Japan's Policy for Nuclear Energy Research, Development and Utilization

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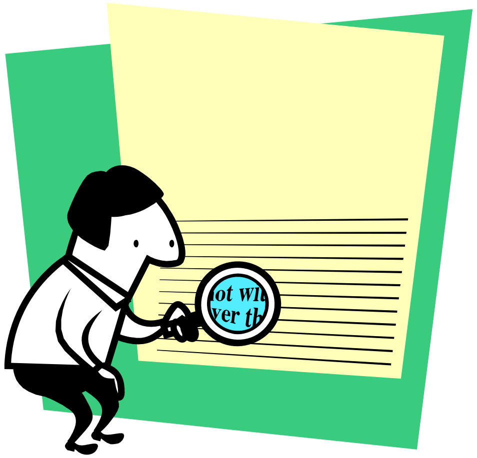
Japan Atomic Energy Commission

*The Joint International Conference of
the 7th Supercomputing in Nuclear Application
and the 3rd Monte Carlo (SNA + MC2010)*

Thank you for inviting me to address.

I made an opening address at the first SNA conference in Mito in 1990 as an organizer.

How tedious it was for the experts of simulation to listen to my reasoning of the importance of simulation!



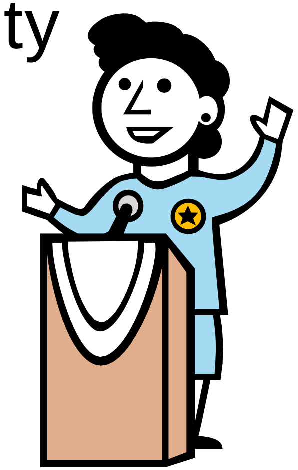
Today I am going to talk about the importance of modeling and simulation for brighter nuclear energy future again as a policy planner.

Take it easy please!

Basic Goal for Nuclear Energy Policy

- Promote safe, secure, safeguarded and sustainable utilization of nuclear energy for the promotion of science and industry and the improvement of a living standard of the people in Japan and
- Contribute to the shaping of international environment for safe, secure, safeguarded and sustainable utilization of nuclear energy in any part of the world.

Strategic Objectives



- Maintain infrastructure for assuring safety, security and nonproliferation and the public trust in it.
- Make the share of nuclear power in electricity generation after 2030 greater than 40 %.
- Store and reprocess used fuel from LWRs and utilize fissile material recovered by the reprocessing in LWRs.
- Develop and operate geological repositories for disposing vitrified high-level radioactive waste from the reprocessing.
- Expand the opportunity of utilizing radiation and maintain a level-playing field for radiation application in science, medicine, agriculture, industry, etc.
- Promote carefully planned but aggressive basic research, near, mid and long-term R&Ds in parallel.

Nuclear Power Generation In Japan: Current Status

- 10 electric power companies (EPCs) are operating 54 LWRs (30 BWRs and 24 PWRs) that supply about 30% of electricity in Japan. This year, 2 units start beyond-40 years-operation.
- Several NPPs are loaded with U-Pu Mixed Oxide fuel.
- 2 units are under construction and 12 units are in preparation.
- 3 nuclear power plants are in the decommissioning stage.
- 3 nuclear power plant vendors, Toshiba, Hitachi, and Mitsubishi Heavy Industries, have supplied these BWRs and PWRs on time and within budget in most cases.
- One large scale low-level waste disposal facility operation for more than 10 years.

Radiation Utilization in Japan: Current Status

- More than 5,000 firms (including industries, hospitals and research organizations) are registered as the user of radiation and radioactive materials.
- The Government sponsors construction and operation of large scale radiation sources such as RIBF, SPring-8, J-PARC, HIMAC etc. They are open to users in science, industry, medicine etc.

RIKEN NISHINA CENTER

RIKEN Nishina Center for Accelerator-Based Science

J-PARC

Portfolio of R&D Activities

i. Basic research: Maintain and expand knowledge basis for nuclear energy, including nuclear physics, materials, mechanics, chemistry, digital simulation. 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; trouble shooting, ageing, power up-rating, safe geological disposal of HLW, etc.

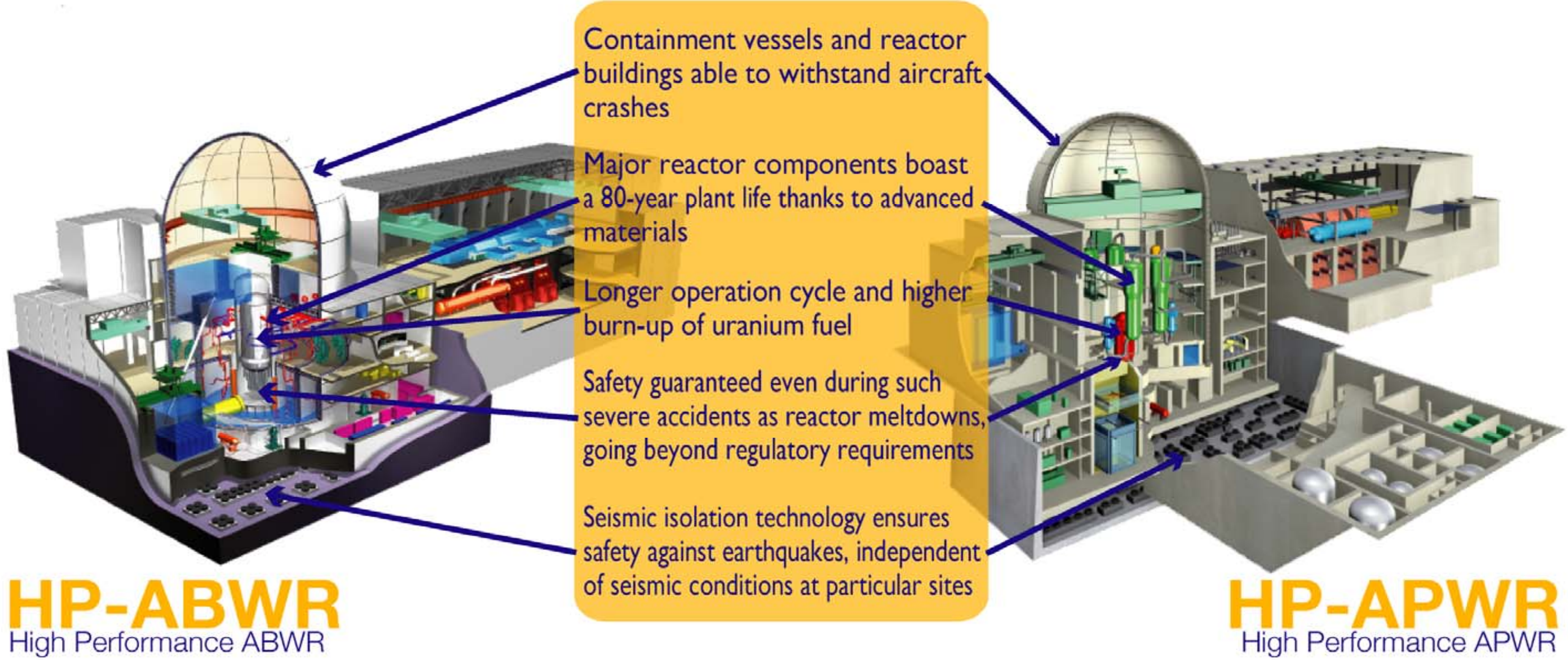
iii. Mid-term research: develop new products and processes to replace those currently in use; next generation LWRs.

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

High-Performance (HP) Next Generation LWRs

for expanding demand of global nuclear power in the 21th century

- Top-level safety and most economical efficiency featured by:
  - -Safety design with hybrid of passive and active
  - -Shortened construction period and reduced power generation costs
- Electric output of 1,800MW$_e$/ 800-1,000MW$_e$ depending on user needs
- Conceptual design through collaboration of Institute of Applied Energy and Japan's three plant vendors (Hitachi-GE, Mitsubishi Heavy Industry and Toshiba)
- Supported by the government and electric utilities.



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 "

<u>Fa</u>st Reactor <u>C</u>ycle <u>T</u>echnology Development Project (<u>FaCT</u>)

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.**

2015

Establishment of Conceptual Design incorporating innovative Technologies

Basic Design & Construction

2025

Operation Start of Demonstration FR & its Fuel Cycle Facility

Validation of Economy & Reliability

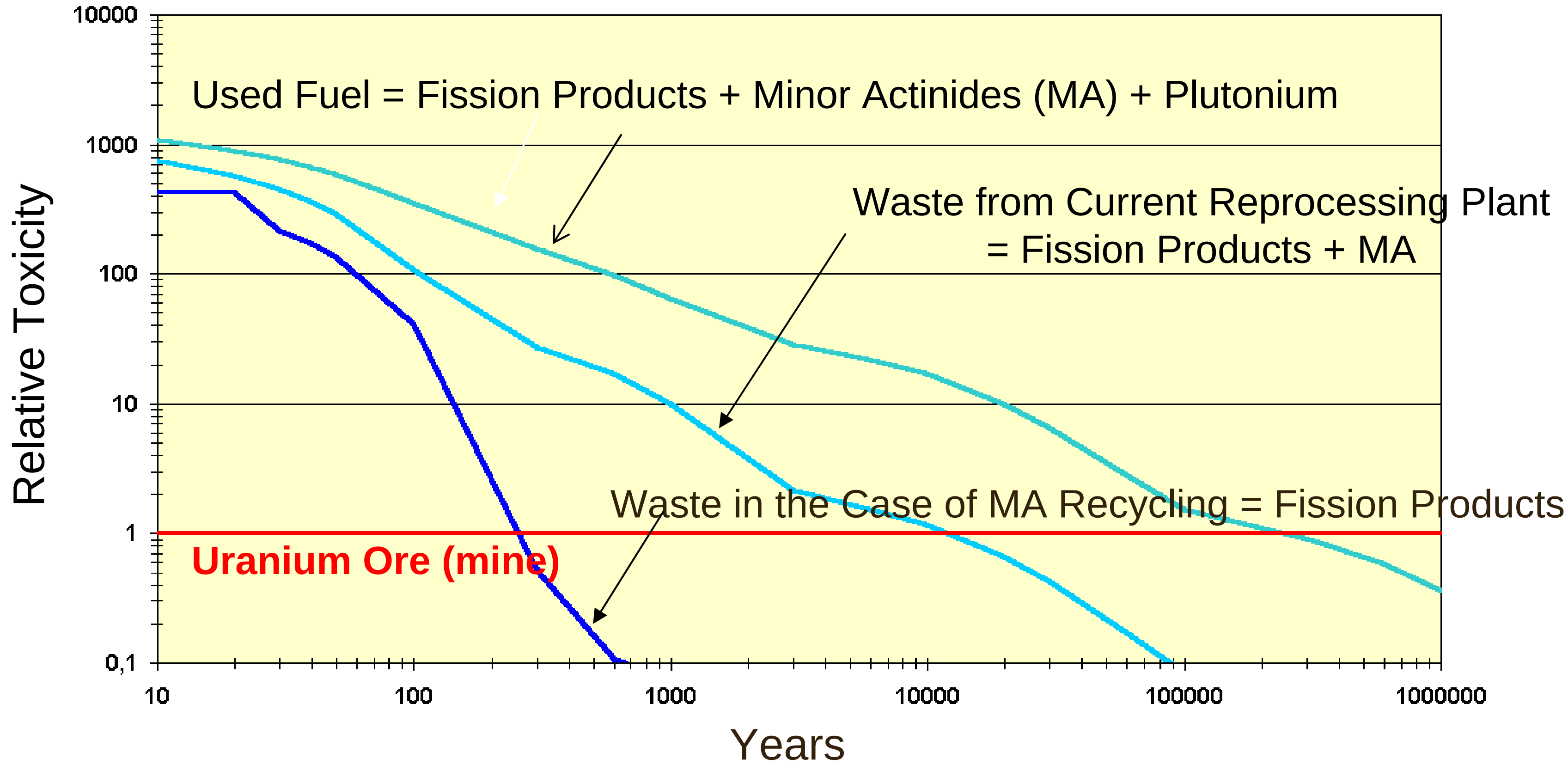
2050

Commercial Introduction of FR & its Cycle Facilities

◆Cooperation with related Organization **◆International Cooperation（GNEP, GEN-IV, INPRO etc.）**

Long-Term Radiotoxicity of Materials to be Disposed of

Each GW-year ~ 20 Tons of Used Fuel [~ 19 T Uranium + ~ 0.7 T Fission Products + 0.2 T Pu + 0.02 T Minor Actinides]

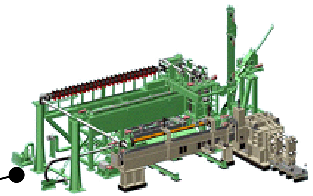


Innovative Fuel Cycle Technologies

Advanced Aqueous Reprocessing

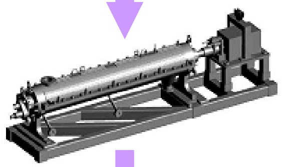
(1) Disassembling and Shearing

Mechanical Disassembling and Shorter Length Bundle Shearing



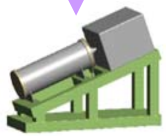
(2) Dissolution

Compact Continuous Dissolver



(3) Uranium Crystallization

Compact Continuous Crystallizer

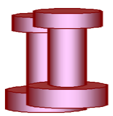


(4) U, Pu and Np Co-extraction

Centrifugal Contactor

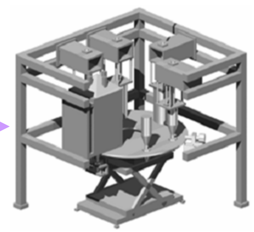
(5) MA Recovery

Extraction Chromatography Method



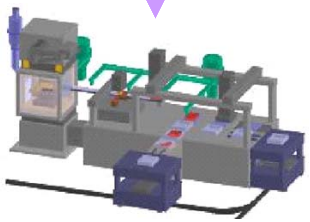
(6) Salt Free Waste Treatment

Simplified Pelletizing Fuel Fabrication



(7) Conversion and Granulation

Microwave Heating Denitration 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.

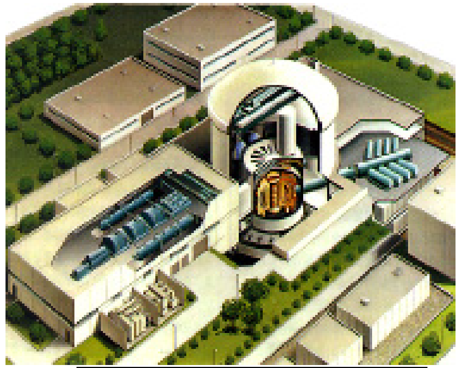
H. Funasaka, Development of FBR Fuel Cycle Technology in Japan, FR09, 2009.

We Are in the Middle of Three-Stage Approach to Fusion Energy Utilization

Gekko-XII (Osaka Univ.)
Inertial Fusion

Helical LHD (NIFS)

Economic Feasibility
- Demonstrate Electric Power
- Improve Economic Competitiveness

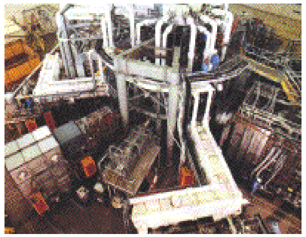


DEMO Reactor

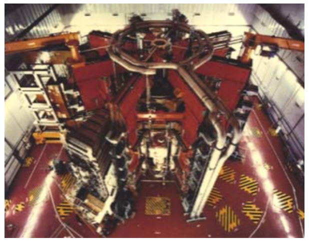
Technological Feasibility
- Realize Long-duration Burning Plasma
- Establish Technology Basis for DEMO Reactor

Scientific Feasibility

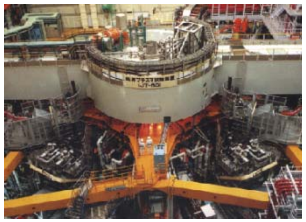
Achieve Break-Even Plasma Condition



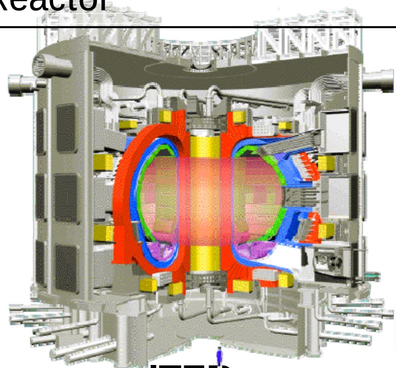
JET



TFTR (US)

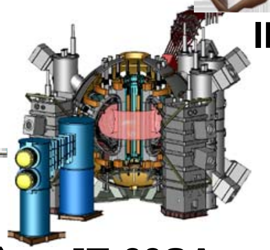


JT-60 (JA)



ITER (Experimental Reactor)

IFMIF



JT-60SA

ITER Project

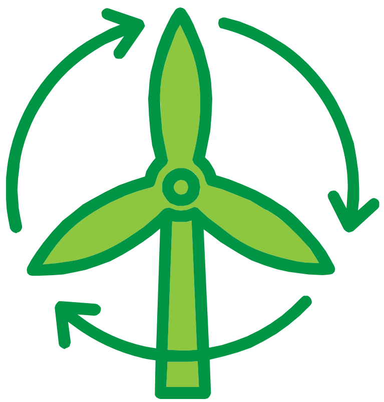
BA Activities

The AEC's Recommendations to R&D Administration

a. Leaders should be capable of leading to invest, innovate and create values where none existed before, having determination to excel and timely decide what he should decide.
b. Three main priorities for leaders should be science, science and science!
c. Leaders should strengthen front-loading and spiral development that facilitate effective interaction with stakeholders, recognizing that devils lie in details.
d. Leaders should encourage development and utilization of high-fidelity science-based modeling and simulation tools.

Why Front-loading and Spiral Development?

- **Front-loading:** the most cost-effective activities for product growth can be done in the early phase of project.
- **Spiral development:** to pursue a robust, safe, secure, safeguard and sustainable nuclear energy system, which should be an integrated socio-technical system, it is essential to promote the evaluation of risk of successful completion of the project through iterative feedback from engineers and end-users at each specific time of their research, development and utilization, which is continued in a spiral way.



Modeling and Simulation

- Successful modeling and simulation is applicable to solving important problems in engineering, science and society. It would provide new intuition and insights making a qualitative contribution to human knowledge.
- Modeling and simulation effort is indispensable to the promotion of front-loading activity. They can be used to reduce the number of prototypes and large-scale experiment needed before demonstration, quantifying uncertainties and design and operational parameters.
- Leaders of R&D organizations should pursue communications between R&D project teams and basic research teams, which are responsible to develop basics of various simulation tools, on the need for and possibility of modeling and simulation.

Current Issues

- The capacity factor of operating plants is currently miserably low. Nonetheless, it is required to improve it to 85% by2020 and 90% by 2030 so as to make the share of nuclear in power generation 49% in 2030 as a part of actions for combating global warming in the basic energy plan decided by the Cabinet this June.
- The reports of delay in the schedule of various projects, including the active test of the Rokkasho Reprocessing Plant, the determination of the site of geological repository for high-level waste, Monju restart, ITER etc. may cause a doubt in the public mind on the reliability and /or sustainability of nuclear power generation in Japan.

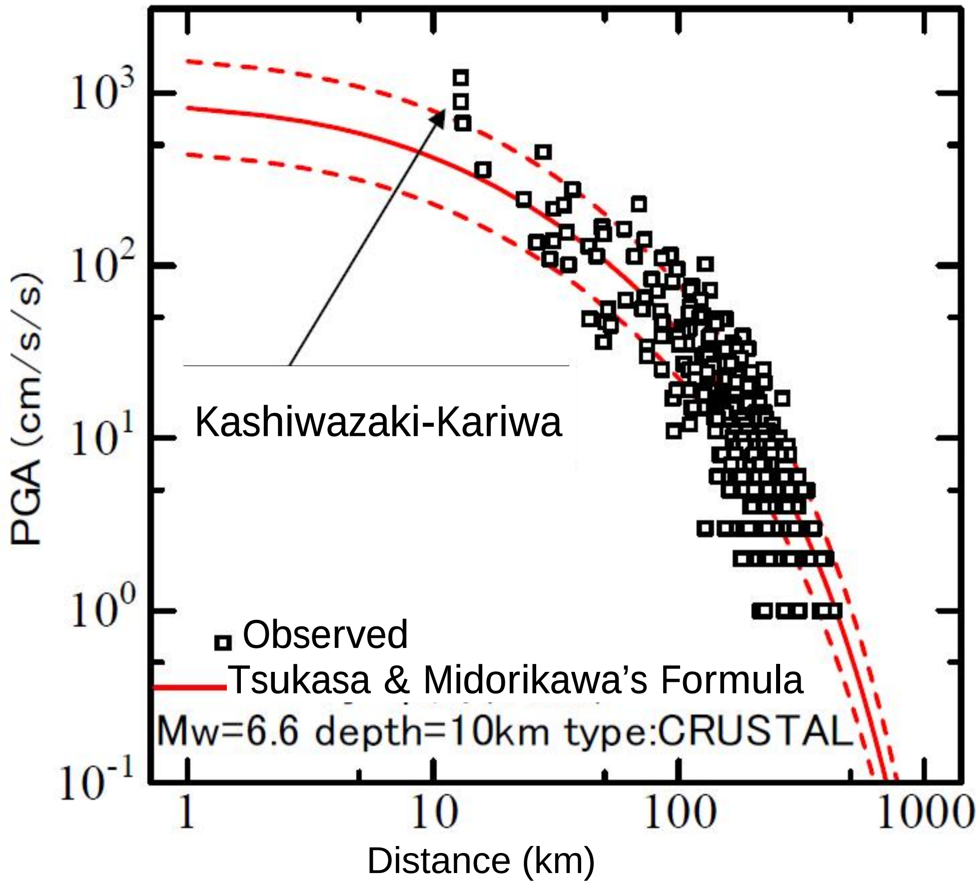
Average Capacity Factors (%)

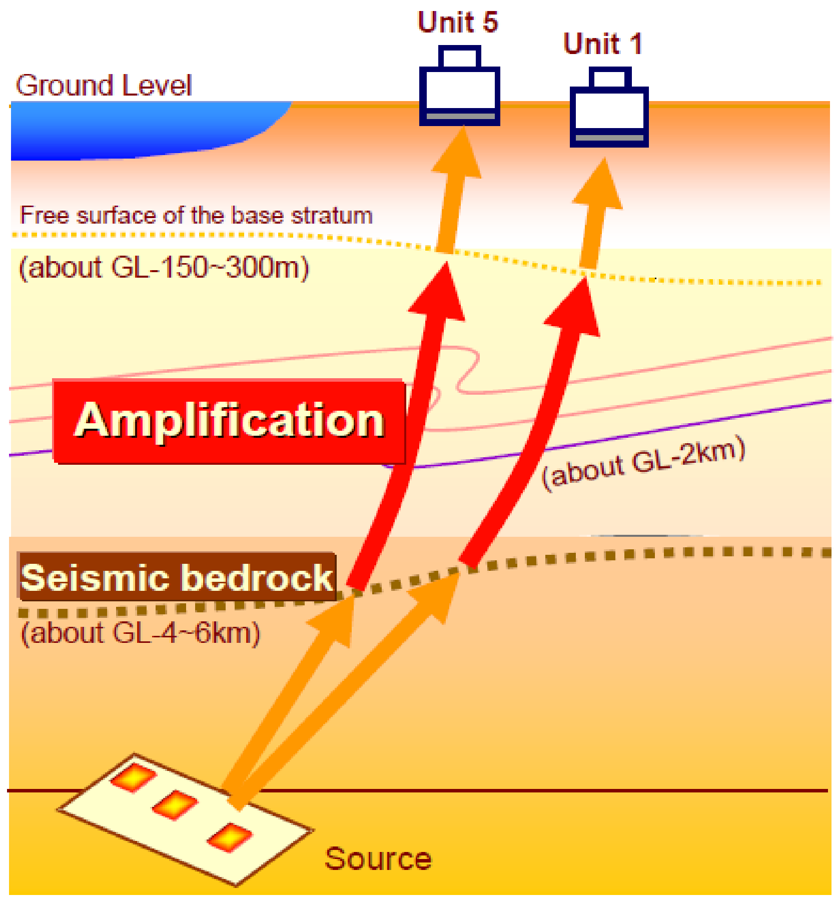
FY	*BWR*	PWR	Total	OUTAGE> 3 Months: Red: due to earthquake
2005	**65.2**	81.5	71.9	***On1-3, H1&2, 2F3***, M3
2006	**63.9**	79.2	69.9	***On1-3, H1&2, 1F1, H5***, S2, M3, G2
2007	**49.7**	77.8	60.7	***K1-7, H1&2, S1&2, On3, 1F1***, Ts2, M2, Tk2, Tk3
2008	**51.1**	73.7	60.0	***K1-7, S1, 1F1, H5,*** Ts2, To1, To2, M2, Tk3, Tk4, O3
2009	**55.5**	78.0	65.7	***K1-7*, S2, 1F3, H4, H5, On2,*** Ts2, To2, O1, O2

* K1,6&7 are now in operation. K5 is ready for restart.

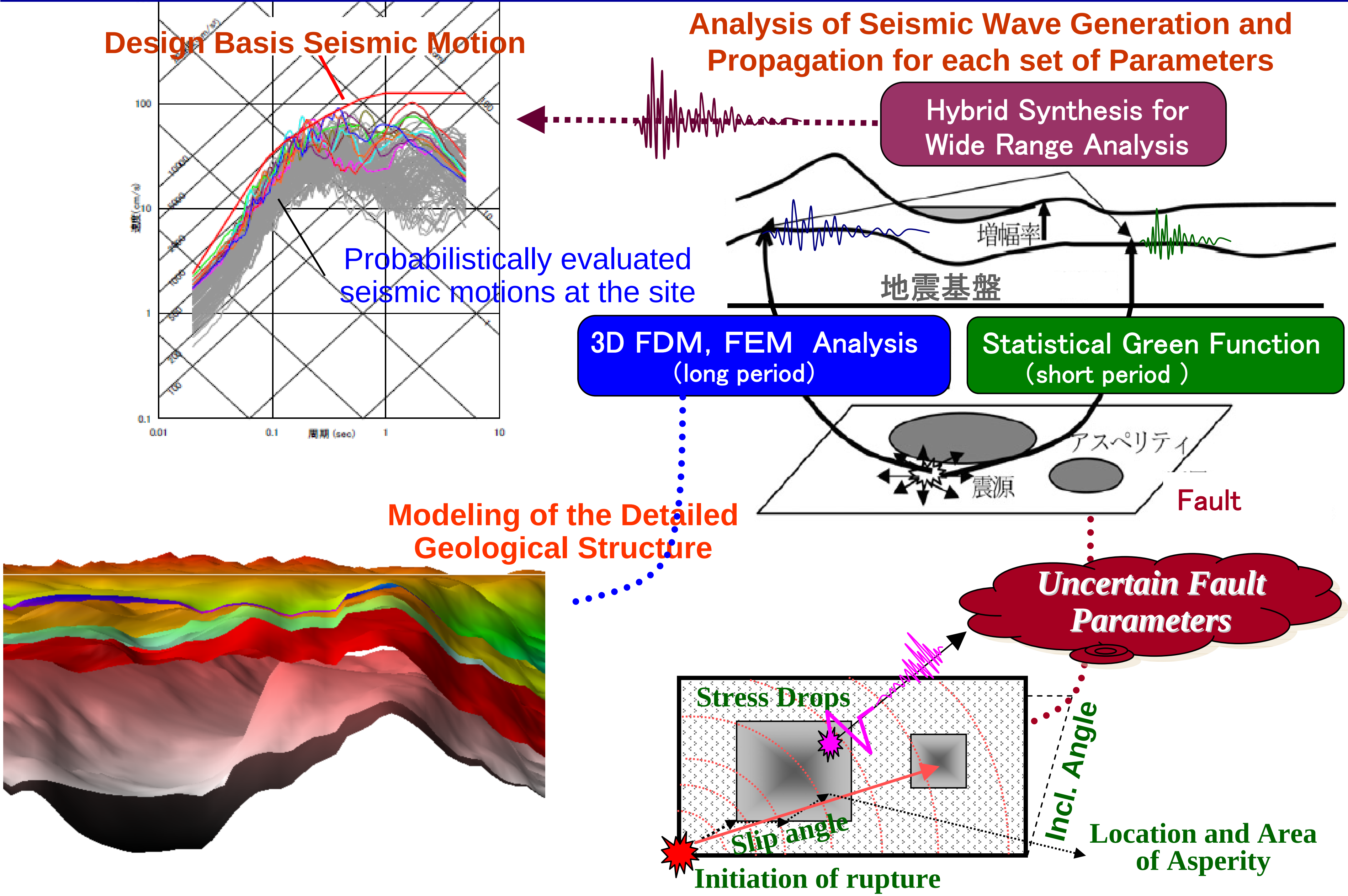
- In recent years, average capacity factors of BWRs have been significantly lower than those of PWRs!
- This is because some of BWRs have experienced strong earthquakes and thereafter have been forced to take a long outage time for inspection and safety review.

The seismic input to Kashiwazaki-Kariwa NPP in the 2007 Niigata-ken Chuetsuoki EQ significantly exceeded the level of design-basis seismic input. This is due to strong anisotropy of seismic energy generation at the fault and focusing and amplification effects caused by the unique geological structure around the site in the propagation of seismic wave from the fault to the site.





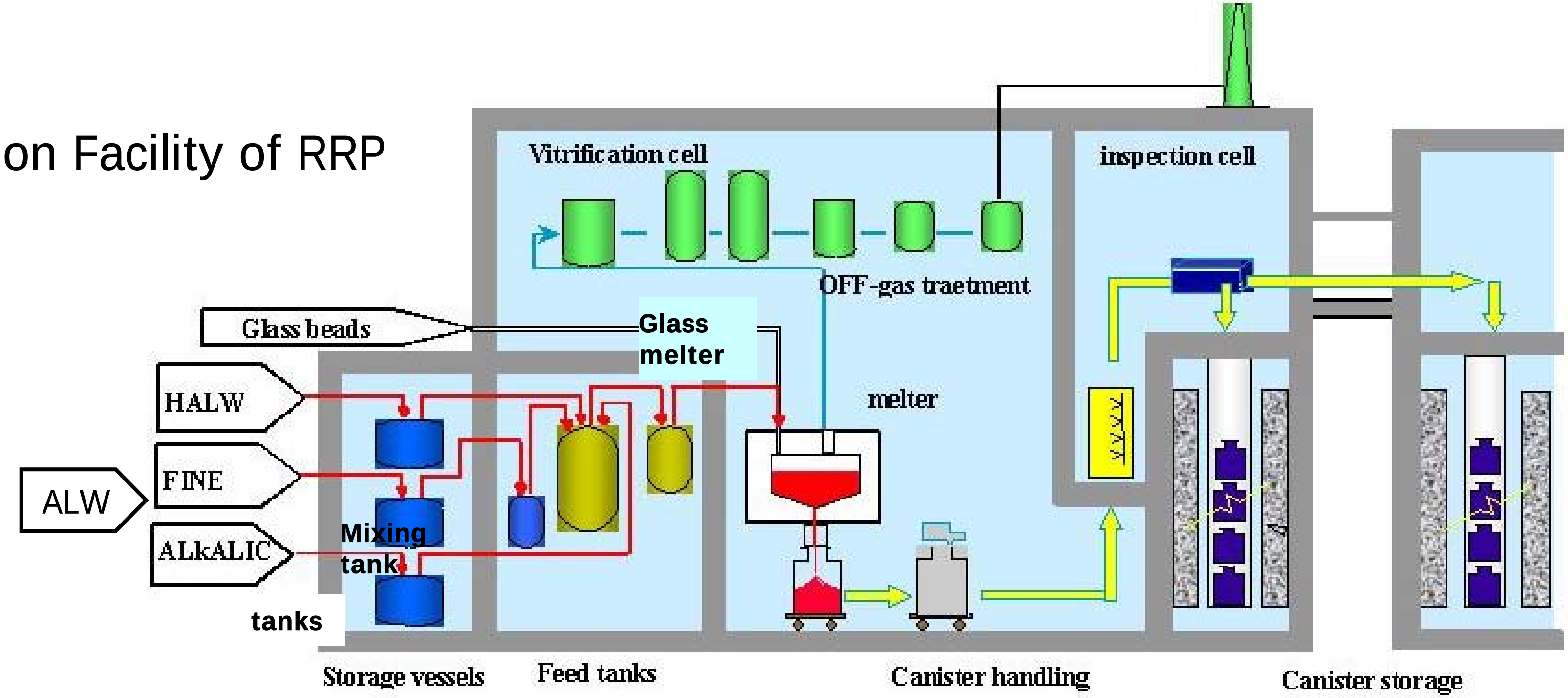
Assessment of Seismic Input based on the Analysis of Seismic Wave Generation and Propagation for Each Set of Uncertain Parameters

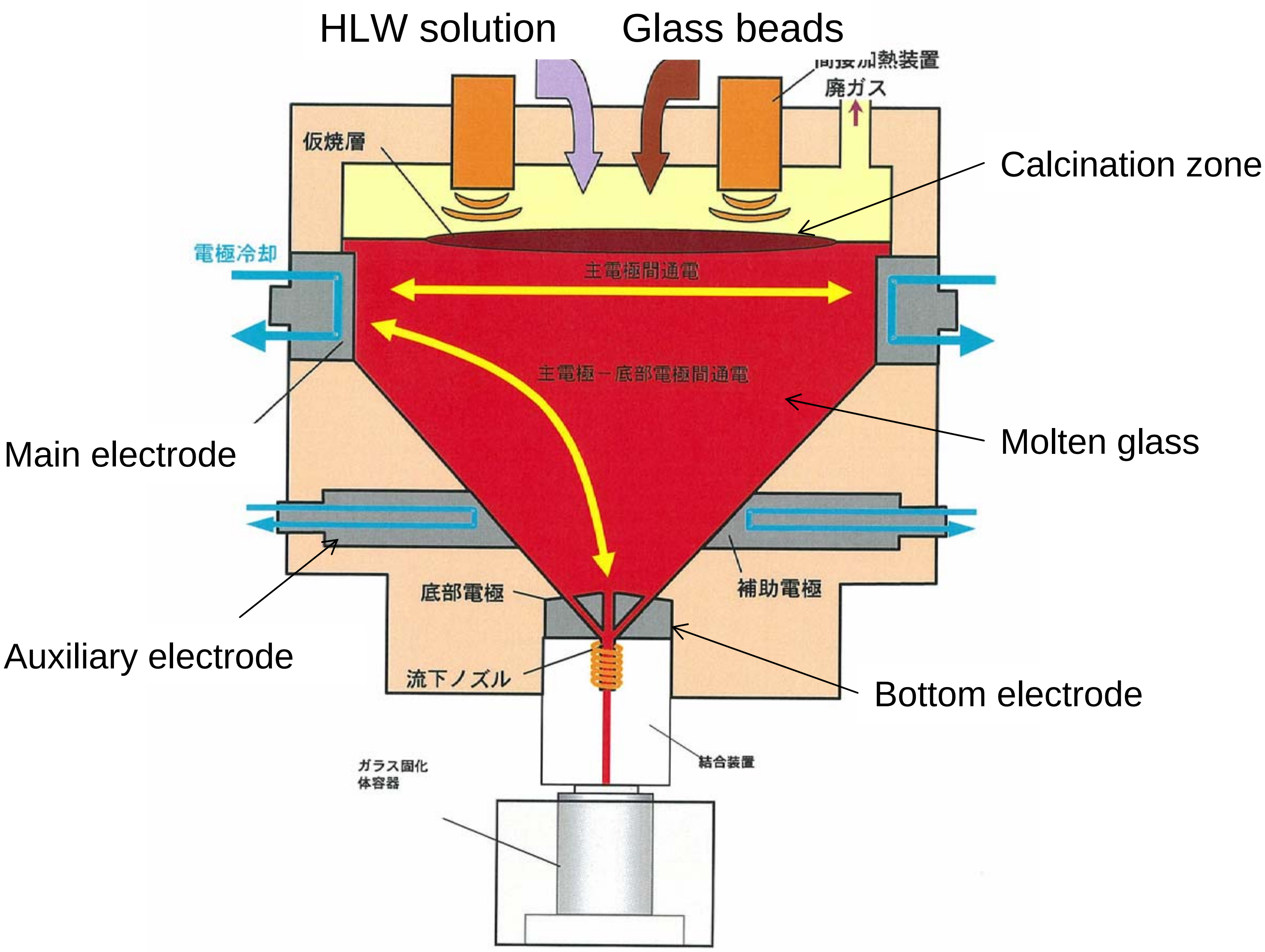


Rokkasho Reprocessing Plant

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

Vitrification Facility of RRP



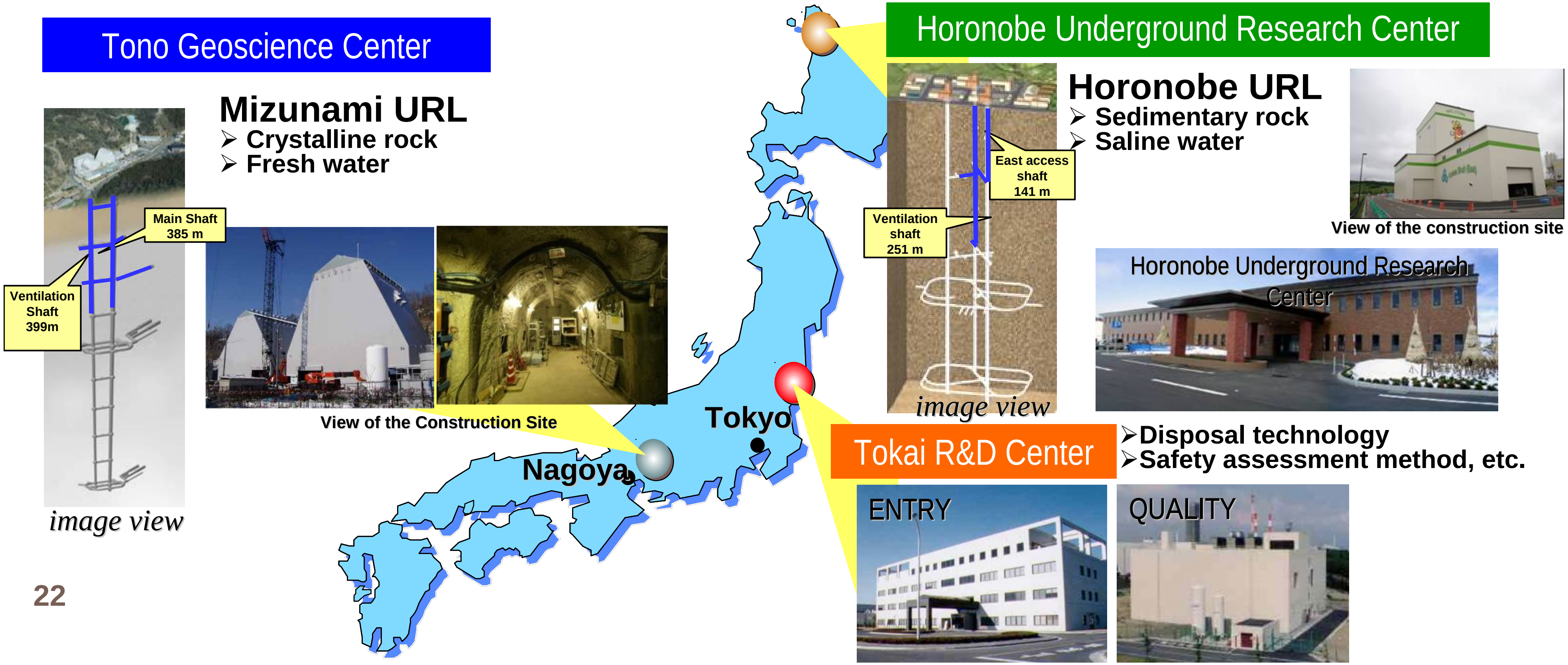


Joule-heated Ceramic Melter

Geologic Disposal of High-Level Radioactive Waste

R&D activity is promoted by the JAEA with a view to developing technical basis for the disposal project by NUMO and for safety regulations.

- Engineering technology and safety assessment methods
- Integrated methods for characterizing the deep geological environment
- Technical knowledge basis



Siting of a HLW Disposal Facility

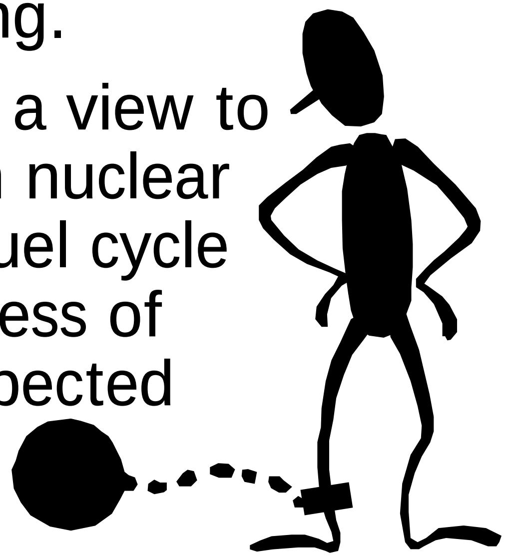
- In 2004, the NUMO, an organization authorized to promote the disposal activity, started to invite mayors of municipalities to apply for site suitability investigation.
- However, so far no mayor has successfully applied: in one case a mayor who applied was defeated in the election due to rally with such an appeal as “Can you and your posterity live with 40,000 highly radioactive canisters each of which has radioactivity equivalent to 30 Atomic Bombs dropped on Hiroshima-city”.
- Since then, the Government as well as the NUMO has started to strengthen public information activities on the safety and importance of the disposal facility at national and municipal levels, taking consideration lessons learned from such cases.

A Result of Opinion Poll (Nov. 2009)

- Do you think it a responsibility of our generation to choose 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%

Key Actions To Overcome These Difficulties

- Continue to inform the public the fact of nuclear energy with the troubles we are faced with, as well as the importance of nuclear energy for both assuring energy security and combating global warming.
- Maintain the public's confidence in both nuclear facility operators, nuclear energy administrator and nuclear safety regulator, engaging openly and transparently with the public so that the public can participate in decision making.
- Strengthen the business risk management with a view to maintaining the stable supply of electricity from nuclear power plants even if the projects related with fuel cycle are delayed, and further increasing the robustness of nuclear power generation against various unexpected technical and institutional occurrences.



Shape Int'l Environment for Safe, Secure, Safeguarded and Sustainable Nuclear Energy Use in the World

Objective 1: Share with international community knowledge, experience and lessons learned:

- Contribute to the activities of the IAEA, NEA, IFNEC for nurturing and maintaining international regime for such nuclear energy use:

Objective 2: Promote mutually beneficial bi- and multilateral cooperative activities with a view to effective and efficient execution of nuclear energy R&D activities:

- GIF, ITER, INPRO, Japan-US, Japan-France cooperation etc,

Objective 3: Shape environment for Japanese nuclear firms to be able to export nuclear power plant systems:

- Conclude nuclear agreement:
- Facilitate the capacity building and human resource development in new comer countries:
- Establish one-stop interface to supply emerging countries consultation on the contents of trade with team-Japan.

Conclusion

- Pursuing safe, secure, safeguarded and sustainable utilization of nuclear energy at home and abroad, Japan is promoting basic, near-term, mid-term and long-term R&D activities in parallel, underscoring the importance of science, front-loading and spiral approach.
- Science-based modeling and simulation with high fidelity and ease are essential in many parts of these efforts for brighter nuclear energy future.
- In order to overcome current difficulties, it is important to inform the public the situation and the importance of nuclear energy and strengthen comprehensive business risk management activities, with a view to maintaining the stable supply of electricity from nuclear power plants whatever technical and institutional delay or surprise may happen.
- It is essential under any circumstances to maintain the public's confidence in both nuclear facility operators, nuclear energy administrator and nuclear safety regulator, engaging openly and transparently with the public so that the public can participate meaningfully in decision making processes.

Thank you