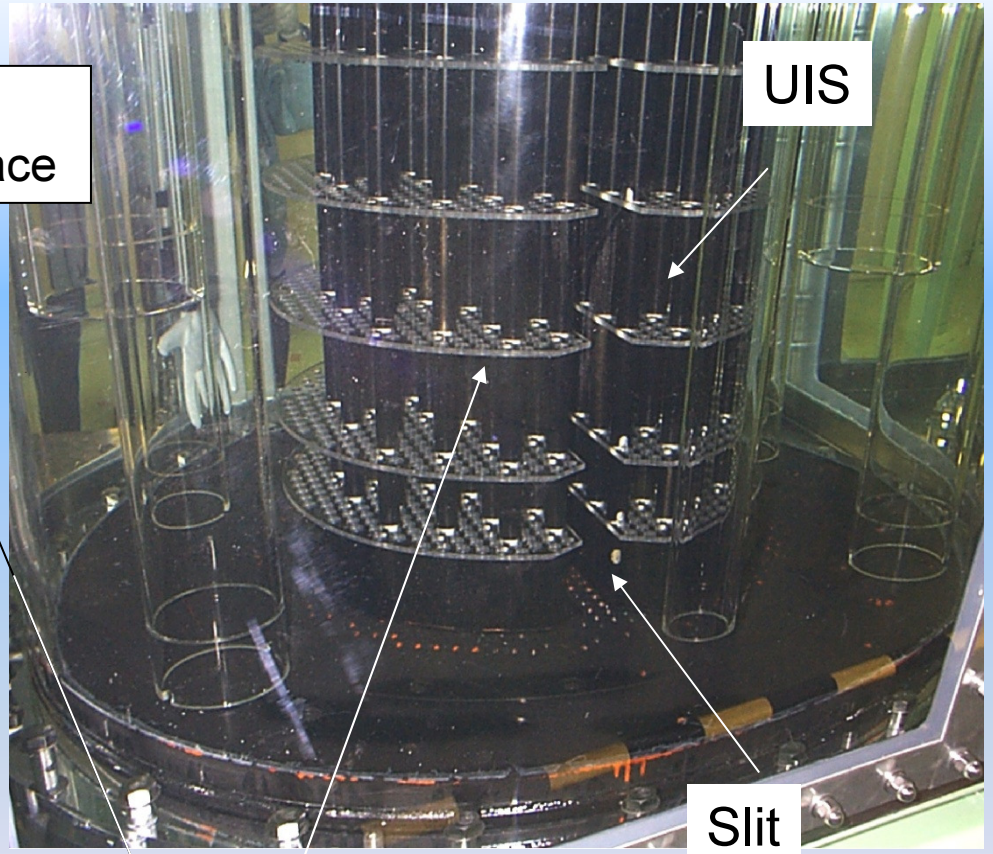
***Flow around Slit**

etc.



Free Surface

Fuel Handling Machine

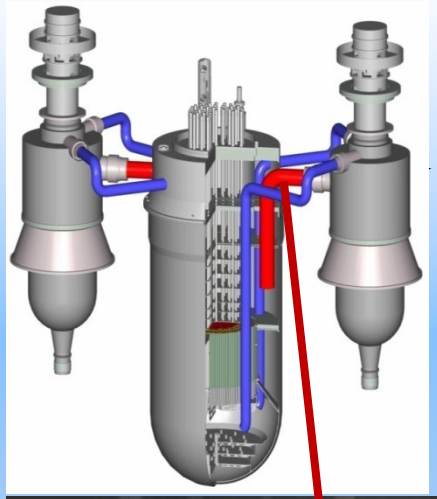


Baffle Plate

FHM arm can go into UIS through the slit.

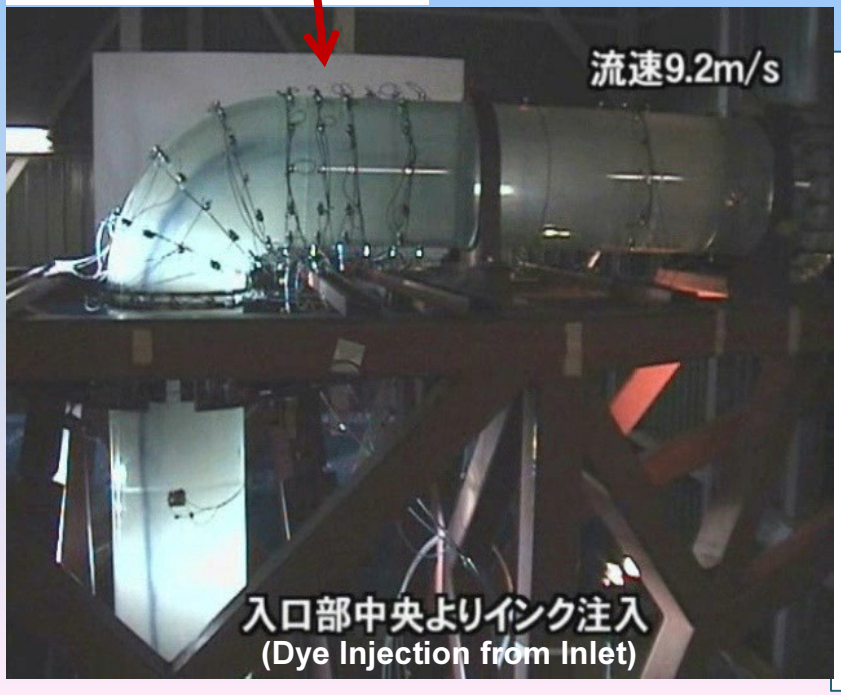
1/10th scaled upper plenum model

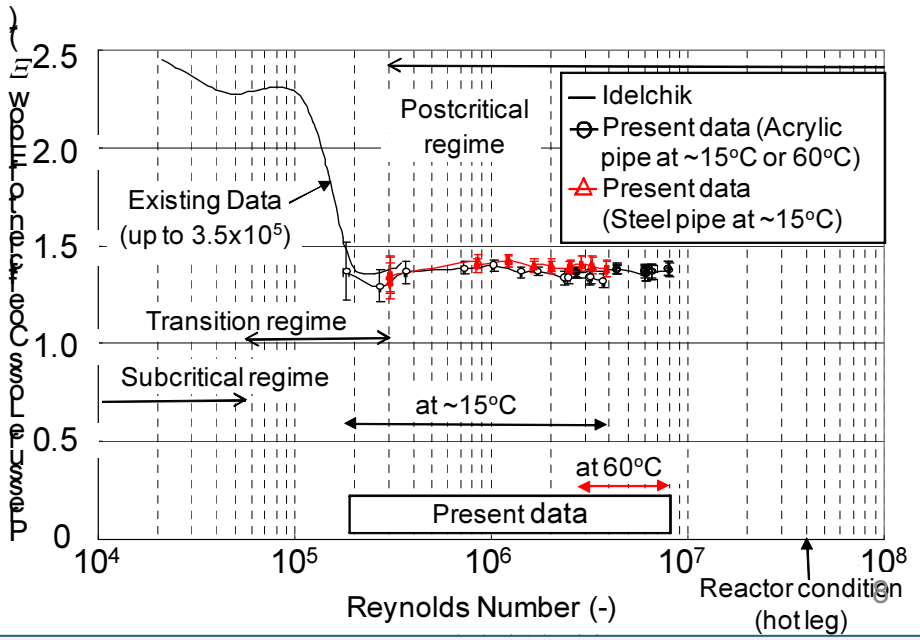
(2)Two-loop cooling system
Piping under Flow of High Reynolds Number



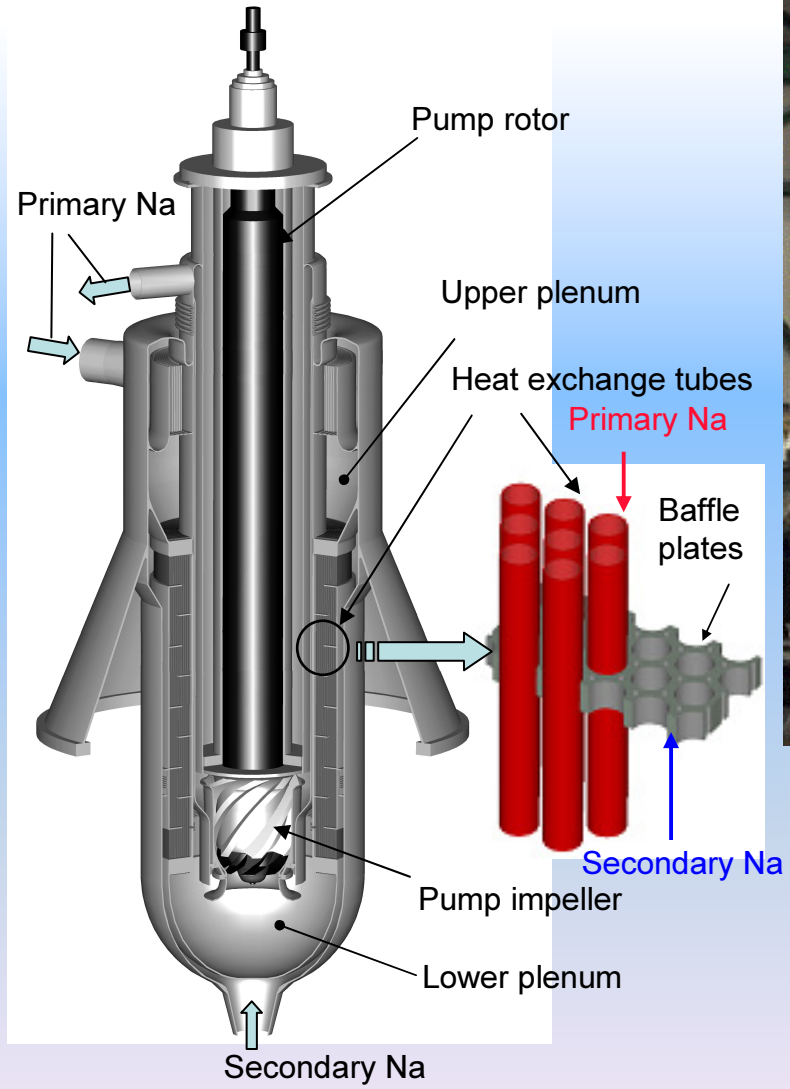
1/3-scale Water Test
1)Visualization Test (acrylic resin)
2)Vibration Test (stainless steel)

- Flow Pattern
- Velocity Profile
- Pressure Loss of Elbow
- Pressure Fluctuation
- Natural Frequency/Mode
- Vibration Response

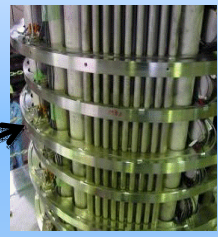


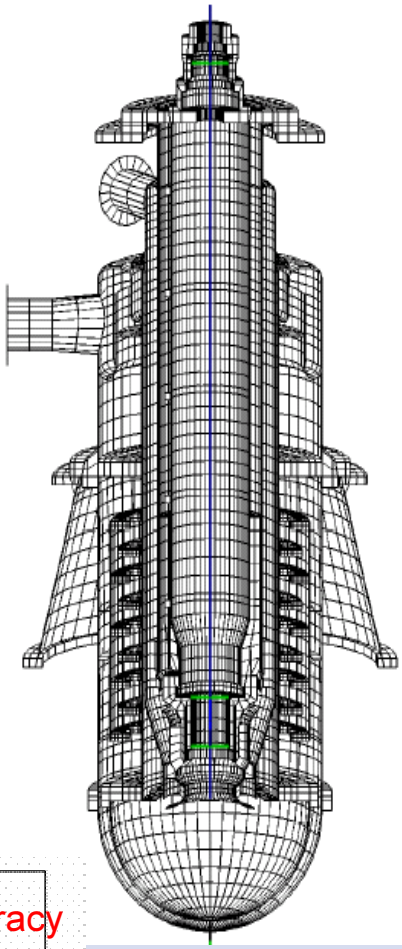


(3)Integrated IHX with Primary Pump

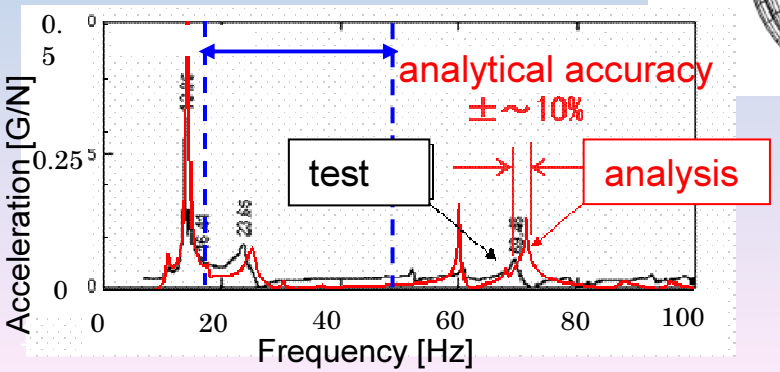


1/4th scaled model



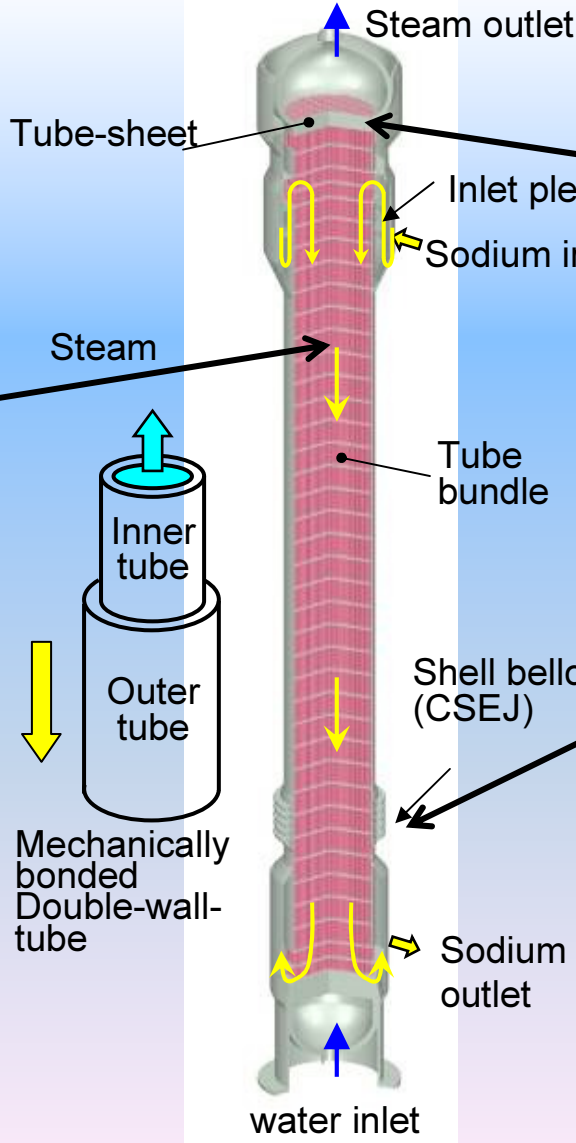


operating range



(4)Trial Manufacturing for Double-walled Tube SG

Trial manufacturing: **mechanically bonded double walled tube with high Cr steel**



Trial manufacturing: **Thick (t1000) forged high Cr steel for tube-sheet material**

Trial manufacturing: **Machine worked CSEJ with high Cr steel**

FR Cycle Development Program in JAPAN

2005 | 2010 | 2015 (JFY)

Feasibility Study

(JFY 1999-2005)

Identify Most Promising Concept

C&R

Experimental FR "Joyo"

Prototype FBR "Monju "

Review & Basic Policy by MEXT &AEC

Fast Reactor Cycle Technology Development Project (FaCT)

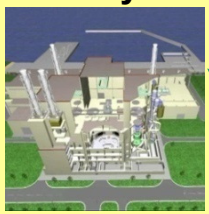
Decision on Innovative Tech. (2010)

Approved Confirmation (2015)

R&D of Innovative Technologies

Preliminary Design of Commercial & Demonstration FR Cycle Facilities

Commercialized FR Cycle



R&D at "Monju"

- ◆ Demonstrating its Reliability as a Nuclear Power Plant
- ◆ Establish Sodium Handling Tech.

2015

Conceptual Design of Commercial and Demonstration FR Cycle Facilities, with Providing Necessary R&D Programs

Detailed Design & Construction

2025

Start of Operation of Demonstration FR & its Fuel Cycle Facility

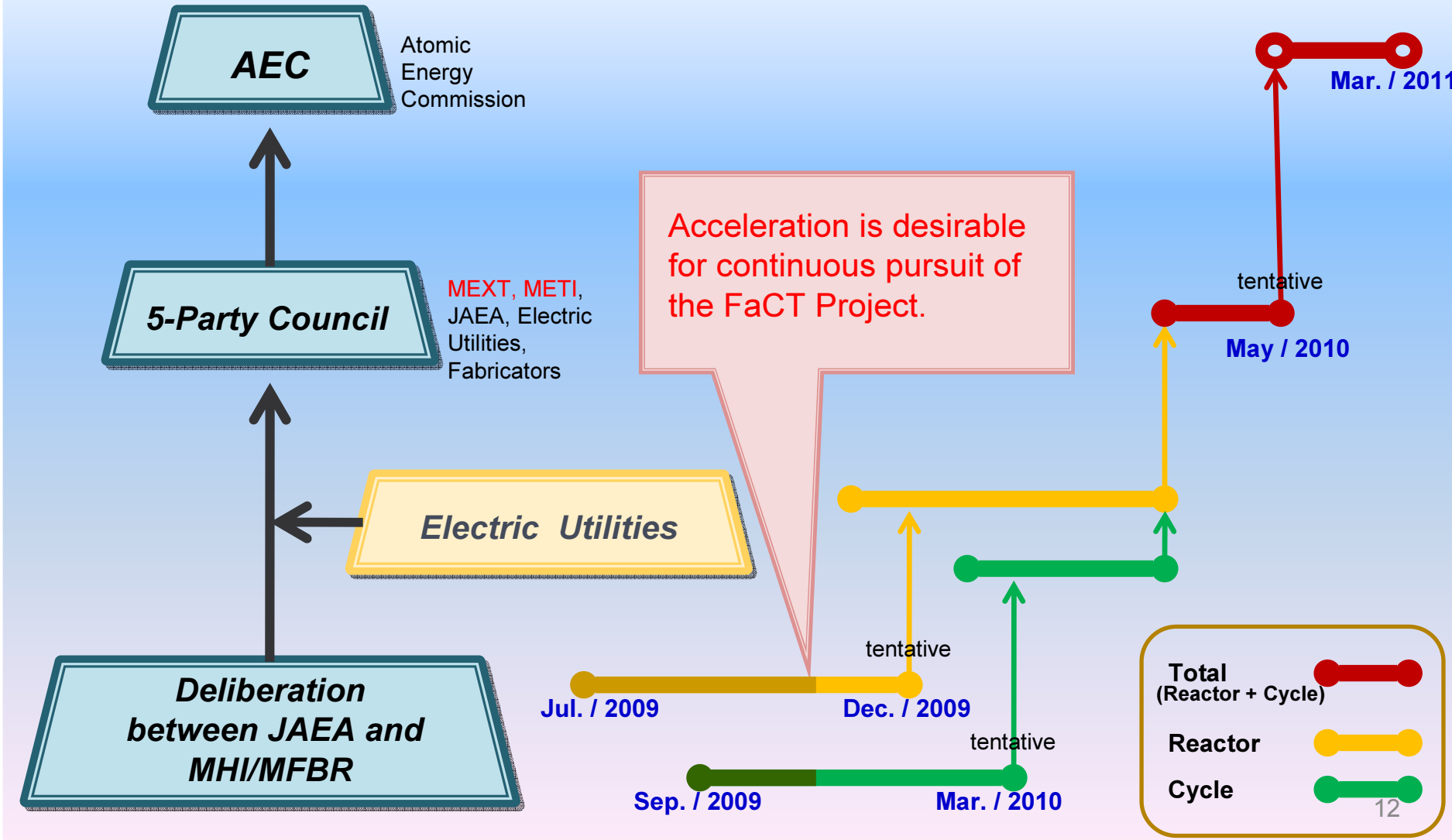
Validation of Economy & Reliability

~2050

Commercial Introduction of FR Cycle Technologies

◆Cooperation with various Organizations ◆International Cooperation (GNEP, GEN-IV, INPRO etc.)

Schedule of the FaCT Project (Phase 1) Decision on Innovative Technologies



Decision on Innovative Technologies

13 innovative technologies are re-classified into 10 items.

Equipment Division	Evaluated Technologies	13 Subjects
Core, Fuel	1. High Burn-up Fuel with ODS Cladding Material	⑦
	2. Enhanced Safety	⑪ ⑫
Reactor Structure	3. Compact Reactor Vessel	④
Primary Loop	4. 2 Loop Cooling System of Large Piping with High Chromium Steel	① ②
	5. Integrated Pump-IHX Component	③
Secondary Loop	6. Higher Reliable SG with Straight Double-walled Tube	① ⑨
DHRS	7. Decay Heat Removal by Natural Circulation	⑪
BOP	8. Simplified Fuel Handling System	⑤
Building	9. CV with Steel Plate Reinforced Concrete	⑥
	10. Advanced Seismic Isolation System for SFR	⑬

International Collaboration

Trilateral Collaboration

JAEA - DOE - CEA

"COOPERATION ON SFR DEMO/PROTOTYPES"

Jan.2008 MOU → Aug.2008 revised

Gen-IV International Forum (GIF)

12 countries, **1** organization

SFR

Parties : Japan, France, US, Korea, EU, China, (Russia)

(Broad long-term R&D items)

SFR Project
- -System Integration and Assessment
- -Safety and Operation
- -Advanced Fuel
- -CD・BOP
- -GACID (Japan-France-US)

Information Exchange

Cooperation

Cooperation

JAEA-EDF Technical Cooperation on the FR Systems (Oct. 2008)

JAEA-CEA Framework Arrangement (Dec.2005)

Japan-France Collaboration

Fast Reactor WG
Fuel cycle WG etc.

JNEP (US-Japan Joint Nuclear Energy Action plan)

*Missions and Objectives were reviewed in Apr., 2009

Japan-US Collaboration

INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles)

TWG-FR (Fast Reactor Technology Working group)

IAEA

Concluding Remarks

- *The FaCT project launched in 2006. JAEA is carrying out the design and R&D of sodium-cooled fast rector (SFR) steadily, aiming at the realization of demonstration FR in 2025 and the deployment of commercialization FR around 2050.*
- *The development targets of FaCT project is consistent with the Generation-Ⅳ goals.*
- *The FaCT project comes near to the milestone of 2010, when we have to examine and decide continuation to investigate individual innovative technologies.*
- *International collaboration plays an important role in the effective development of FR cycle technology. We would like to encourage international collaboration.*