DELIBERATION OF POST 3.11 FAST REACTOR R&D STRATEGY IN JAPAN

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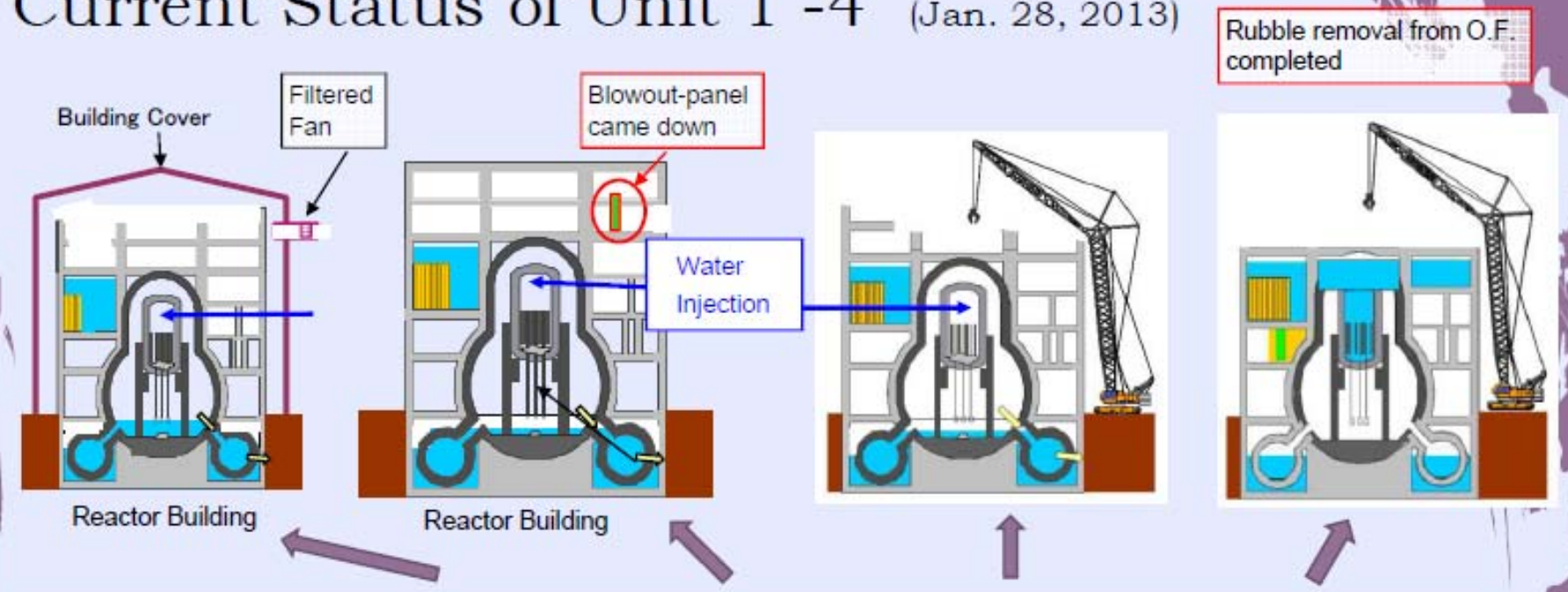
On March 11, 2011 the Great East-Japan earthquake and the resulting tsunami struck people and facilities including nuclear power plants located on the Pacific coast of Japan.

Current Status of Unit 1 -4 (Jan. 28, 2013)



	Unit #1	Unit #2	Unit #3	Unit #4
Core Melt	Y	Y	Y	N
Hydrogen Explosion	Y	N	Y	Y
RPV Temp. (℃)	18	31	31	NA
PCV Temp. (℃)	20	32	31	NA
PCV Water level (m)	+2.8	+0.6	Unknown	NA
Dose rate O.F.(mSv/h)	53.6	880	500	1.3
# of SPF	392	615	568	1,533
SFP Temp. (℃)	10	12	9	20

Challenges for Promoting the Cleanup of Disabled Unit 1-4

- *Major short-term challenges*
  - Management of accumulated contaminated water
  - Reduction of environmental radiation dose
  - Improvement of work environment
  - Retrieval of spent fuel from spent fuel pool
- *Challenging R&D projects for cleanup*
  - Equipment/device development, assessment & analysis of fuel conditions and fuel/debris characterization, with a view to preparing for fuel debris removal
  - Development of technologies for conditioning and storage of radioactive waste
  - Development of various robots and remote manipulation devices for cleanup activities.

Off–Site Consequences

- About 80,000 people are still requested to be out of hometowns and about the same number of peoples have made choice to leave home. People are suffering from a psychological agony due to fear of radiation exposure, separation of family, disruption of communities etc.
- 11 municipalities are designated as special decontamination area where the Government is promoting decontamination to reduce annual exposure there below 20mSv/y in two years, excluding areas where doses are higher than 50mSv/y.
  - Three cities have decided, however, that they would not return to hometown in five years, appealing for the uniform remediation.
  - One of the biggest issues in this respect is the appropriate measure for and level of decontamination of forests that cover more than 70% of the areas.

Off–Site Consequences (cont'd)

- Though anyone has not been hurt by the radiation so far, the accident has caused several hundred deaths due to the worsening of diseases owing to dislocation, including emergency evacuation from hospitals, and the stress of life in a shelter after dislocation.
- Production of agricultural and marine produce is still restricted depending upon circumstances. In addition, the sales of the products from Fukushima Prefecture have plummeted due to consumer fear, even though they are not contaminated.
- Damage compensation is estimated at present to be at least 6 trillion yen (70 billion US$). In addition, as only two NPPs are allowed to restart after refueling and inspection outages, the expense of electric utility companies for fossil fuel in 2012 was at least 3 trillion yen (40 billion US$) larger than that in 2010. Therefore total disaster cost will be larger than 6 + 3 + 3+ …

Publication of Various Accident Investigation Reports

- *The IAEA International Fact-Finding Expert Mission*
  - ✓ There were insufficient defence-in-depth provisions for tsunami hazards.
- *The Independent Investigation Commission of a NPO*
  - ✓ The crisis was essentially a man-made disaster caused by TEPCO's systematic failures and weaknesses in the government's regulatory regime.
- *The Government's Investigation Committee*
  - ✓ The government and TEPCO failed to prevent the disaster because they were reluctant to invest time, effort and money in protecting against a natural disaster considered unlikely: they were overly confident that events beyond the scope of their assumptions would not occur.
  - ✓ A culture of complacency about nuclear safety and poor crisis management led to the nuclear disaster.

Publication of Various Accident Investigation Reports (cont'd)

- *National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (NAIIC)*
  - ✓ The accident was clearly "manmade." It was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties. They supported faulty rationales for decisions and actions and effectively betrayed the nation's right to be safe from nuclear accidents.
  - ✓ What must be admitted - very painfully - is that this was a disaster 'Made in Japan'. Its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience; our reluctance to question authority; our devotion to 'sticking with the program'; our groupism; and our insularity.
- ◆ Most of them judged that though the accident was triggered by a massive force of nature, it did unfold as such due to existing weaknesses regarding defence against natural hazards, regulatory oversight, accident management and emergency response.

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Deliberation of Energy Strategy

- The Government has started the deliberation in 2011 and concluded it last year, though the conclusion involved several serious problems to resolve.
- The new government said that it goes back to the drawing board again.
- Short-term challenges for Japan are, in any case;
  - Restart idling nuclear power plants, as an important power source, that satisfy the new safety rules to be set by **the Nuclear Regulation Authority, which was established as an independent nuclear regulatory agency last year.**
  - Mobilize all policy resources for promoting energy conservation, and utilization of both advanced fossil power stations and renewable energies so as to assure stable supply of energy, compensating the decrease in the contribution of nuclear power.

The Gist of New Safety Rules To Be Set By the NRA

A. Ensure that design base external events (seismic, seismic-tsunami and other events) are properly evaluated and reflected in the design:
B. Satisfy the requirement 20, **design extension condition** of the IAEA safety design standard, covering extended losses of power and ultimate heat sink by providing a diverse and flexible alternative capability to supply power and cooling:
C. Ensure that **severe accident management procedures**, including reliable hardened vents for specific reactor containments, that take into consideration of the fact that external events might affect the entire site are in place.

- In connection with A, all the nuclear operators have been asked to accelerate the survey and characterization of **active faults around the site, including their interlock condition**, based on the most up-to-date knowledge in seismological field and detailed geological studies.

Will Operators Upgrade Their Plants in Compliance With the NRA's New Rules

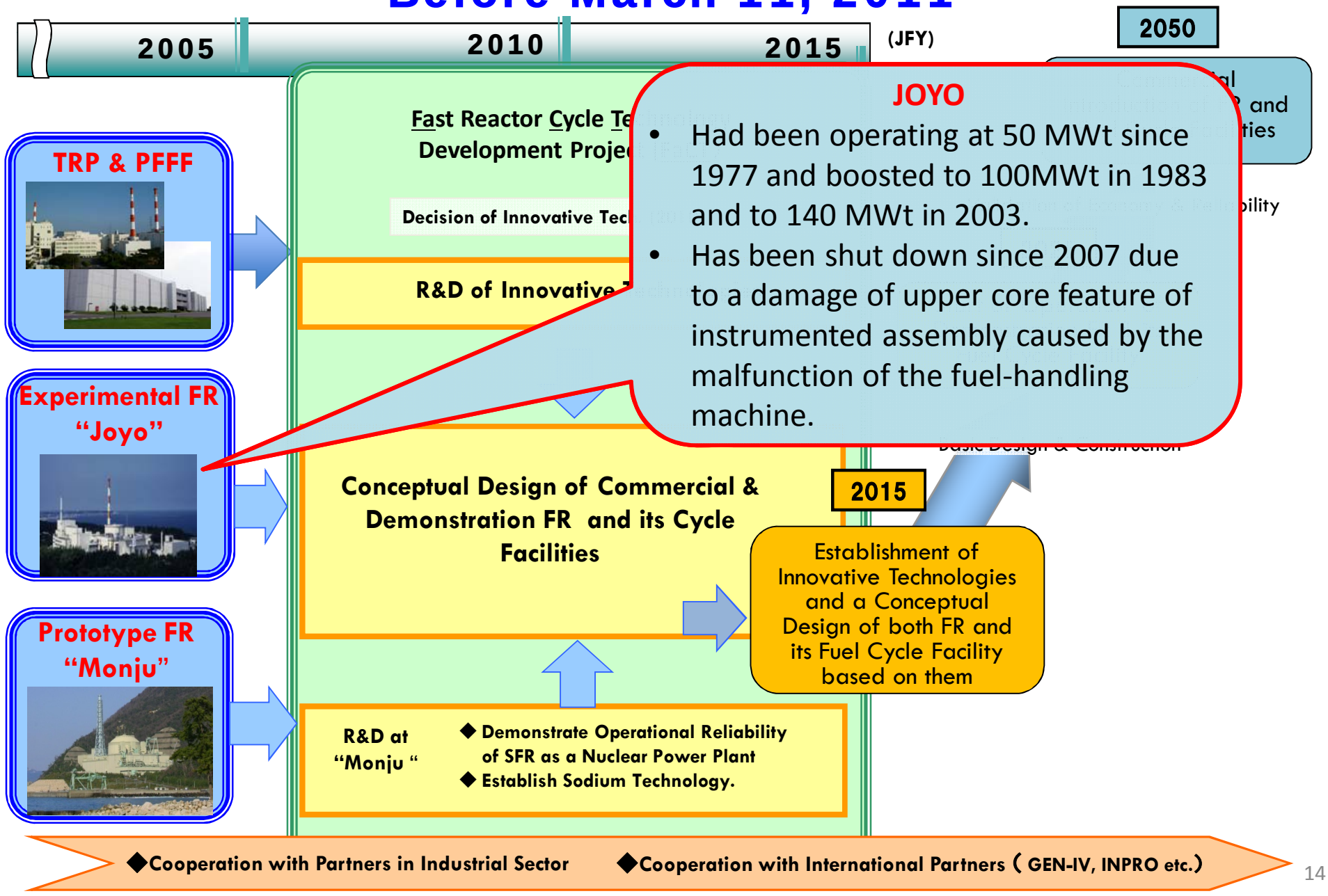
- ✓ The **new safety rules for FR and fuel cycle facilities based on the same principle** will be published later in this year.

- ◆ Each nuclear operator will soon decide whether he will make significant amounts of investment to conform his plant to the new set of rules and the new requirements arising from findings about active faults, taking into consideration of its capacity and age.
- ◆ It is fair to say that as **not all units will recover their operation,** the contribution of nuclear power in the future power production in Japan will decrease to a certain extent.

Objectives of Nuclear Energy R&D the Government Should Promote at Present

- Develop innovative technologies usable for decontaminating affected areas and managing associated radioactive waste effectively and efficiently, and those for promoting cleanup and decommissioning of the severely damaged units at Fukushima.
- Improve computer simulation tools for severe accident analysis that can be used to estimate the distribution of core debris in the stricken units, and those for seismic engineering analysis that can be used to explore innovative approaches of improving seismic safety of NPPs effectively and efficiently.
- Pursue steady progress in the use of plutonium recovered by reprocessing in LWRs and in the assurance of safe geological disposal of high-level radioactive waste, including used fuel.

FR and its Fuel Cycle R&D Projects in Japan
Before March 11, 2011



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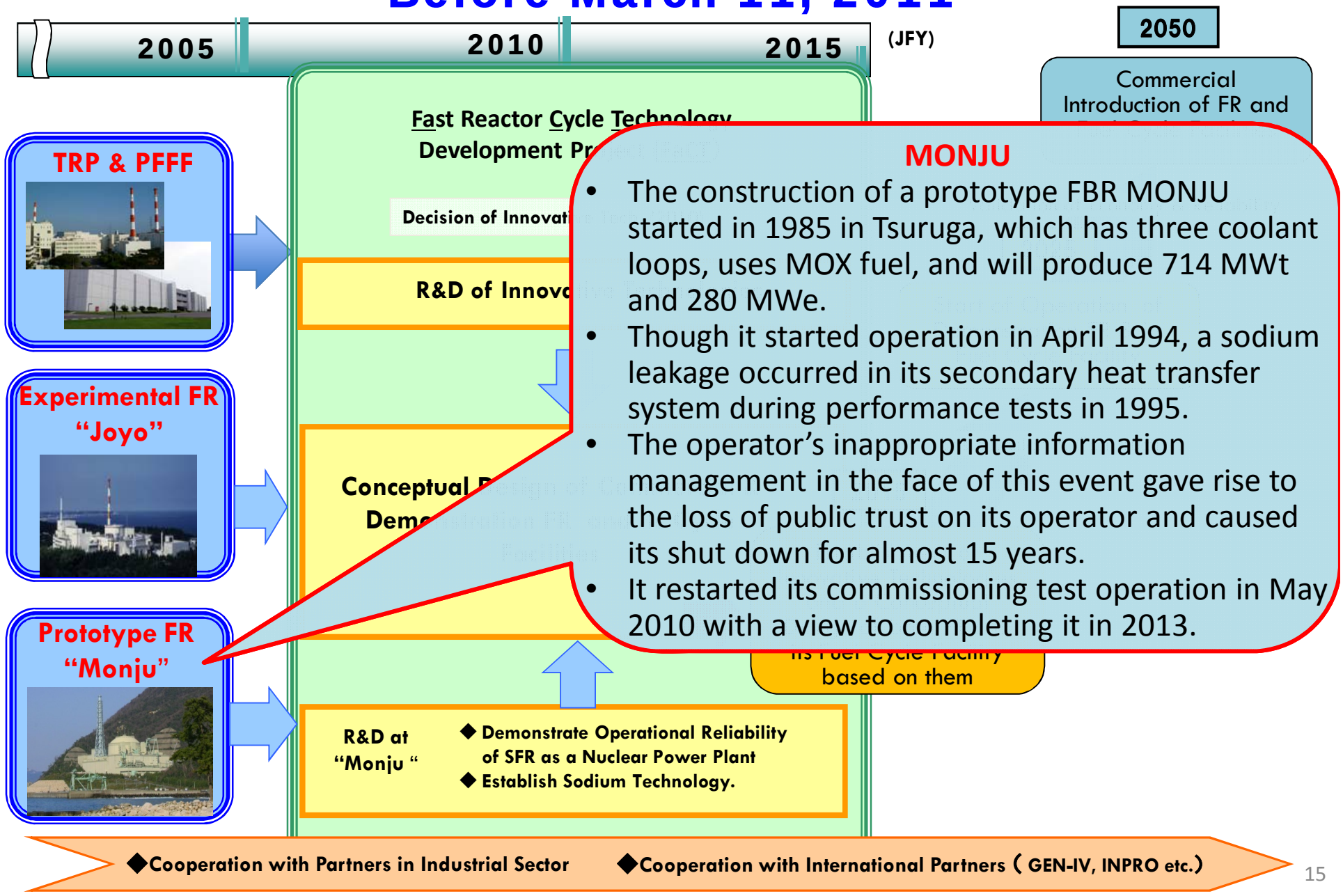


MONJU

- The construction of a prototype FBR MONJU started in 1985 in Tsuruga, which has three coolant loops, uses MOX fuel, and will produce 714 MWt and 280 MWe.
- Though it started operation in April 1994, a sodium leakage occurred in its secondary heat transfer system during performance tests in 1995.
- The operator's inappropriate information management in the face of this event gave rise to the loss of public trust on its operator and caused its shut down for almost 15 years.
- It restarted its commissioning test operation in May 2010 with a view to completing it in 2013.

FR and its Fuel Cycle R&D Projects in Japan
Before March 11, 2011

2005 — 2010 — 2015 (JFY)

2050

Commercial Introduction of FR and Fuel Cycle Facilities

TRP & PFFF

Experimental FR "Joyo"

Prototype FR "Monju"

Fast Reactor Cycle Technology Development Project (FaCT)

Decision of Innovative Tech. (

Conceptual Design of Cor
Demonstration FR and
Facilities

Innovative Technologies and a Conceptual Design of both FR and its Fuel Cycle Facility based on them

R&D at "Monju "

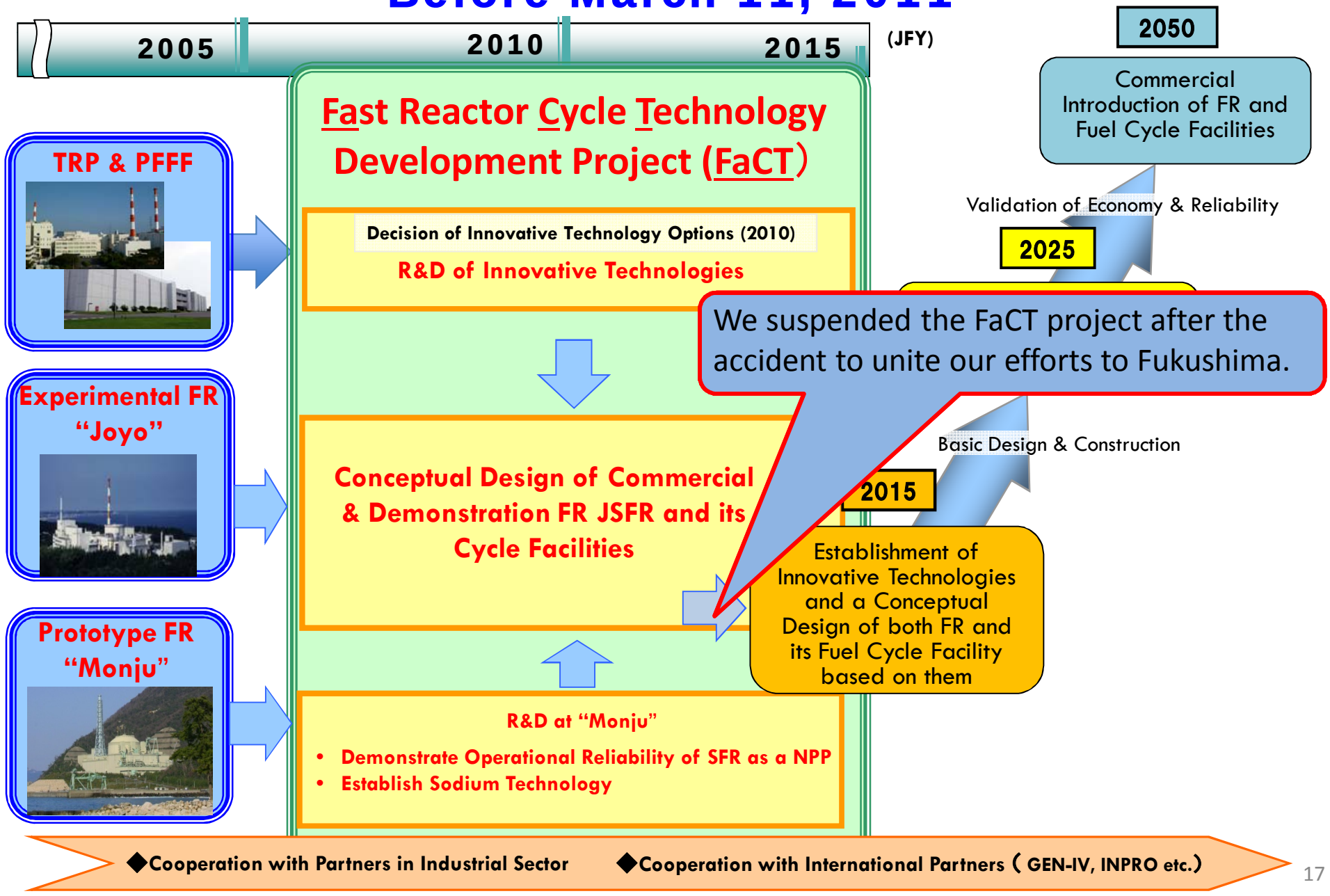
- ◆ Demonstrate Operational Reliability of SFR as a Nuclear Power Plant
- ◆ Establish Sodium Technology.

MOX Fuel for JOYO and MONJU

- The construction of Tokai Reprocessing Plant (TRP) was started in 1971 for the recovery of plutonium from used LWR fuel.
- MOX fuel for JOYO and MONJU has been fabricated at the Plutonium Fuel Production Facility (PFPF) since 1988.

◆Cooperation with Partners in Industrial Sector ◆Cooperation with International Partners (GEN-IV, INPRO etc.)

FR and its Fuel Cycle R&D Projects in Japan
Before March 11, 2011



Objectives of FR R&D After the Suspension of the FaCT project

While deliberating the effective uses of both research and engineering capabilities and knowledge basis developed through the FaCT project in the development of sustainable nuclear technology worldwide.

- Accomplish full power operation of MONJU to establish basis for safe, secure and proliferation-resistant SFRs:
  - Improve severe accident management procedures for MONJU so as to satisfy new safety rules to be set by the NRA.
  - Complete system startup tests (SST) in order to check the performance of MONJU as designed.
  - Continue to operate it as an international fast neutron irradiation facility and enrich the knowledge basis for safe, secure and proliferation-resistant SFRs.

International Workshop on Research Collaboration Making Use of MONJU

- Japanese government will host an international workshop in April that explores various possibilities of utilizing MONJU for conducting international collaborative research and development activities.
- Participation from countries interested in R&D on fast reactors will be welcome.

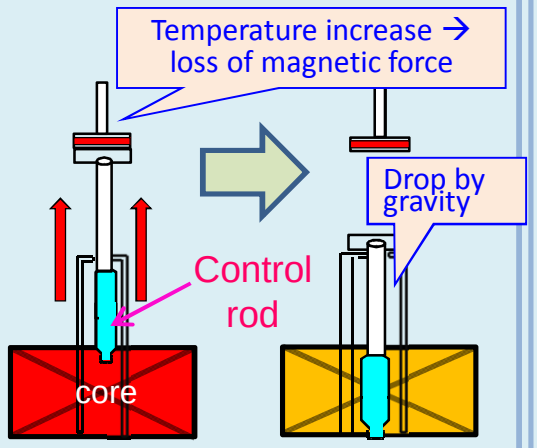
R&D Activities for Strengthening Safety of Next Generation SFR

- Pursue built-in passive features for the working of critical safety functions
- Strengthen defence-in-depth features by introducing measures to control beyond design basis events, as contemplated in Requirement 20 , **design extension condition** of the IAEA Safety Standards No. SSR-2/1: Safety of Nuclear Power Plants: Design, 2012.
  - Promote PSA utilizing simulation tools such as SAS 4A, SIMMER, and CONTAIN/LMR to extract information useful for contemplating effective measures to prevent and/or mitigate severe accidents of SFRs.

Supplementing or Superseding the DID Strategy

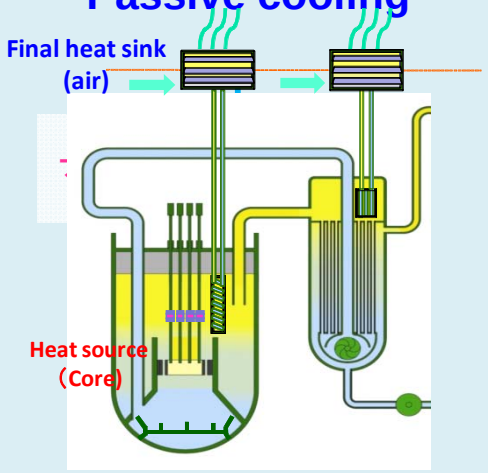
❖ Build passive features in the existing safety systems for the working of alternate safety functions, without adding another active systems, as countermeasures for prevention & mitigation of severe accident.

Passive shutdown



➢ Drop-down of Control Rods

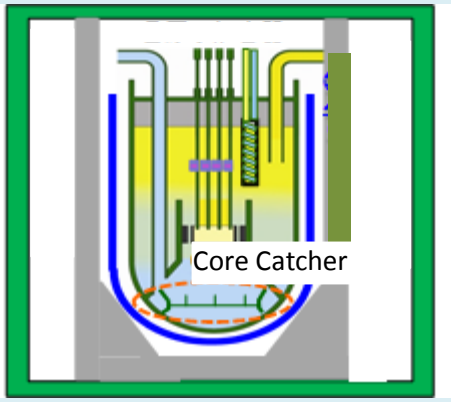
Passive cooling



➢ Cooling by Natural Circulation, with the final heat sink of air

Containment

e.g.

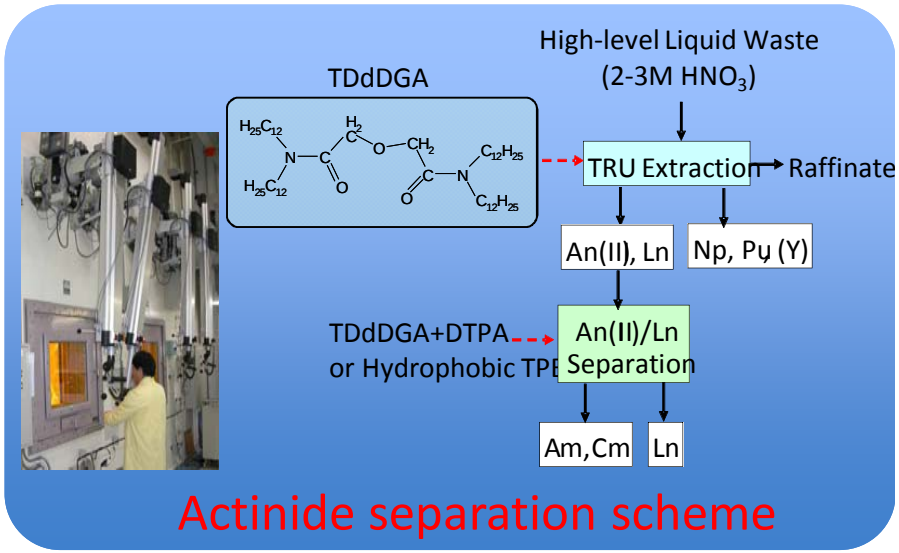


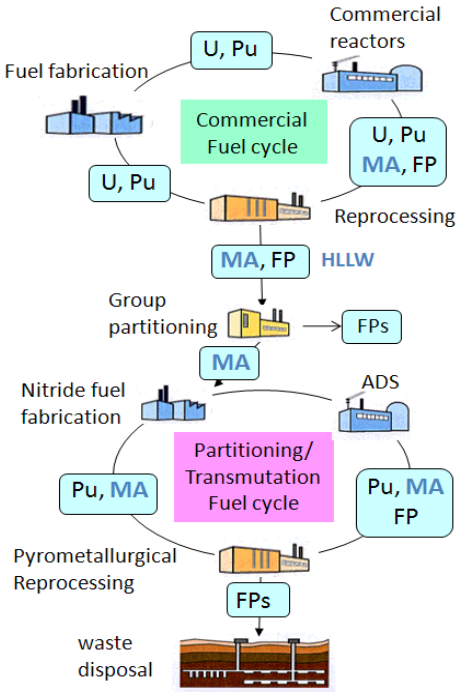
➢ Retention of molten fuel in Reactor Vessel & Maintain Radioactive Material within Containment Vessel

R&D for Minimization of Volume and Toxicity of Waste From Nuclear Power Generation

- Fuels under development: oxide, nitride, metal
- R&D issues
  - Fuel fabrication technology
  - Irradiation performance and cladding materials
  - Reprocessing technologies; aqueous process/pyro-process
  - Assurance of safety, security and proliferation resistance

R&D for Double Strata P&T Concept





Four-groups partitioning: process design for TRU-recovery from high level liquid waste (HLLW)

ADS: subcritical core design, Pb-Bi cooled system design, TRU-transmutation evaluation

Nitride fuel: fabrication, fuel performance, ^{15}N-enriched

Pyro-metallurgical reprocessing: process design for treating spent nitride fuel

International Cooperation

- Japan has been working together with members of the Generation IV International Forum (GIF) and the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) to lay the groundwork for the fourth generation SFR system, in particular.
- Japan should make utmost effort to share its experience and lessons derived from the severe accident at Fukushima with the world, as it is a responsibility of Japanese nuclear community to contribute to strengthening nuclear safety worldwide.
- Japan should also continue to promote multilateral and bilateral dialogue and cooperation with members of GIF and INPRO groups with a view to developing sustainable nuclear energy systems as a long term project, making best use of knowledge basis and research and engineering capabilities cultivated through SFR R&D activity extended over a long period.

Summary

- New nuclear energy strategy is still in the process of deliberation in Japan. Though many of idled plants will be restarted after renovation of their safety features in accordance with new safety rules set by the NRA, the contribution of nuclear power in Japan will probably not return to the level before 3.11.
- Japan is in the process of reviewing its strategy for SFR R&D with a view to making it compatible with the new situation to be realized under new safety regulation as well as new energy strategy to be formulated within a year.
- It is contemplated that major emphasis of the SFR R&D should be on a) the completion and use of MONJU, b) FR safety and c) waste minimization, not to mention the making effective use of our knowledge basis and research and engineering capabilities cultivated through the FaCT project in the development of sustainable nuclear energy systems worldwide for future generations of mankind.
- Promotion of international cooperation should be an essential ingredient of the strategy.

Thank you for your attention