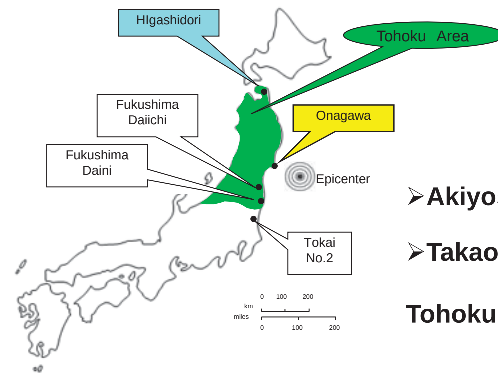
Safety Countermeasure of Onagawa NPS after the Great East-Japan Earthquake and Tsunami

March 6, 2014 at **City University of Hong Kong**

March 7, 2014 at Nuclear Society Seminar of Hong Kong



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Purpose of improving safety

➢On March 11,2011, we were able to respond appropriately against earthquake and tsunami.

➢However, this success does not guarantee for the next potential disaster or accident.

➢We need continuous effort to keep safety.

Presentation Outline

1. Steps for improving safety
2. Lesson from Onagawa
3. Lesson from Fukushima Daiichi
4. Immediate Upgrades
5. Further Safety Improvements
6. Roadmap
7. Summary

Step for improving safety

▼3/11/2011
- Great Earthquake
- Fukushima Daiichi accident →

➢ We appropriately managed the crisis

1st step

➢ Immediate Safety Upgrades
- Mobile electric supply car
- Levee (17m above sea level)

2nd step

Lesson from Onagawa →
Lesson from Fukushima →

➢ Continuous improvement of safety
- Safety countermeasure for severe accident

▼3/6/2014
- Present Status

➢ **Filed safety screening permission to the government** **(December 27,2013)**

Lesson from Onagawa (1)

1.Re-evaluate the tsunami height

➢Although tsunami height on 3/11 was lower than the site grade, there was not very much margin.

✓Tsunami prediction:13.6m - Actual tsunami height:13m

✓Site grade:13.8m (before earthquake:14.8m)

➢New findings: Interlocking movement of tsunami sources was observed in the 3/11's tsunami.

2.Secure water tightness.

➢There is a possibility that unexpected leak path still exists like the internal flooding of unit 2.

➢Backup method in case the water tightness was broken.

Lesson from Onagawa (2)

3.Reduce the possibility of fire

- The fire, which occurred from the non-safety related switch gear panel of unit 1, did not spread to the safety related equipment by effort of in-house firefighting team.
- However, if this fire spread to the safety related equipment, the situation would become worse.

4. Further improvements

- For example, by including the various ways for logistics support.

Lesson from Fukushima Daiichi (1)

1. **Protect from flooding**
   - **Flooding leads to loss of power**
2. **Enhance Electric Power Supply**
   - **Loss of power leads to the loss of instrumentation and ultimate heat sink (UHS)**
3. **Enhance Cooling System**
   - **Even when UHS is lost, keep be capable of removing decay heat is important**

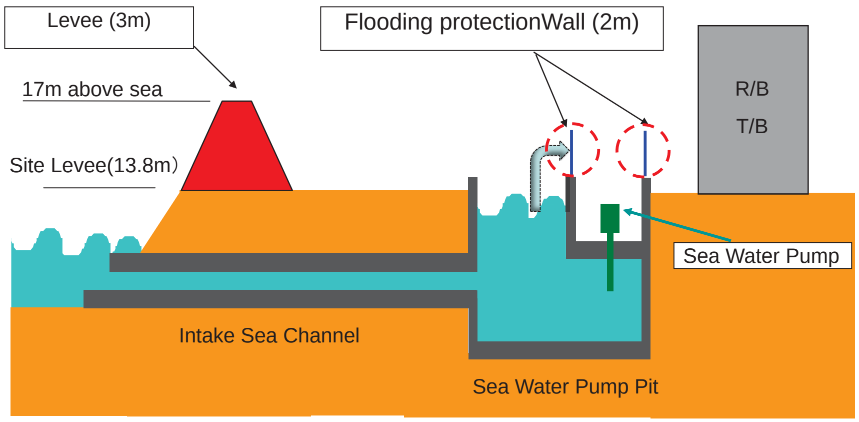
Lesson from Fukushima Daiichi (2)

4. **Enhance Confinement System**
   - **Minimize the amount of radioactive release to the environment**

Evacuees: Government Headquarters of Great East Japan Earthquake (Dec 21, 2011) Approx. 335 thousand

5. **Fortify Emergency Response Center**
   - **Enhance the working environment for site staff when severe accident occurs**
     - **Reduce the radiation level**
     - **Diverse communication tool**

Immediate Upgrade : Sea Wall



Immediate Safety Upgrades

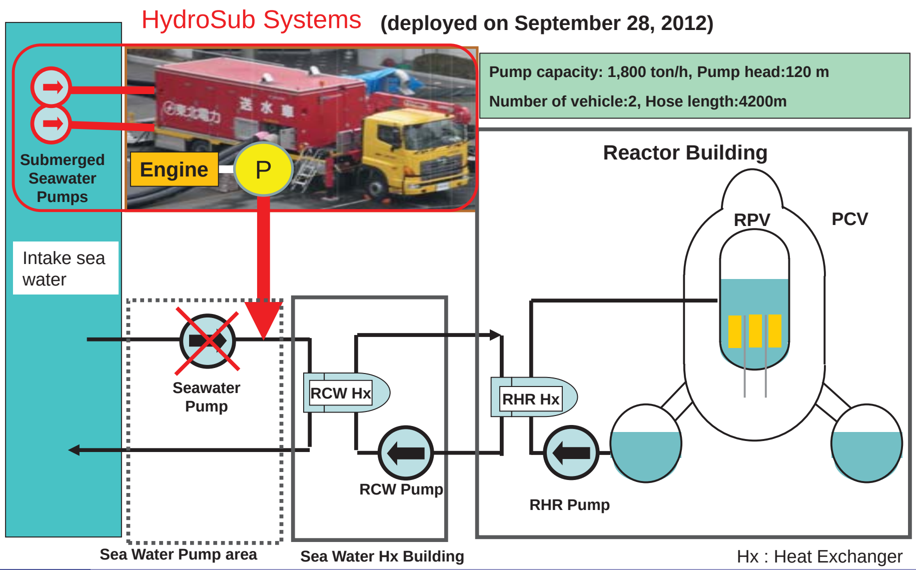
Enhancement	Countermeasure	Status
Protect from Flooding	Construction of levee & sea flood walls	Deployed
	Replacement of building door to the watertight sealed door	Under work
Electric Power Supply	Power supply car	Deployed
	Air-Cooled EDG	Deployed
Cooling System	Alternative water injection pump car	Deployed (3 vehicles)
	Alternative mobile sea water pump car	Deployed (2 vehicles)
	Spare motor for sea water pumps	Deployed

Immediate Upgrade : Additional Seawalls

* subsidence

Immediate Upgrade : Construction of Levee

Immediate Upgrade : Enhance cooling system

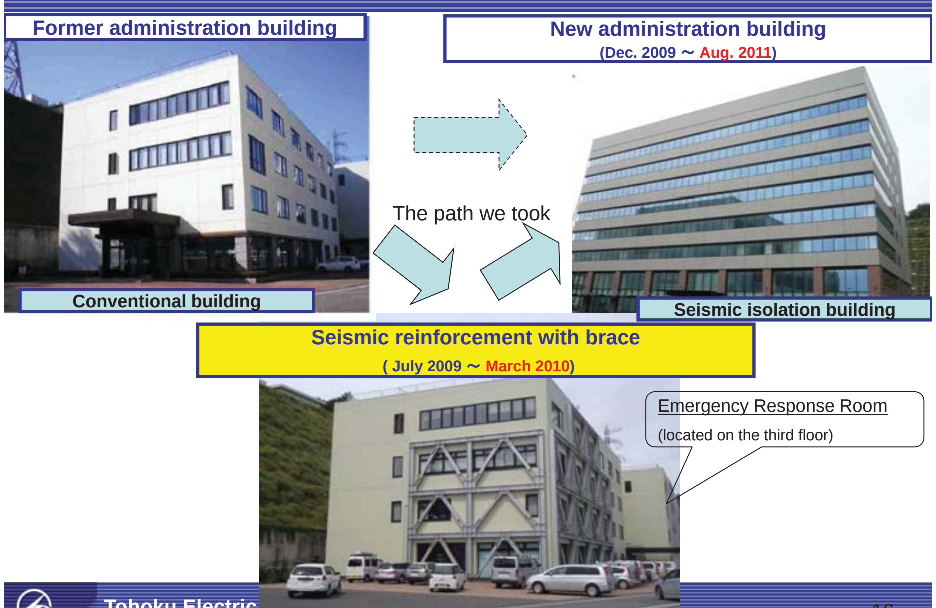


Immediate Upgrade : Enhance Electric Power Supply (1)

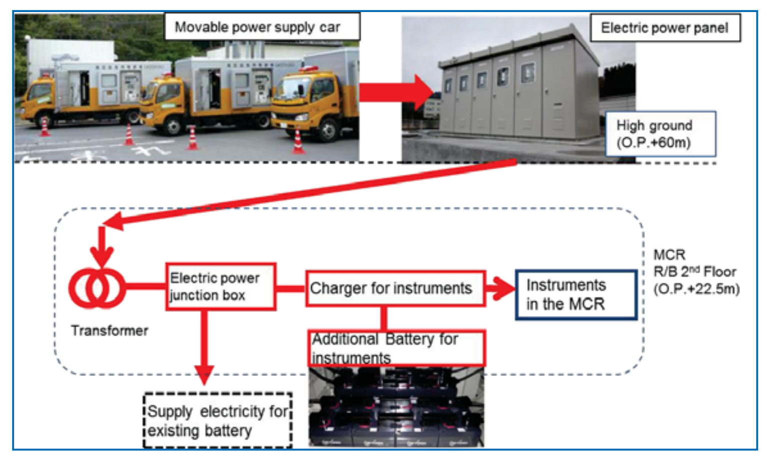
Step1: Movable Power-Supply Car
- Rate Output: 400kVA X 4 units
- Deploy on a ground at 22m above sea level

Step2: Installation of Air-cooled Diesel Generator
- Rate Output:5,000kVA X3 units
- Set up on a small hill at 52m above sea level

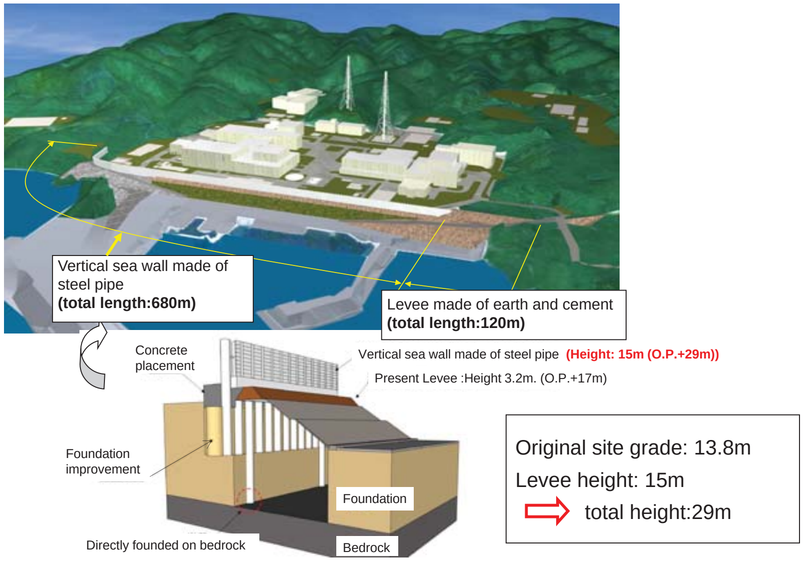
Immediate upgrades: Emergency Response Center



Immediate Upgrade : Enhance Electric Power Supply (2)



Further Enhancement: New Levee



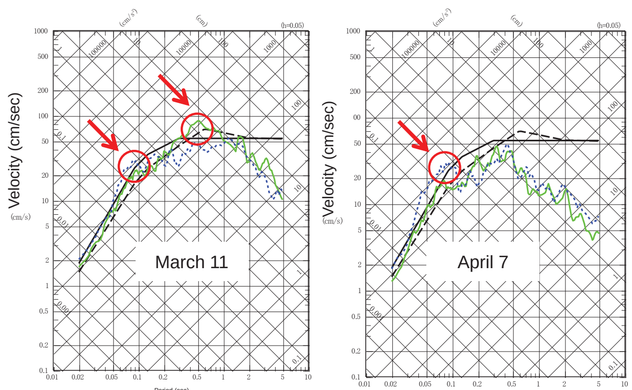
Original site grade: 13.8m
Levee height: 15m
⇨ total height:29m

Further Safety Enhancement

Function	Enhancement	Status
Re-evaluate Tsunami height	New levee	Under work
Re-evaluate Design basis ground motion	Further seismic reinforcement	Under work
Confinement System	Filtered PCV (Primary Containment System)	Under work
Electric Power Supply	Stationary Gas Turbine Generator	Under work
	Add DC (Direct Current) Battery	Planning
Cooling System	Mobile heat exchanger	Planning
Emergency Response	Fortify Emergency Response Center	Planning

Reevaluate the design basis seismic ground motion (DBSGM)

Observed Earthquake Response Spectrum: North-South Direction / East-West Direction



We found:

the value of the observed earthquake spectrum exceeded that of the design basis seismic ground motion in a short period

↓

We decided to set up new "Design Basis Seismic Ground Motion"

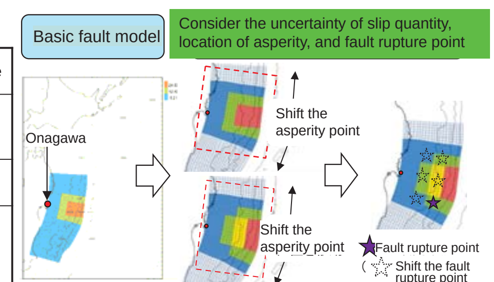
—— Design Earthquake Motion Ss-D（Horizontal）
(Earthquake ground motion with the site specific earthquake source locations)
········ Design Earthquake Motion Ss-B（Horizontal）
(Earthquake ground motion with no such specific source locations)

Reevaluate tsunami prediction

- First, re-evaluated the tsunami height, considering that interlocking movement of tsunami sources was observed in the 3/11's tsunami. Although tsunami height on 3/11 was lower than the site grade, there was not much margin.
- Based on new regulation, and the new findings of 3/11 tsunami, we set up new tsunami sources.
- In addition, we considered the uncertainty (fault location, disproportion of slip, fault rupture pattern, etc.)
- New prediction: tsunami maximum height :O.P. 23m .(note: O.P.is Onagawa Peil, and datum plane for construction,)

Considered tsunami sources

	Main tsunami sources	Magnitude
Interplate earthquake (plate boundary)	Tsunami earthquake（1896, Meiji-sanriku earthquake）	Mw8.3
	Great Earthquake（3/11 earthquake）	Mw9.0
Oceanic interaplate earthquake	Normal fault type earthquake（1933, Syouwa-sanriku earthquake）	Mw8.6
Earthquake Induced by Inland crustal movement	F-2fault,F-4fault,F-5fault, F-6fault～F-9fault	Mw6.2～7.0

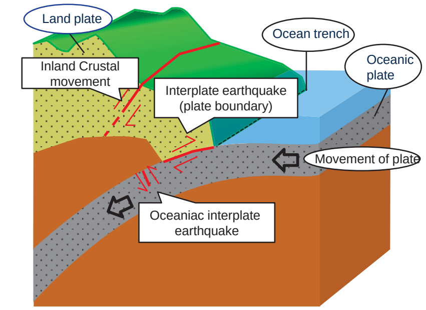


Consider the uncertainty of tsunami sources
(Example of 3/11 great eastern earthquake)

Review the earthquake pattern

Set up new design basis ground motion

Earthquake pattern	Considered earthquake
Interplate earthquake (plate boundary)	3/11/2011 Tohoku Great Eastern Earthquake (Mw9.0)
Oceanic interaplate earthquake	4/7/2011 Miyagikenoki-earthqake(M7.2)
Earthquake caused by inland crustal movement	F-2fault,F-4fault,F-5fault, F-6fault～F-9fault

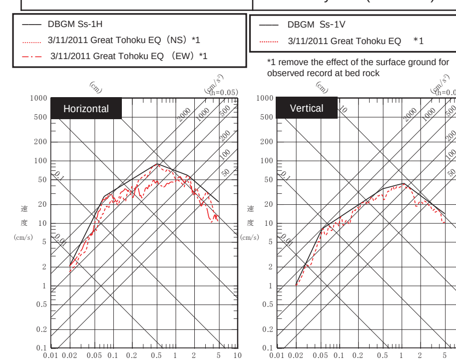


Earthquake pattern and where the earthquake occur

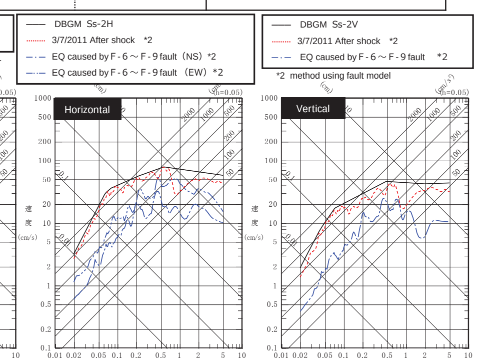
Set up new Design Basis Seismic Ground Motion (Ss)

Reference earthquake for review, and Design Basis Seismic Ground Motion (DBSGM)

Earthquake occurrence pattern	Reference earthquake for review	Magnitude	Design basis ground motion (H: Horizontal, V: Vertical)
Interplate earthquake (plate boundary)	3/11/2011, Great Tohoku earthquake	M9.0	Ss-1H (640gal) Ss-1V (320gal)
Oceanic interaplate earthquake	4/7/2011, After shock	M7.5	Ss-2H (1000gal) Ss-2V (600gal)
Inland crustal movement	Induced by fault (F-6 ～F-9)	M7.1	



Response spectrum for Ss-1



Response spectrum for Ss-2

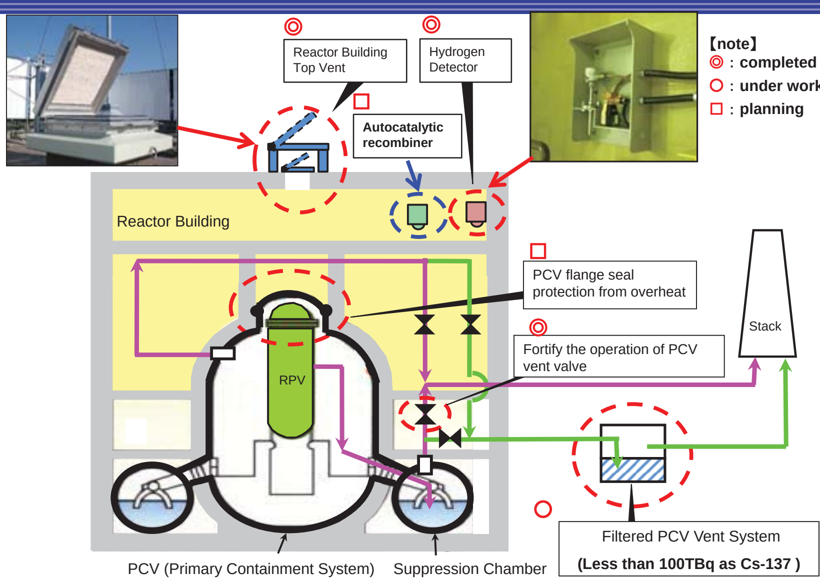
Further Safety Enhancement：Additional Seismic reinforcement

- **Status of seismic-resistant work**
  - Based on the findings of 3/11/2001 Great Earthquake and 4/8/2011 aftershock, additional seismic reinforcement has been under work for pipe, cable, sea water intake structure, and reactor building.
- **Principle for seismic reinforcement**
  - Design Basis Accident SSC (Structures, Systems and Components) is designed to withstand the seismic ground motion based on their importance.
  - S class SSC is designed not to be damaged by design basis seismic ground motion (Ss).

（Example of seismic reinforcement ）

install additional support

Further Safety Enhancement : Filtered PCV System



Alternative power supply system

Enhance AC power system

➢ **Permanently-installed facilities**

- **Gas turbine generator**: set up at high ground and secure diversity from design base EDG.

➢ **Alternative mobile power supply units**

- **Mobile electric power car**

Enhance DC power system

➢ **Permanently-installed facilities**

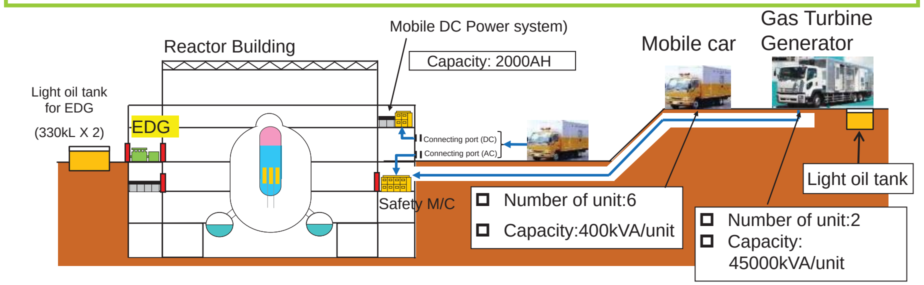
- **Battery**: at least 8 hours for the initial, and capable for 24hours by removing unnecessary loads.

➢ **Alternative mobile battery charger units**

- Increase the number of batteries + **Mobile battery charger**: supply DC power for more than 24 hours.

Reserve fuel oil

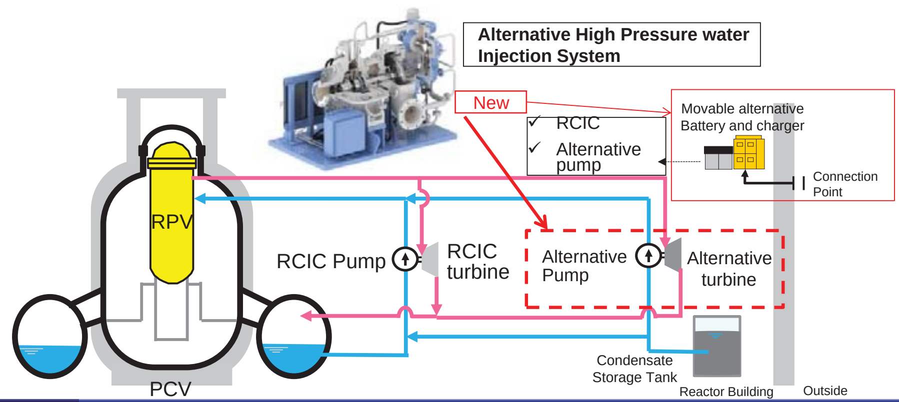
- Install an **oil tank in the basement**.



Alternative High pressure Injection System

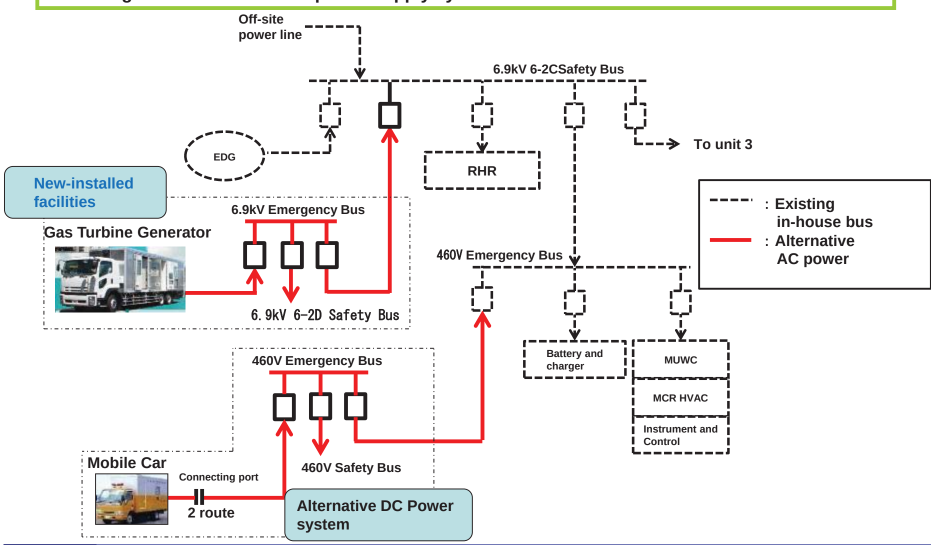
➢ Reactor Water make-up which does not depend on AC power is crucial when reactor pressure is high.
Then, existing RCIC (Reactor isolated Core Injection Cooling System) + Alternative: High Pressure Water Injection System (New)

➢ Key feature: No DC is need. It works even submerged.



Alternative power supply system

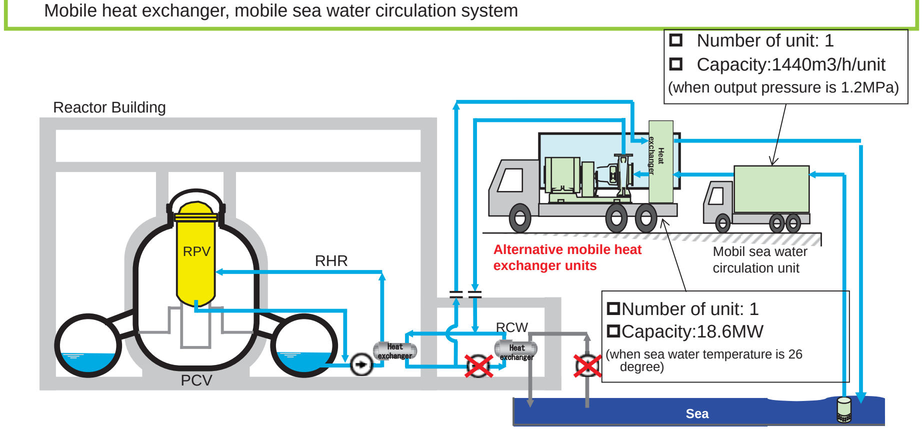
◆ **Configuration of alternative power supply system**



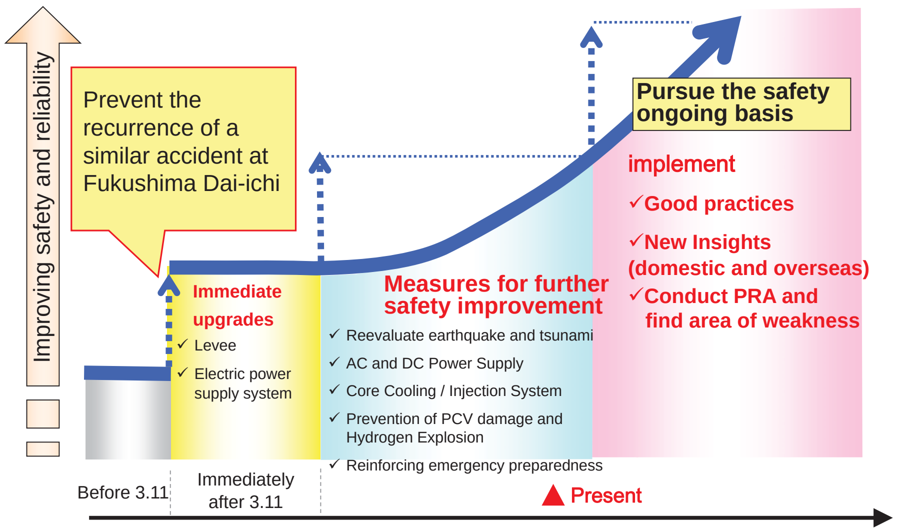
Alternative mobile heat exchanger system

◆ Purpose
Preventing the core damage, even when the ultimate heat sink (such as RHR (reactor residual heat remove system) failed its function.

◆ **Configuration**
Mobile heat exchanger, mobile sea water circulation system



Road Map :Pursuit of safety



Fortify Emergency Response Center

Artist Rendition of Emergency Response Center once completed

<u>Fortify ERC furthermore</u> for sever accident

Key Features

- Seismic-isolation building
- Thick skeleton for radiation shielding

(<u>Less than 100mSv/7days</u> when SA occurred)

- Diverse communication tool
- Exclusive diesel generator

Conclusion

- There is no end of pursuing nuclear safety
  - Always consider the new findings
  - Careful preparedness is necessary
- Challenging point
  - How many equipment or barriers (Defense In Depth) do we need?

    ⇨ Risk Assessment

Thank you for your kind attention!

Total overview of enhancement for Severe Accident