Japan's Nuclear Energy Policy: Current Status and Issues

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After Dinner Lecture at the 4th Annual Asia-Pacific Nuclear Energy Forum
on Small and Medium Reactors (SMRs): Benefits and Challenges

June 17, 2010

Japan Atomic Energy Commission

- The Commission is composed of five commissioners appointed by Prime Minister with the Diet's consent for three-year term. One of them is appointed as the Chairman.





- Its role is to plan, deliberate, and decide on the basic policies to promote the research, development and utilization of nuclear energy, except those to regulate their safety that are assigned to the Nuclear Safety Commission.
- Its performance goal is to assure transparency and openness of policy making process so that the public have a opportunity to meaningfully participate in its policy making.
- It has no authority to request the budgets for specific activities necessary for implementing the policies.

JAEC's Strategic Policy Goals For Facilitating Nuclear Energy Utilization

- Maintain proper infrastructure for the promotion of safe, secure and safeguarded utilization of nuclear energy, and make the share of nuclear power in electricity generation greater than 40 % in 2030.
- Reprocess used-fuel from LWRs within the domestically available capability and utilize fissile material thus recovered in LWRs for the time-being, and dispose the vitrified high-level radioactive waste from reprocessing process into geological repository.
- Promote nuclear energy technology research and development (R&D) efforts, including those aim at commercializing fast breeder reactor and its fuel cycle technology that can attain better fuel utilization and waste minimization before 2050.
- Promote international cooperation for assuring safe, secure and safeguarded utilization of nuclear energy in every part of the world and pursue mutually beneficial international cooperation in nuclear energy technology R&D activities for better utilization of resources.

Outline

1. Nuclear Power Generation
2. Nuclear Fuel Cycle
3. Nuclear Energy R&D Efforts
4. International Cooperation
5. Conclusion

Nuclear Power Generation: Current Status

- As Tomari-3 started operation in last December, 10 electric power companies are currently operating 54 LWRs (49 GWe) that supply about 30% of electricity.
- Tsuruga-1 started operation beyond 40 years in April this year and Mihama-1 will do so in December.
- The nuclear power contributes to the reduction of the 300 Mt CO2 emission annually: it also contributes to the increase in Japan's energy self-supply ratio from 4 % to 16 %, if it is categorized as an indigenous energy source.
- 2 units are under construction and 3 applications to construction permit are in the regulatory review process. Electric utilities plan to start operation of 8 more plants in ten years.

Nuclear Power Generation: Issues

- The government hopes that the share of nuclear power in power generation will be increased to 49% in 2030 as a part of actions to combat global warming. How can we do them?
  - Improve the capacity factor of operating plants, continuing safe operation through strong risk and quality management and
  - Promote the ageing management of long life plants with a view to continuing their operation beyond 40 years and explain its effectiveness, as everyone has observation of life's pathos owing to ageing that causes diminishing strength, flexibility, beauty etc.
  - Promote the construction of new plants, informing the public the importance of nuclear energy for both assuring energy security and combating global warming and facilitating cooperation among utilities, including joint investment for better utilization of available sites.

Nuclear Power Generation : Results of Pubic Opinion Survey

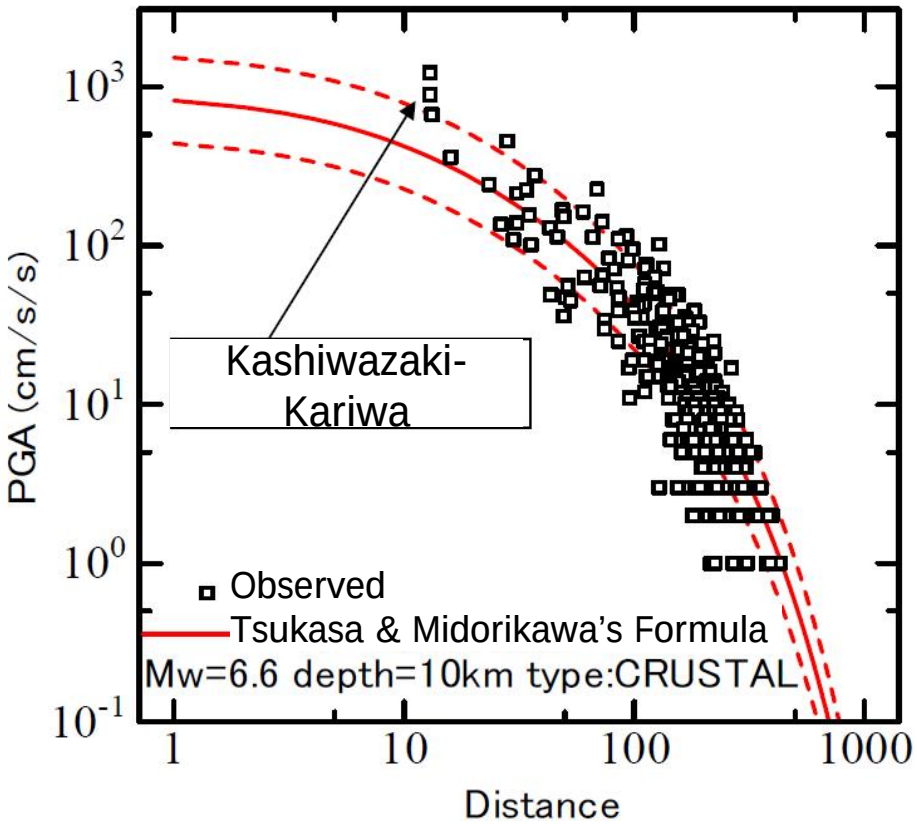
	2005	2009
• Promotion or phase out		
– Positively promote	8.0%	9.7%
– Cautiously promote	47.1%	49.8%
– Maintain status quo	20.2%	18.3%
• Feel easy or feel uneasy		
– Feel Easy	4.4%	6.1%
– Feel easy on balance	20.4%	35.7%
– Feel uneasy on balance	48.1%	43.4%
– Feel uneasy	17.8%	10.5%

✓ Why feel uneasy: accident is probable: accident has occurred. Japan is a country with frequent earthquakes.

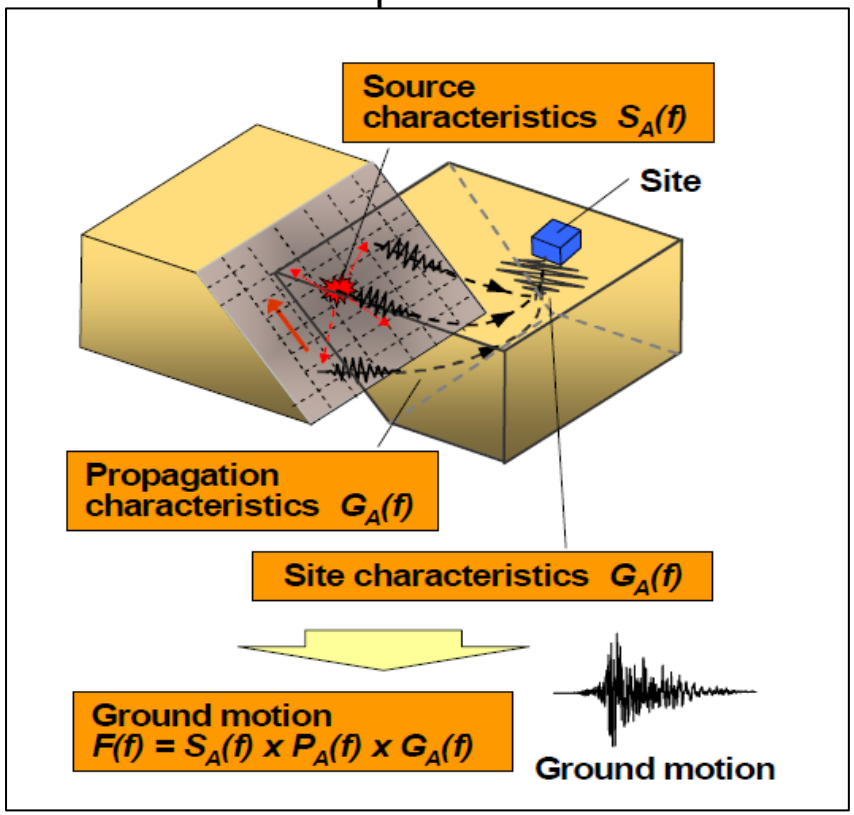
Nuclear Power Generation: The Priority Task is to Maintain Public Confidence.

- Ensure openness and assure the public meaningful participation in regulatory decision making processes, as local governments can ask the operator to put off the start of new activities and or the restart from unplanned outages by reason of public uneasiness.
- Complete the review of the seismic safety of all units in accordance with NSC's new seismic safety review guideline as soon as possible, taking into consideration the lessons learned from the 2007 seismic event at Kashiwazaki-Kariwa plant in which we experienced seismic motion significantly exceeding the design basis seismic motion.

Lessons Learned from the 2007 Seismic Event at KK NPP



The Concept of "Fault Model"



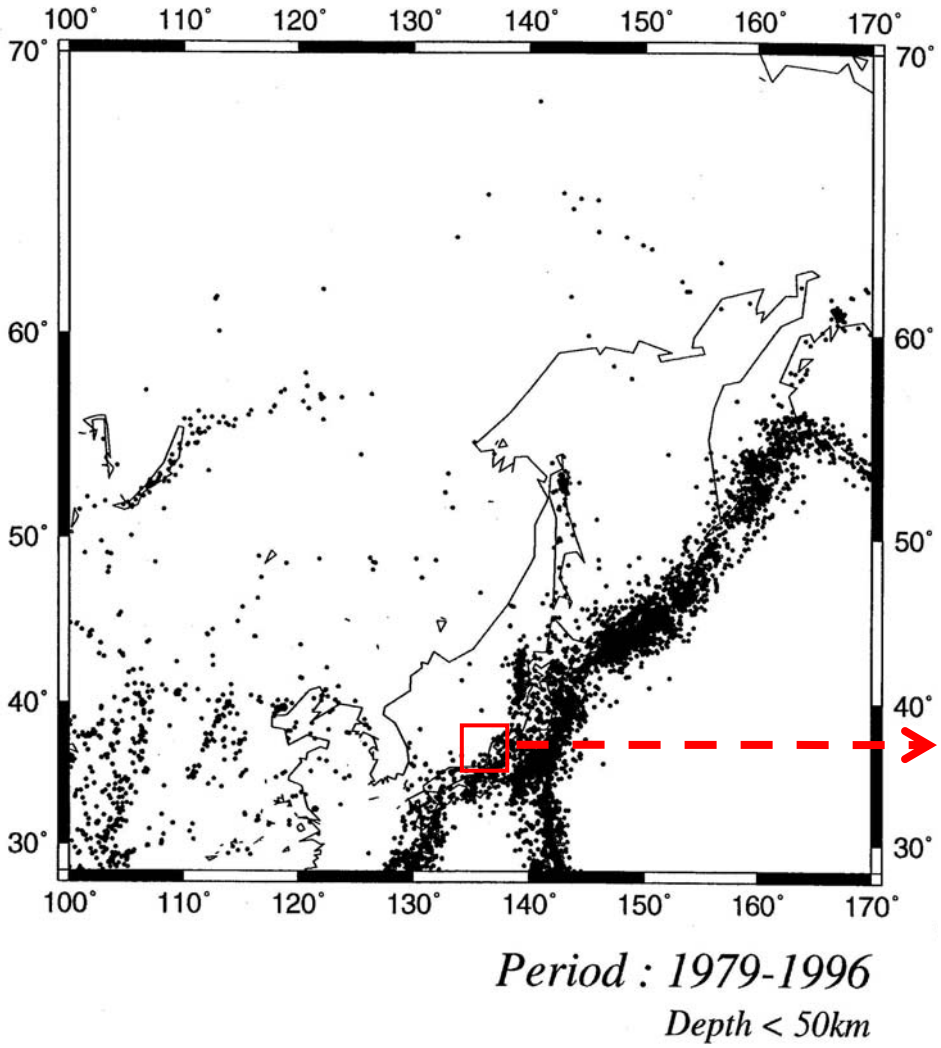
- We could reproduce the ground motion at the site by using **"fault model"** in which not only the source characteristics (number of asperities, their sizes and locations on the fault) but also the propagation characteristics of crust geological structure (such as folding structure) and the site characteristics (such as low velocity sediment layers in the free base stratum under the plant) are considered.

Assurance of Seismic Safety

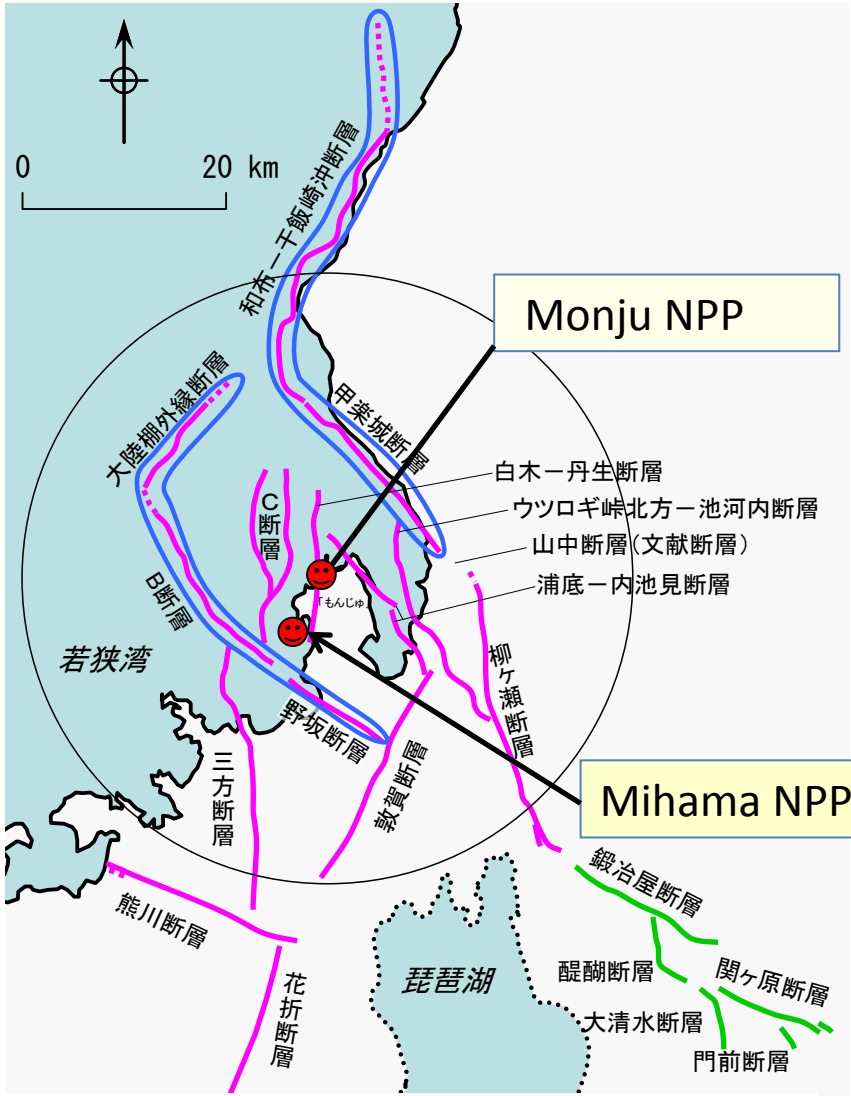
- As Japanese islands were formed as a result of collision of Eurasian plates, North-American plates, Pacific plates and Philippine Sea plates, there are many active faults in the crust where the islands are located as well as on and in the subducting plates.
- Each plant operator is now required by the new guideline to review the earthquake motion to be caused by nearby faults, utilizing the fault model as appropriate in determining the design base seismic motion for the plant.

Epicenter Map in Northeast of Asia*

*Preliminary Determination of Epicenters (PDE), USGS/NEIC



Active Faults around Monju and Mihama NPPs



Current Status: KK-1, 6, 7 resumed operation completing the review.
The review of all units in Japan will be completed in a year.

Outline

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Nuclear Fuel Cycle: Front-End Activities

- Uranium supply
  - Utilities have concluded long-term contracts with various uranium suppliers in diverse areas and participated in mining projects in Canada, Kazakhstan etc.
- Uranium enrichment services
  - Utilities have concluded long-term contracts with major suppliers
  - A small fraction of the demand has been supplied by the JNFL Rokkasho Enrichment Plant: JNFL has started the introduction of the advanced centrifuge machine, replacing the existing machine, with a view to bringing the capacity up to 1,500 t SWU/ year, within about 10 years.

Used Fuel Management

- One-third of used fuel generated in the past was reprocessed mostly in France and UK, and about 1000 tons in JAEA's Tokai Reprocessing Facility. Remaining two-thirds have been stored and will be reprocessed in the Rokkasho Reprocessing Plant (RRP) .
- Out of 40,000 tons to be generated during 2009 – 2046, 16,000 tons will be reprocessed in RRP and 24,000 tons will be stored at reactor and away-from-reactor storage facilities : they will be reprocessed at the second commercial reprocessing plant in the future.
- This year the RFS started the construction of used fuel storage center for TEPCO and JAPC in Mutsu, Aomori Prefecture.

Utilization of Pu Recovered

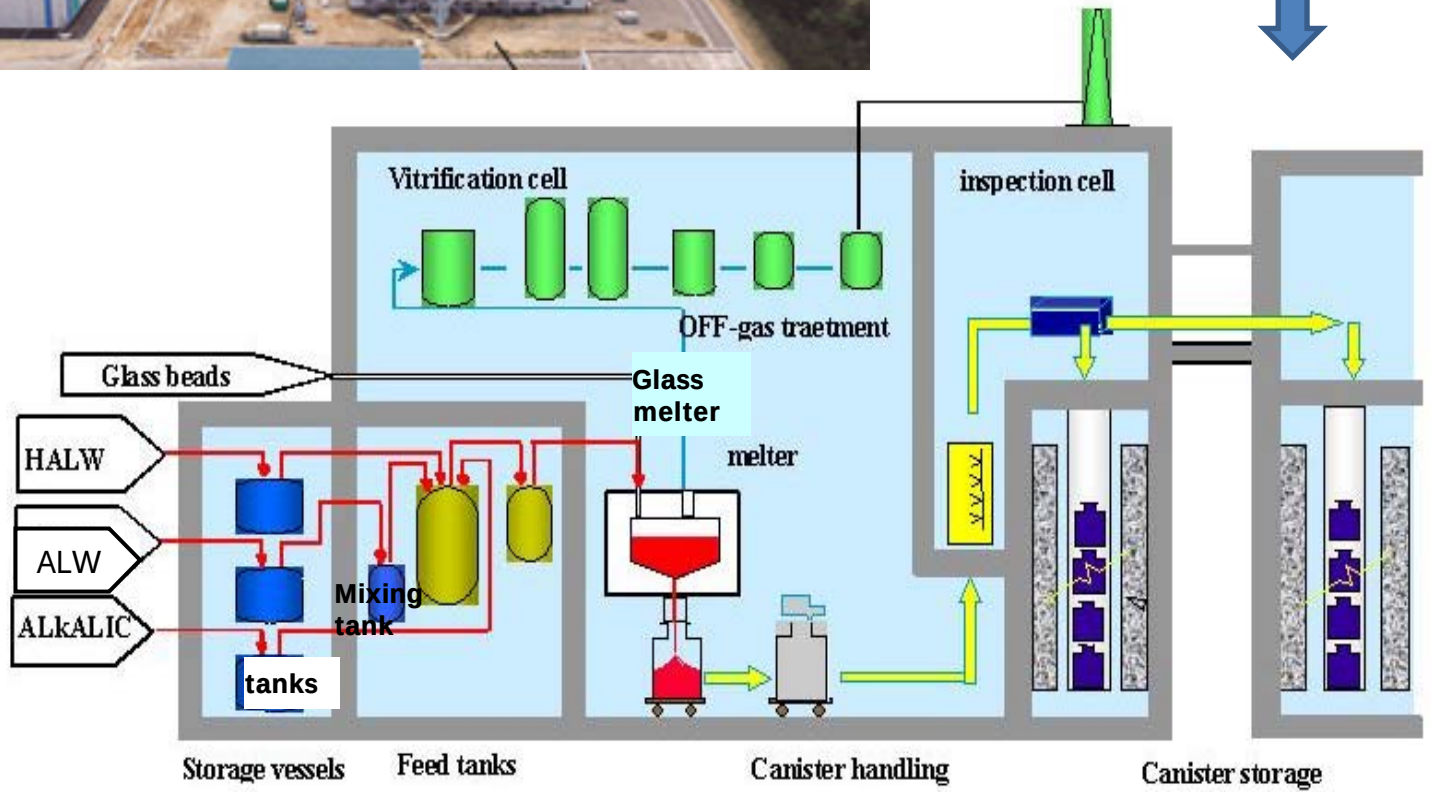
- Pu-U mixture recovered at Tokai Reprocessing Facility has been fabricated into MOX fuel for prototype ATR Fugen, Experimental FBR Joyo and prototype FBR Monju.
- The utilization of Pu recovered by European Reprocessors has been started: it is fabricated into MOX fuel for LWRs in Europe and used in Japan: Currently 7 LWRs (including Ohma ABWR of which core will be fully loaded with MOX fuel) were licensed to partially load MOX fuel and Genkai -3 started the operation, loading MOX fuel since last November and Ikata -3, since March this year.
- The Pu- U mixture to be recovered at RRP is to be fabricated into MOX fuel for LWR. The Rokkasho MOX fuel fabrication plant is under construction and will start operation in 2015.

JNFL's Rokkasho Reprocessing Plant

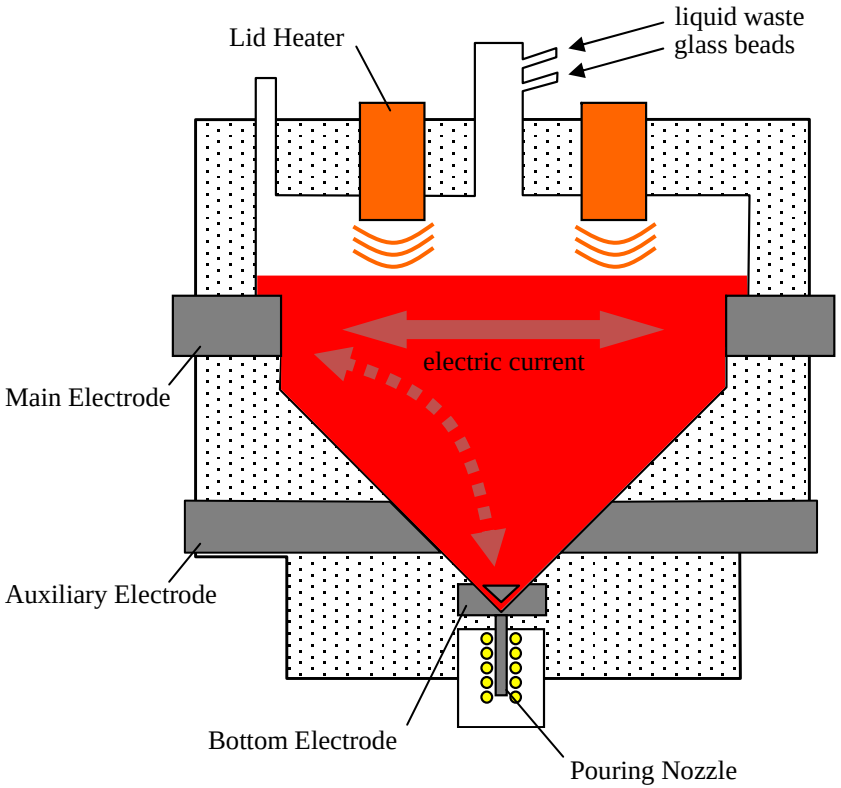
- The completion of commissioning test has been delayed several years due to a series of trouble in establishing operational procedure of the joule-heating ceramic glass-melter in the high-level waste vitrification line.
- Currently JNFL is struggling to recover a piece of broken refractory brick laying in the bottom of the melter.
- The JNFL announced that they would complete the test in October 2010.

Rokkasho Reprocessing Plant

Vitrification Facility of RRP



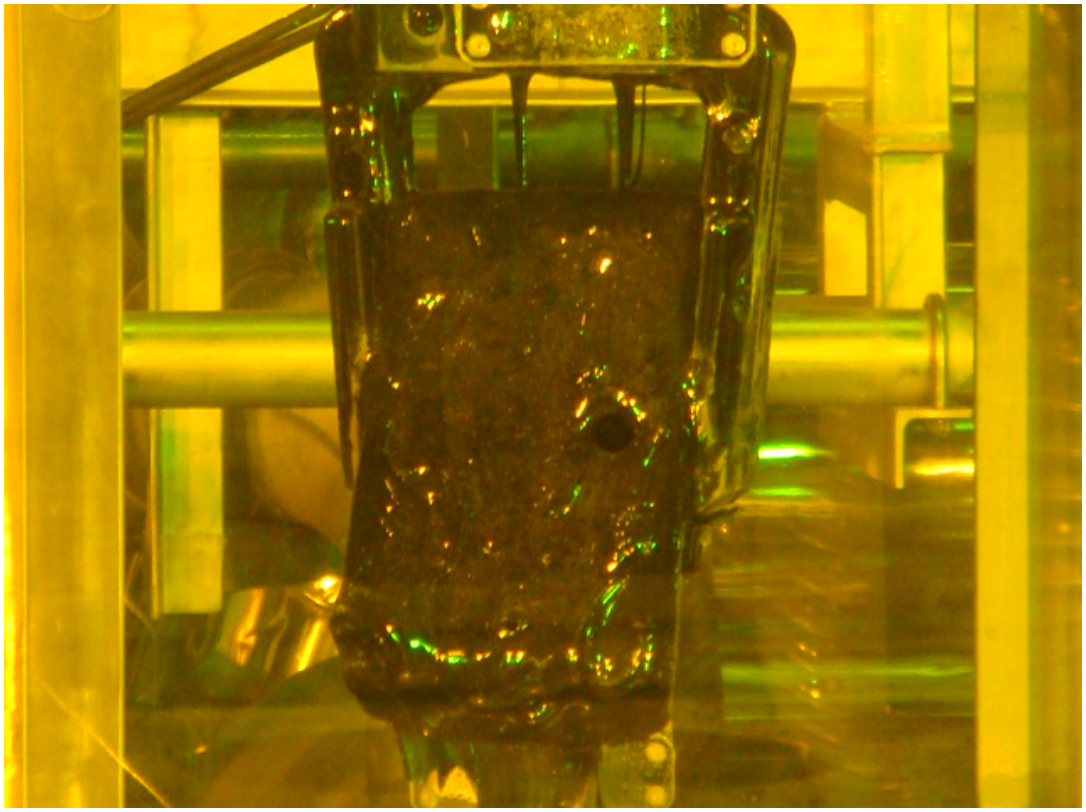
Joule Heating Ceramic Glass Melter (JHCGM) at RRP



Cross section of JHCGM

- Liquid waste and glass beads are melted by direct current heating.
- The glass at bottom area is heated by direct current between the main electrode and the bottom electrode.
- Molten glass is poured periodically to a stainless steel canister.
- Pouring Nozzle is heated by high frequency induction heater.
- One canister was manufactured every 16 hours.

Picture of the brick recovered yesterday



Geological Disposal of HLW: History

1985: AEC asked JAEA (PNC at that time) to study the feasibility of geological disposal of HLW in Japan.

1999: JAEA (JNC at that time) published a report on the technical feasibility of geological disposal of HLW in Japan.

2000: AEC asked Government to establish new organizations that promote the siting, construction and operation of the geologic repository and Nuclear Waste Management Organization (NUMO) was established.

2002: JAEA(JNC at that time) started the construction of two underground research laboratories, aiming at improving the reliability of disposal technology.

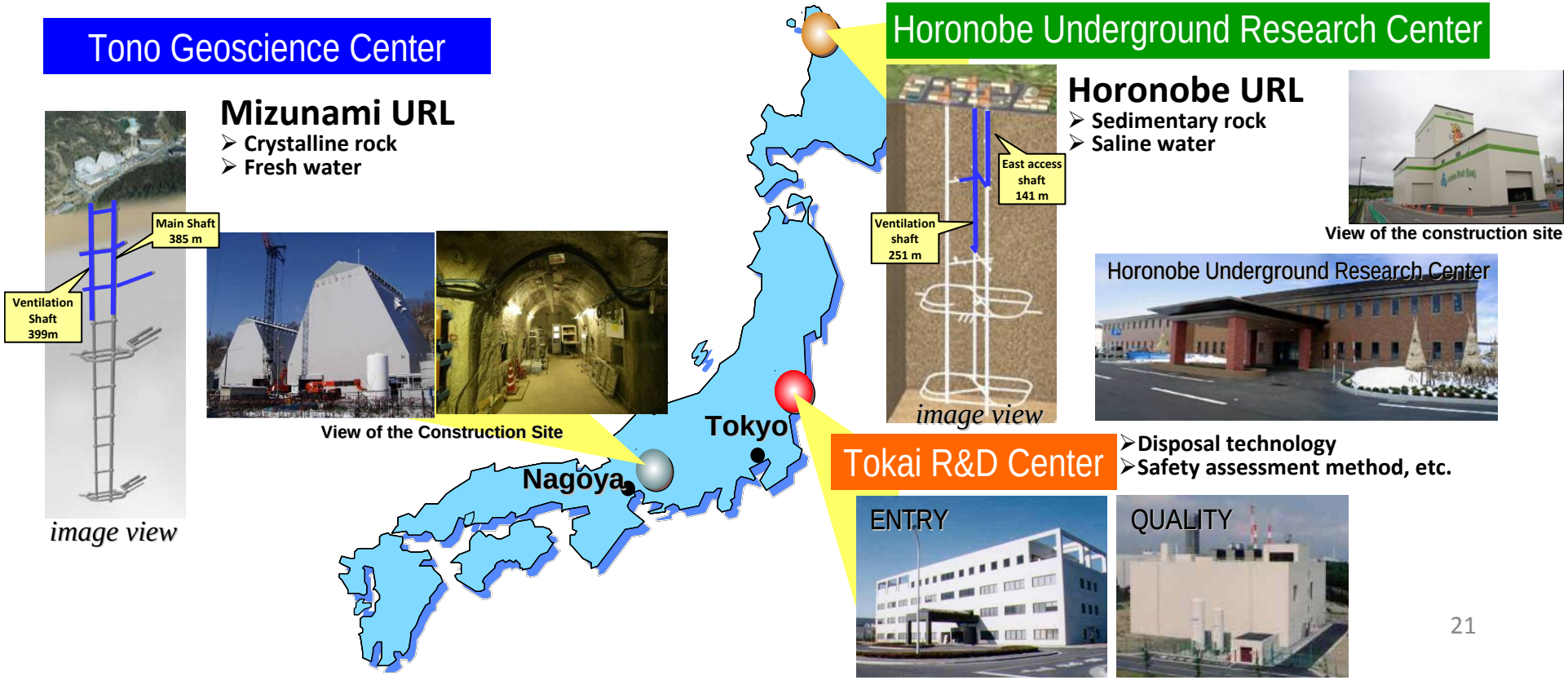
Geologic Disposal of HLW: JAEA's R&D Efforts

OBJECTIVE:

- To develop technical basis for disposal project and for safety regulations

ACTIVITIES:

- Demonstrate engineering technology and safety assessment methods
- Develop integrated methods for characterizing the deep geological environment
- Develop knowledge basis for promoting geological disposal activities



Geologic Disposal of HLW: Siting of Geologic Repository

- In 2000, the AEC decided that activities related with the disposal of HLW should be promoted in an open and transparent way and the site of the disposal facilities should be determined based on the application from municipalities.
- In 2004, the NUMO, an organization authorized to promote the disposal activity, started to invite mayors of municipalities to apply for site suitability investigation.
- In five years no mayor had successfully applied: we witnessed that even the announcement of a mayor to study the merit and demerit of the application paralyzed the administrative affairs of the municipal office due to rallies and demonstrations to protest the announcement as well as the intense media attention.
- The AEC asked the Government and the NUMO to strengthen the public outreach activities in 2008.

Geologic Disposal of HLW: Siting of Geologic Repository (cont'd)

- The Government and the NUMO have started to strengthen public information activities on the safety and the importance of the geologic repository and the merit of entertaining the siting of the repository that can be expected from the principle of equity of benefit.
- 2009 public opinion poll:
  - Our generation should decide the site without delay: agree (51.9%): agree on balance (30.3%).
  - How do you think when your or your neighboring municipality plan to accept a HLW repository: affirmative (3.2%): affirmative on balance (12.9%); negative on balance (34.3%); negative (45.3%).
- How can we overcome the NIMBY syndrome?: The AEC asked to continue to talk about safety, responsibility, benefit, and give the opportunity to see the related facilities including mock up facilities: a picture is worth a thousand words.

Outline

- JAEC's Strategic Policy Goals
- Nuclear Power Generation
- Nuclear Fuel Cycle
- Nuclear Energy R&D Efforts
- International Cooperation
- Conclusion

R&D Portfolio for Pursuing Sustainable Nuclear Energy Technology

- **Basic and generic R&D**: for sustaining expertise in nuclear science and engineering, including material science, earthquake engineering, advanced modeling and simulation, advanced safeguards technology, etc.
- **Short and medium term R&D**: for assuring safe, reliable and efficient operation of LWR and its fuel cycle, and commercializing advanced LWRs with reduced capital cost, robustness in maintaining safety and reliability and improved human consciousness.
- **Long-term R&D**: for developing fourth generation nuclear energy technology, focusing on the fast reactor and its fuel cycle, hydrogen generation and fusion energy

Short and Medium-Term R&D Efforts: Treatment of Radioactive Wastes from R&D Activities

<u>High Level Waste Glass Melter</u>

- Noble metal control
- Maintenance technology
- Advanced Simulation
- Advanced melter

<u>Low Level Waste Treatment</u>

- Nitrate Decomposition
- Cementation
- High compaction

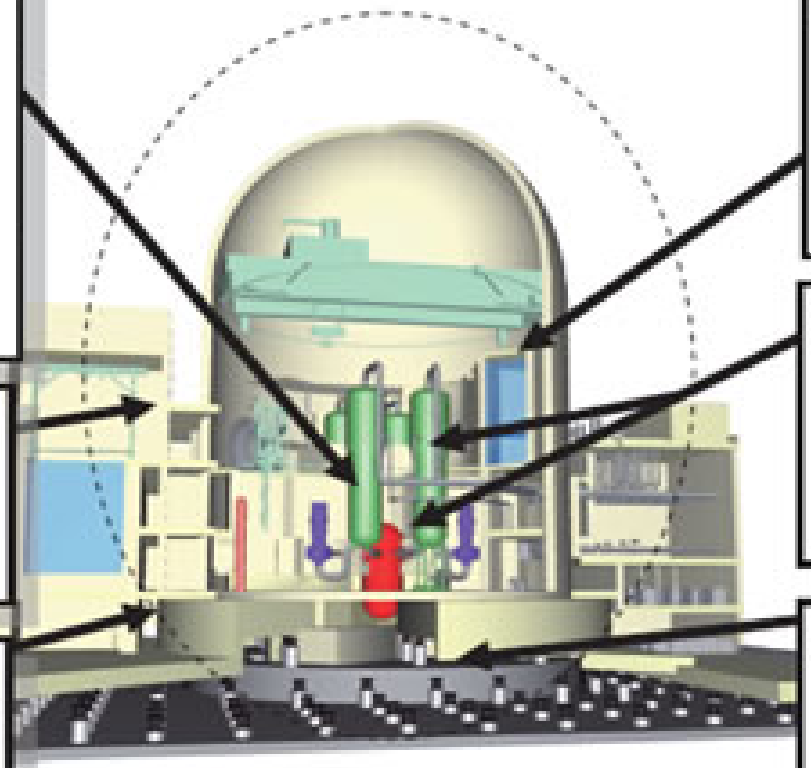
References:
•S. Nomura, ICAPP2009
•JAEA R&D Review 2008

Mid-term R&D Activities: Next Generation LWRs

(1) Significant decrease of spent fuel discharge and highly improved availability by innovative fuels with uranium enrichment above 5%.

(2) Significant shortening of construction period by innovative construction techniques.

(3) Improvement of both plant availability and safety by innovative digital man-machine interface technologies.



(4) Simultaneous realization of higher plant safety and economy by harmonizing passive and active safety systems.

(5) 80 years plant lifetime and significant reduction of worker's exposure by new materials and innovative coolant chemistry control.

(6) Standardization of plant design independent of site conditions by seismic isolation technologies.

Source: The Institute of Applied Energy HP

1. Technologies shown in the above figure were identified as promising and their development has been promoted.
2. The results of the development will be reviewed in this year and the roadmap for introducing selected technologies will be determined soon.

R&D of Fast Reactor & Its Fuel Cycle Technology: Goals

To make nuclear technology competitive and sustainable in the energy supply market of the latter half of the 21st century, by developing fast reactor and its fuel cycle technology that can attain

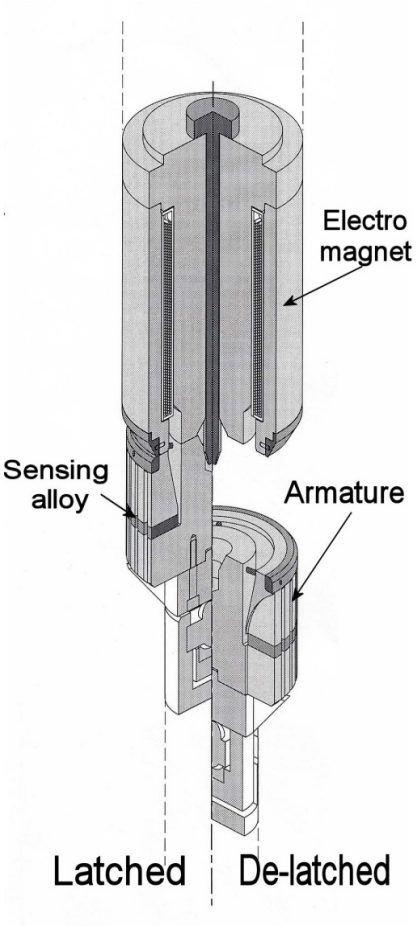
- **Efficient resource utilization**: breeding makes it possible to multiply energy production of U up to 60.
- **Waste minimization**: Pu & MA recycling significantly reduces the heat generation rate of vitrified waste to be disposed of and increases the capacity of geological repository.
- **Improved proliferation resistance**: co-conversion of Pu and MAs in reprocessing and use of MA bearing fuel / use of Thorium.

R&D of Fast Reactor & Its Fuel Cycle Technology: Issues

- Technological Issues:
  - ✓ Acceptance of positive coolant void coefficient in safety design of sodium cooled large fast core reactors: to assure that core melt is non-energetic and or that its occurrence probability is extremely low.
  - ✓ Development of both reprocessing technology to recover mixed plutonium and miner actinides (MAs) from used fuel and fuel fabrication technology to fabricate U-Pu-MA fuel, taking into consideration the high radioactivity and high heat generation rate of actinides in the processes.
  - ✓ Introduction of integrated components to reduce volume and length of piping is worth pursuing or not.
- Programmatic Issues:
  - ✓ Appropriateness of selected requirement: is it necessary and feasible to pursue international harmonization of standards for safety, proliferation resistance and physical protection
  - ✓ How to accelerate technology demonstration: international coordination of national/regional activities.

Safety Provisions to Prevent and Mitigate Core Disruptive Accident

SASS (Self-Actuated Shutdown System)



Core outlet coolant temperature rise

↓

Sensing alloy temperature reaching the Curie point

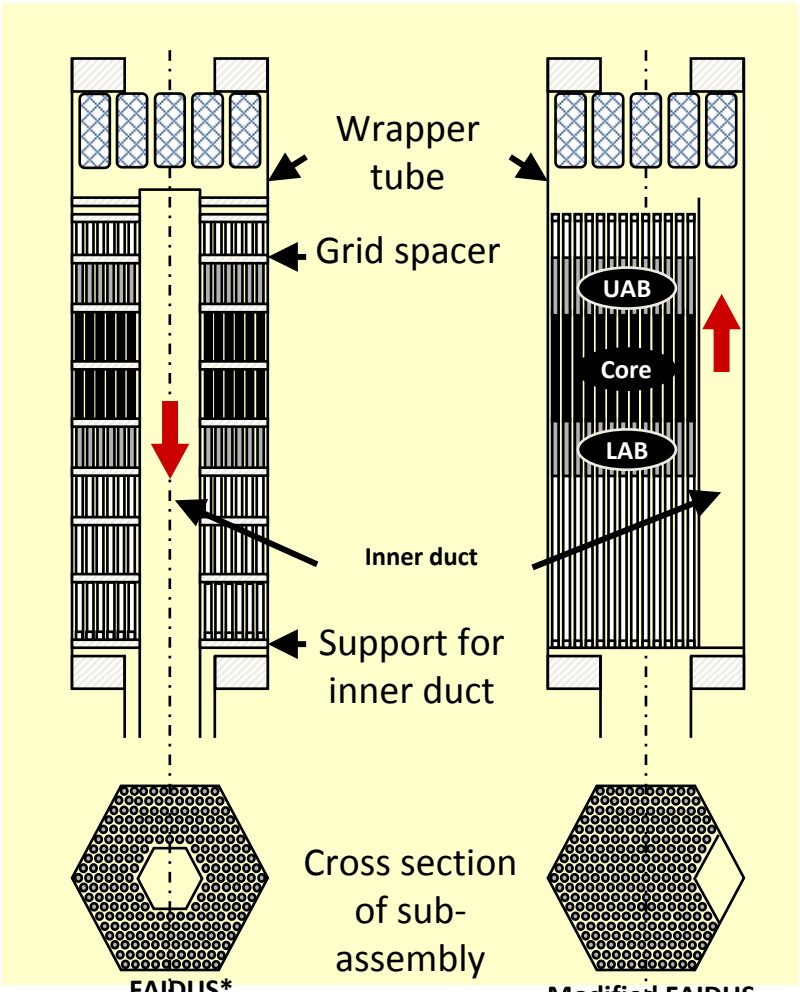
↓

De-latch due to decreasing magnetic force

↓

Insertion of the rod by gravity

Fuel Assembly Designs to Enhance Molten Fuel Discharge



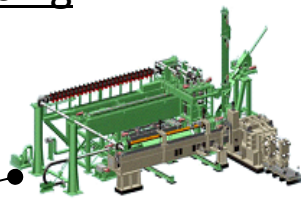
R. Nakai, Design and Assessment Approach on Advanced SFR Safety with Emphasis on CDA Issue, FR09, 2009.

Innovative Fuel Cycle Technologies

Advanced Aqueous Reprocessing

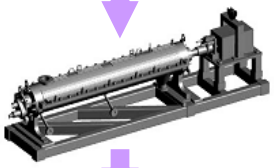
(1) Disassembling and Shearing

Mechanical Disassembling and Shorter Length Bundle Shearing



(2) Dissolution

Compact Continuous Dissolver



(3) Uranium Crystallization

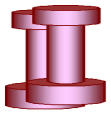
Compact Continuous Crystallizer

(4) U, Pu and Np Co-extraction

Centrifugal Contactor

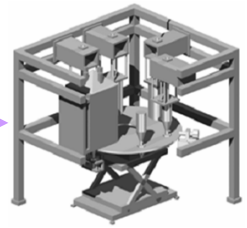
(5) MA Recovery

Extraction Chromatography Method



(6) Salt Free Waste Treatment

Simplified Pelletizing Fuel Fabrication

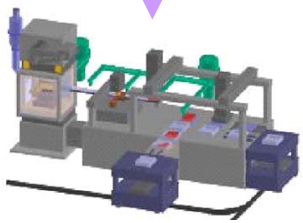


(7) Conversion and Granulation

Microwave Heating De-nitration and Granulation

(8) Pelletizing

Die Wall Lubrication Pelletizing



(9) Sintering

Sintering and Adjustment of O/M Ratio

(10) Studies of Fuel Physical Properties

Physical Properties of MOX Fuel with MA etc.

(11) In-cell Remote Handling Technology

Automatic Operation and Remote Maintenance

(12) Fuel Handling Technology

Cooling System for MOX fuel with MA etc.

H. Funasaka, Development of FBR Fuel Cycle Technology in Japan, FR09, 2009.

Innovative Technologies for JSFR

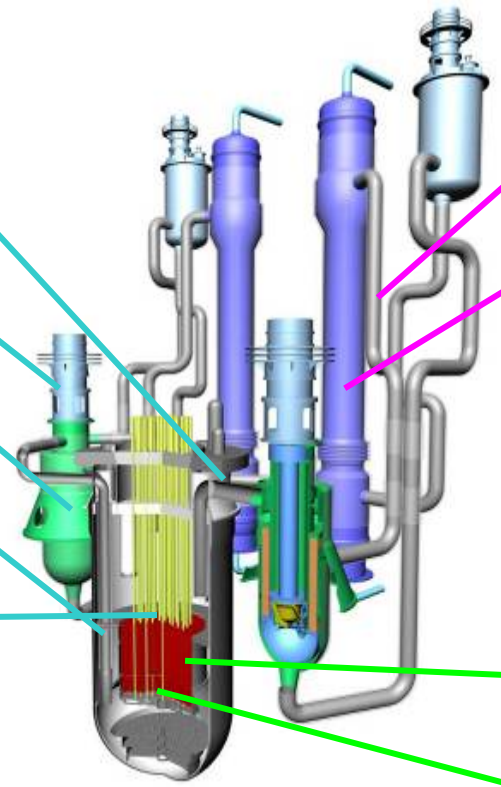
Enhanced Economy

○ 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: steel plate reinforced concrete building

○ Long operation by high burn-up fuel

- ⑦ Advanced fuel material



Enhanced Reliability

○ Sodium technology

- ⑧Sodium leak tightness with double-walled piping
- ⑨High reliability SG with double-walled tube
- ⑩ High inspectability of inside of sodium boundary

Enhanced Safety

○ Core safety

- ⑪Passive shutdown and decay heat removal
- ⑫Re-criticality free core

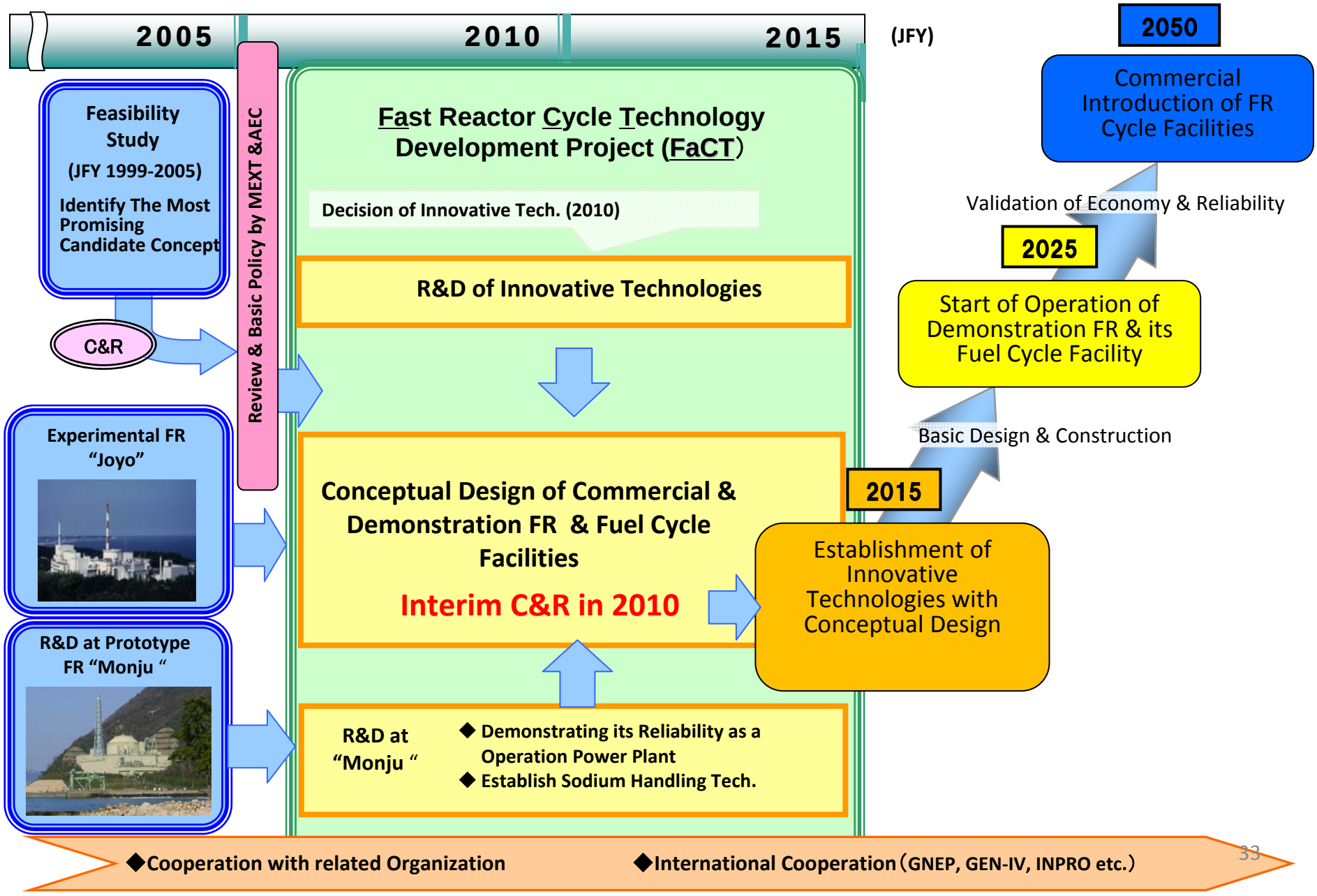
○ Seismic reliability

- ⑬Seismic reliability in core assemblies

- ⑭Plant design study (D-FR/C-FR)
- ⑮ Large-scale sodium tests

T. Nagata, Progress on reactor system technology in the FaCT project toward the commercialization of fast reactor cycle system, FR09, 2009.

FR Cycle Development Program in JAPAN



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International Cooperation: Objectives and Actions

- Shape international environment for promoting safe, secure and proliferation-resistant utilization of nuclear energy.
  - ✓ Contribute to the activities of the IAEA, the NEA, IFNEC etc.
  - ✓ Contribute bilaterally to the development of nuclear infrastructure in countries that want to enjoy the benefit of nuclear power generation in the near future.
- Promote mutually beneficial cooperative activities with Australia, Canada, China, EU, France, Russia, UK, USA Kazakhstan etc.
- Facilitate innovative nuclear energy technology R&D efforts, such as fast reactor and its fuel cycle technology R&D and fusion energy R&D.
  - ✓ GIF, ITER, bilateral cooperation

Oversea Business of Japanese Nuclear Industries

- Japanese nuclear industries have completed many NPP construction projects on time and on budget, in cooperation with electric utilities, supplying high quality systems and components.
- The AEC has suggested them not only to continue to supply high-quality products to the global market, but also to pursue, in cooperation with those electric utilities, to share with foreign operators the organizational culture to value quality, a sense of security, cleanliness of workplaces and visualization that has been cultivated in Japan.
- The AEC has also proposed Government to
  - arrange measures to reduce the financial risk accompanied with oversea business;
  - Pursue a revision of ODA guidelines of the OECD and inclusion of nuclear energy in the flexibility mechanisms of the Post-Kyoto Regime.

Japan-US Joint Nuclear Energy Action Plan

- Cooperate to promote nuclear energy research and development
  - ✓ Fast Reactor Technology including sensors for USV.
  - ✓ Fuel Cycle Technology
  - ✓ Simulation and Modeling including advanced simulation for enhanced safety of NPPs
  - ✓ Small and Medium Reactors including GCR technology
  - ✓ Safeguards & Physical Protection:
  - ✓ Waste Management including waste vitrification technology
- Collaborate
  - ✓ On effective use of nuclear power plants
  - ✓ On policies and programs that support the construction of new nuclear power plants
  - ✓ To support peaceful use of nuclear energy in third countries, examining barriers and opportunities as well as efforts to engage with third countries
- Explore possible ways to establish nuclear fuel supply assurance mechanism

A Global Vision of Fuel Cycle Services in the Future

- The operation of 1000 -1500 GWe nuclear power generating capacity in 2050 is a moderate prediction from the viewpoint of controlling the risk of global warming, though it will be necessary for realizing this size of nuclear capacity in 2050 to maintain safe, reliable and economical operation of nuclear power plants and add continuously more than 20 units in a year.
- Global community with 1,500 GWe LWRs will need 10 enrichment centers each of which capacity is 18,000 t SWU/y and 10 reprocessing centers each of which capacity is 3,200 t/y.
- The assurances of these services beyond national boundaries by these 10 + 10 centers may make it unnecessary for “consumer” countries to argue for indigenous enrichment and reprocessing programs, though they should dispose the used-fuel or the high-level waste sent back from the reprocessing center with MOX fuel.

Cradle-to-Grave Services Beyond National Boundaries

- To realize such world, suppliers should define, on the long-term basis, options of multi-lateralization that would be appealing to “consumer states”, including to invite them as co-owners, in parallel with pursing to find answers to questions concerning how an international organization would manage safety regulation, make export control decisions, raise the funding required, gain access to competitive technology, and maintain security of technologies. Need for another Gates?
- Mr. Ponemann: if this multilateral organization can establish regional or international interim storage facilities for spent fuel or even high-level waste disposal repository, countries considering nuclear energy can enjoy cradle to grave services:
- How can we realize his proposal? The prerequisite for being able to make such an offer in any country may be the establishment of the recognition that such businesses will be profitable and socially acceptable. Many entrepreneurs will challenge to realize his idea after the first round of successful activities to establish repositories in several countries.

Conclusion

- Unremitting attention to quality of activities based on the integrated business risk management is essential to enjoy the benefit of nuclear energy. Japan has made many mistakes in this endeavor both in technical dimension and societal dimension and now hopes to work with global communities, utilizing the knowledge obtained through these bitter experiences to make nuclear energy available to those who want to use it as one of the mainstay technologies for electricity generation to the fostering of economic growth/poverty eradication, energy security and low-carbon economy.
- Japan is currently struggling to find technologies that will contribute to the sustainability of the global community and ways to develop them, including fast neutron reactors and its fuel cycle technologies that are expected to satisfy the goals for safety, reliability, economy, resource utilization and proliferation resistance desirable for the nuclear energy systems in the future society, in collaboration with international nuclear community.

Thank You for Your Attention