Civil Nuclear Development in Japan

Mitsuru UESAKA
Japan Atomic Energy Commission (JAEC)

Tohru SUZUKI
Tokyo City University

Ayako TAKEUCHI
Mitsubishi Heavy Industries, Ltd.

INSC Workshop, September 17, 2025

Contents

Japan Atomic Energy Commission (JAEC)

(as of July 2025)

Commissioners

Chairperson
Dr. UESAKA, Mitsuru

Commissioner
Mr. NAOI, Yosuke

Commissioner*
Dr. YOSHIHASHI, Sachiko

*. Term of Dr. OKADA Yukiko ended in June 2025;
Dr. YOSHIHASHI Sachiko appointed thereafter.

Decisions, Statements

White Paper on Nuclear Energy 2024, June 2025
https://www.aec.go.jp/en/kettei/hakusho/

Basic Policy for Nuclear Energy, February 2023
https://www.aec.go.jp/en/kettei/kihon/

Plutonium Utilization in Japan, October 2017
https://www.aec.go.jp/kettei/kettei/20171003_e.pdf

JAEC website

https://www.aec.go.jp/en/

White Paper on Nuclear Energy 2024

Special Report: Nuclear Technology Supporting Daily Life

Ch1. Lessons learned from the TEPCO Fukushima Daiichi Nuclear Power Station Accident and Efforts toward Reconstruction and Revitalization
Ch2. Safe Utilization of Nuclear Energy for Energy Security and Carbon Neutrality
Ch3. International Collaboration in Response to Global Trends
Ch4. Peaceful Use of Nuclear Energy, Non-Proliferation, and Nuclear Security
Ch5. Rebuilding Public Trust in Nuclear Energy
Ch6. Decommissioning and Radioactive Wastes Management
Ch7. Advancement and Application of Radiation and Radioisotope Technologies
Ch8. Promoting Innovation in Nuclear Energy Utilization
Ch9. Human Resource Development and Strengthening of Nuclear Supply Chain

The white-Paper booklet will be distributed after the presentation.

JAEC's Basic Policy for Nuclear Energy (Key Points)

Revised in 2023

1. "Basic Policy for Nuclear Energy" and Background of Revision

- A 'compass' to show long-term directions for the government nuclear policy and to define Basic Objectives and Important Initiatives.
- The former "Basic Policy for Nuclear Energy" was decided in July 2017, and it was approved to respect by the Government of Japan.
- It was decided to revise approximately every five years considering rapidly changing environment, and the JAEC started the revision in Nov. 2021. Having accumulated discussion with and hearing from experts, the new Basic Policy was approved in Feb. 2023.

2. Basic Idea

- Effective utilization of nuclear energy is important for Japan from the viewpoint of seeking for every possible option to secure energy supply and to realize carbon neutral society.
- On the other hand, nuclear energy can cause serious disasters when it is used in wrong ways.

⇒ It is important to utilize nuclear technology wisely, recognizing its 'pluses' and 'minuses' and paying full attention to safety.

3. Changes in Environment Surrounding Nuclear Energy

- Uncertainty over stable energy supply / Increased geopolitical risk
- Development and construction of innovative nuclear reactors worldwide / Extension of operating periods of existing nuclear power plants
- Expanded movement toward carbon neutrality
- Reaffirmation of ensuring the safety of nuclear facilities against terrorism and military threats

4. Important Initiatives

- To break away from the "safety myth" and promote the stable use of nuclear energy under the principle of ensuring safety as a major prerequisite. The government and the industry should play their respective roles, while carefully communicating with the public, without turning a blind eye to the issues related to radioactive waste treatment and disposal, as well as new issues that may emerge as a result of the development and construction of innovative reactors, in addition to improving the environment for smooth project implementation.
- The Government and the industry should work together to maintain and strengthen supply-chains and human resource development, which are fundamental for nuclear applications, not only in nuclear energy applications but also in non-energy applications.

1. Continue to reflect on the Fukushima Daiichi Accident and learn lessons.

2. Use nuclear energy for stable energy supply and carbon neutrality.

3. Proceed domestically and internationally based on global trends

4. Ensure peaceful use of nuclear energy, non-proliferation and nuclear security under international collaboration.

5. Rebuild public trust and confidence for using nuclear energy

6. Undertake decommissioning and radioactive waste management under the involvement of the government

7. Promote the utilization of radiation and radioisotopes

8. Facilitate innovations relevant to nuclear energy utilization

9. Strengthen human resource development

Action Plan for Promotion of Production and Utilization of Medical Radioisotopes (Outline)

31st May, 2022 Atomic Energy Commission, Japan

Background

Expectations for Radioisotope Therapy

- Increased focus on *"theranostics"* (therapy + diagnosis)

Movements and Problems in Japan

- *Restart of research reactors* that can produce large amounts of radioisotopes (JRR-3, "Joyo")

On the other hand, insufficient number of
- *Hospital beds* for radioisotope therapy
- *Human resources* who promote production and utilization of radioisotopes

International Situation

- *Vast investment* for radioisotope production and R&D
- Forming network of research reactors and accelerators
- Accelerated *competition for acquisition* of radioisotopes and their raw materials

Developing the Action Plan that aims to provide domestic radioisotopes to patients

The Action Plan contributes to
- Improvement of people's welfare by enhancing the medical system through cutting-edge nuclear science and technology
- Ensuring economic security in terms of medical services

Goals to be Achieved during next decade

①Establishment of a Stable Radioisotope Diagnostic System through *partial domestic production of Mo-99/Tc-99m*
②Implementation of *Radioisotope Treatment Using Domestic Radioisotopes*
③*Dissemination of Radioisotope Treatment* in Medical Setting
④Making Radioisotope-Related Fields, centered on Medicine, as a *"Strength" of Japan*

Contents of the Action Plan

(1)Promoting Initiatives for Domestic Production and Stable Supply of "Important Radioisotopes"

- Stable supply of *Mo-99/Tc-99m* using JRR-3 and accelerators (Manufacturing approximately *30% of domestic demand* by the end of FY2027 as far as possible, and supply to domestic)
- Strengthening R&D for mass production of *Ac-225* using "Joyo" and accelerators (Production demonstration by FY2026 with "Joyo")
- Strengthening efforts to commercialize *At-211* (Indicating usefulness as a pharmaceutical product by FY2028)

(2)Establishment of systems and structure to promote utilization of radioisotopes in medical setting

- Establishment of hospital rooms for radioisotope treatment (Average number of months to wait for radioisotope treatment: *3.8m (2018) ->2m (2030)*)
- Preparation for commercialization of new radiopharmaceuticals (Th-227, Ga-68)

(3)Promoting R&D Contributing to Domestic Production of Radioisotopes

- Technical development support for production by research reactors and accelerators
- Promotion of initiatives by the Fukushima International Research and Education Organization
- Establishment of systems of non-clinical studies of radiopharmaceuticals

(4)Strengthening Research Infrastructures, Human Resources, and Networks for Production and Utilization of Radioisotopes

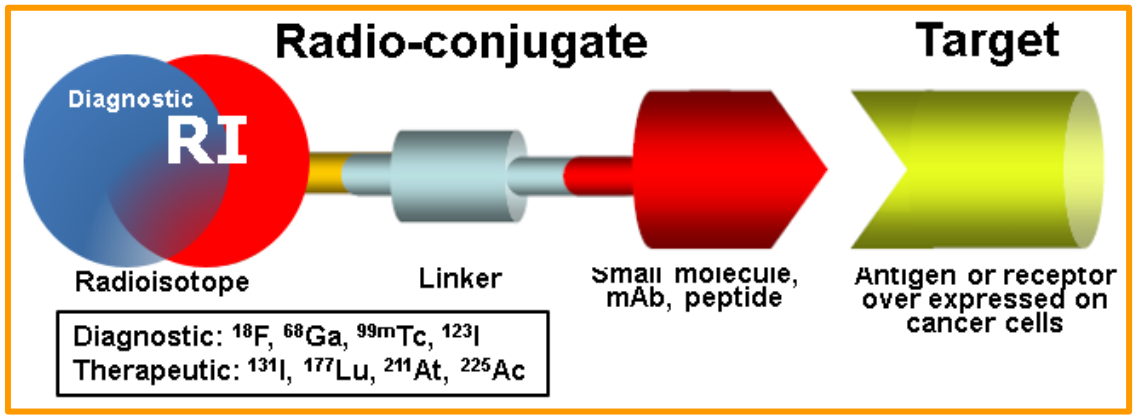
- Strengthening Human Resources in the Field of R&D and Medical Setting
- Strengthening the Supply Chain in line with Domestic Production
- Study of Mechanisms for Waste Treatment and Disposal

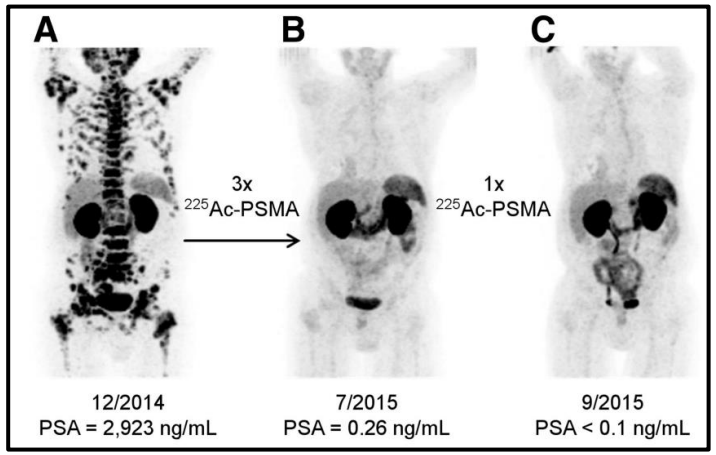
Radiation Application Highlight – Theranostics -

Theranostics is a concept of personalized medicine that combines diagnostics and therapeutics for each patient, using the same or similar diagnostic agent as the therapeutic agent, in order to 1) avoid harm to the patient and 2) ensure that the treatment is effective.

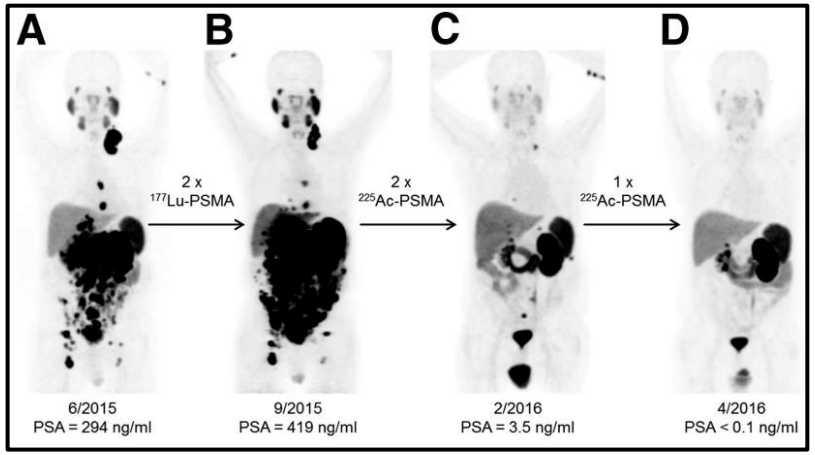
How it works?

Diagnostic or therapeutic isotopes bind to antibodies, peptides, or small molecules via chelation etc. Radio-conjugates bind specifically to antigens or receptors overexpressed on cancer cell membranes and emit radiation from those sites.





^{68}Ga-PSMA PET/CT scans of patient A. Pretherapeutic tumor spread (A), restaging 2 mo after third cycle of ^{225}Ac-PSMA-617 (B), and 2 mo after one additional consolidation therapy (C).



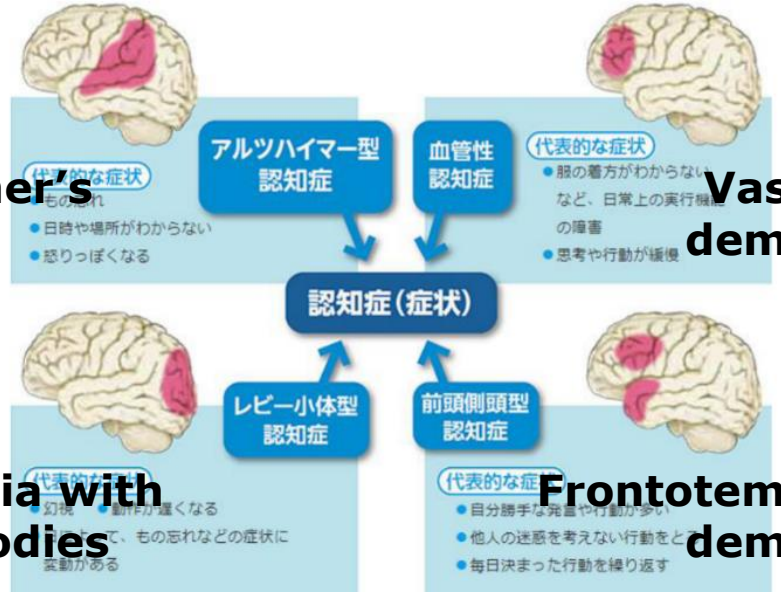
68Ga-PSMA-11 PET/CT scans of patient B. In comparison to initial tumor spread (A), restaging after 2 cycles of β-emitting ^{177}Lu-PSMA-617 presented progression (B). In contrast, restaging after second (C) and third (D) cycles of ^{225}Ac-PSMA-617 presented impressive response.

The left figures are notable for the fact that the ^{225}Ac-labelled agent has resulted in the complete remission of systemic metastases from prostate cancer.
However, the image is also symbolizing what theranostics is all about.
We can optimize the treatment plan precisely for each patient using theranostics technique.

Ref) Kratochwil et. al., "225Ac-PSMA-617 for PSMA-Targeted α-Radiation Therapy of Metastatic castration-Resistant Prostate Cancer", J. Nucl. Med. 2016, 57 (12), 1941-1944.

Diagnosis by Nuclear Medicine and Treatment of Alzheimer Dementia

Region-specific hypoperfusion associated with clinical symptoms

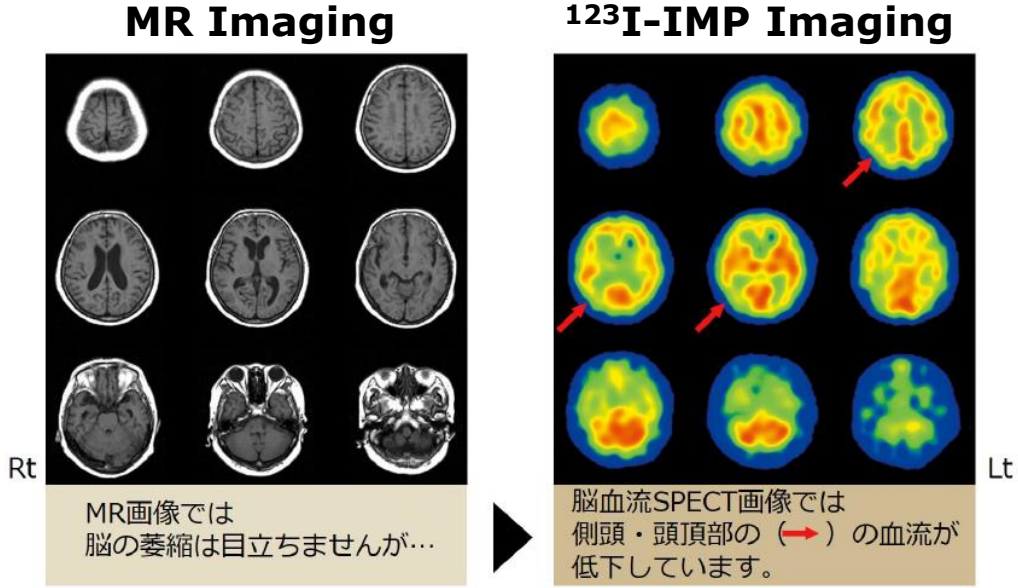


Alzheimer's disease

Vascular dementia

Dementia with Lewy bodies

Frontotemporal dementia



Source：Nihon Medi-Physics Co.,Ltd

Nuclear medicine scanner

SPECT(Mo99/Tc99m)

Amyloid b PET(C11, F18)

Source: SHIMIZU Keiji, Radiological Technology Department, Kobe City Medical Center General Hospital, 2025

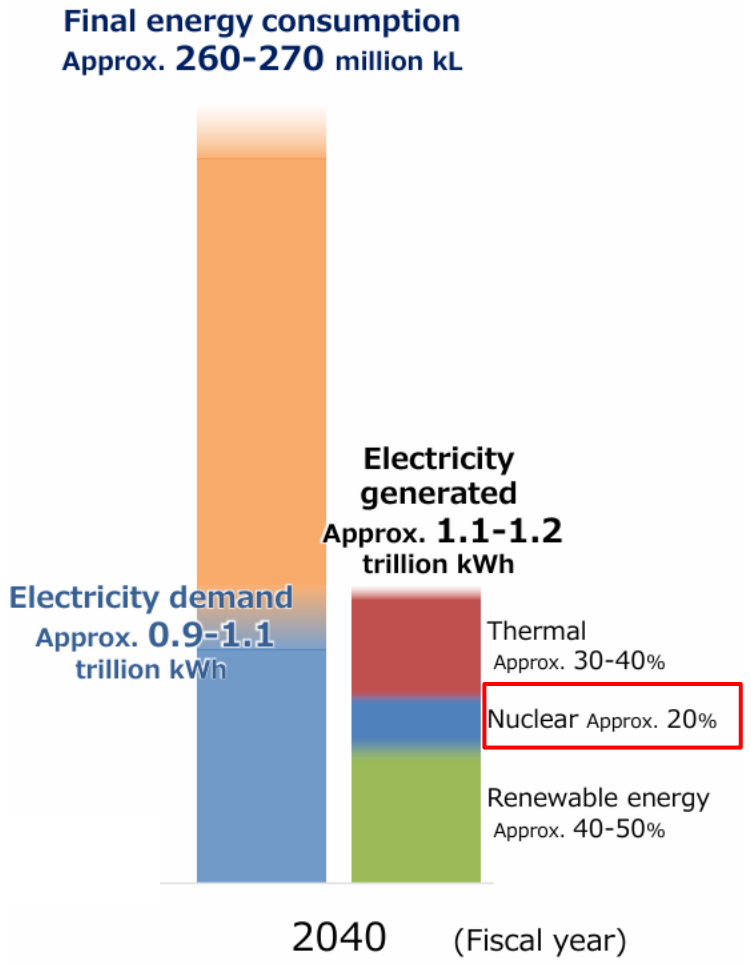
Lecanebab

Eisai Co., Biogen

The 7th Strategic Energy Plan issued in Feb. 2025

Strategic Energy Plan | Agency for Natural Resources and Energy

- Nuclear energy is designated as a power source that significantly contributes to national energy security, decarbonization, affordability, and exhibits minimal cost volatility.
- The plan presents a policy to replace existing nuclear reactors with next-generation advanced reactors in order to promote the use of nuclear power as a decarbonized energy source.
- In the energy supply and demand outlook, the electricity mix for fiscal year 2040 is expected to include nuclear power with a share of **approx. 20%**.



The energy supply and demand outlook

Current status of NPPs in Japan

- 14 nuclear reactors have been restarted, and four have been granted safety assessment approval by the NRA. (Sep. 2025).
- In 2024, Onagawa NPS Unit 2 and Shimane NPS Unit 2 resumed commercial operations. These were the first BWRs restarted after the Fukushima Daiichi accident.

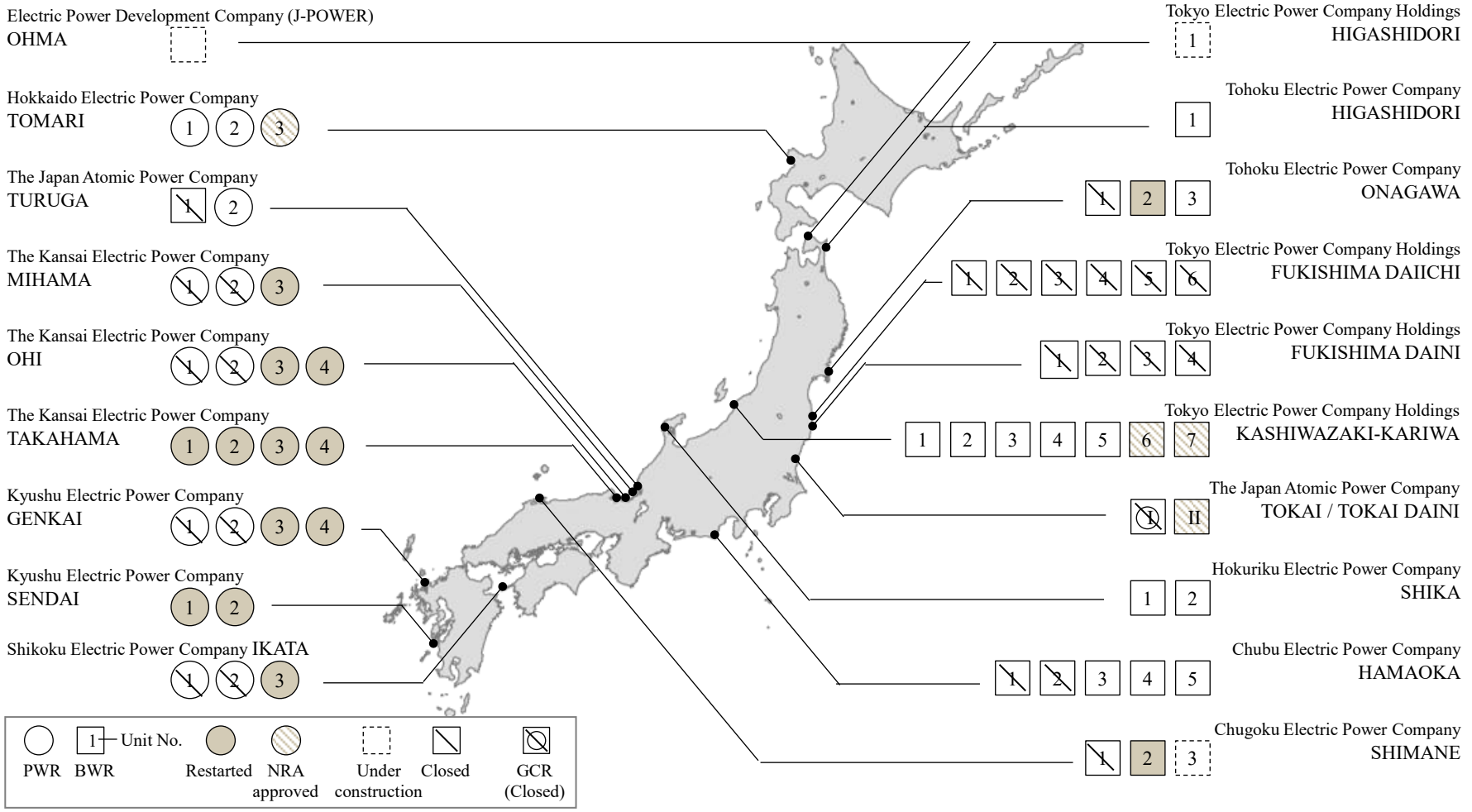
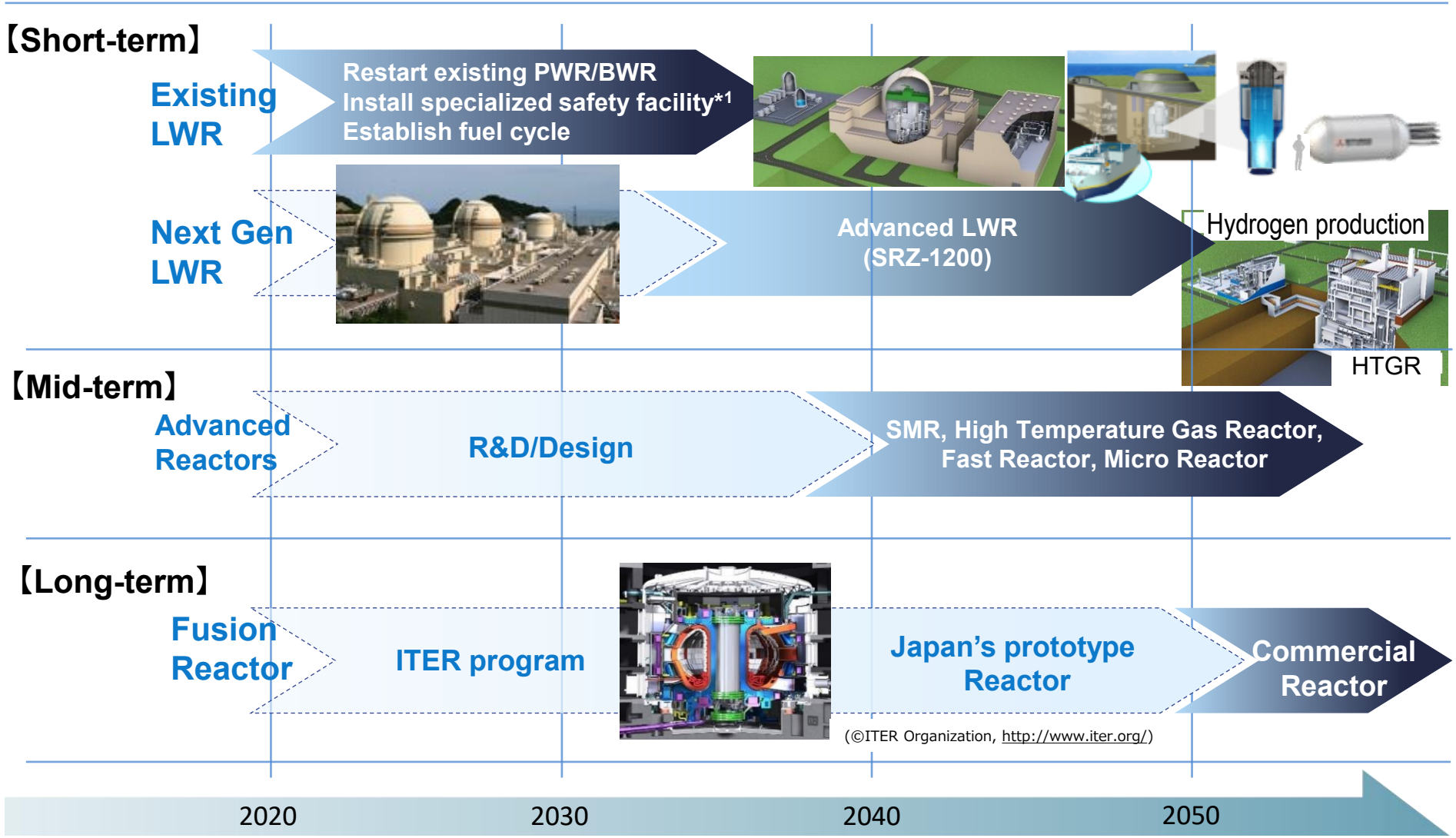


Figure Current status of Nuclear Power Plants in Japan (as of September 2, 2025)
Source: Modified from Mimaki, Yamamoto, et. al., Pressurized Water Reactors, JSME Series in Thermal and Nuclear Power Generation Vol. 6, 2024

Roadmap of Civil Nuclear Development



*1 Specialized safety facility: Facility designed to safely shut down the plant in the event of of intentional airplane crashes or other terrorism.

Line-up of Advanced Reactors

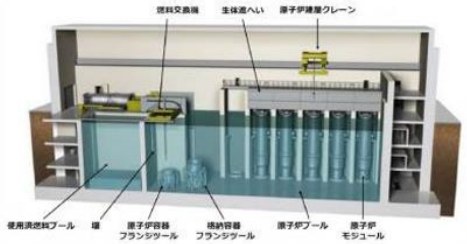
Cabinet Decision/The 7th Strategic Energy Plan (Feb. 2025)

- **Maximum utilization of existing plants**
  - Acceleration of the **restart of nuclear power plants**
- **Development of advanced reactors**
  - Deployment of **next-generation advanced reactors** within the sites where decommissioning has been decided

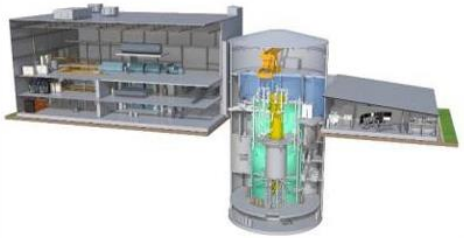
1) Advanced LWR

SRZ-1200, MHI

2) SMR (Small Module Reactor)



VOYGR, NuScale



BWRX-300, Hitachi-GE

3) Fast Reactor

Joyo,JAEA

4) HTGR

HTTR, JAEA

5) Fusion Reactor

ITER

The next generation advanced reactors

1) Development of Advanced LWR

● Plant features

- ➢ New safety measures and advanced technologies to be incorporated from the design stage
- ➢ Strengthened functions for preventing accidents and mitigating their consequences
- ➢ Achievement of highest-level safety

● Current status of development in Japan

- ➢ **MHI** is developing a standard plant design of **SRZ-1200** with Japanese PWR Utilities.
  - Basic design is almost completed
  - Various experiments and tests for licensing are progressing smoothly
- ➢ Japanese PWR Utilities started discussions with Japanese NRA in Dec. 2024, aiming at enhancing foreseeability of regulations regarding their applicability to new plant design features.

2) Development of SMR (Small Module Reactor)

● Plant features

- ➢ Small LWR with an output of 300MW or less
- ➢ Core cooling by natural circulation (without cooling pump or external power)

● Current status of development in Japan

- ➢ In US and Canada, development of SMR is underway aiming the operation start before 2030 in order to supply power to data centers.
  - The CNSC has approved OPG to begin construction of the first **BWRX-300** in the **Darlington** site.
- ➢ Japan supports participation of Japanese companies in overseas projects and R&D.
  - **Hitachi-GE** is participating in the joint development of the **BWRX-300** and plans to utilize Japan's domestic supply chain to **provide key equipment** such as reactor internal structures.

(*Source*: Hitachi GE Vernova Nuclear Energy)

(*Source*: Ontario Power Generation website)

3) Development of Fast Reactor

● Plant features

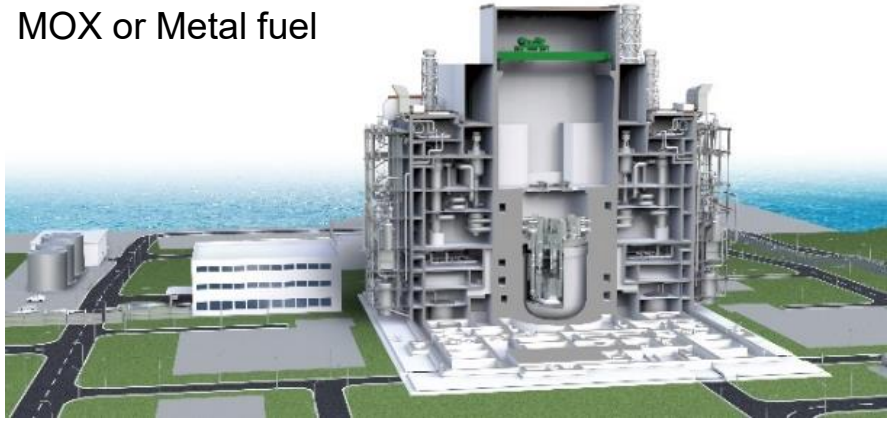
- ➢ Sodium coolant for efficient plutonium combustion
- ➢ Improvement of effectiveness for Nuclear Fuel Cycle by reducing waste volume and toxicity

● Current status of development in Japan

- ➢ A project of **Demonstration Fast Reactor** development utilizing GX Transition Finance began in 2023.
- ➢ Knowledge gained from domestic reactors (**Joyo**/ **Monju**) and Japan-France joint development will be incorporated, as well as lessons learned from the Fukushima Daiichi Nuclear Power Plant accident and international safety design standards to enhance safety.

Main features of Demonstration Fast Reactor

Electric output: 600MW class
Sodium-cooled Tank Reactor
MOX or Metal fuel



- Enhancing Safety
- High Technology Maturity
- Expansion to Diverse Outputs

4) Development of HTGR (High Temperature Gas-Cooled Reactor)

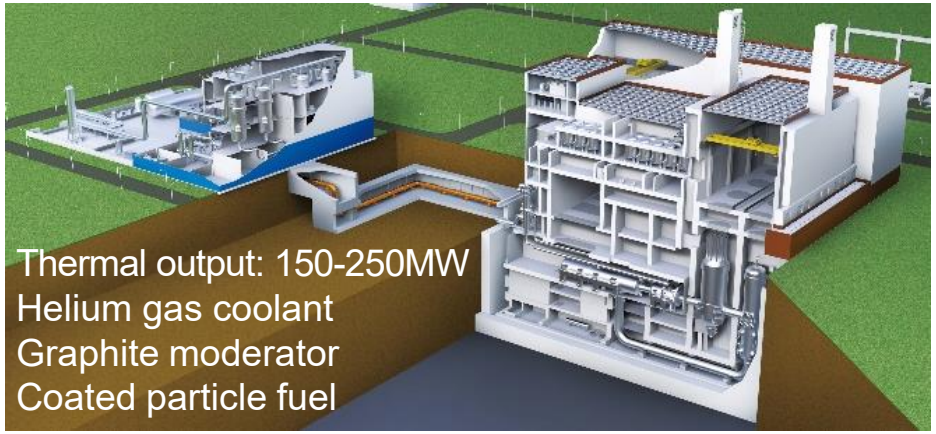
● Plant features

- ➢ Hydrogen production by utilizing high-temperature in addition to electricity generation
- ➢ Helium coolant due to its chemical stability
- ➢ Natural cold shutdown even if the cooling function is lost, due to graphite moderator

● Current status of development in Japan

- ➢ A **project of demonstration reactor development** utilizing GX Transition Finance began in 2023.
- ➢ Aiming to **hydrogen production tests** using research reactor **HTTR**※, an application for modification permission was submitted to NRA in Mar. 2025.
- ➢ Based on the technology and knowledge gained from HTTR, **demonstration of HTGR** aims to scale up and realize stable hydrogen production through high-temperature heat supply.

Main features of HTGR



- Inherent safety prevents core meltdown in case of accident
- Scaling up and increasing output based on HTTR technologies
- Stable large-scale H2 production by high temperature (900°C)

*HTTR: High Temperature engineering Test Reactor (https://www.jaea.go.jp/04/o-arai/nhc/en/faq/httr.html)

5) Development of Fusion Reactor

● Plant features

- ➢ Power generation using thermal energy obtained from nuclear fusion reactions

● Current status of development in Japan

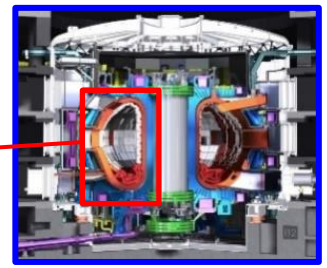
- ➢ US startups have announced their efforts aiming to commercialized fusion energy around 2030.
- ➢ The International Experimental Reactor **ITER** Project and the Domestic Research Reactor **JT-60SA** Project are being promoted.
- ➢ The global movement and venture activities for fusion development are growing.
- ➢ **MHI** will contribute to fusion development by actively participating in the ITER project and the response to prototype reactors.

JT-60SA (Ibaraki, Japan)

【**Purpose**】
To support research for ITER & prototype reactors

ITER (France)

【**Purpose**】
Scientific/Technical Demonstrations of Fusion



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

【Toroidal Field(TF) Coil for ITER】
Long & large equipment required high-precision manufacturing
MHI is the world's first to ship 5 TF coils

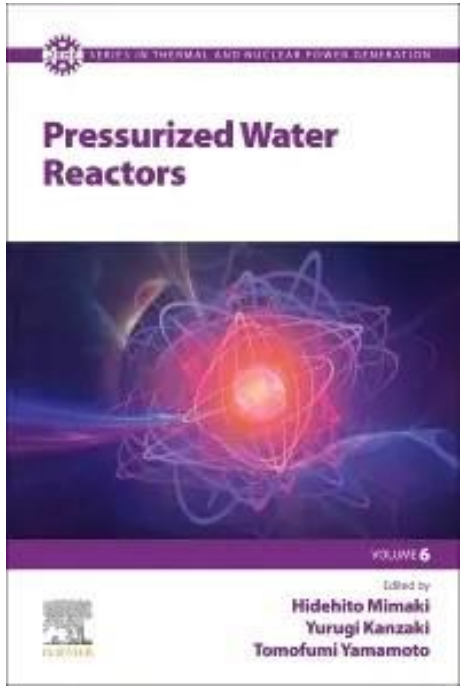
Prototype Reactor

【Purpose】
Stable power generation & economic demonstration

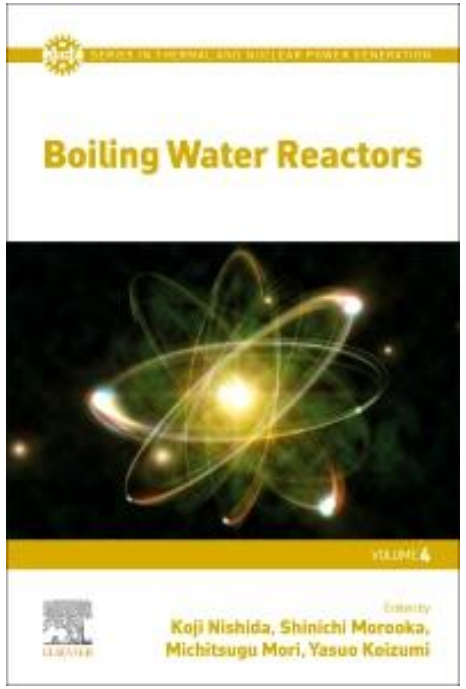
Practical use

JSME Series in Thermal and Nuclear Power Generation

- This series documents the development of thermal and nuclear power generation technologies in Japan up to the present day.
- The PWR and BWR volume outlines the evolution of these commercial reactors, from initial deployment to current state-of-the-art technologies.



Vol.6: Pressurized Water Reactors (PWR)
Editors: Mimaki, Kanzaki, Yamamoto
https://shop.elsevier.com/books/pressurized-water-reactors/kanzaki/978-0-12-823583-6



Vol.4: Boiling Water Reactors (BWR)
Editors: Nishida, Morooka, Mori, et al.
https://shop.elsevier.com/books/boiling-water-reactors/nishida/978-0-12-821361-2

Vol.1 : Fundamentals of Thermal and Nuclear Power Generation
Vol.2 : Advances in Power Boilers
Vol.3 : Sodium-cooled Fast Reactors
Vol.5 : High Temperature Gas-cooled Reactors