

# JAPANESE NUCLEAR ENERGY POLICY

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

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  - Rokkasho Reprocessing Plant (RRP)
  - HLW disposal
- ▣ R&D of Fast Neutron Reactors (FNR)

# Nuclear Power Generation: Current Status

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- 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 the 200 Mt CO<sub>2</sub> 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

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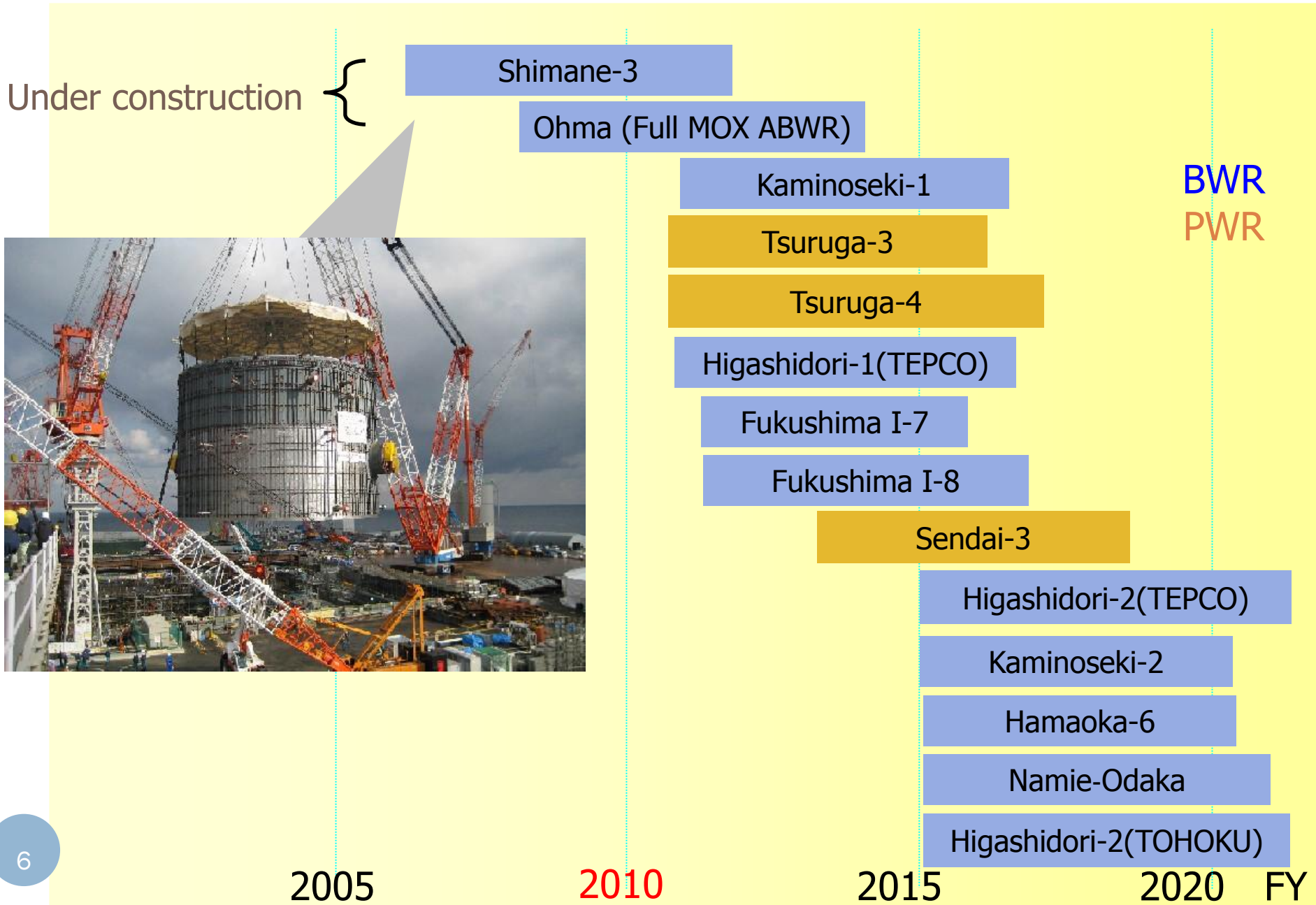
- Maintain sound infrastructure for safe, secure, safeguarded and sustainable utilization of nuclear energy.
- Reprocess used-fuel from LWRs with the domestically available capability, utilize fissile material thus recovered in LWRs for the time-being, and dispose the vitrified high-level radioactive 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 common responsibilities with partners.

# Nuclear Power Generation: Current Issues

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- 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 Public Opinion Survey

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<u>Opinion</u>	<u>2005</u>	<u>2009</u>
• <b>Promotion or phase out?</b>		
• Positively promote	8.0%	9.7%
• Cautiously promote	47.1%	49.8%
• Maintain status quo	20.2%	18.3%
• <b>Feel easy or feel uneasy?</b>		
• 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%
• <b>Why feel uneasy?</b>		
• 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.

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

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- **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 ATR and FNR that utilize plutonium recovered from the reprocessing of spent LWR fuel, constructing experimental FNR JOYO, prototype ATR FUGEN, prototype FNR MONJU and the Tokai reprocessing plant, recognizing that it is important for pursuing energy security by way of nuclear energy utilization 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, 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

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- 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

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- 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).
- 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 interim storage facilities 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

# Use of MOX Fuel

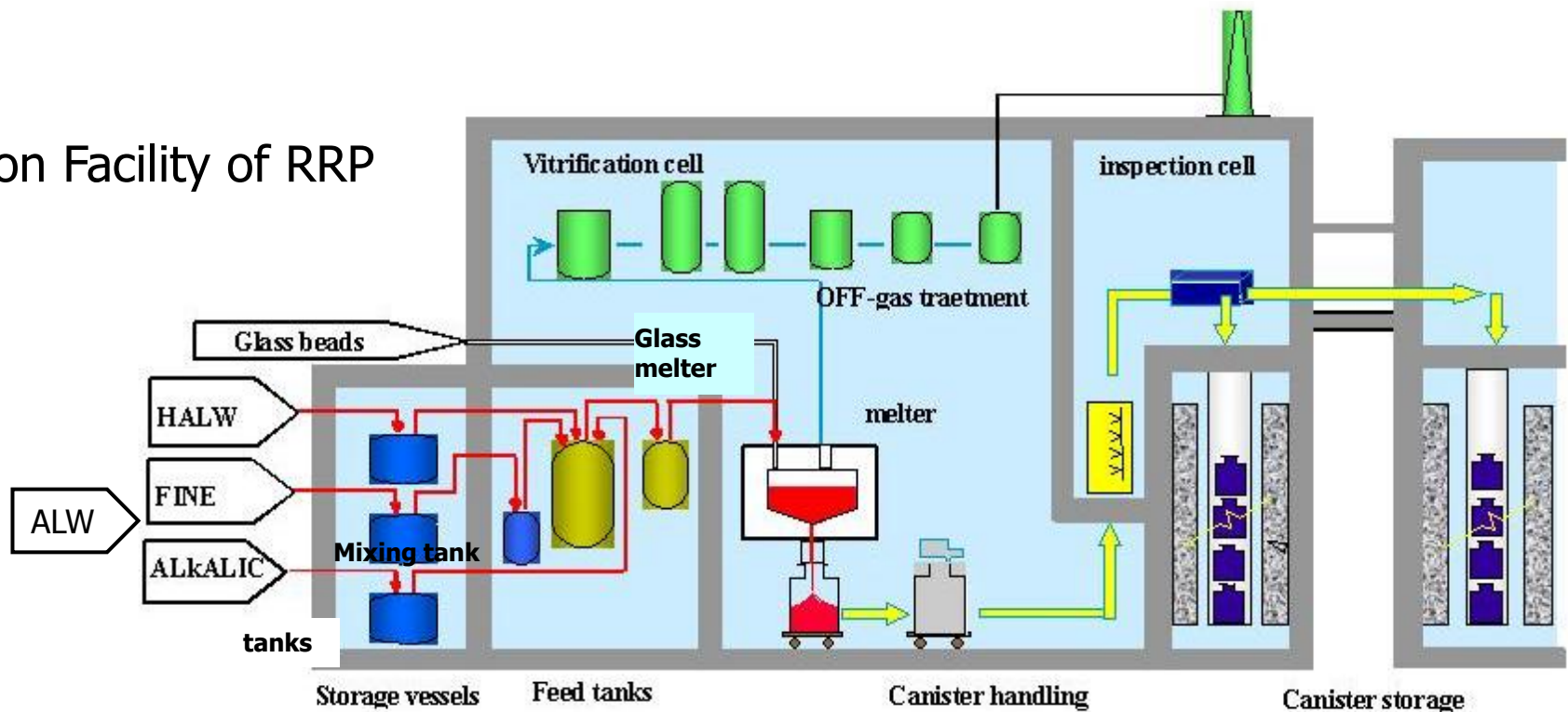
- The Prototype ATR FUGEN (now retired), the experimental FNR JOYO and the prototype FNR MONJU have been loaded with MOX fuel fabricated at the Plutonium Fuel Fabrication Facility (PFFF) at Tokai, utilizing plutonium transported from Europe and recovered at the TRP.
- 7 LWRs (including Ohma ABWR of which 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.
- Spent MOX fuel from LWRs shall be stored until fast neutron reactors will be introduced:

# 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

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- **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. These activities are to be financed from this fund. The fee is about 0.3 yen/kwh (~1 yen/kwh from nuclear) which is based on the analysis of life-cycle cost of the activity.

# Geological Disposal of HLW

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- 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:
  - ▣ 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 as complex geology is expected in Japan.



# 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.

### JAEA Tono Geoscience Center

#### Mizunami URL

- Crystalline rock
- Fresh water



Main Shaft  
385 m

Ventilation Shaft  
399m



View of the Construction Site



image view

### JAEA Horonobe Underground Research Center

#### Horonobe URL

- Sedimentary rock
- Saline water

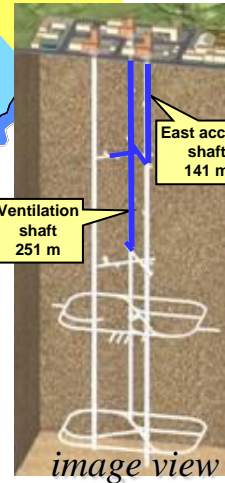


image view



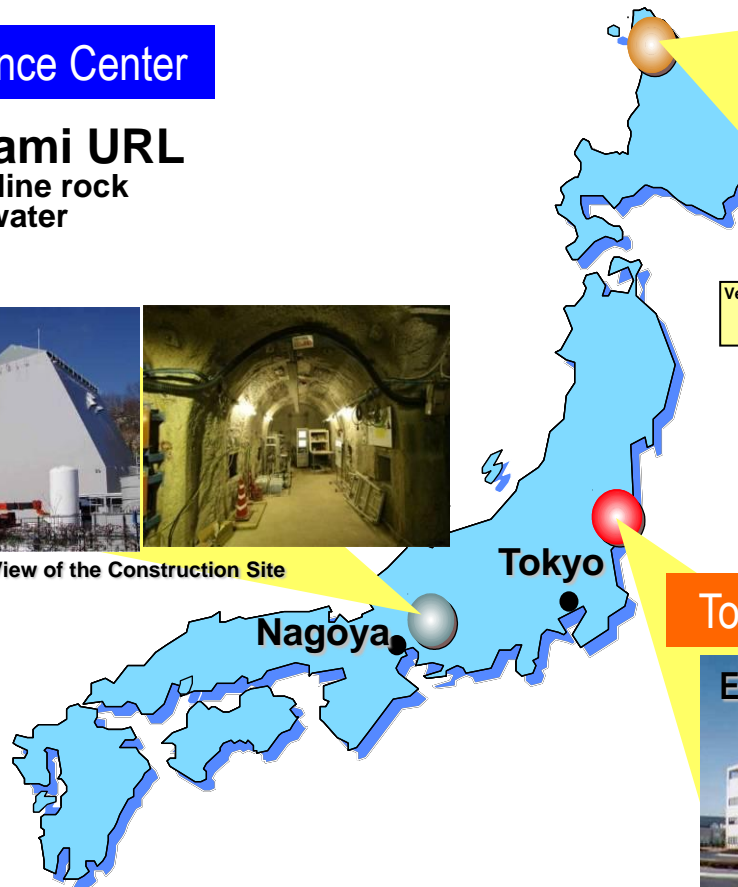
View of the construction site

#### Horonobe Underground Research Center



### Tokai R&D Center

- Disposal technology
- Safety assessment method, etc.





# 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)

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- 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 suggested 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

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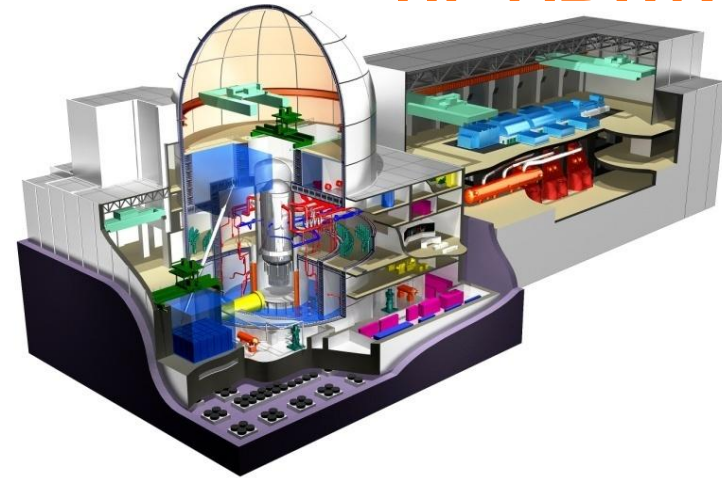
- i. Basic research: maintain and expand knowledge basis for nuclear energy, including nuclear physics, materials, mechanics, chemistry, digital simulation, and maintain test facilities for R&D, such as test reactors, hot laboratories, sophisticated measuring apparatus.
- ii. Near-term research: create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

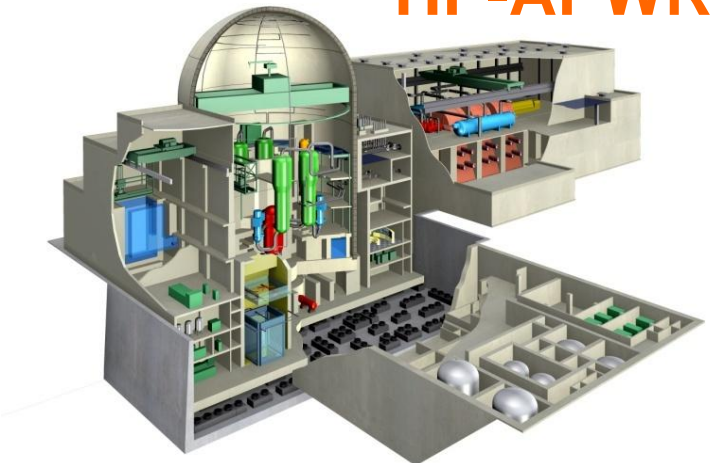
Government is supporting the R&D of next generation high-performance LWRs that meet;

- ✓ 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

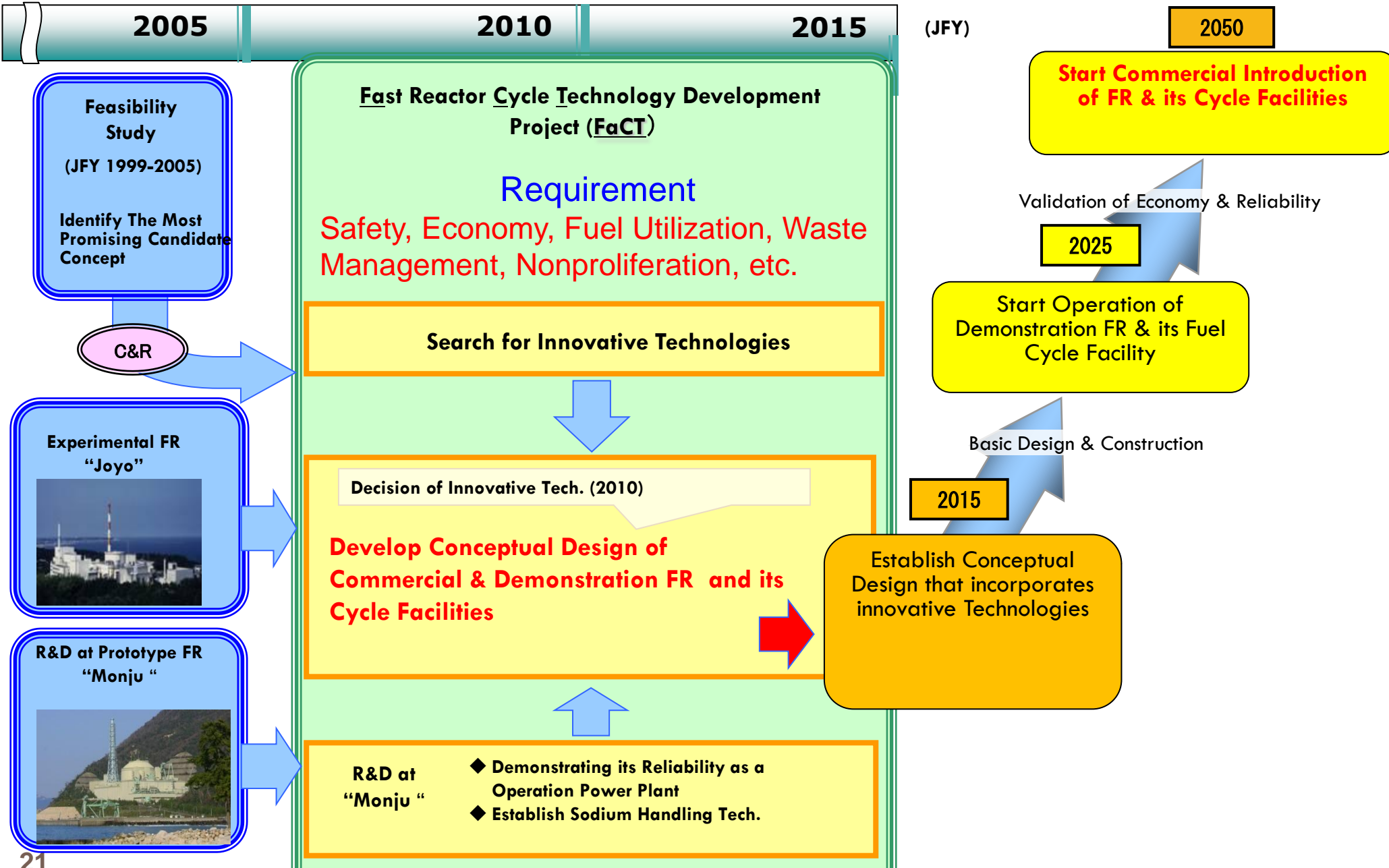
HP-ABWR



HP-APWR



# FaCT: FR & Its Fuel Cycle Technology R&D



# FR & Its Fuel Cycle Technology R&D

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- 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 Government has just started the external review of the intermediate results of this activity. The JAEA and others are expected to jointly propose a feasible design of the system before 2015.
- 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 energy users 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

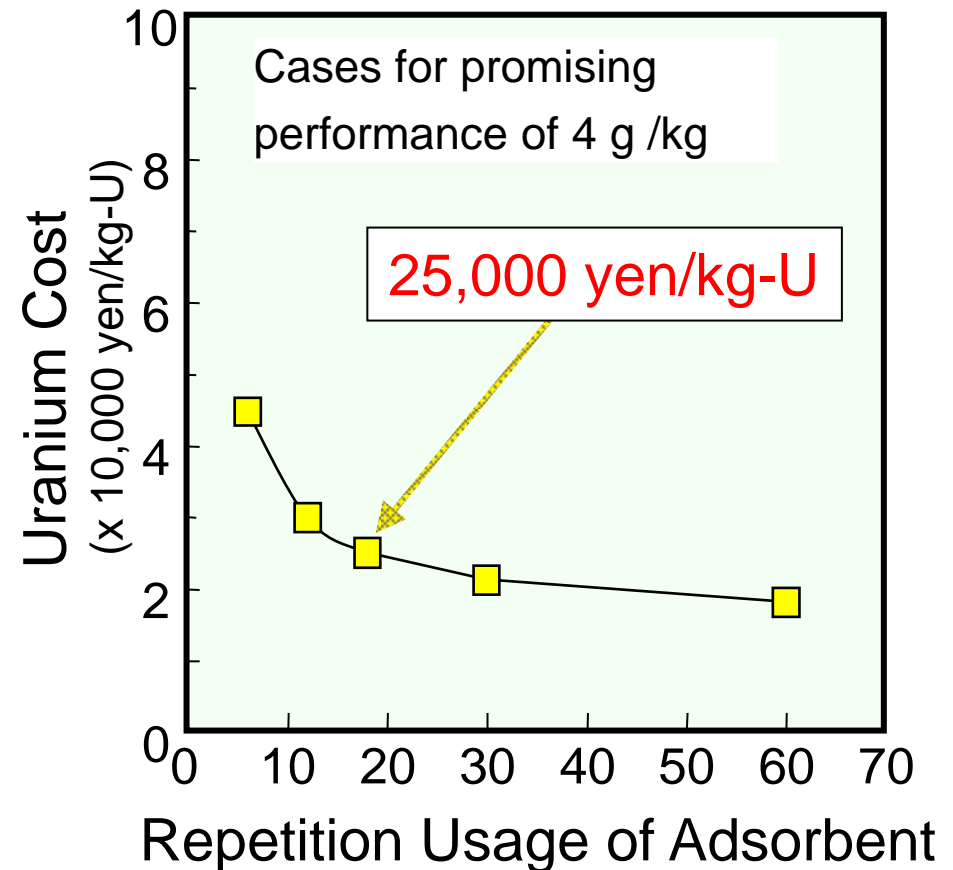
## Design study of uranium recovery system

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

Braid type Adsorbent  
(based on amidoximes group)



Uranium Recovery from Seawater



# Advantages and Disadvantages of the Recycling Approach

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## □ 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	Scenario ②	Scenario ③	Scenario ④
			Recycle	Recycle Only by RRP	Direct Disposal	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.