Nuclear R&D in Japan after the Fukushima NPP Accident

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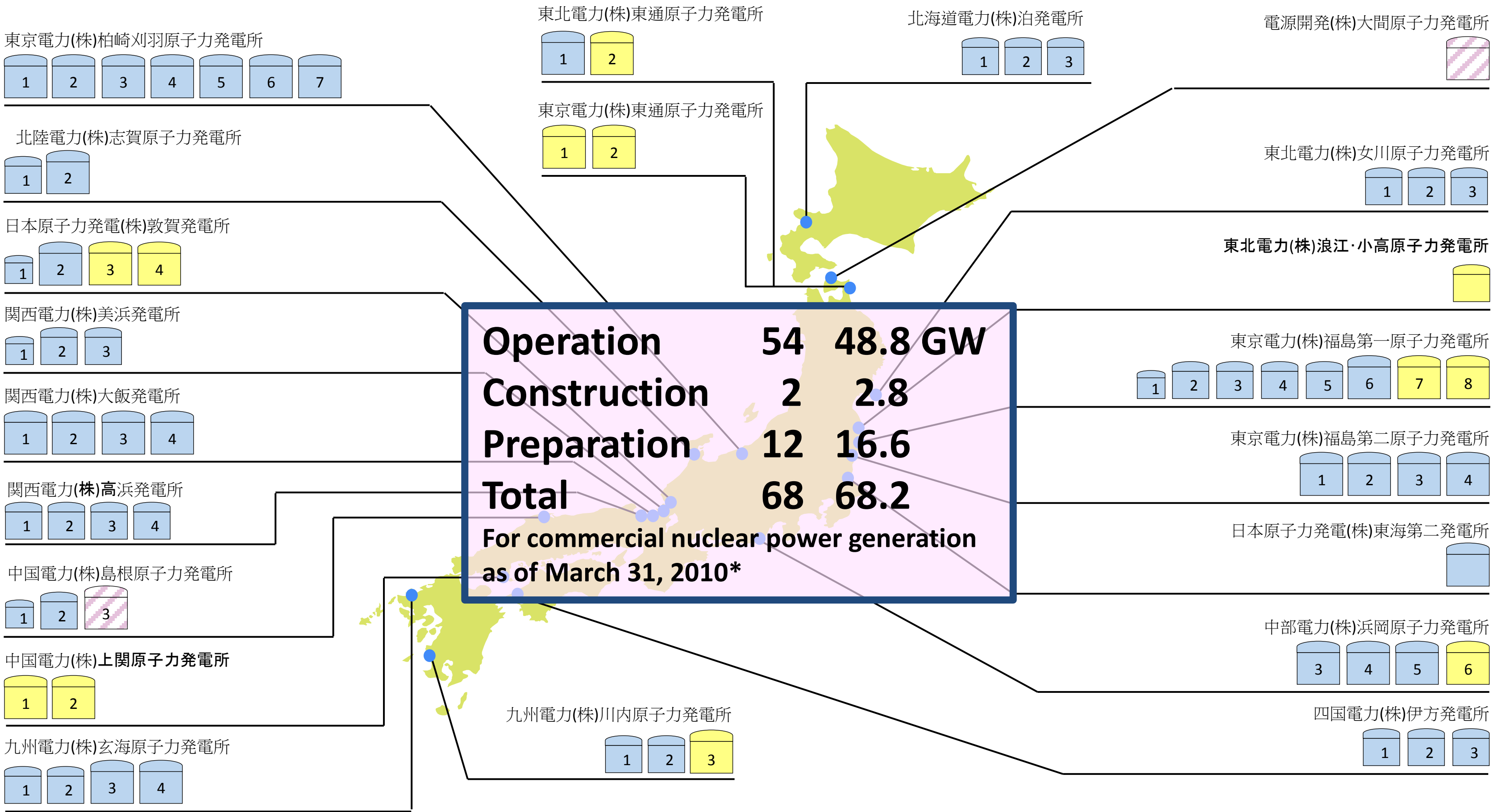
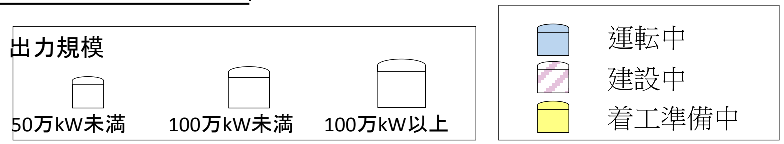
  - For future

Nuclear Power Generation in Japan

Ref. Agency for Natural Resources and Energy, "Nuclear Energy 2010", March 31, 2010





	基　数	合計出力（万kW）
運　転　中	54	4884.7
建　設　中	2	275.6
着工準備中	12	1,655.2
合　　計	68	6,815.5

運転終了：日本原子力発電（株）東海発電所 1998.3.31／中部電力（株）浜岡原子力発電所1、2号機 2009.1.30

Nuclear Power Generation in Japan

Before and After the Fukushima NPP Accident

- **Before the Accident**
  - Operation 54 BWR(26), ABWR(4), PWR(24)
  - Under construction 2 ABWR(1), Full MOX ABWR(1)
  - Preparation for construction 12 BWR(9), PWR(3) at 8 sites
  - Sources of power generation (%) in 2009:
    Nuclear (29), Natural Gas (29), Coal (25), Hydro (8), Oil (7)
- **After the Accident**
  - Termination of operation 4 Fukushima Daiichi 1-4 *(April 2012)*
  - Restart of operation 2 Ohi-3 and 4 (PWR) *(July 2012)*
  - Construction continues 2 Ohma-1 (Full MOX ABWR) ,
    Shimane-3 (ABWR) *(Sept 2012)*

Safety Issues after the FK* NPP Accident

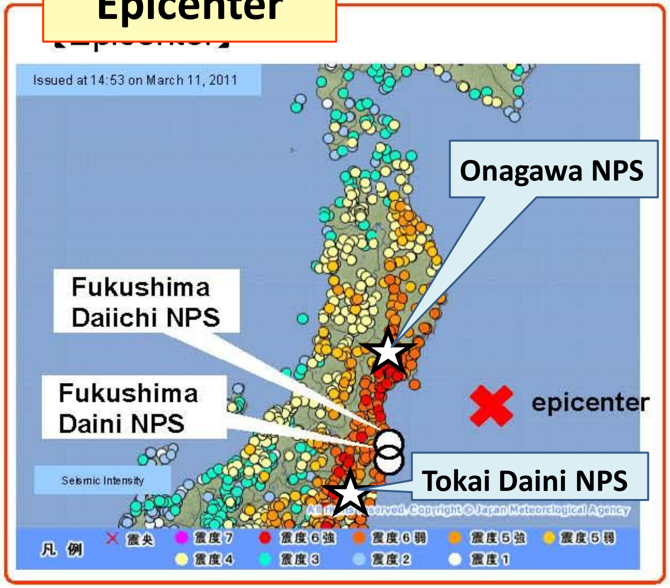
Tohoku Pacific Ocean Earthquake

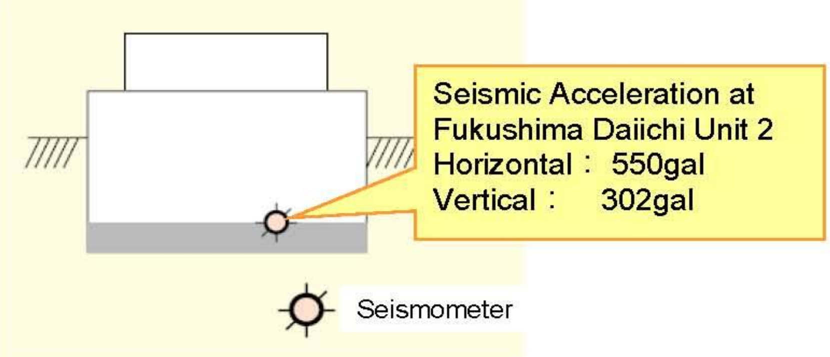
(denotes Fukushima)*

External hazard beyond the design basis

- **Time:** 2:46 pm on Fri, March 11, 2011.
- **Place:** Offshore Sanriku coast (northern latitude of 38 degrees, east longitude of 142.9 degrees), 24km in depth, Magnitude 9.0
- **Intensity:** **Level 7** at Kurihara in Miyagi prefecture
  Upper 6 at Naraha, Tomioka, Okuma, and Futaba in Fukushima pref.
  Lower 6 at Ishinomaki and Onagawa in Miyagi pref., Tokai in Ibaraki pref.
  Lower 5 at Kariwa in Niigata pref.
  Level 4 at Rokkasho, Higashidori, Mutsu and Ohma in Aomori pref., Kashiwazaki in Niigata pref.

Epicenter

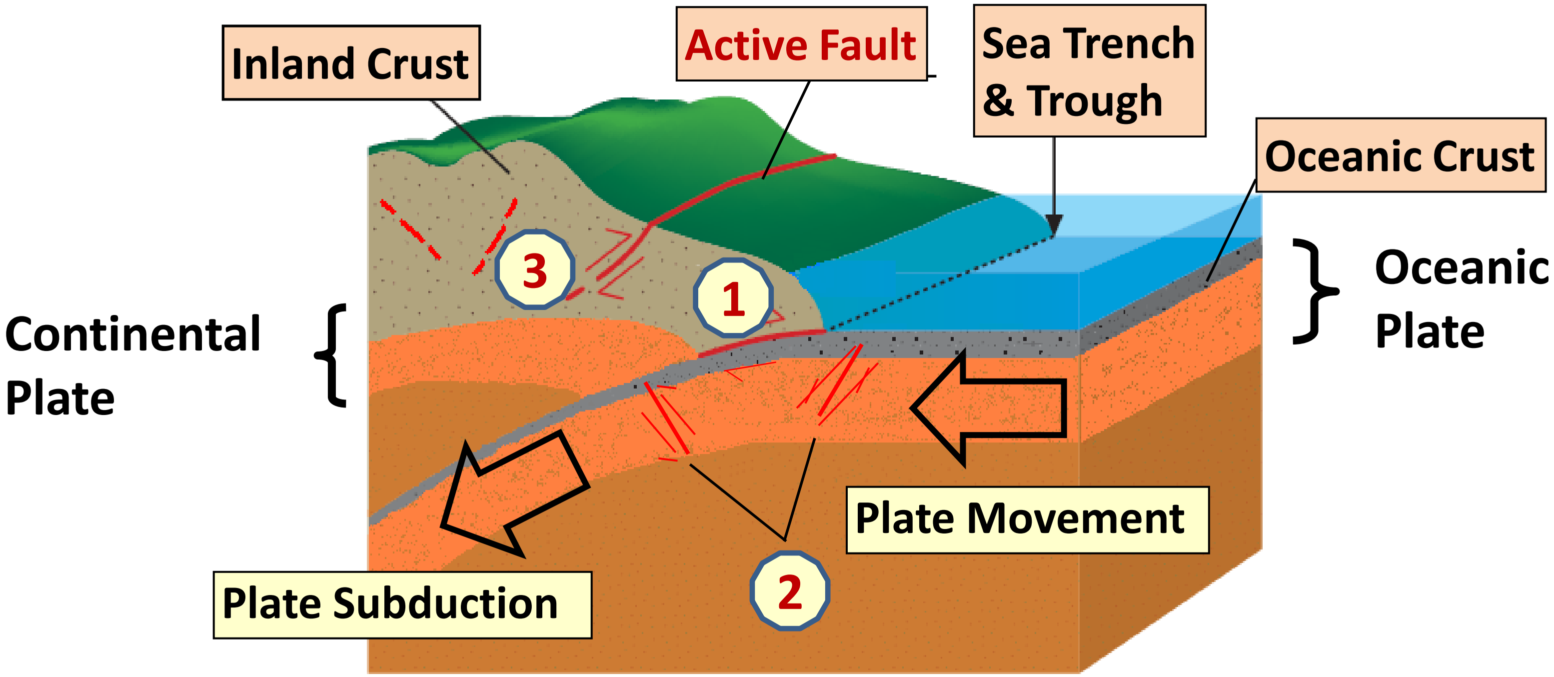




* gal: a unit of acceleration defined as cm/s².

Tohoku Pacific Ocean Earthquake

Typical Earthquakes and Active Faults



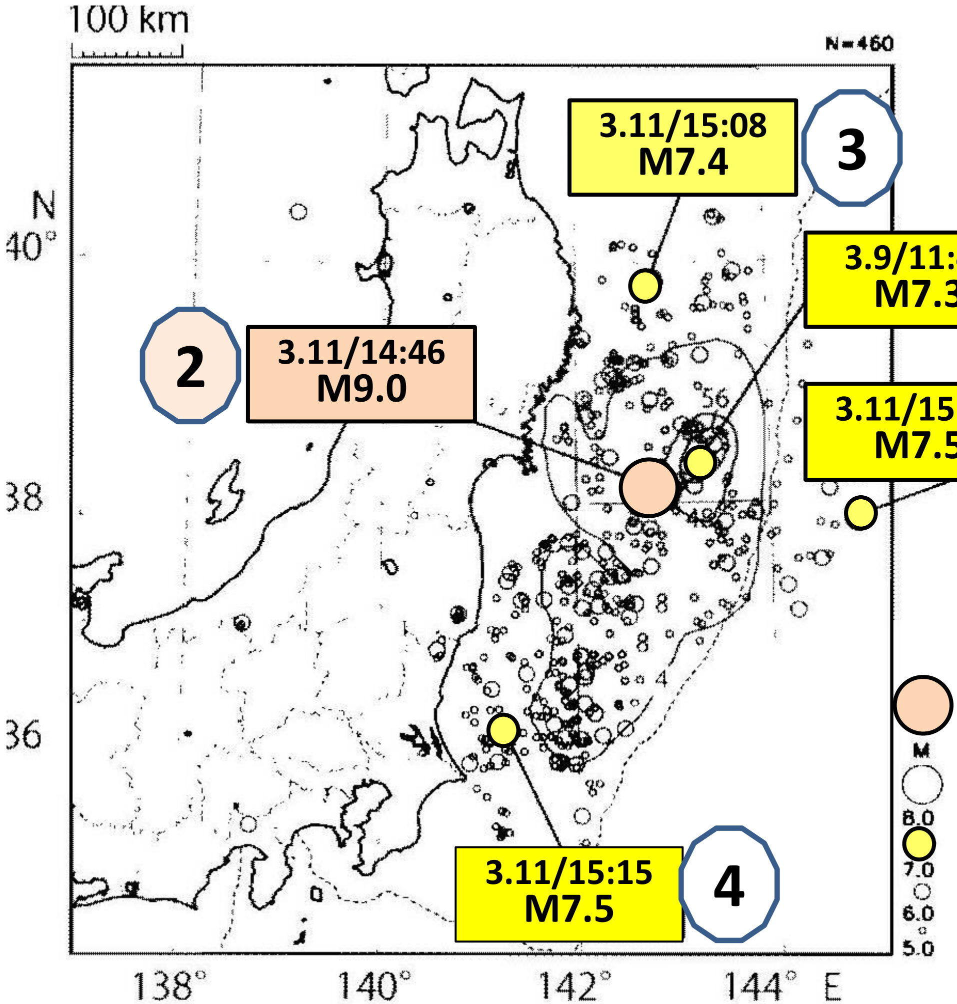
Earthquakes :

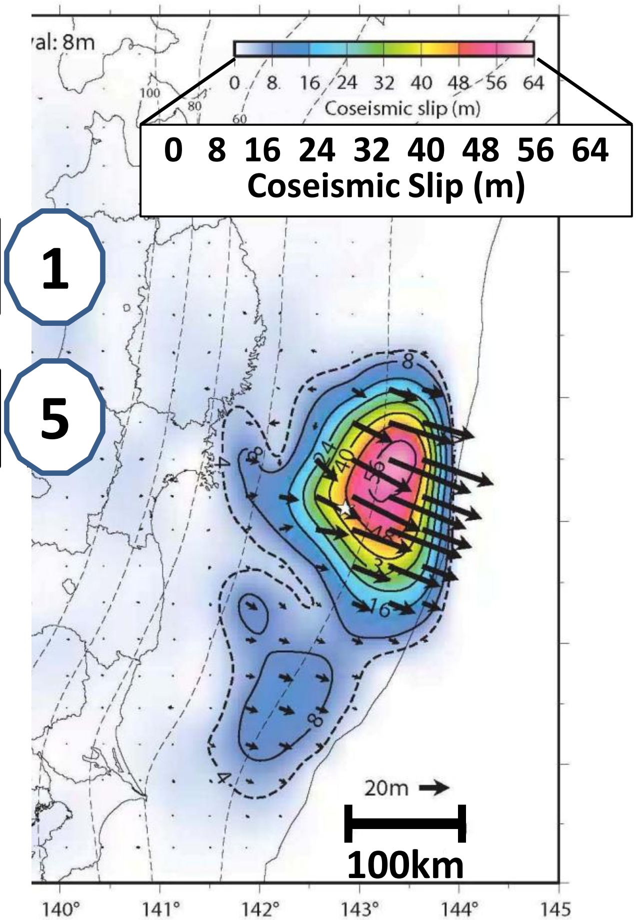
1 Inter Plate E.Q. ,Inland, 2 Intra Plate E.Q., 3 Inside-crust E.Q.

Tohoku Pacific Ocean Earthquake

Earthquakes and Coseismic Slip

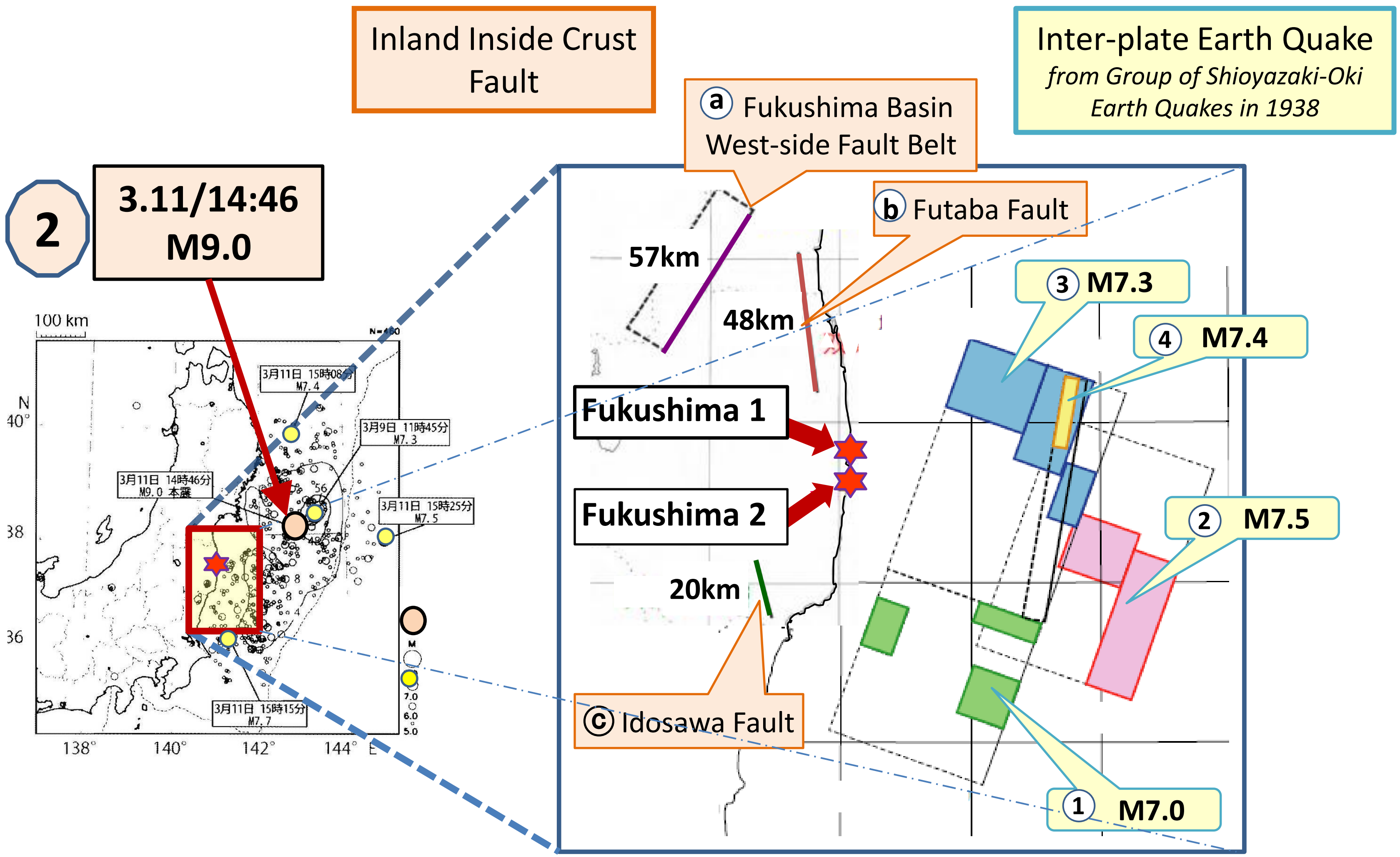
Ref: (1) N. Hirata, Gakushikaiho, No.893, p84, March 2012, (2) GSI of Japan, http://www.gsi.go.jp/common/000060854.pdf





Seismic Safety Analysis at Fukushima NPP

For the back-check analysis of seismic safety in 2009



Maximum Response Acceleration

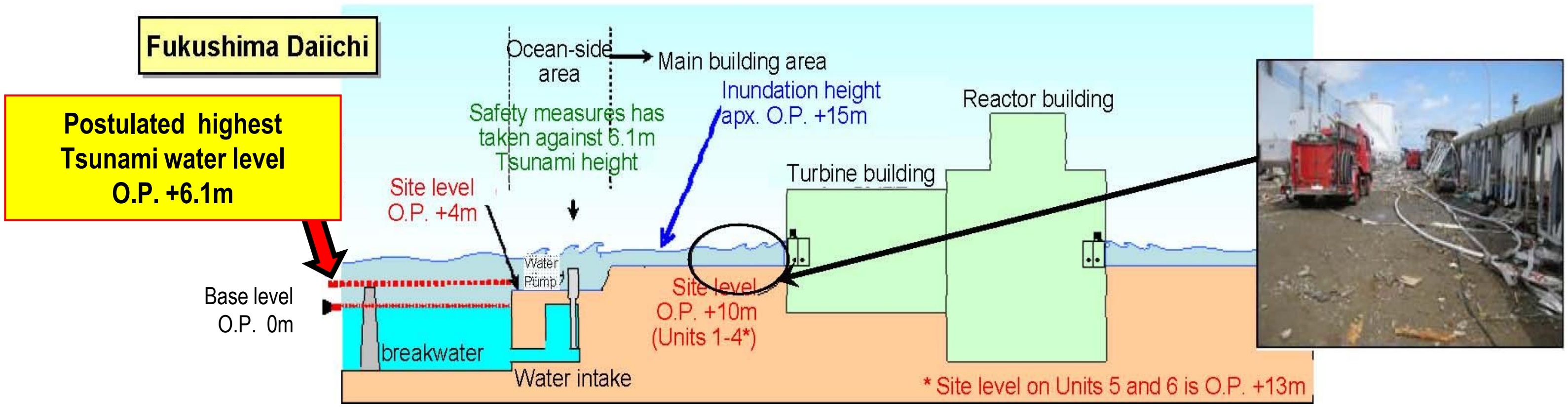
Comparison with the licensing basis

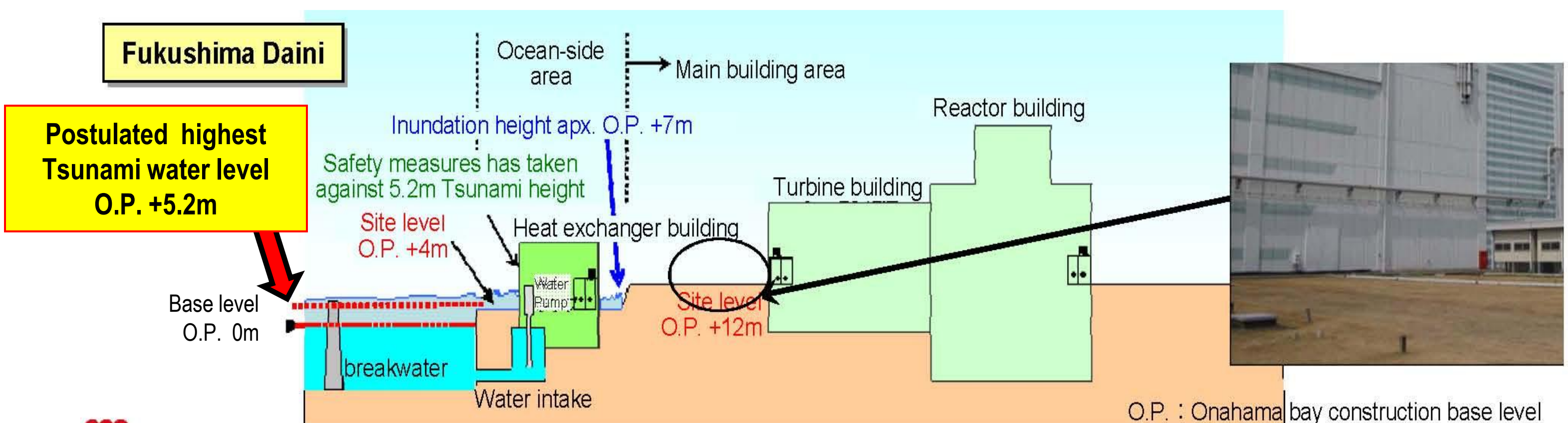
Note: [yellow box] ***The licensing basis was exceeded.***		Data			Licensing Basis(*)		
		Horizontal		Vertical	Horizontal		Vertical
		E-W	N-S		E-W	N-S	
Fukushima Daiichi	Unit 1	460	447	258	487	489	412
	Unit 2	348	**550**	302	441	**438**	420
	Unit 3	322	**507**	231	449	**441**	429
	Unit 4	281	319	200	447	445	422
	Unit 5	311	**548**	256	452	**452**	427
	Unit 6	298	444	244	445	448	415
Fukushima Daini	Unit 1	254	230	305	434	434	512
	Unit 2	243	196	232	428	429	504
	Unit 3	277	216	208	428	430	504
	Unit 4	210	205	288	415	415	504

Note: (*) Results of the *back-check analysis* of seismic safety based on the revised seismic safety design guideline.

Tsunami

At Fukushima Daiichi and Daini NPP

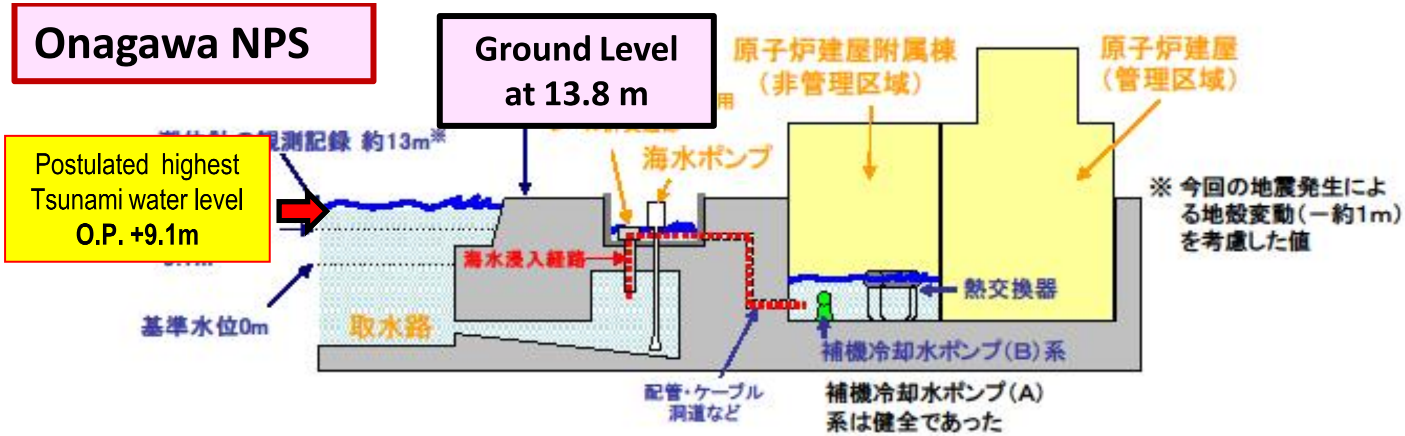


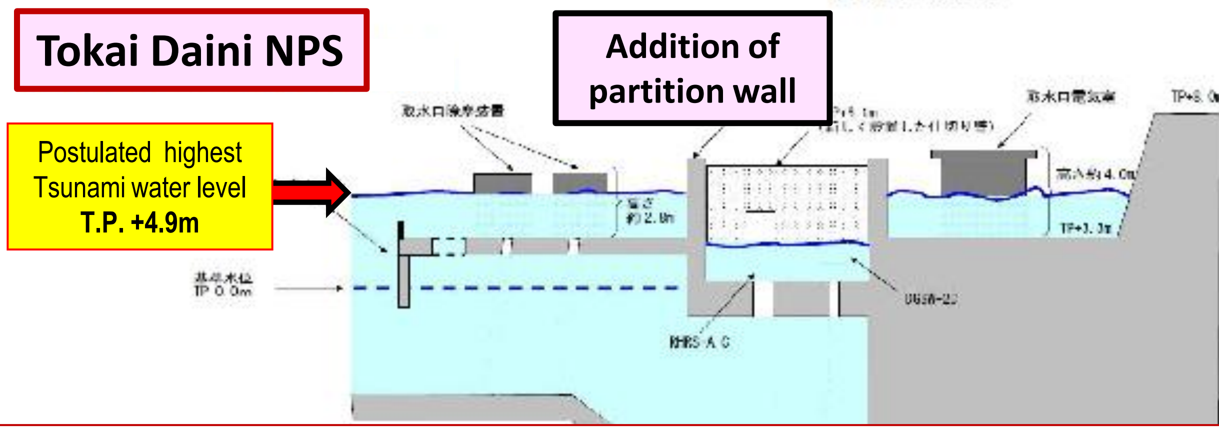


東京電力

Tsunami

At Onagawa NPP and Tokai Daini NPP





Note: Safety conscious and defense in depth approach saved NPP at Onagawa and Tokai Daini from the tsunami .

Damage by Tsunami

Comparison of damages to NPS

NPS	Fukushima Daiichi	Fukushima Daini	Onagawa	Tokai Daini
Ground Level	**10m** *(Unit 1 to 4)* **13m** *(Unit 5 to 6)*	**12m**	**13.8m**	**8 m**
Inundation H (Postulated)	**5.4 to 5.7m**	**5.1 to 5.2m**	**9.1m**	**4.9m**
Inundation H (Observed)	**14 to 15m**	**6.5 to 7m**	**13m**	**5.4m**
External Power	**0/6**	**1/4**	**1/5**	**0/3**
Emergency Generators	**0/8** *U1 to U4* **1/5** *U5, U6*	**3/12**	**6/8**	**2/3**
Cooling	Injection N.A *(U1 to U4)* Lost seawater PMP *(U5, U6)*	Lost seawater PMP *(U1,U2,U4)*	Continued	Continued

Note: Safety conscious and defense in depth approach saved NPP at Onagawa and Tokai Daini from the tsunami .

Safety Issues after the FK*NPP Accident

Issues of importance for nuclear safety (1/2)

- **External Hazard beyond the design basis**
  - Earthquake, tsunami, typhoon, flood, volcano etc.
  - Man made hazard
- **Accident Management to prevent and mitigate severe accident**
  - Mitigate accident consequences and prevent severe accident to protect the public and the environment.
  - Secure availability of Engineering systems, Emergency power and cooling water supply, Communication tools, operators, Instrumentations to provide information to operators etc.
  - Be aware of independency as well as inter-dependency at multiple unit site.

Safety Issues after the FK*NPP Accident

Issues of importance for nuclear safety (2/2)

- **Crisis Management**
  - Protection of the public and workers from radiation hazard
  - Coordination among the central and local governments, operating organization, regulatory bodies, expert teams etc.
- **International cooperation and information exchange**
  - Exchange of information and experience

Safety Issues After the FK* NPP Accident

Investigation by the Government Committees

- The two committees of the Diet and of the Cabinet for investigation of the Fukushima Nuclear Power Plants were established in 2011 to investigate causes and mitigation of the accident and decisions by TEPCO, the Regulators and the government.
- The two committees, the Diet and the Cabinet Investigation Committees have published their final report in July 2012 and made recommendations to the Government concerning safety issues of concern for the use of nuclear energy.
- All reports are publicly available in Japanese language. Summary reports are available in English.

Recommendation

The Diet Investigation Committee

- In order to prevent future disasters, fundamental reforms must take place. These reforms must cover both the structure of the electric power industry and the structure of the related government and regulatory agencies as well as the operation processes. They must cover both normal and emergency situations.
- Safety concerns include;
  - A "man-made" disaster, Earthquake damage, Evaluation of operational problems, Emergency response issues, Evacuation issues, Continuing public health and welfare issues, Reforming the regulators, Reforming the operator, Reforming laws and regulations , Cosmetic solutions

Recommendation

The Cabinet Investigation Committee

- In order to prevent recurrence of a nuclear disaster and mitigating its damage, the committee recommends
  (1) Basic stance for safety measures and disaster Preparedness,
  (2) Safety measures regarding nuclear power generation,
  (3) Nuclear disaster response systems,
  (4) Damage prevention and mitigation,
  (5) **Harmonization with international practices**,
  (6) Relevant organizations, and
  (7) **Continued investigation of accident causes and damage**.

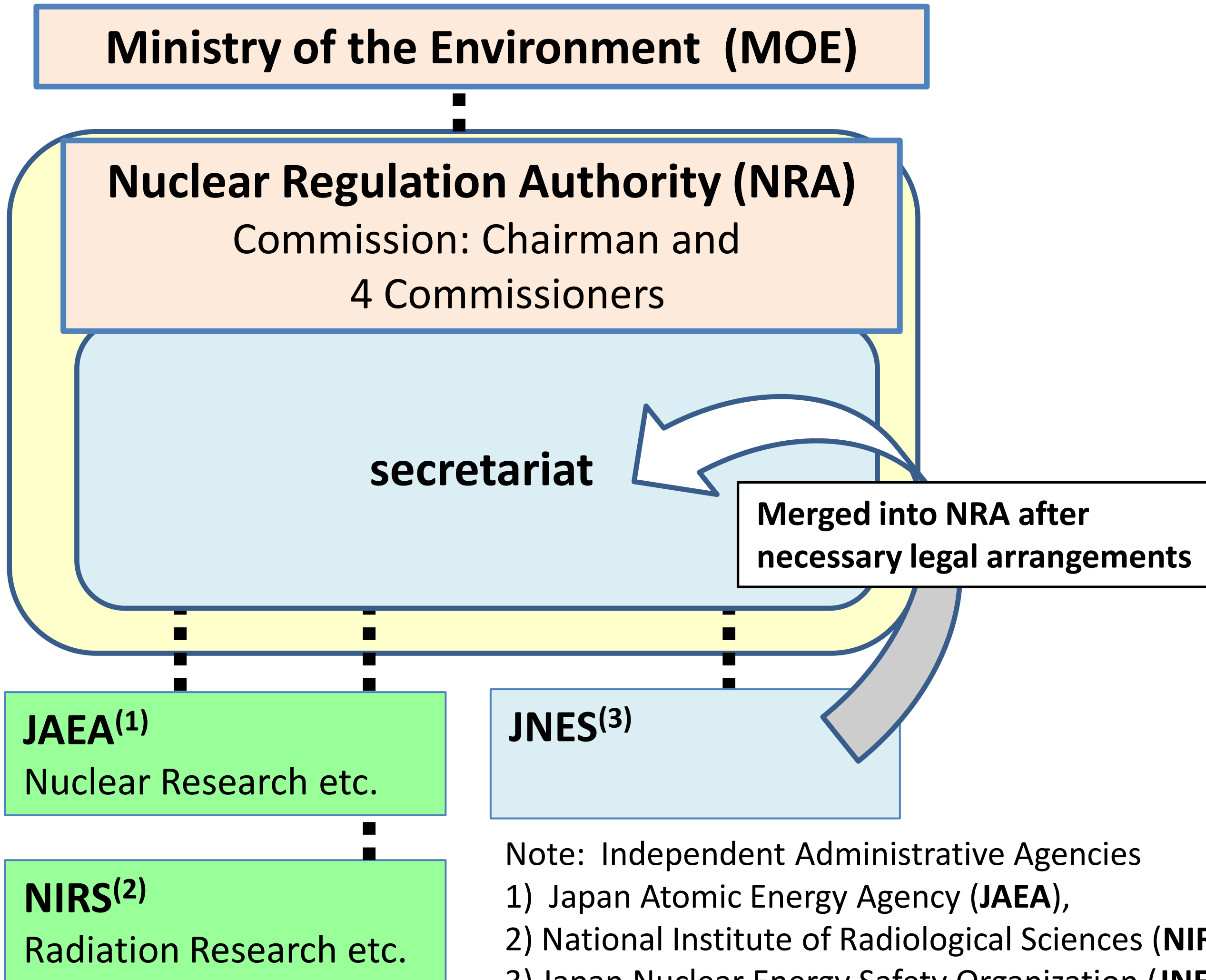
Nuclear Regulation Authority (NRA)

New Nuclear Regulatory Organization of Japan

- NRA was established on September 19, 2012, as an independent commission body affiliated to Ministry of the Environment (MOE) by separating nuclear regulation function (NISA) from nuclear promotion function of Ministry of Economy, Trade and Industry (METI).
- NRA consists of Chairman and four commissioners with secretariat and supporting administrative agencies.

New Regulatory Organizations

Ref: http://www.nsr.go.jp/archive/nisa/english/files/Sideevent_handout.html



Note: Independent Administrative Agencies
1) Japan Atomic Energy Agency (**JAEA**),
2) National Institute of Radiological Sciences (**NIRS**),
3) Japan Nuclear Energy Safety Organization (**JNES**)

Safety Issues after the FK* NPP Accident

International Organizations

- IAEA
  - Side events at GC, Special meeting at CNS
  - Release of status report etc.
- NEA
  - Special task group on Fukushima
  - Integrated activities among CSNI, CNRA, CRPPH etc. on the Fukushima Safety Issues

Research and Development for Nuclear Safety

To achieve higher level of safety and reliability

- **External Hazard beyond the design basis**
  - Investigation of potential source of natural hazard and development of advanced technology for early detections should be continued.
  - Exchange and share of information should be continued.
- **Multiple Unit Site**
  - Lessons learned from the Fukushima clearly showed some difficulty of separating multiple unit sites in the case of accident caused by common phenomena, for this case, earthquake and tsunami. R&D should include careful investigation at multiple plant site.

Research and Development for Nuclear Safety

To achieve higher level of safety and reliability

- **Accident Management to prevent and mitigate severe accident**
  - Development of technology to mitigate accident sequence should be continued to enhance level of safety by taking lessons learned from the past experience.
  - Careful consideration must be made not only to systems and components of importance, but to auxiliary systems and components supporting the important ones. R&D for improving reliability is encouraged.
- **Continued investigation of accident causes and damage**
  - It seems that no unknown severe accident phenomena or events have been observed. Investigation of the plant site is necessary and careful investigation of all units must be carried out to find out any evidence during the decommission process.

Research and Development for Nuclear Safety

To achieve higher level of safety and reliability

- **Crisis Management**
  - Reliable and dependable systems must be prepared to inform the public and the rest of the world about accident. Lates knowledge must be adopted for this purpose.
  - Preparation for crisis management must be established before accident occurs.
- **International cooperation and information exchange**
  - Method of information dissemination must be improved by taking into the latest technology for this purpose.
- **Transfer knowledge and secure experts and skilled workers**
  - Knowledge must be transferred to next generation to keep safe operation of NPP around the world.

Decommission of the Fukushima NPP

Mid-and-Long Term Roadmap for the FK-Daiichi 1-4

Present *(Completion of Step 2)*	***Within 2 Yrs***	***Within 10 Yrs***	***After 30-40 Yrs***
Step 1, 2	**Phase 1**	**Phase 2**	**Phase 3**
<Achieved Stable Conditions> -Condition equivalent to cold shutdown -Significant Suppression of Emissions	Period to the start of fuel removal from the spent fuel pool (Within 2 years)	Period to the start of fuel debris removal (Within 10 years)	Period to the end of decommissioning (After 30-40 years)
Step 1: **Under control** **Step 2:** **Cold shutdown**	-Commence the removal of fuels from the spent fuel pools (Unit 4 in 2 years) -Reduce the radiation impact due to additional emissions from the whole site and radioactive waste generated after the accident (secondary waste materials via water processing and debris etc.) Thus maintain the effective radiation dose to be less than 1 mSv / year at the site boundaries caused by the aforementioned. -Maintain stable reactor cooling and accumulated water processing and improve their credibility. -Commence R&D and decontamination towards the removal of fuel debris -Commence R&D of radioactive waste processing and disposal	-Complete the fuel removal from the spent fuel pools at all Units -Complete preparations for the removal of fuel debris such as decontamination of the insides of buildings, restoring PCVs and filling PCVs with water. Then commence the removal of fuel debris (Target: within 10 years) -Continue stable reactor cooling -Complete the processing of accumulated water -Continue R&D on radioactive waste processing and disposal, and commence R&D on the reactor facilities decommission	-Complete the fuel debris removal (in 20-25 years) -Complete the decommission (in 30-40 years) -Implement radioactive waste processing and disposal

Actions towards systematic staff training and allocation, motivation improvement, and securing of workers' safety will be continuously implemented.

R&D for new technology is needed for achieving goals of the Mid-and-Long Term Roadmap.

Decommission of the Fukushima NPP

Mid-and-Long Term Roadmap for the FK-Daiichi 1-4

Phase 1 *(within 2 years*):*

From the end of Step 2 to start of fuel removal

- Fuel removal from the spent fuel pool (Unit 4)
- R&D for RW processing and disposals

Phase 2 *(within 10 years*)*

From the end of Phase 1 to start fuel debris removal

- Fuel debris removal
- R&D for RW processing and debris removal

Phase 3 *(within 30 to 40 years*)*

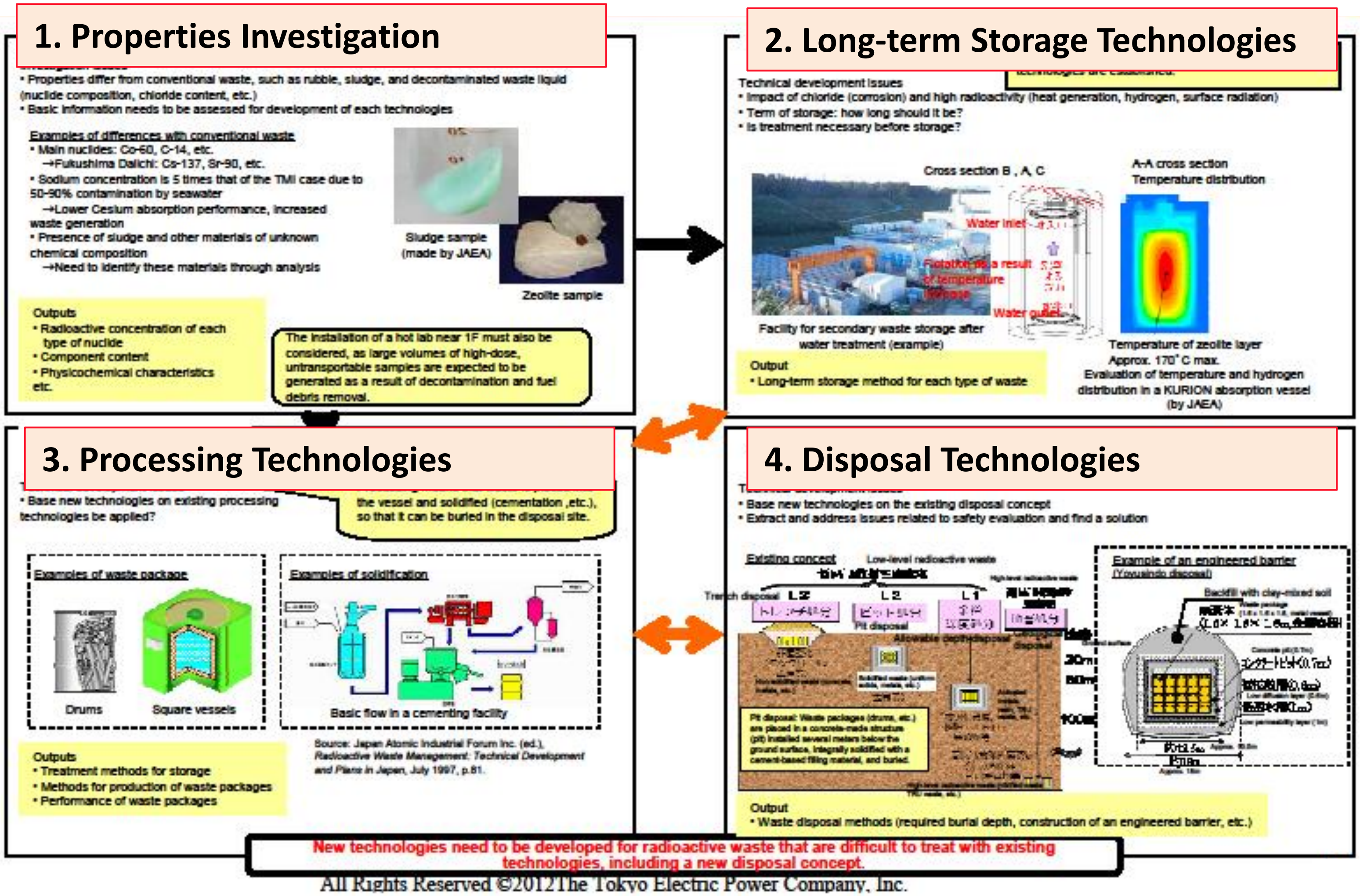
From the end of Phase 2 to the end of decommissioning

- Complete removal of fuel debris (20 to 25 years*)
- Complete decommissioning (30 to 40 years*)
- Implement RW processing and disposal

Note: (*) Years after the completion of Step 2

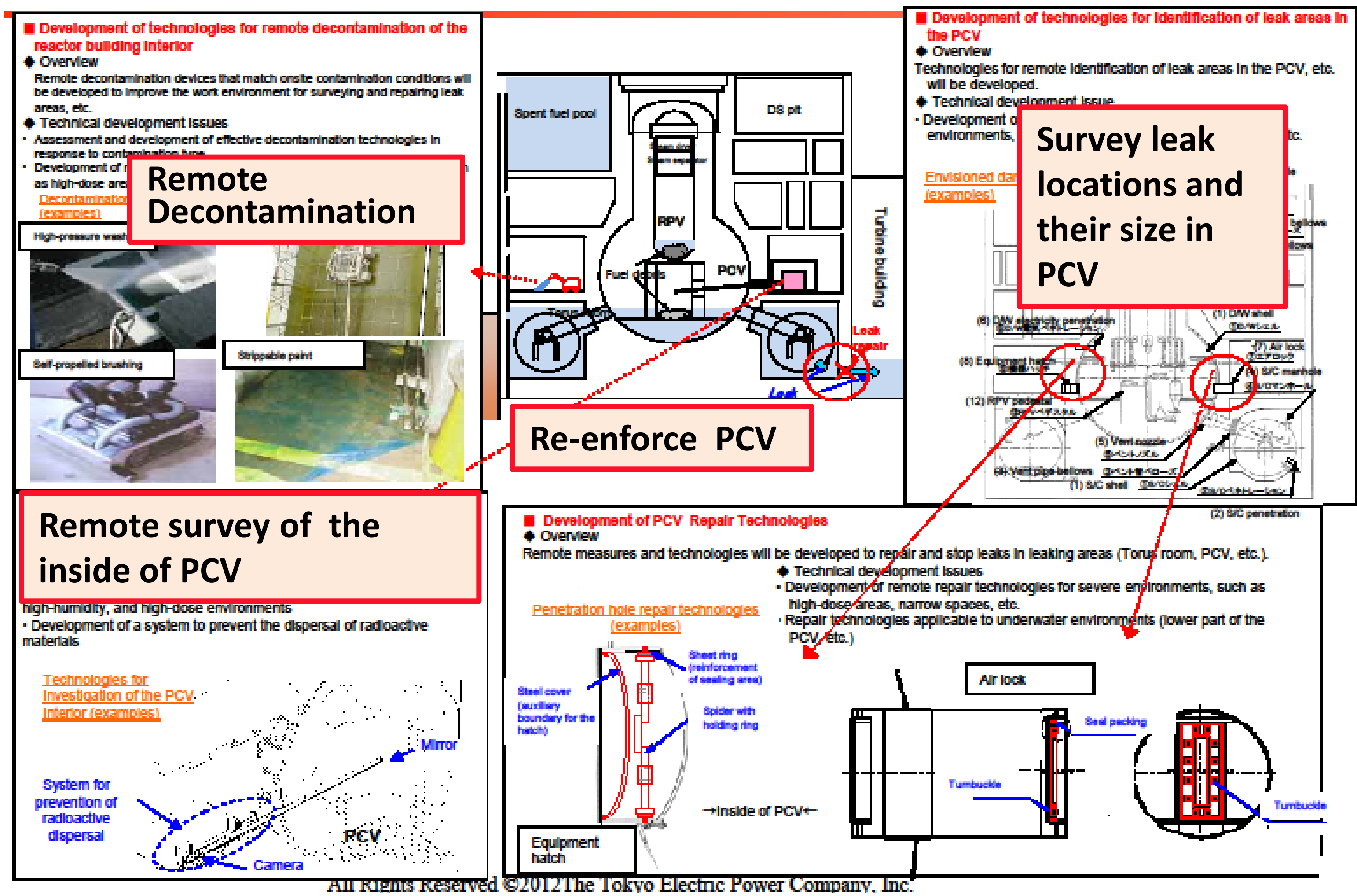
R&D for Decommission Process

Removal of Fuel Debris



R&D for Decommission Process

Radioactive waste processing and disposal



End of Presentation

Thank you for your attention.