Accident of Fukushima Daiichi NPP on March 11, 2011

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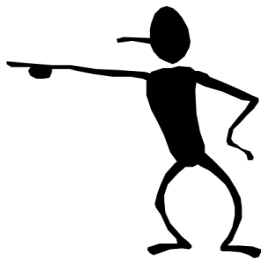
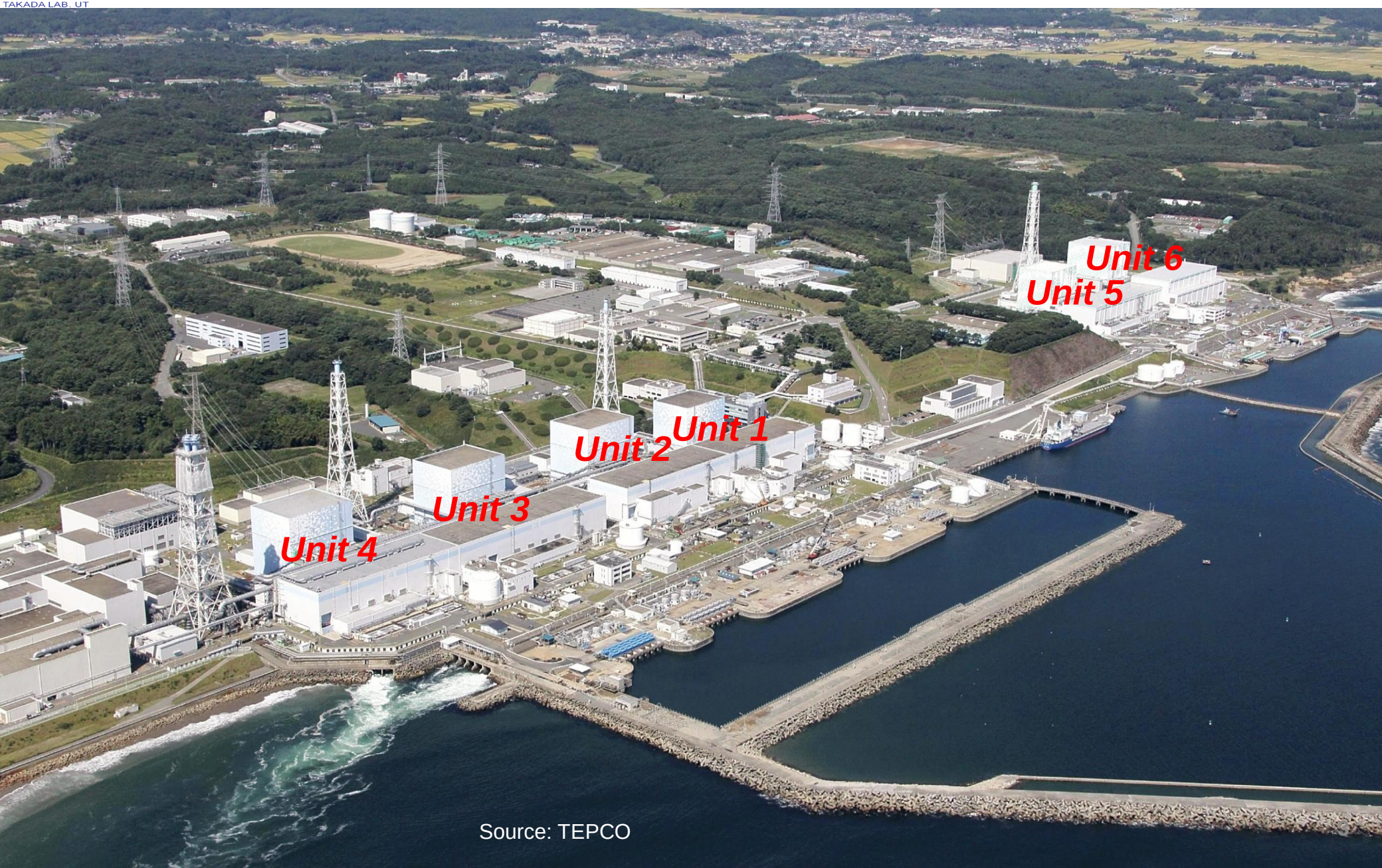
Summary

1. Outline of accident of Fukushima Daiichi NPP
2. Ground motion
3. Great Tsunami
4. Behavior of Plants
5. Conclusion: Lessons learned from Accident

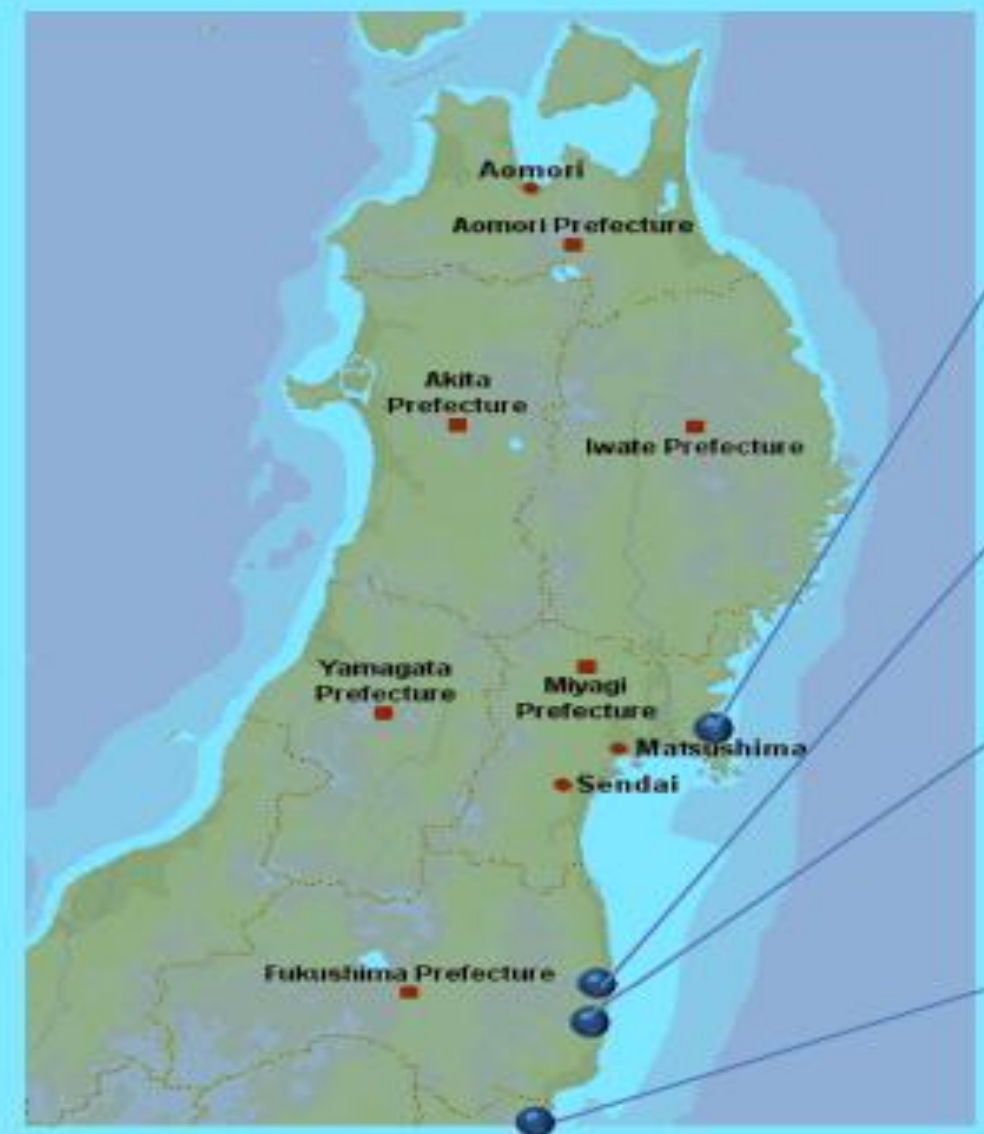


Fukushima Daiichi NPPs operated by TEPCO



Source: TEPCO

NPPs in Eastern Coast of Japan



Onagawa (Tohoku)

Unit1: 524 MW, 1984-
Unit2: 825 MW, 1995-
Unit3: 825 MW, 2002-

Fukushima Daiichi * (TEPCO)

Unit1: 460 MW, 1971-
Unit2: 784 MW, 1974-
Unit3: 784 MW, 1976-
Unit4: 784 MW, 1978-
Unit5: 784 MW, 1978-
Unit6: 1,100 MW, 1979-

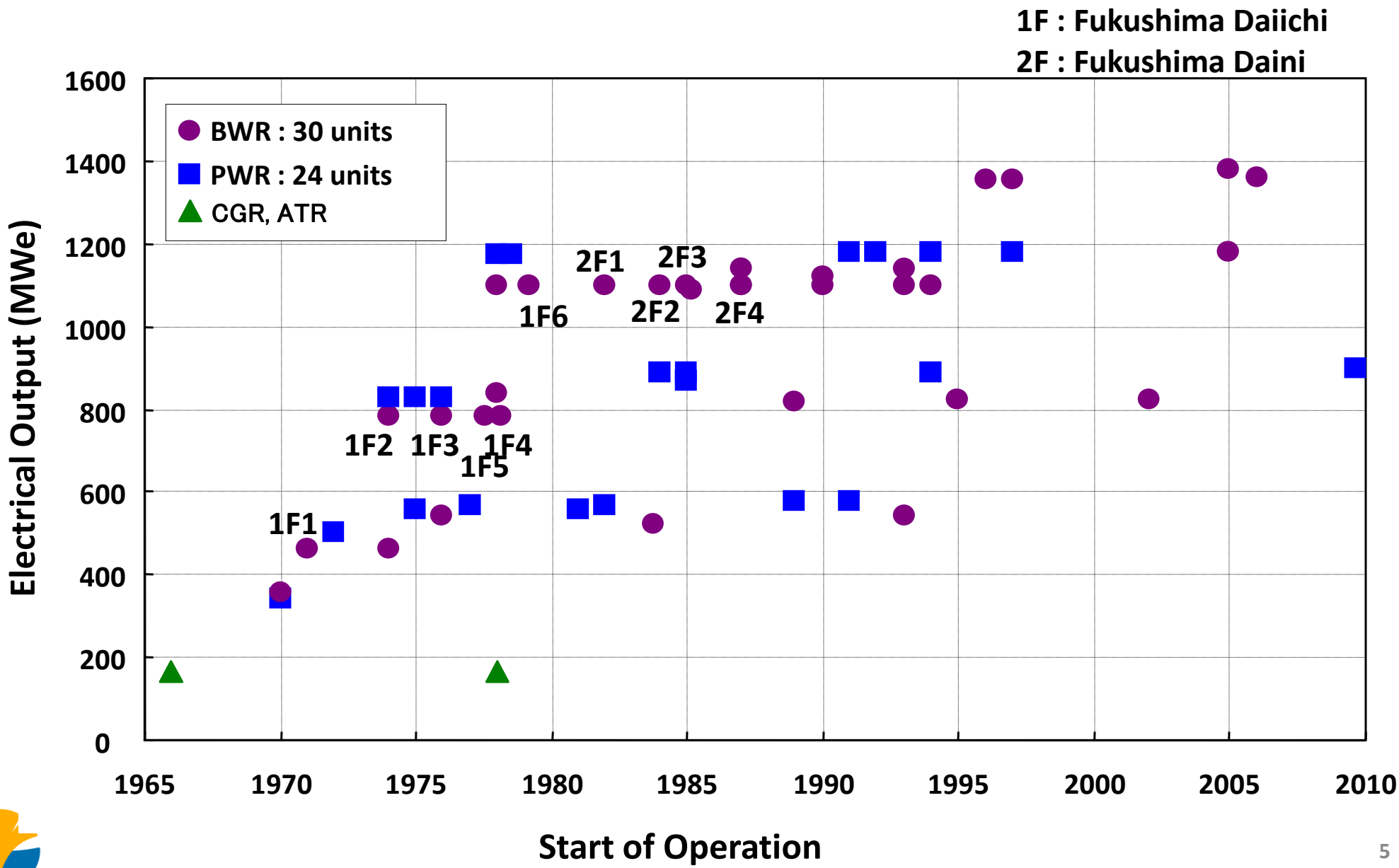
Fukushima Daini (TEPCO)

Unit1: 1,100 MW, 1982-
Unit2: 1,100 MW, 1984-
Unit3: 1,100 MW, 1985-
Unit4: 1,100 MW, 1987-

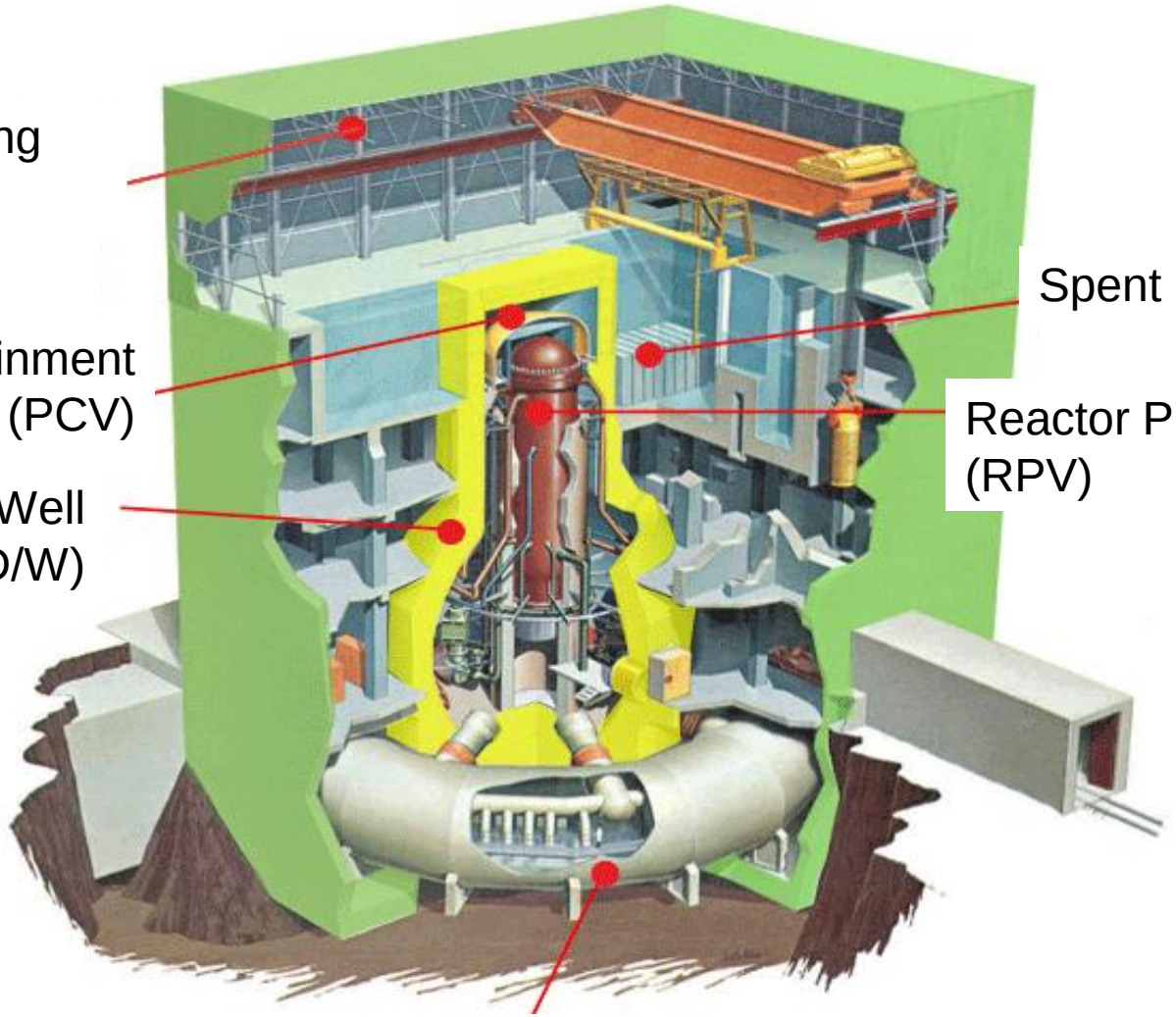
Tokai-2 (JAPCO) (1,100 MW, 1978-)

*** Fukushima Daiichi locates approximately 230 km north of Tokyo**

Nuclear Power Plants in Japan



Overview of Mark-I Type BWR (Units 1 to 5)



Updated 2011.03.27

出典：http://nei.cachefly.net/static/images/BWR_illustration.jpg

2. Earthquake Ground Motion

Great East Japan Earthquake

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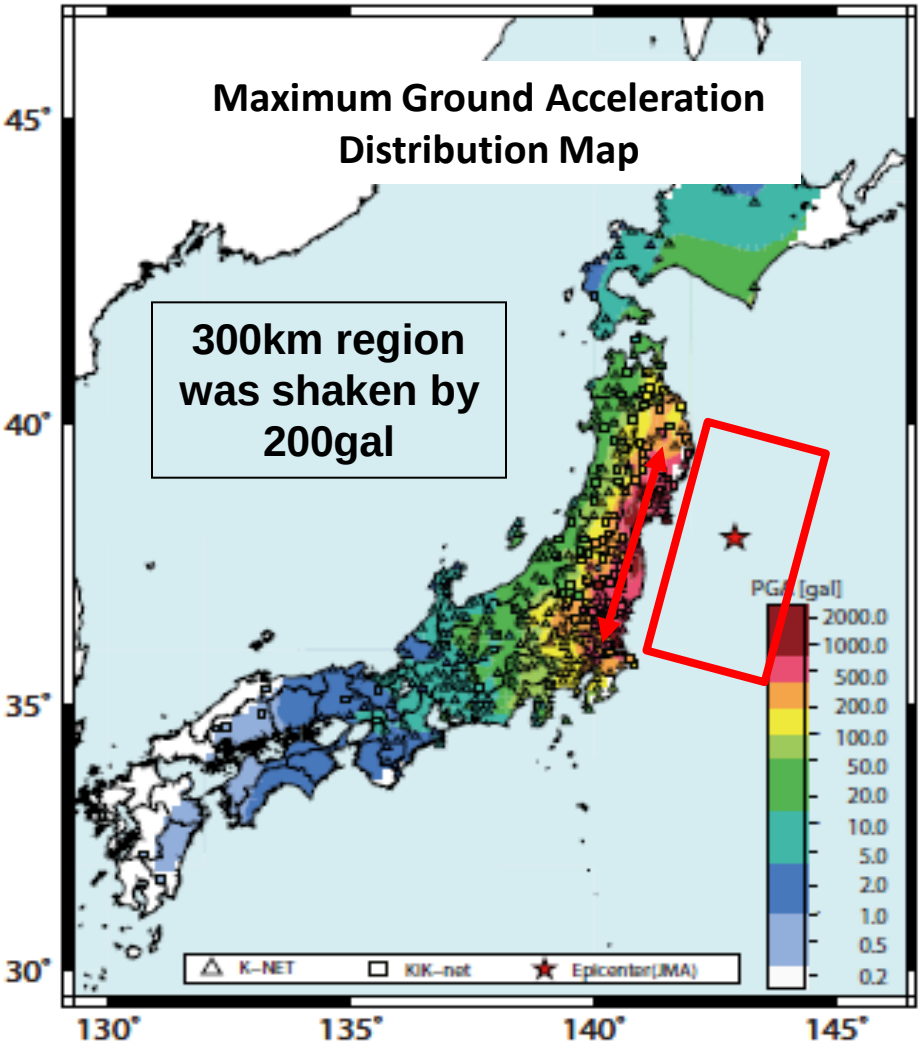
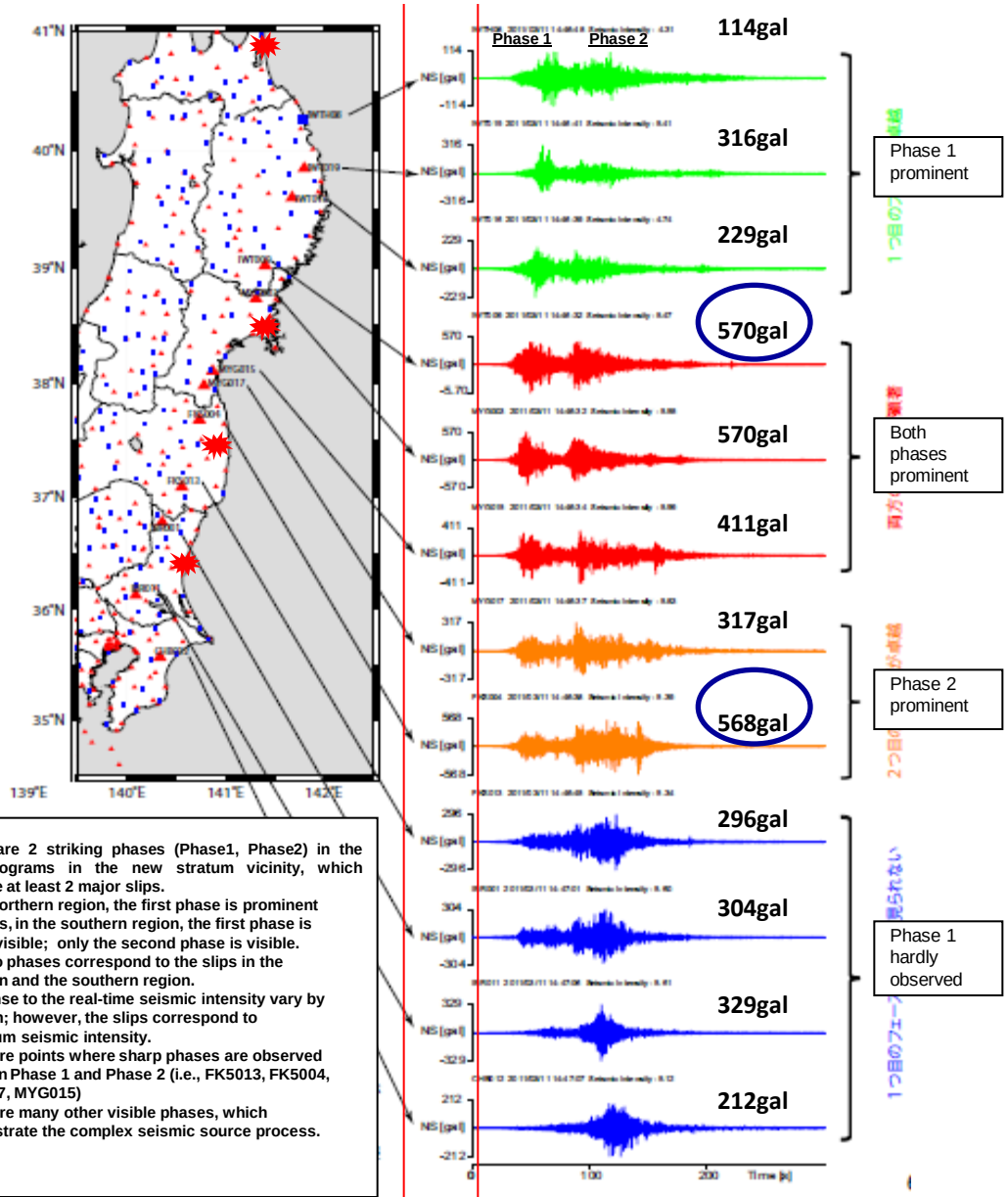
@2:46pm local time, March 11th, 2011 hypocenter depth 24Km M9



References: Central Disaster Prevention Council reports, etc.

Scope & duration of the ground acceleration

Broad Scope 500km **High Acceleration more than 500gal** **Duration over 2 min.**



There are 2 striking phases (Phase1, Phase2) in the accelerograms in the new stratum vicinity, which indicate at least 2 major slips.
In the northern region, the first phase is prominent whereas, in the southern region, the first phase is hardly visible; only the second phase is visible.
The two phases correspond to the slips in the northern and the southern region.
Response to the real-time seismic intensity vary by location; however, the slips correspond to maximum seismic intensity.
There are points where sharp phases are observed between Phase 1 and Phase 2 (i.e., FK5013, FK5004, MYG017, MYG015)
There are many other visible phases, which demonstrate the complex seismic source process.

Recorded Intensity of Ground Motion and Design Earthquake Ground Motion

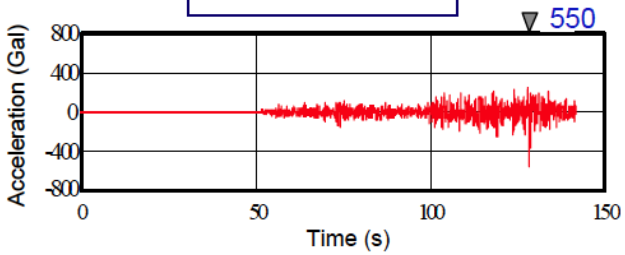
		Observed Maximum Response Acceleration * (Gal)			Max Response Acceleration against Basic Earthquake Ground Motion (Gal), Ss		
		Horizontal (N-S)	Horizontal (E-W)	Vertical	Horizontal (N-S)	Horizontal (E-W)	Vertical
Fukushima Daiichi	Unit 1	460	447	258	487	489	412
	Unit 2	348	550	302	441	438	420
	Unit 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

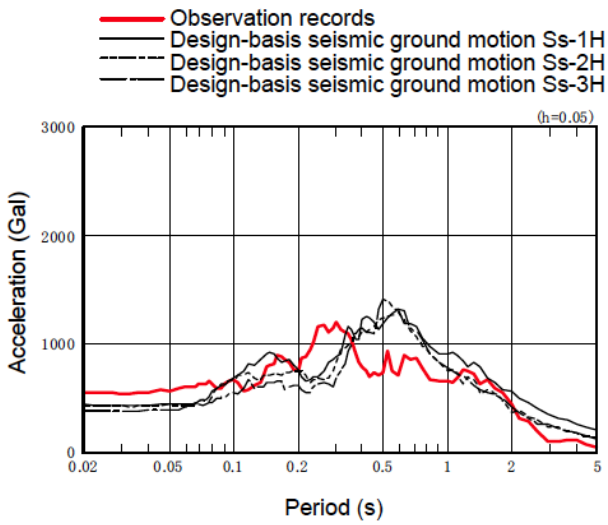
* At the lowest basement of reactor building

Comparison of 2011 Great East Japan Earthquake and 2007 NCO Earthquake

2011 Great East Japan Earthquake

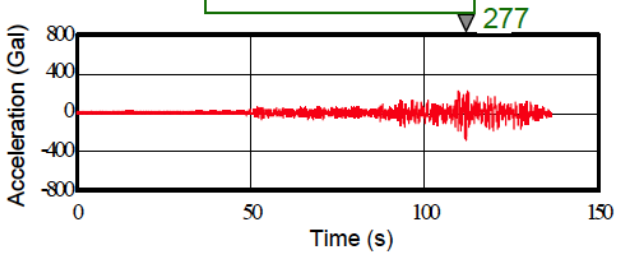
Fukushima dai-ichi

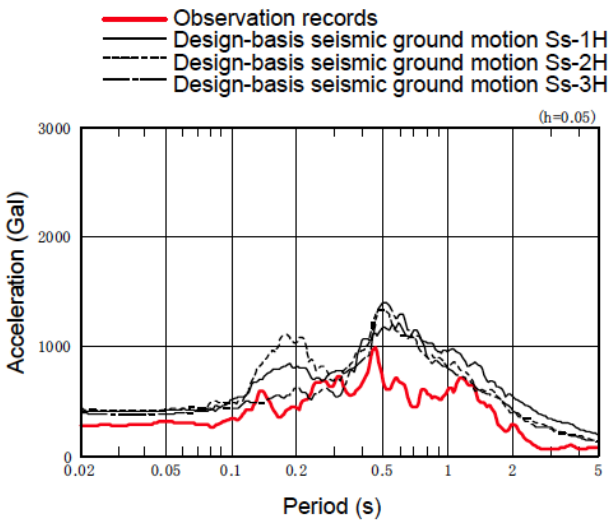




Unit 2 EW

Fukushima dai-ni

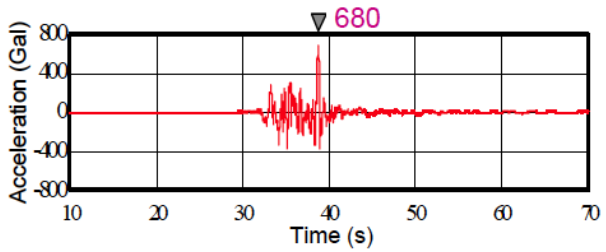


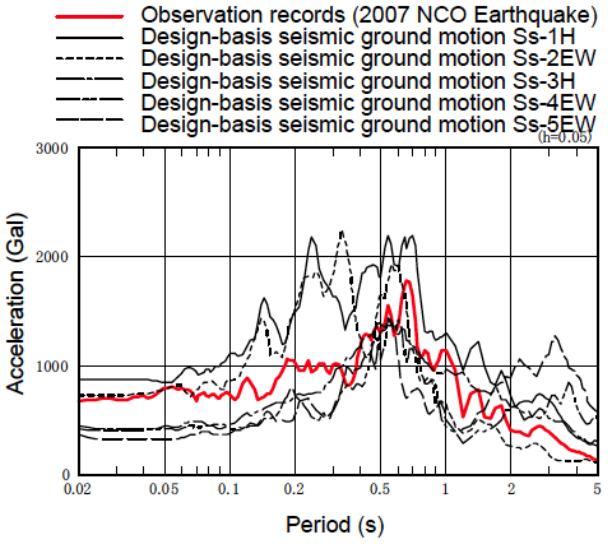


Unit 3 NS

2007 NCO Earthquake

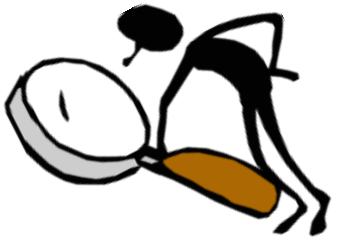
Kashiwazaki-Kariwa

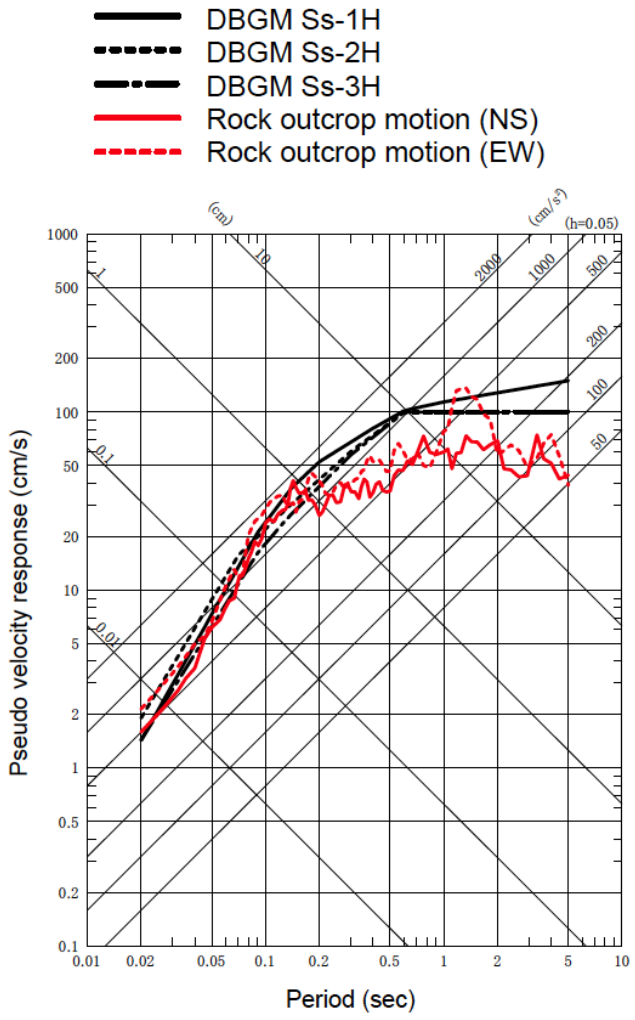




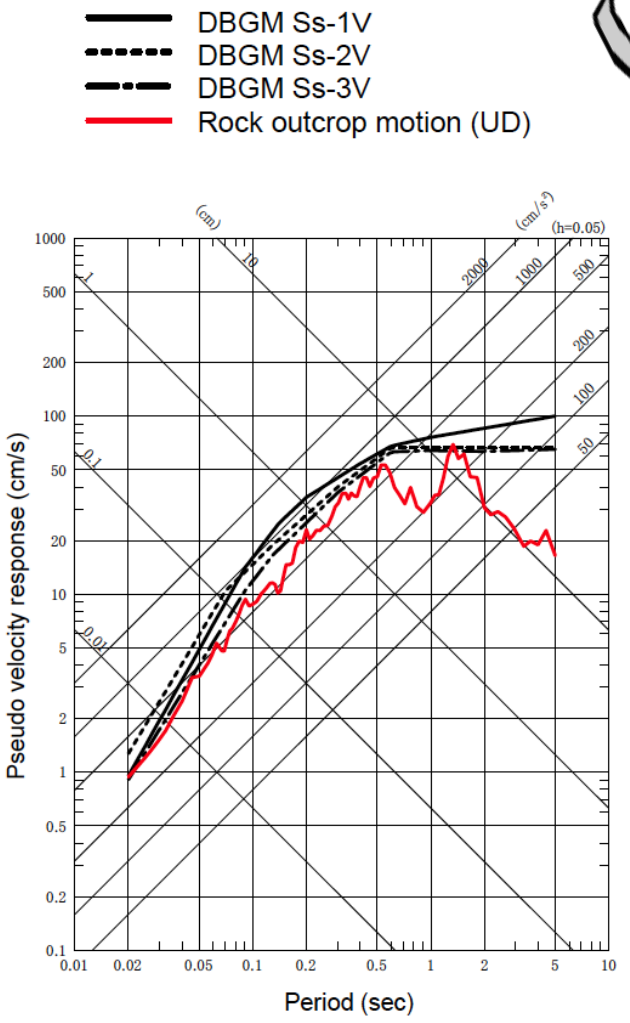
Unit 1 EW

Estimated rock outcrop motion: Fukushima dai-ichi south downhole



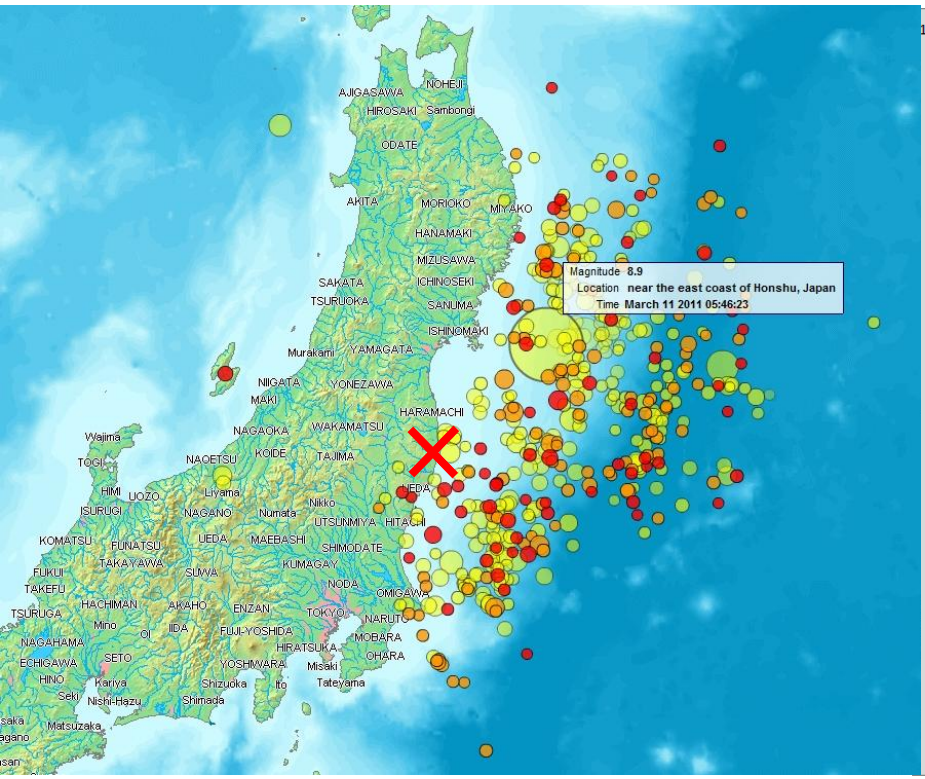


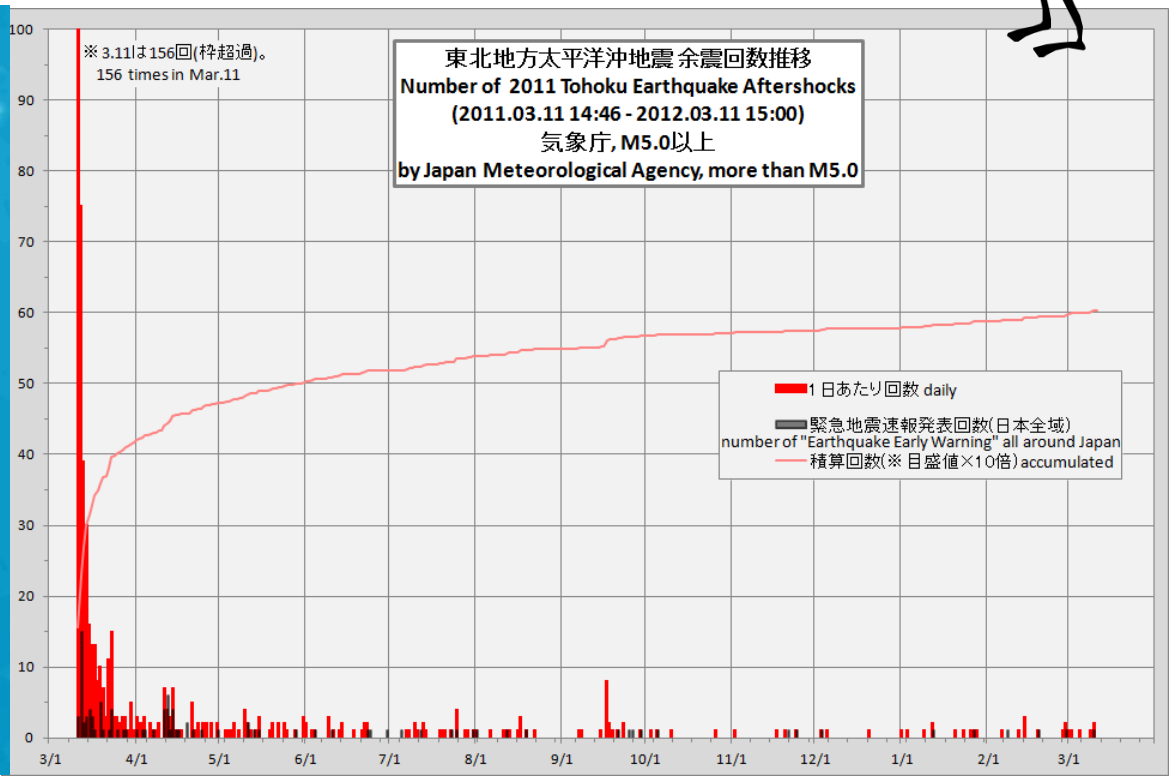
Response spectra of DBGMs and rock outcrop motion (NS&EW)



Response spectra of DBGMs and rock outcrop motion (UD)

Aftershocks of March 11 Earthquake





Location of Aftershocks

Occurrence History of Aftershocks (1 year)

3. Tsunami

Tsunami triggered by the Great East Japan Earthquake

Damage Scenario & Observed Tsunami Run-up Height

A comparison of the Tsunami Run-up Heights of Past 3 Major Earthquakes in the Tohoku Region
&
3.11 Great East Japan Earthquake

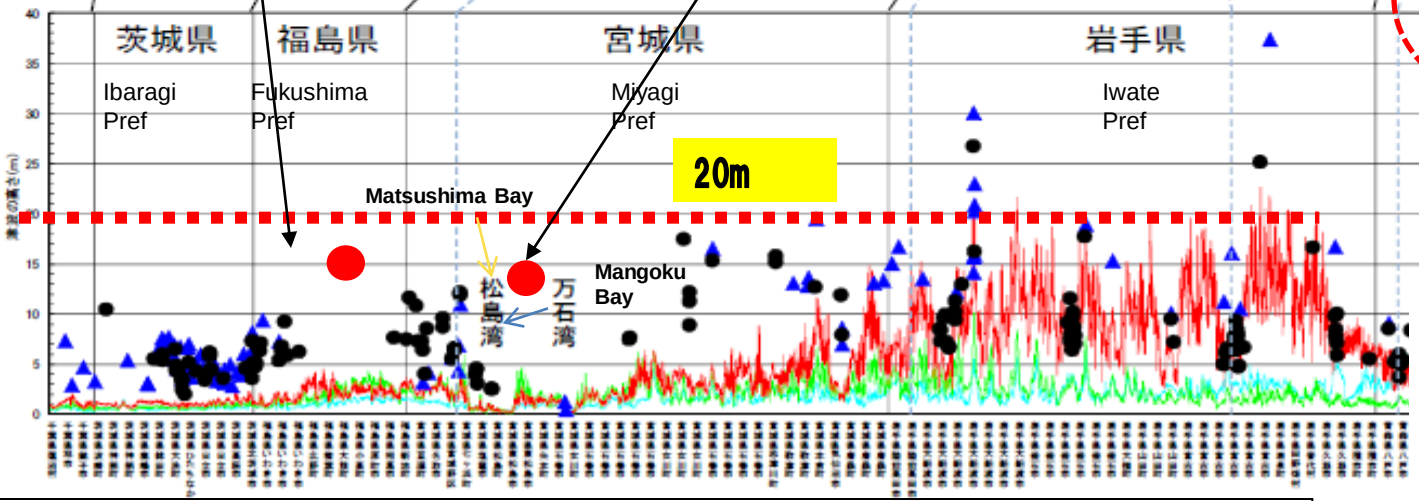
Tokai Plant

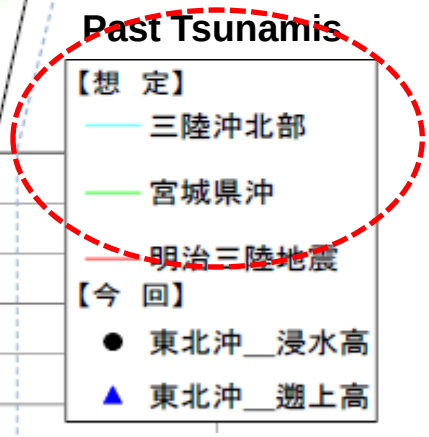
Fukushima Plant

Onagawa Plant

Higashi-dori Plant

Why did no one simulate the occurrence of a Tsunami in the region?





Scenario : 3 Major Earthquakes /Tsunami

-Sanriku-oki
-Miyagi-ken-oki
-Meiji Sanriku Earthquake (1896)

3.11, 2011

● Tohoku-oki inundation height
▲ Tohoku-oki run-up height

References:
Tsunami run-up heights of the scenario 3 major earthquakes: research conducted by the Special Committee on the Countermeasures against Earthquake Disaster in Relation to Subduction Zone Earthquake Around Japan Trench and Chishima Trench.
The Great East Japan Earthquake inundation height & run-up height: research conducted by the Coastal Engineering Committee, Japan Society of Civil Engineers
Other References: Central Disaster Prevention Council reports, etc.

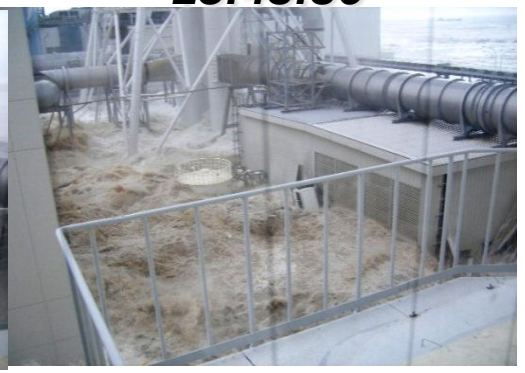
Tsunami, March 11, 2011

15:42:40

15:42:46

15:43:26

15:43:36



15:43:54

15:44:18

15:44:44

15:44:58

15:46:10

Tsunami height in Fukushima Daiichi was about 15 m.

Source: TEPCO

Comparison of Tsunami Height between Daiichi and Daini

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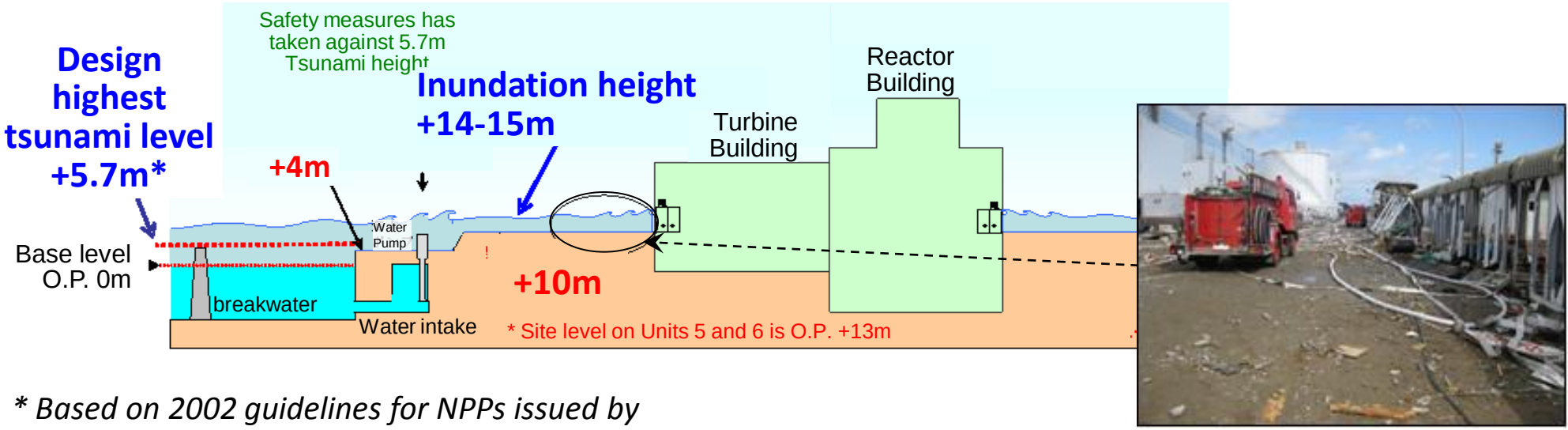
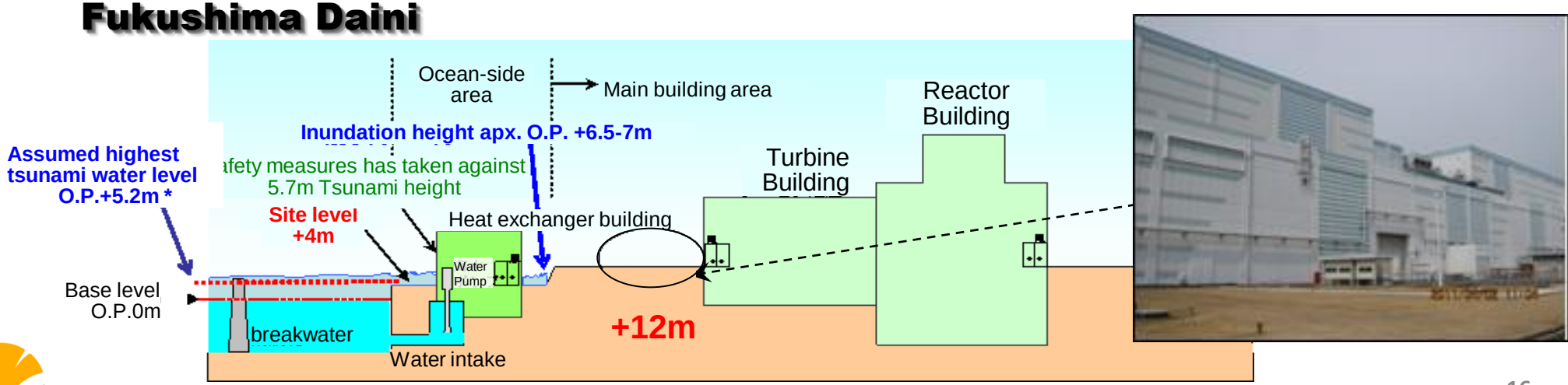
Fukushima Daiichi



** Based on 2002 guidelines for NPPs issued by the Nuclear Civil Engineering Committee of JSCE*

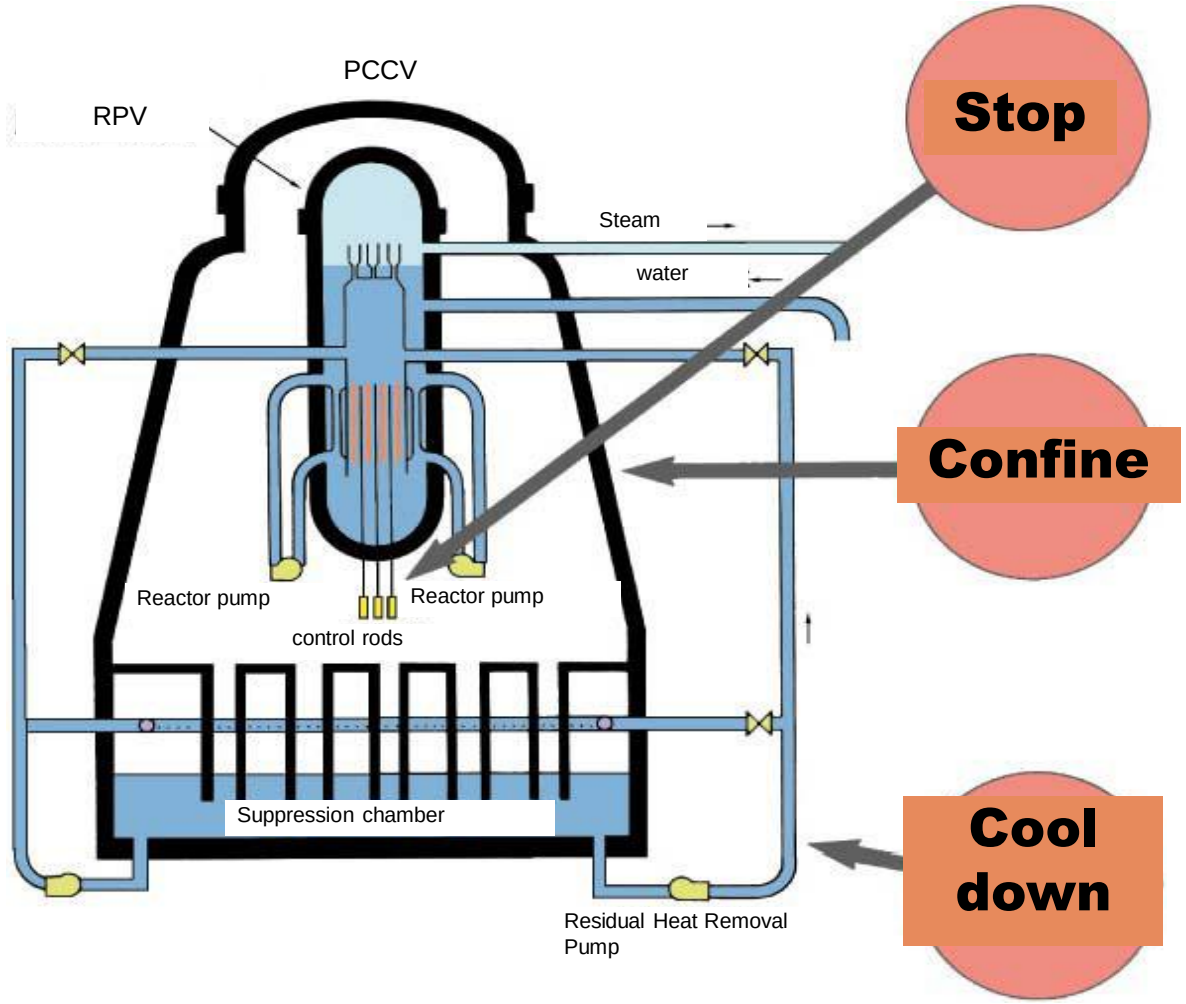
Fukushima Daini



O.P. : Onahama bay construction base level

4. Behavior of Plant

Basic Safety Requirements of NPP



Three Fundamental Principles to Prevent Accident

Differences among Units 1-4 of Fukushima Dai-ichi

➢ ***Fukushima Daiichi Units 5 & 6***

- Elevation of the ground is 13 m. (Units 1 - 4 : 10m)
- One air cooled EDG of Unit 6 which is located on the ground level was survived.
- Metal Clad Switchgears were not lost.
- Temporary sea water pump installed after the earthquake was operable, making use of power from survived EDG.

➢ ***Fukushima Daini NPPs***

- External power was not lost.
- RHR function of Unit 3 was survived.
- Motors of sea water pumps for Unit 1,2 and 4 were replaced by March 14, followed by re-activation of core cooling function.

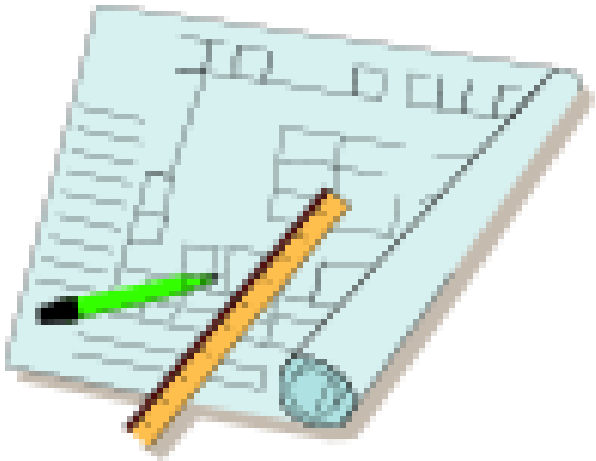
➢ ***Onagawa NPPs***

- Elevation of the plants was 14.8m which is higher than Tsunami height.

➢ ***Tokai-2***

- Although off-site power was lost until May 13, 2 out of 3 EDGs were not lost thanks to the recently installed barrage to one of 2 seawater pump area to protect pumps from tsunami.

5. Conclusion
Lessons learned from Accident



Lessons learned from Accident

1 Need of appropriate DB scenario for **Anti-tsunami design method based on risk concept**

Design basis tsunami height 5.7m against 15m of actual tsunami height

2 **Severe Accident Management**

Need of **robustness and diversity** in responding to beyond DBAs such as station black-out for long-duration, loss of ultimate heat sink

-Appropriate design philosophy to sustain safety function against common cause failures brought by natural hazards

-Appropriate AM measures for both prevention and mitigation of SAs

3 Implementation of **Seismic PRA and Tsunami PRA**

Including their interaction assessment

Response and Preparedness based on residual risk

Effective measure to the unforseen events

4 **Total Risk Management (Robustness)**

Covering total system behavior and on-site and off-site facilities

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END

Thank you for your attention.