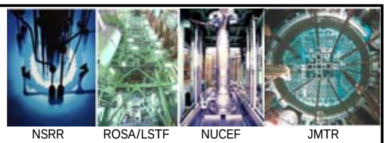


# Perspective on Long-Term Safety Research for New Reactors and New Technologies

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## Outline

- Nuclear Energy Policy in Japan
- **Advanced LWRs: "Next Generation LWRs"**
  - Development by Joint Project of METI, Utilities and Three Major Vendors
  - R&D for Seismic Isolation System
- **FBR**
  - FR Cycle Technology Development in Japan
  - Innovative Technologies for Safety Enhancement
  - R&D for Prevention of Re-criticality during CDA
- **HTGR**
  - Development toward "Hydrogen Society"
  - Technical Issues and R&D Plan
- Challenges for Safety Research

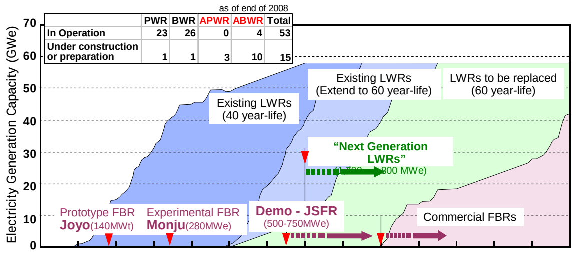


## Nuclear Energy Policy in Japan

- **Framework for Nuclear Energy Policy** (AEC, 2005)
  - Maintain nuclear power's share 30-40% or more even beyond 2030.
  - Prepare advanced LWRs for replacement of existing NPPs at around **2030**. Large LWRs are a prime candidate from scale merit.
  - Strive for commercial use of FBRs from around **2050** based on "FS on Commercial FBR Cycle" and operation of "Prototype FBR, Monju."

as of end of 2008

| | PWR | BWR | APWR | ABWR | Total |
|---|---|---|---|---|---|
| In Operation | 23 | 26 | 0 | 4 | 53 |
| Under construction or preparation | 1 | 1 | 3 | 10 | 15 |

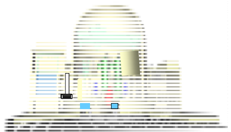


## "Next Generation LWRs" 3

Development by Joint Project of METI, Utilities and Three Major Vendors

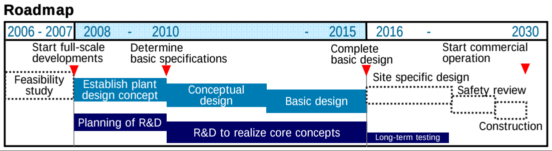
- In April 2008, METI with industries launched development of "Next Generation LWRs" aiming at coping with the need to replace existing NPPs in Japan after 2030. They are also expected to be a global standard design. The Institute of Applied Energy (IAE) undertakes overall management of this development program.

- **Six Core Concepts:**
  1) **Fuel with uranium enrichment above 5%**
     ⇒ High capacity factor, high burnup
  2) **Seismic isolation technologies**
  3) **Plant life of 80 years** and significant reduction of occupational dose
  4) Significant **shortening of construction period**
  5) **Optimized combination of passive and active systems**
  6) Innovative **digital technologies**



✓One PWR and one BWR
✓1,700 – 1,800 MWe class

- **Roadmap**




## "Next Generation LWRs" 4

R&D for Seismic Isolation System

### Background

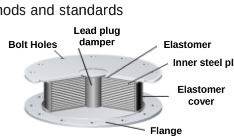
- Seismic risk is a dominant contributor in Japan.
- Regulatory Guide for Reviewing Seismic Design of NPPs (amended in Sep. 2006) requires evaluation of "residual risk". Plant specific seismic PSA is on-going.

### Goal

- **Standardized structural design** independent from site specific conditions enabled by application of seismic isolation system

### R&D Plan

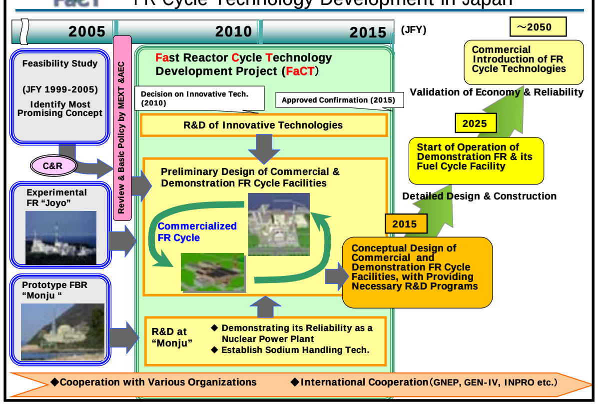
- Development of large-scale seismic isolation system
  - **Full-scale / Large-scale model tests in Phase II (FY 2011-2015)**
    - ✓Characterization/Demonstration of seismic isolation system
    - ✓Piping integrity at the interface between seismically isolated building and non-isolated ones, etc.
  - Development of evaluation methods and standards




*Seismic isolation system*

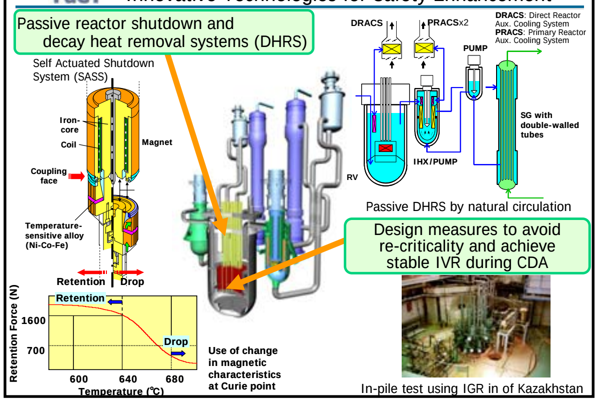
## Toward Commercialization of FBR 5

FR Cycle Technology Development in Japan



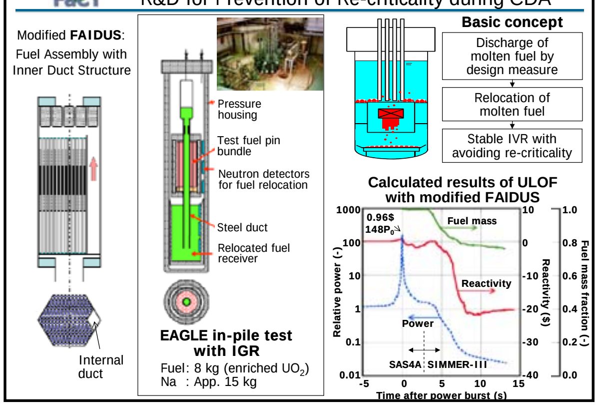
## Toward Commercialization of FBR
Innovative Technologies for Safety Enhancement






## Toward Commercialization of FBR
R&D for Prevention of Re-criticality during CDA

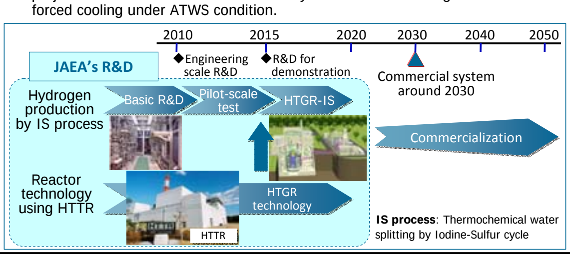




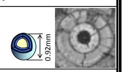

## HTGR Development toward "Hydrogen Society"



- Roadmap for Innovative R&D of Nuclear Energy against Global Warming (AEC, 2008)
  - One of the candidates is:
    - ✓ **HTGR technology and innovative hydrogen production technology by thermochemical water splitting**
    - ✓ It is expected to propose a prototype commercial system around 2020.
- "Safety Demonstration Tests" at HTTR planned to be conducted as OECD/NEA project will demonstrate its intrinsic safety characteristics during total loss-of-forced cooling under ATWS condition.



## HTGR Development toward "Hydrogen Society" 9
### Technical Issues and R&D Plan

| | Key Issues | JAEA's R&D Plan |
|---|---|---|
| Fuel (Coated fuel particles / Prismatic block type) | ▪ Fuel behavior under transient / accident conditions | ▪ Irradiation tests with HTTR, etc.<br>▪ RIA tests with NSRR  |
| | ▪ FP transport | ▪ HTTR operation data analysis |
| High temperature materials | ▪ Deployment of new materials with longer life | ▪ Deployment of carbon/carbon composite, etc.<br>▪ Development of structural integrity evaluation method<br>▪ Irradiation tests with HTTR, JOYO, etc. |
| Safety assessment | ▪ Upgrade of methods and models | ▪ Verification through "Safety Demonstration Tests" (OECD/NEA HTTR project being proposed)<br>▪ Development of PSA methods and application |
| Hydrogen production | ▪ Improvement of process efficiency | ▪ Pilot plant test of the thermochemical IS process |
| Process heat application | ▪ Coupling technologies between hydrogen production system and HTGR | ▪ Development of turbo-machinery and high temperature isolation technologies (high temperature valve, hot gas duct, etc.)<br>▪ Development of safety design guide for coupling |

## Challenges for Safety Research 10
### - Short Term and Mid Term -

- Under the environment of decreasing priority / budget for R&D on existing LWRs worldwide, major challenge is "**declining infrastructure** (facilities and expertise)" :
  - We need to maintain infrastructure while resolving current safety issues on such as:
    - ✓ Life extension, burnup extension, power uprate,
    - ✓ Use of risk information, PSA for external events, and
    - ✓ Radioactive waste disposal.
  - Lincensing and operation of new reactors would benefit from the availability of such infrastructure:
    - ✓ **ROSA** for system integral tests, RIA tests with **NSRR** for new fuel, **NUCEF** for criticality, **JMTR** for irradiation of new fuel / materials, and
    - ✓ Experience and knowledge on safety review and analysis.

**ROSA** : Rig of Safety Assessment
**NSRR** : Nuclear Safety Research Reactor
**NUCEF** : Nuclear Fuel Cycle Safety Engineering Research Facility
**JMTR** : Japan Material Testing Reactor

## Challenges for Safety Research 11
### - Long Term -

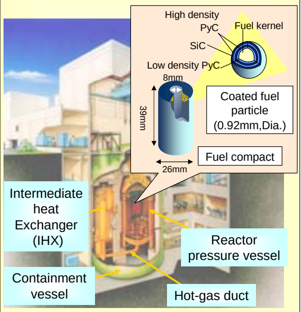
- Public expectations for new reactors would be directed toward "lower risks".
  - PSA would play a more prominent and fundamental role in the licensing process to deal with diverse design measures to cope with beyond-DBA scenarios.
  - Understanding of phenomena gained from R&D would play a vital role for high level of confidence on PSA.
    - ✓ Seismic isolation system,
    - ✓ Measures to avoid re-criticality during CDA,
    - ✓ Coupling between hydrogen production system and HTGR, etc.
  - For efficient use of available resources of both regulatory and industry sides, "regulatory – industry cooperation in R&D" with due consideration of regulatory independence will be a key.
  - International role- and cost-sharing with industry participation would become vital.

Appendix

## HTTR: High Temperature Engineering Test Reactor:

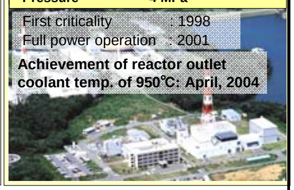
### HTTR

**Graphite-moderated and helium-cooled HTGR**




### Major specification

| | |
|---|---|
| Thermal power | 30 MW |
| Fuel | Coated fuel particle / Prismatic block type |
| Core material | Graphite |
| Coolant | Helium |
| Inlet temperature | 395 °C |
| Outlet temperature | 950 °C (Max.) |
| Pressure | 4 MPa |



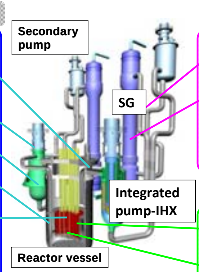

Appendix

## Toward Commercialization of FBR

### R&D needs

***Economic Competitiveness***

- ○ Reduction of Mass & Volume
  - ① Shortened 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 plates and reinforced concrete building
- ○ Long operation by high burn-up fuel
  - ⑦ Advanced fuel material




- ⑭ Plant design study (Demo-FR/Commercial-FR)
- ⑮ Large-scale sodium tests

***Enhanced reliability***

- ○ Sodium technology
  - ⑧ Sodium leak tightness with double-walled piping
  - ⑨ Higher reliable SG with double-walled tubes
  - ⑩ Higher inspection ability inside of sodium boundary

***Enhanced safety***

- ○ Core safety
  - ⑪ Passive shutdown and decay heat removal
  - ⑫ Re-criticality free core
- ○ Seismic reliability
  - ⑬ Seismic reliability in core assemblies