JAPANESE NUCLEAR ENERGY POLICY

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Contents

A snapshot of current policy (particulars are given in the prepared text titled "A Note on the Back-end Policy: Past and Present".)

- Policy goals
- Nuclear power generation
- Front-end of fuel cycle
- Back-end of fuel cycle
  - History
  - Assurance of Nonproliferation
  - Spent fuel
  - Use of MOX fuel
  - Rokkasho Reprocessing Plant (RRP)
  - HLW disposal
- R&D of Fast Neutron Reactors (FNR)

Nuclear Power Generation: Current Status

- 10 electric power companies are operating 54 LWRs (30 BWRs and 24 PWRs: 49 GWe) that supply about 30% of electricity.
- They contribute to the reduction of about 200 Mt CO_2 emission annually and to the increase in energy self-supply ratio from 4 % to 16 % under the assumption that nuclear energy is an indigenous energy source.
- Tsuruga-1 started operation beyond 40 years in April this year and Mihama-1 will do so in December.
- 3 units have loaded MOX fuel fabricated in Europe: the number will be 5 before the end of the year.
- 2 units (Ohma, Shimane-3) are under construction, 3 units (Tsuruga-3&4, TEPCO Higashidori-1) are under regulatory review and 3 units (Tokai GCR, Hamaoka-1&2) are in the decommissioning phase.

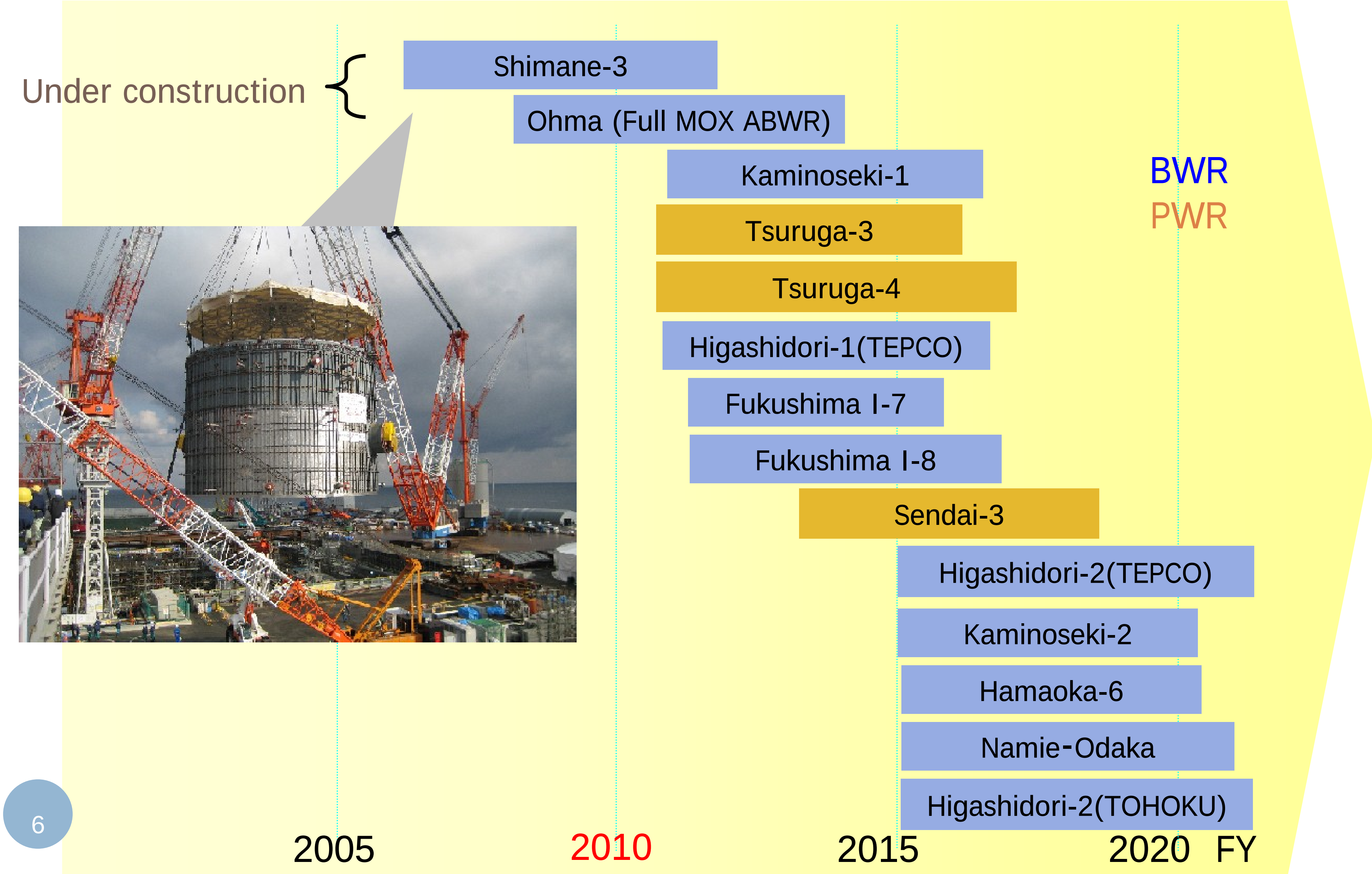
Policy Goals

- Maintain sound infrastructure for safe, secure, safeguarded and sustainable utilization of nuclear energy.
- Reprocess used-fuel from LWRs within the domestically available capability, utilize fissile material thus recovered in LWRs for the time-being, and dispose the vitrified high-level radioactive waste (HLW) from reprocessing process into a deep geologic repository.
- Promote nuclear energy research and development (R&D) efforts, including those aiming at commercializing fast neutron reactor and its fuel cycle technology that can attain better fuel utilization and waste minimization before 2050.
- Promote international cooperation and trade for contributing to the assurance of safe, secure, safeguarded and sustainable utilization of nuclear energy in every part of the world and for pursuing mutual benefit and fulfilling common responsibilities with partners.

Nuclear Power Generation: Current Issues

- The Government recently decided to expect the increase of the share of nuclear power to about 40% by 2020, and to about 50% by 2030, as one of the most important actions to combat global warming. Therefore it is necessary to;
  - Improve the average plant capacity factor (below 70% in recent years due to several plants' delay in restart from seismic event) to 85% by 2020 and to 90% by 2030, pursuing managerial excellence in operation and maintenance, including forward-looking ageing management of long-life plants:
  - Promote the construction of new plants, replacing aged plants in some cases: 9 new units should start operation by 2020, and 14 new units by 2030.
  - Pursue the understanding of the public on the validity of managerial innovation to be introduced from the viewpoint of safety assurance, as well as on the importance of nuclear energy for both assuring energy security and combating global warming.

Electric power companies will add new plants continuously as in the past.



Nuclear Power Generation : Results of Pubic Opinion Survey

Opinion	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?***
  - A major accident is probable.
  - Major accidents have occurred.
  - Japan is a country with frequent earthquakes.

☛ It seems essential to unfailingly promote open and transparent risk communication with the public, in parallel with taking new scientific knowledge and lessons learned from the operation experiences in the world into consideration of safety regulation and operation incessantly.

Front-End of Fuel Cycle: What Should We Do?

- **Secure uranium**
  - Maintain long-term supply contracts with various suppliers in diverse areas.
  - Participate in mining projects.
- **Secure conversion and enrichment services**
  - Maintain long-term contract with major suppliers
  - Assure domestic enrichment capacity at 1,500 ton SWU level in 10 years by installing the next generation centrifuge machine in Rokkasho Uranium Enrichment Plant
- **Secure fuel fabrication services**
  - Maintain competitiveness of fuel fabricators in Japan.

Back-End of Fuel Cycle: History

- Since 1960s, the Japanese government has been promoting the R&D of advanced thermal reactor (ATR) and fast neutron reactor (FNR) that utilize plutonium recovered from the reprocessing of spent LWR fuel by constructing experimental FNR JOYO, prototype ATR FUGEN, prototype FNR MONJU and the Tokai reprocessing plant, recognizing that for pursuing energy security by way of nuclear energy utilization it is important to aim at establishing closed fuel cycle.
- Electric power companies jointly decided in 1970s, sharing the recognition with the Government, to invest into the reprocessing business in Europe so as to assure a necessary amount of reprocessing service for the time being and to start the construction of a commercial reprocessing plant in Aomori, i.e. the Rokkasho Reprocessing Plant (RRP) by establishing Japan Nuclear Fuel Ltd, (JNFL).
- In the end of 1990s, after they rejected to invest into the construction of a demonstration ATR, they decided to start the use of MOX fuel in one-third of their LWRs, utilizing the plutonium recovered in Europe for the time being and later that recovered at the RRP also.

To Assure International Confidence in Observing the Commitment of Nuclear Nonproliferation

- Recognizing the importance of assuring international confidence in observing the commitment of nuclear nonproliferation, Japan started in cooperation with the IAEA, the United States, France etc. the development of an adequate concept and technologies for the IAEA safeguards to large bulk-plutonium handling facilities before starting the construction of the RRP. The current IAEA safeguards activities at the RRP are based on them.
- To increase transparency, Japan has published annually the quantities and the locations of separated plutonium it holds since 1997, and since 2005, electric power companies and other relevant organizations have published at the beginning of every fiscal year the objectives of the reprocessing (when and how to use the plutonium recovered) to be executed in the year, based on the recommendation of the JAEC.

Back–End of Fuel Cycle

- **Past:** 5600 tons of used LWR fuel and 1500 tons of used GCR fuel were reprocessed in Europe. 1020 tons of used LWR fuel were reprocessed at Tokai Reprocessing Plant (TRP).
- **Future:** among 66,000 tons to be generated before 2046:
  - 32,000 tons will be reprocessed in the Rokkasho Reprocessing Plant (RRP).
  - 34,000 tons will be stored at spent fuel storage facilities at reactor and or away-from-reactor for the time being and will be reprocessed at the second commercial reprocessing plant in the future.
- **Key activities are to;**
  - Expand the use of MOX fuel in LWRs and FNRs
  - Start the operation of RRP
  - Assure the capacity of interim storage of spent fuel
  - Prepare disposal facilities for TRU waste and HLW
  - Deliberation of the second reprocessing plant

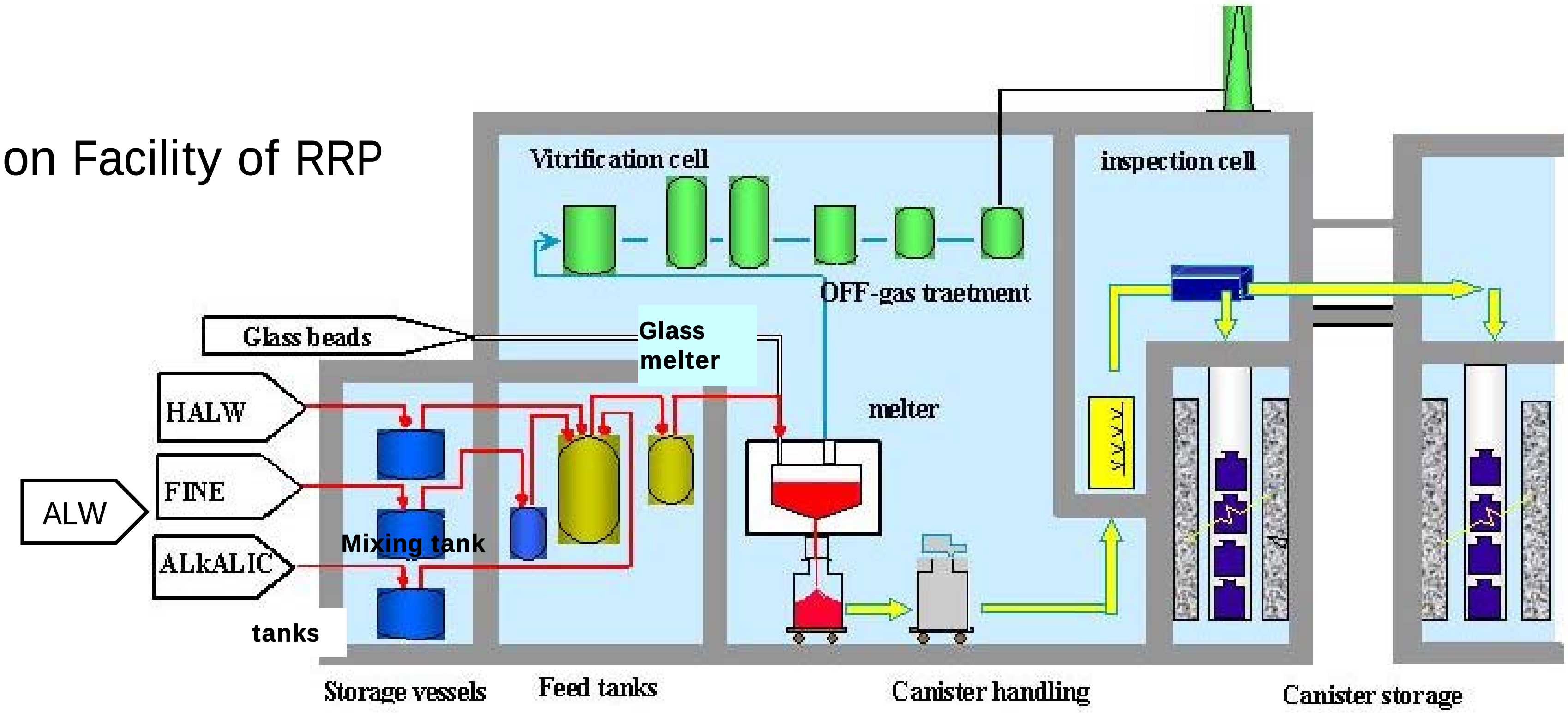
Use of MOX Fuel

- The Prototype ATR FUGEN (now retired), the experimental FNR JOYO and the prototype FNR MONJU have been loaded with MOX fuel fabricated at the Plutonium Fuel Fabrication Facility (PFFF) at Tokai, utilizing plutonium transported from Europe and recovered at the TRP.
- 7 LWRs (including Ohma ABWR of which core can be fully loaded with MOX fuel) were licensed to load MOX fuel and 2 LWRs are under regulatory review. 3 units are in operation with MOX fuel : the number will be 5 before the end of the year and will be 16–18 in due course.
- The JNFL started the construction of the Rokkasho MOX fuel fabrication plant (JMOX) in October.
- The deliberation about the management of spent MOX fuel from LWRs is started soon in the context of when and how the second reprocessing plant should be built.

Rokkasho Reprocessing Plant of the JNFL

The completion of commissioning test has been delayed due to a series of troubles in establishing operation procedure of the joule-heated ceramic melter in the high-level waste vitrification line.

Vitrification Facility of RRP



Rokkasho Reprocessing Plant

- **New Schedule**
  - The JNFL recently announced that it will be completed in two years, based on the analysis of the results of a series of mock-up tests to reproduce the undesirable phenomena in the melter and modeling and simulation activity with a view to establishing the operating procedure.
- **Finance**
  - Along with the deregulation of electric industry, the Government established in 2005 a fund for reprocessing and related activities including the decommissioning of facilities involved, collecting fees from electricity customers based on the generation of spent fuel. The fee is about 0.3 yen/kwh (~1 yen/kwh from nuclear power plants) which is based on the analysis of life-cycle cost of the activity.

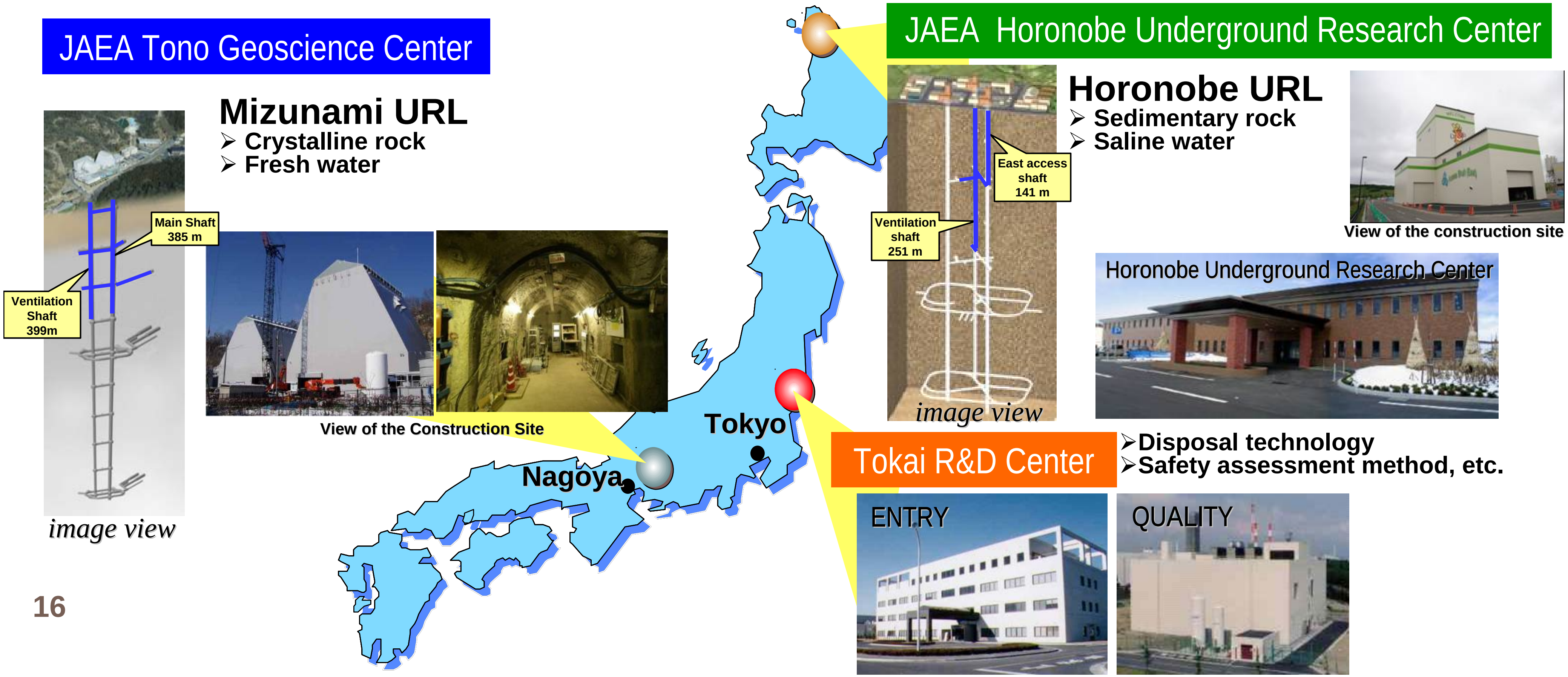
Geological Disposal of HLW

- Since 1970s, an expert group had discussed the feasibility of disposing a vitrified HLW in a geologic repository, after storing for 30 to 50 years at a surface facility to allow cooling, based on a multi-barrier system in stable geology at a depth greater than 300 m below ground surface.
- The group concluded in 1992 that;
  - A sufficiently stable deep geological environment to ensure the performance of the multi-barrier system can be found in Japan, even though the country is located in a tectonically active zone and complex geology is expected in many part of Japan:
  - The repository can appropriately be designed and constructed based on presently available engineering technologies:
  - Long-term safety can be ensured through the performance of the multi-barrier system, with particular emphasis on near-field performance provided by a massive engineered barrier system.

R&D of the JAEA to Develop Technical Basis for HLW Disposal Project by the NUMO and for Safety Regulation

ACTIVITIES:

- Development of engineering technology for repository and safety assessment methods
- Development of integrated methods for characterizing the deep geological environments at two typical geological environments in Japan.



Siting of a HLW Disposal Facility

- In 2002, the NUMO, an organization authorized to promote the disposal activity in 2000, started to invite mayors of municipalities to apply for site suitability investigation. Although there have been several preliminary moves and one failed application, so far no mayor has successfully applied.
- The Government as well as the NUMO have started to strengthen public information activities on the safety and the importance of the disposal facility at both national and municipal levels, taking into consideration lessons learned from the difficulties mayors have confronted with.
- Proactive approaches have been introduced, in parallel with pursuing the present explain-and-wait approach.
- The activity of the NUMO is also supported by a special fund for HLW disposal similar to the fund for reprocessing activity.

A Result of Opinion Poll (Nov. 2009)

- Do you think it our generation's responsibility to decide the site for geologic repository for HLW?
  - Yes, I think so. 51.9%
  - On balance I think so. 30.3%
- How do you think if your or your neighboring municipality plans to invite the repository?
  - I agree. 3.3%
  - On balance I agree. 12.9%
  - On balance I disagree. 34.3%
  - I disagree. 45.3%

AEC is suggesting the NUMO and the Government to;

- continue actions to promote mutual communication with the public patiently, exploring innovative ways for increasing the probability of application.
- Prepare facilities that demonstrate the concept of the repository and the safety of the disposal: a picture is worth a thousand words.

R&D Portfolio for Pursuing Sustainable Nuclear Energy Use

i. Basic research: maintain and expand knowledge basis for nuclear energy, including nuclear physics, materials, mechanics, chemistry, digital simulation, and maintain test facilities for R&D, such as test reactors, hot laboratories, sophisticated measuring apparatus.

ii. Near-term research: create knowledge for using existing assets effectively such as that for trouble shooting, ageing, power up-rating, safe geological disposal of HLW, etc.

iii. Mid-term research: develop new products and processes to replace those currently in use; next generation LWRs.

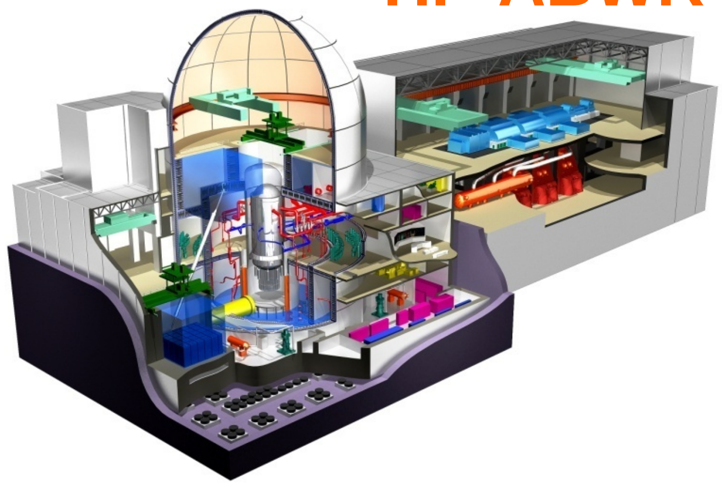
iv. Long-term research: explore innovative products and processes that open new / sustainable nuclear energy use; fast reactor and its fuel cycle, HTGR, fusion energy, etc.

Next Generation LWRs

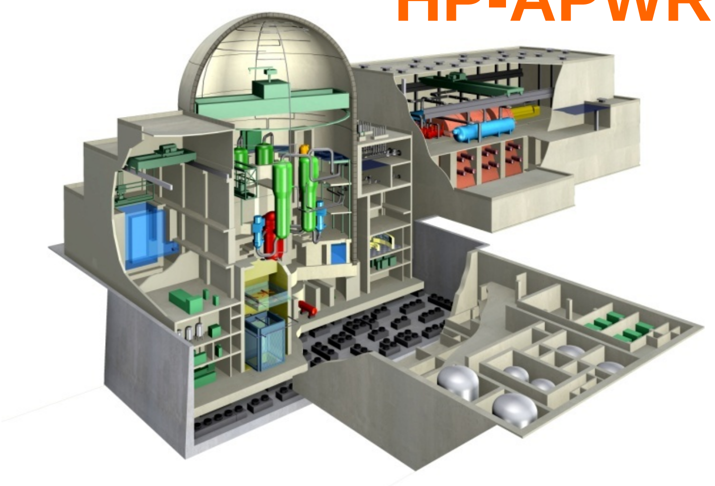
Government is supporting the R&D of next generation high-performance LWRs that meet;

- ✓ Replacement demand in 2030's but the desire of making attractive technologies deployable in preceding LWRs as well in 2020's;
- ✓Goals set for safety & security/economics/waste/ etc. at a higher level, that should be satisfied with innovative materials, components and seismic isolation features.
- ✓1800MWe and 900MWe class plants to cope with demands of operators with diverse grid size

HP-ABWR



HP-APWR



FaCT: FR & Its Fuel Cycle Technology R&D

2005 | 2010 | 2015 | (JFY) | 2050

Feasibility Study
(JFY 1999-2005)

Identify The Most Promising Candidate Concept

C&R

Experimental FR "Joyo"

R&D at Prototype FR "Monju "

Fast Reactor Cycle Technology Development Project (FaCT)

Requirement

Safety, Economy, Fuel Utilization, Waste Management, Nonproliferation, etc.

Search for Innovative Technologies

Decision of Innovative Tech. (2010)

Develop Conceptual Design of Commercial & Demonstration FR and its Cycle Facilities

R&D at "Monju "
- **Demonstrating its Reliability as a Operation Power Plant**
- **Establish Sodium Handling Tech.**

Establish Conceptual Design that incorporates innovative Technologies

2015

Basic Design & Construction

Start Operation of Demonstration FR & its Fuel Cycle Facility

2025

Validation of Economy & Reliability

2050

Start Commercial Introduction of FR & its Cycle Facilities

- **Cooperation with related Organizations**
- **International Cooperation (US-F-J, GEN-IV, INPRO etc.)**

FR & Its Fuel Cycle Technology R&D

- In 2006, the JAEC asked the JAEA to step up the activity to promote the research and development of fast neutron reactor and its fuel cycle technology, specifying goals in economy, safety and reliability, waste management, and proliferation resistance and physical protection from the viewpoint of making it a sustainable energy technology in the future.
- Currently, in cooperation with electric power companies and nuclear reactor vendors, the JAEA is exploring innovative technologies and reviewing their effectiveness in realizing innovative fast reactor and its fuel cycle system in which not only plutonium but also minor actinides are recycled that should satisfy the goals. The JAEA and others are expected to jointly propose a feasible design of the system before 2015. The Government has just started the external review of the intermediate results of this activity.
- The JAEC believes it important to pursue close cooperation with like-minded countries including the United States and France in promoting this endeavor, as it is a global interest and a duty of major nuclear technology suppliers to make nuclear energy more sustainable.

Conclusion

- Recognizing that it is important for pursuing energy security by way of nuclear energy utilization to aim at establishing closed fuel cycle, Japanese government has been promoting the R&D of advanced reactors that utilize plutonium recovered from the reprocessing of spent LWR fuel, though these activities have not been going smoothly, and commitment, perseverance and engagement with the public have been required for the Government in promoting them.
- Sharing the same recognition with the Government, electric utilities jointly invested in Europe to assure reprocessing services for the time being and in the establishment of reprocessing capability in Japan based on the result of the Government R&D activities so as to assure stable operation of nuclear power plants, though the latter activities are just begin to take shape.
- Japan will continue to promote the research and development of fast reactor and its fuel cycle technology that will meet the goals in economy, safety and reliability, waste management and proliferation resistance and physical protection, set from the viewpoint of making it a safe, secure and safeguarded and sustainable energy technology in the future.

Thank you for attention!

Back up slides

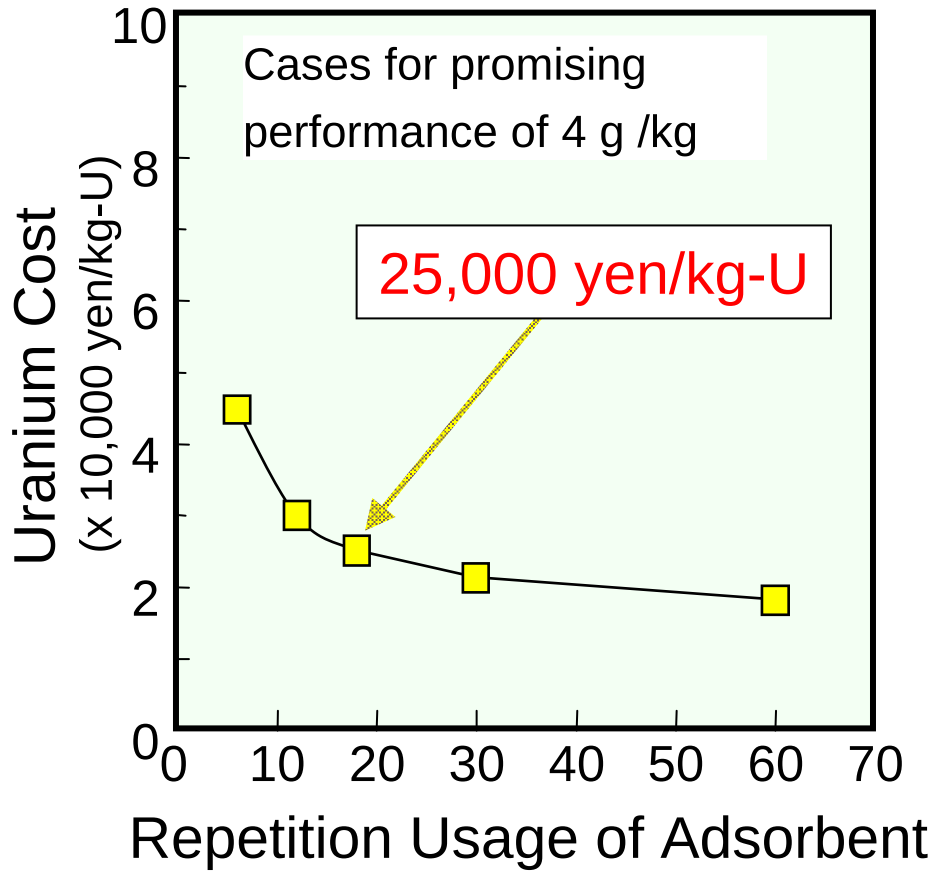
Recovery of Uranium from Seawater

Design study of uranium recovery system

- Capacity: 1,200 ton U/y
- Adsorbent performance: 2 g U/kg for 60 days
- Necessary sea surface: 134 km^2
- Cost of Uranium: 90,000 yen/kg

Braid type Adsorbent
(based on amidoximes group)

Uranium Recovery from Seawater



Recovery of Uranium from Seawater

- Researchers at Takasaki Radiation Chemistry Research Laboratory of the JAERI discovered that a cloth made of hydrophilic amidoxime fivers synthesized by radiation-induced graft polymerization is an excellent uranium adsorbent cloth in seawater and demonstrated the adsorbent performance of 0.5 g U/kg adsorbent, soaking it in seawater for 20 days. They also discovered that the performance could be improved by factor 2 by making the fiver into braids.
- Based on these results, they made a design study of a uranium recovery system of which capacity is 1,200 ton U/y, assuming the performance of 2 g/kg adsorbent soaked in sea water in 60 days and 6 cycle durability of adsorbent. The system is composed of total weight of adsorbent 100, 000 ton, of which total length was 100,000 km, distributed over 134 km^2 sea surface and 116 work ships of 1000 ton load for distribution and collection of the adsorbent braids and braids processing plant. The cost of uranium in this case is about 90, 000 yen/kg.
- Since 70% of the cost comes from the production of the adsorbent, if the performance of adsorbent can be a promising value of 4 g/kg and the durability of braid type adsorbent can be extended from 6 to 18 times, the cost of uranium will become 25, 000 yen/kg.
- The JAEC believes that based on this result, the priority of research should be given to the improvement of the adsorbent and its performance and durability, in particular.

Advantages and Disadvantages of the Recycling Approach

- Advantages:
  - The approach helps significantly reduce the volume of spent fuel to be stored and thus the volume of high-level wastes to be disposed of.
  - It can help manage the accumulation of plutonium.
  - It can improve the utilization of natural uranium around 15%.
  - It is a good precursor for the closed fuel cycle based on fast reactors to be established in the latter half of this century.
- Disadvantages:
  - It results in an economic penalty over the no-recycle option: the increases in cost of electricity is 10% or so, though this does not change the economic competitiveness of nuclear power generation.
  - The existence of the facility to separate pure plutonium is considered by some to increase proliferation risk.
  - The use of a number of processes for the execution of recycling may increase routine and accidental radioactivity releases.

Estimated Fuel Cycle Cost (discount rate 2%)

Unit :Yen/kWh

Item \ Scenario			Scenario ① Recycle	Scenario ② Recycle Only by RRP	Scenario ③ Direct Disposal	Scenario ④ Moratorium
Fuel Cycle Cost	Front End	Uranium Fuel	0.57	0.57	0.61	0.61
		MOX Fuel	0.07	0.05	—	0.01
	Back End	Reprocessing	0.63	0.42	—	0.17
		Storage, Transport and Disposal of HLW	0.16	0.10	—	0.06
		Treatment, Storage and Disposal of TRU Wastes	0.11	0.07	—	0.03
		Interim Storage	0.04	0.06	0.14	0.13
		Direct Disposal of SF	—	0.12～0.21 (0.09～0.21)※2	0.19～0.32 (0.14～0.32)※2	0.09～0.16 (0.07～0.16)※2
	Total		1.6 (1.5)※1	1.4～1.5	0.9～1.1	1.1～1.2
Electricity Generation Cost			5.2 (5.1)※1	5.0～5.1	4.5～4.7	4.7～4.8

※1 The case where the unit cost of the second reprocessing plant is halved.
※2 The range of cost in the case where the horizontal emplacement in disposal drift is included.

Electricity Generation Cost (40 Years of Operation)

Unit :Yen/kWh

	Capacity Factor	Discount Rate				
		0 %	1 %	2 %	3 %	4 %
Hydro	45 %	8.2	9.3	10.6	11.9	13.3
Oil	30 %	14.4	15.0	15.7	16.5	17.3
	70 %	10.4	10.6	10.9	11.2	11.6
	80 %	10.0	10.2	10.5	10.7	11.0
LNG	60 %	6.2	6.4	6.6	6.8	7.1
	70 %	6.0	6.1	6.3	6.5	6.7
	80 %	5.8	5.9	6.1	6.2	6.4
Coal	70 %	5.3	5.6	5.9	6.2	6.5
	80 %	5.0	5.2	5.4	5.7	6.0
Nuclear	70 %	5.4	5.5	5.7	5.9	6.2
	80 %	5.0	5.0	5.1	5.3	5.6
	85 %	4.8	4.8	4.9	5.1	5.4

Issues in Fuel Cycle Policy Debate

- Delays and cost over-run being experienced at present suggest that it will be difficult to realize closed fuel cycles in consistent with the requirement of maintaining their business risks to an acceptable level and it will be uneconomical if such negative externalities as increase in proliferation concern and public risk are taken into consideration.
- The realization of closed fuel cycles provides significant merit from the viewpoint of energy security and stability in nuclear power supply. In addition, various activities toward its realization and diverse societal assets accumulated in this process such as technologies, relationships of trust with communities, various international agreements, etc. are basis for the continuation of nuclear power generation in Japan and resources to be nurtured if we continue to enjoy the benefit nuclear energy will bring about in the future.

Conclusion of Policy Debate

- Considering the current status, it is appropriate to pursue the recycling of fuel materials through reprocessing of spent fuel, as we want to use nuclear power as a long-term and one of the major methods for power generation.
- The entities should steadily promote the realization of activities planned through rigorous risk assessments and managements.
- The Government should start from 2010 the deliberation of the future fuel cycle strategy to be followed after the retirement of RRP, taking into consideration of the progress in the R&D for FBR and its fuel cycle systems.
- It is appropriate to promote basic research on the science and technology of direct disposal of spent fuel so as to be able to enjoy flexibility in the review of fuel cycle strategies in future.