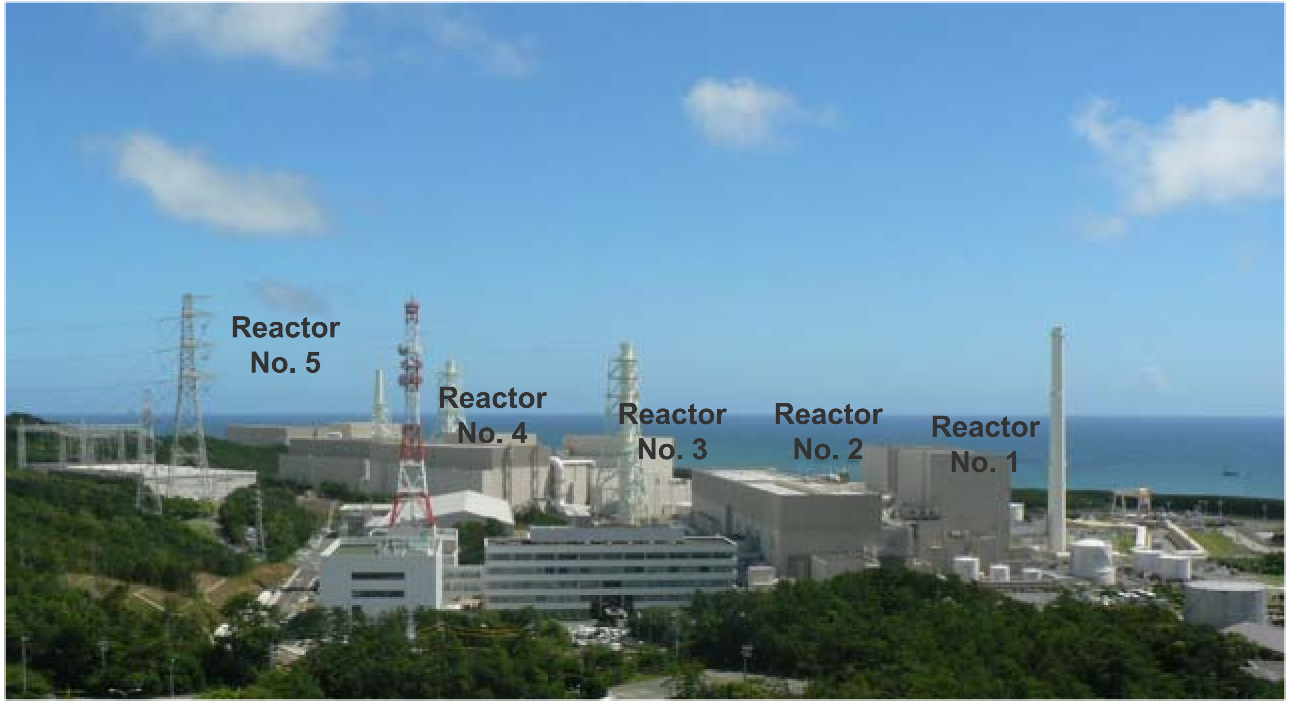
# Tsunami Countermeasures at Hamaoka Nuclear Power Station




**July 22, 2011**

# Introduction

- This is to announce that Chubu Electric Power has established tsunami countermeasures for the Hamaoka Nuclear Power Station that reflect knowledge learned heretofore, including from the recent accident caused by the Tohoku-Pacific Ocean Earthquake at Tokyo Electric Power Co., Inc.'s Fukushima Daiichi Nuclear Power Station.

- Because we take society's increased concerns about the safety of nuclear power very seriously, the tsunami countermeasures announced herein are intended to enhance the safety of the Hamaoka Nuclear Power Station.

- We had previously confirmed the Hamaoka Nuclear Power Station's safety against tsunami, taking into account tsunami that have had a major impact on the area in the past, such as those from the Ansei-Tokai and Hoei earthquakes. Additionally, we have now completed emergency safety measures that considered the accident caused by the Tohoku-Pacific Ocean Earthquake at the Fukushima Daiichi Nuclear Power Station.

# Overview of Tsunami Countermeasures

- Under the current tsunami countermeasures, we have decided to take two sets of "flooding prevention measures," namely 1) measures such as building a sea wall to prevent flooding on the station site, and 2) measures to prevent flooding in buildings if there is flooding on the station site.
- In addition, we will "strengthen emergency countermeasures" to ensure multiple and diverse cooling functions so that reactors can be reliably and safely brought to cold shutdown even in the event of "loss of all AC power" and "loss of seawater cooling function," problems that occurred at the Fukushima Daiichi Nuclear Power Station.

<Flooding prevention measures>

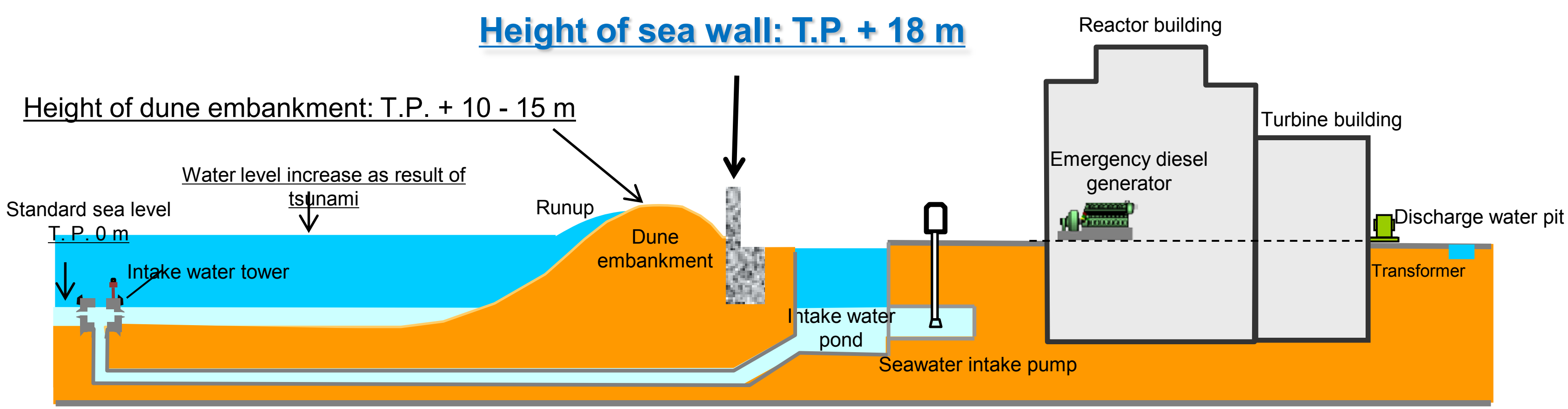
| | |
|---|---|
| Flooding prevention measures 1 | : Prevent flooding on the station site<br>Measures such as building a sea wall (T.P. + 18 m) to prevent flooding on the station site |
| Flooding prevention measures 2 | : Prevent flooding in buildings<br>Maintain seawater cooling function and prevent flooding in buildings if there is flooding on the station site |

<Strengthen emergency countermeasures>

| | |
|---|---|
| Strengthen emergency counter-measures | : Ensure cooling function<br>Ensure cooling function in a scenario that assumes loss of all AC power and loss of seawater cooling function<br>◆Provide multiple and diverse alternative means of ensuring water injection, heat removal and power supply so that we can maintain the reactor in a stable hot shutdown state and reliably and safely bring it to cold shutdown |

# Overview of Tsunami Countermeasures

◆ We have decided that the sea wall to be built on the seaward side of the station site is to be T.P. (Tokyo Bay mean sea level) + 18 m, in light of the height of the dune embankment in front of the Hamaoka Nuclear Power Station (T.P. + 10 - 15 m) and the runup height of the tsunami that hit the Fukushima Daiichi Nuclear Power Station (about T.P. + 15 m).




◆ Moreover, we have investigated events such as the **triple interlocked Tokai/Tonankai/Nankai earthquakes** and anticipate that the tsunami runup height at the Hamaoka Nuclear Power Station would be **about T.P. + 8 m**.

◆ We created **a virtual tsunami model of a magnitude 9 earthquake (the same as the Tohoku-Pacific Ocean Earthquake)**, and **trial calculations** indicated that the height would be **about T.P. + 10 m**.

# Overview of Tsunami Countermeasures

- Chubu Electric Power will continue to take the necessary and appropriate measures based on new knowledge from studies of the accident at the Fukushima Daiichi Nuclear Power Station, the investigation of the Central Disaster Management Council, and so on.

- In light of knowledge from the accident at the Fukushima Daiichi Nuclear Power Station, we will anticipate the simultaneous occurrence of earthquake, tsunami and nuclear power station damage and, together with our Group companies, will work to revise and strengthen our disaster prevention system.

- We will work in close partnership with local governments and other authorities to respond to citizens' needs in the event of disaster, offering our knowledge and proactively cooperating in other ways as well.

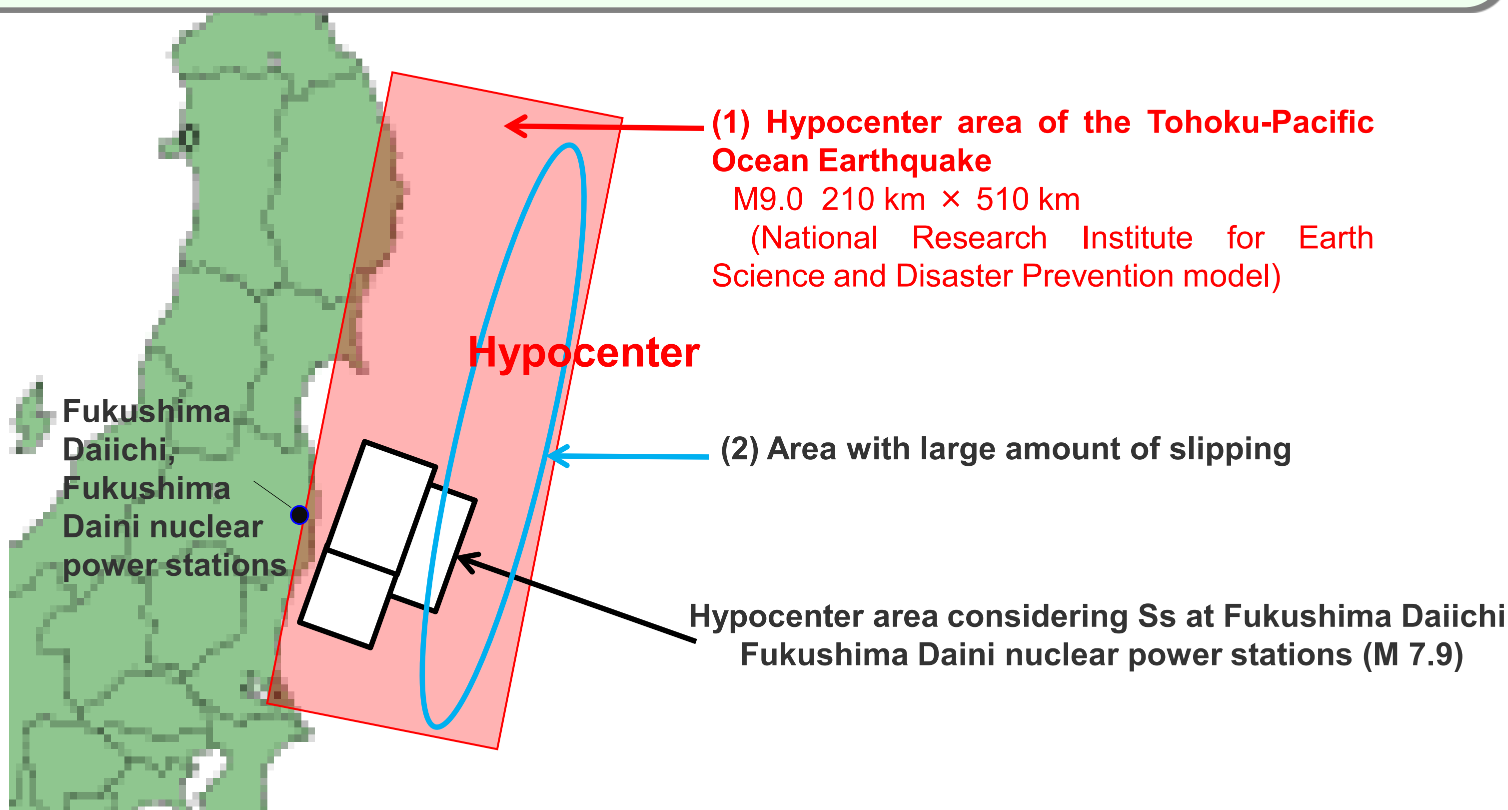
# Safety against Tsunami in Light of Knowledge Learned from the Tohoku-Pacific Ocean Earthquake

# Characteristics of the Magnitude 9 Tohoku-Pacific Ocean Earthquake

The Tohoku-Pacific Ocean Earthquake is believed to have featured the simultaneous occurrence of "ordinary earthquake interlocking" and a "tsunami earthquake" that does not have strong tremors:

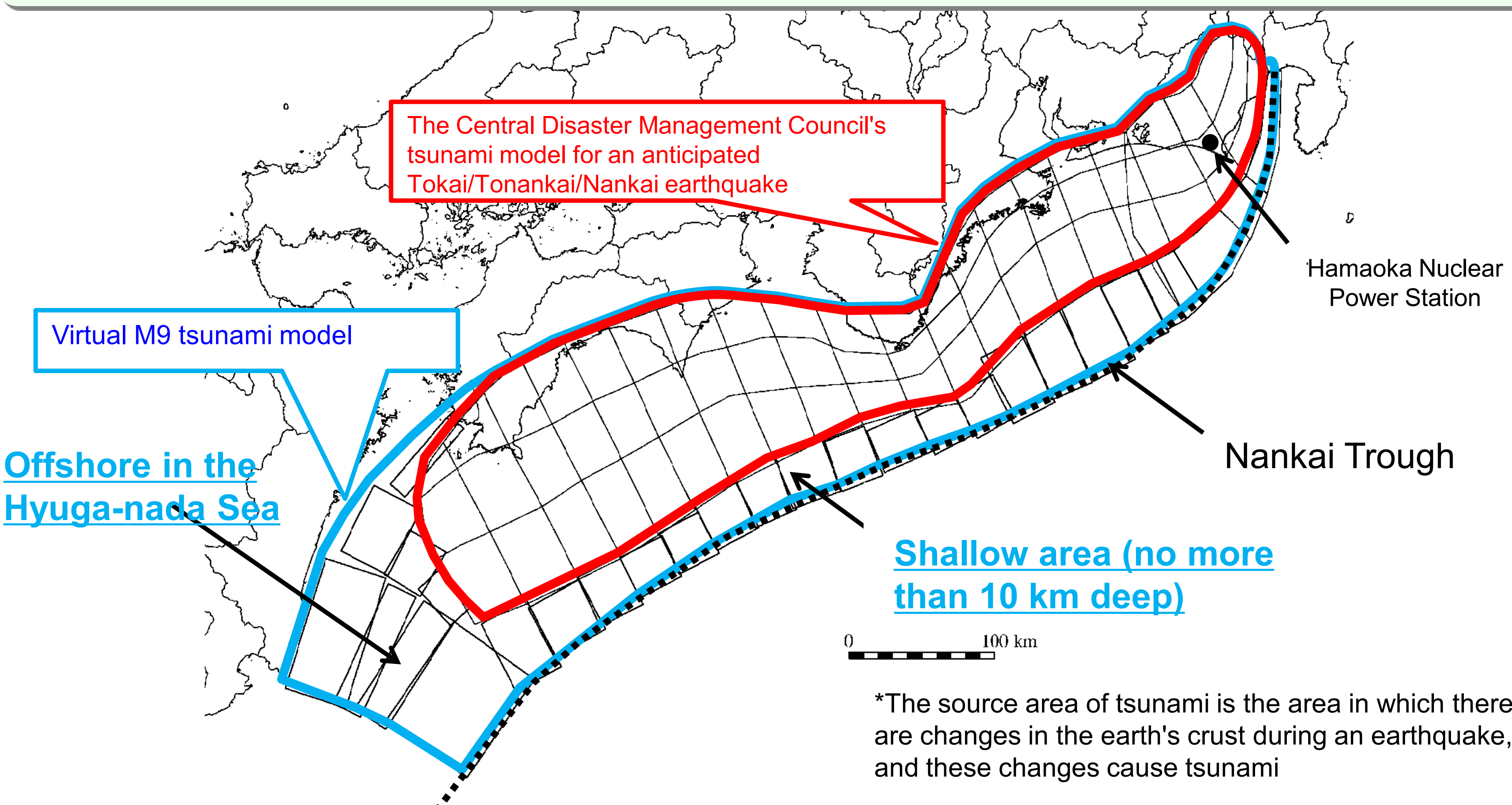
**(1) interlocking occurred over a very wide area, from the Sanriku coast to Ibaraki Prefecture coast**, causing the magnitude (M), a measure of earthquake energy, to rise to 9.0;

**(2) there was a great deal of slipping in places where the plate boundaries were shallow**; this made it possible for a very large tsunami to occur.



# Virtual M9 Tsunami Model at Hamaoka Nuclear Power Station

◆The mechanism of the tsunami from the Tohoku-Pacific Ocean Earthquake will be the subject of further study and analysis.
◆In light of the accident at the Fukushima Daiichi Nuclear Power Station caused by the unexpectedly large tsunami, we looked at the triple interlocked Tokai/Tonankai/Nankai earthquake, created a virtual tsunami model of an M9 earthquake that expanded the source area of tsunami* to the Sea of Hyuga coast and the area along the Nankai Trough, and calculated the tsunami runup height.




*The source area of tsunami is the area in which there are changes in the earth's crust during an earthquake, and these changes cause tsunami

# Calculated Results Using Virtual M9 Tsunami Model

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◆The tsunami runup height at Hamaoka Nuclear Power Station was **about T.P. + 10 m**

↓

◆This height **would not exceed the height of the dune embankment in front of the power station (T.P. + 10 - 15 m).**

◆**Concerning seismic resistance**

① At the Hamaoka Nuclear Power Station, we use the target ground motion (approx. 1,000 gal) to do seismic durability enhancement work, and considering the size of a triple interlocked Tokai/Tonankai/Nankai earthquake (M8.7) evaluated with standard seismic motion Ss, we forecast there would be a margin of safety over this ground motion.

② Of the areas in which an M9 earthquake might occur, the Sea of Hyuga coastal area (which is far from the station) and the shallow area of “tsunami earthquakes” (which would not have strong short-cycle tremors) are believed to have little impact on the station site. Based on the above, we believe that the station has sufficient safety in the event of seismic activity.

◆A Central Disaster Management Council study and other reviews are currently proceeding, and we will respond appropriately to any new knowledge learned.

# Stance on Tsunami Countermeasures

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- An important key to ensuring nuclear power station safety is the so-called "stop, cool and contain" rule.
- Of these, all the AC power that is essential to the function to "cool" the reactor was lost at Fukushima Daiichi (loss of all AC power).
- It is believed that because the function of using seawater to cool reactor facilities was lost (loss of seawater cooling function), the "cooling" function was lost, which led to the severe accident.
- Under the current tsunami countermeasures, we have decided to take two sets of "flooding prevention measures," namely 1) measures such as building a sea wall to prevent flooding on the station site, and 2) measures to prevent flooding in buildings if there is flooding on the station site.
- In addition, we have decided to "strengthen emergency measures," by assuming "loss of all AC power" and "loss of seawater cooling function" such as occurred at the Fukushima Daiichi Nuclear Power Station.

**<Flooding prevention measures>**

| | |
|---|---|
| Flooding prevention measures 1 | : **Prevent flooding on the station site**<br>Measures such as building a sea wall (T.P. + 18 m) to prevent flooding on the station site |
| Flooding prevention measures 2 | : **Prevent flooding in buildings**<br>Maintain seawater cooling function and prevent flooding in buildings if there is flooding on the station site |

**<Strengthen emergency countermeasures>**

| | |
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| Strengthen emergency counter-measures | : **Ensure cooling function**<br>Ensure cooling function in a scenario that assumes loss of all AC power and loss of seawater cooling function<br>◆Provide multiple and diverse alternative means of ensuring water injection, heat removal and power supply so that we can maintain the reactor in a stable hot shutdown state and reliably and safely bring it to cold shutdown |

# Prevent Flooding on the Station Site (Flooding Prevention Measures 1)

◆We will prevent flooding on the station site.

(1) We will practice "flooding prevention" that keeps tsunami from directly getting into the station site.

(2) We will also take "overflow countermeasures" so that if a tsunami causes the sea to rise and therefore raises the water level in Intake water ponds, etc., the seawater will not overflow.

"Flooding prevention measures," those that prevent tsunami themselves from flooding the station site, include:

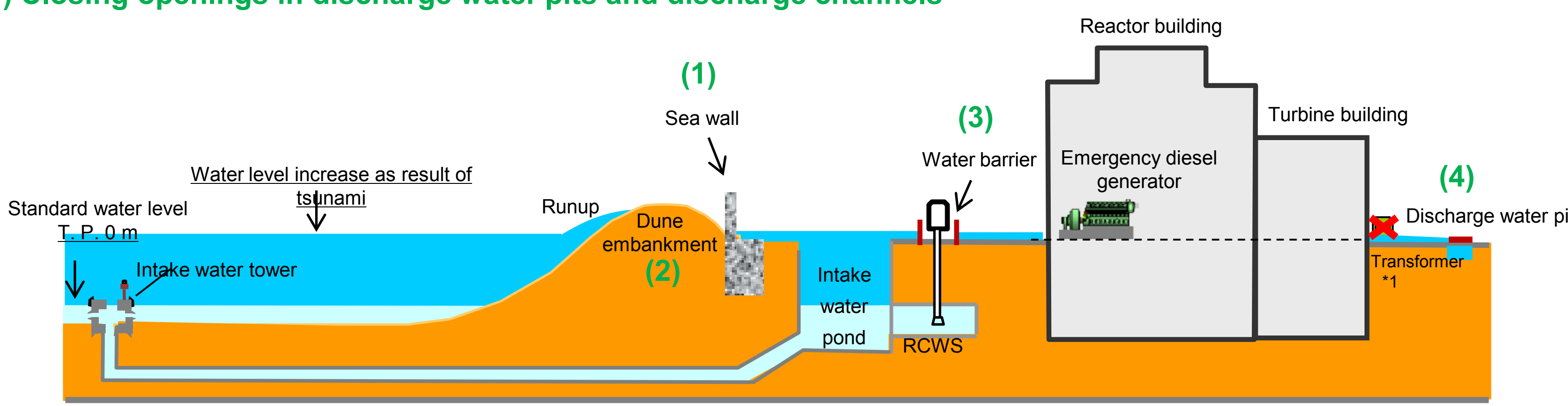
(1) Building a sea wall (T.P. + 18 m high) on the seaward side of the station site

(2) Building up the dune embankment in front of the station site and building up embankments on the east and west sides

"Overflow countermeasures" include:

(3) Placing water barriers (1.5 m high) in the seawater intake pump area

(4) Closing openings in discharge water pits and discharge channels




*1 We are assuming that outdoor transformers would become unusable if there is flooding on the site; we do not assume the station will get power from outdoor transformers right away even if external power supply is restored.

# Flooding Prevention (Structure of Sea wall)

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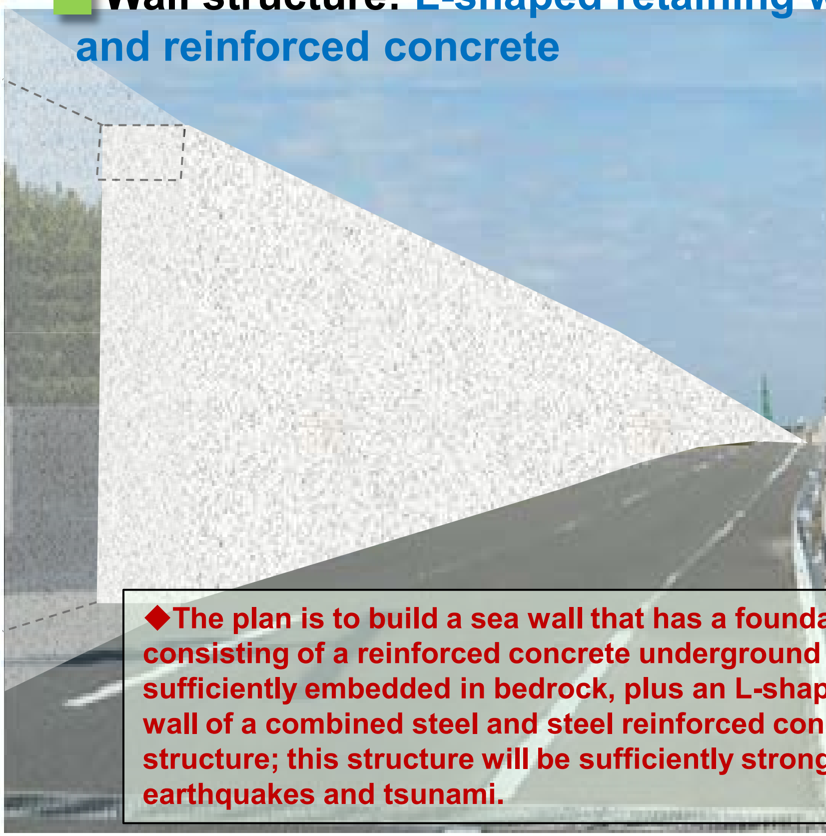
## Height: T.P. + 18 m

The height of the sea wall was previously announced as "T.P. + 12 m or higher," but considering the height of the dune embankment in front of the Hamaoka Nuclear Power Station (T.P. + 10 - 15 m) and the tsunami runup height at Fukushima Daiichi (approx. T.P. + 15 m) , it was decided to build the sea wall to a height of T.P. + 18 m.

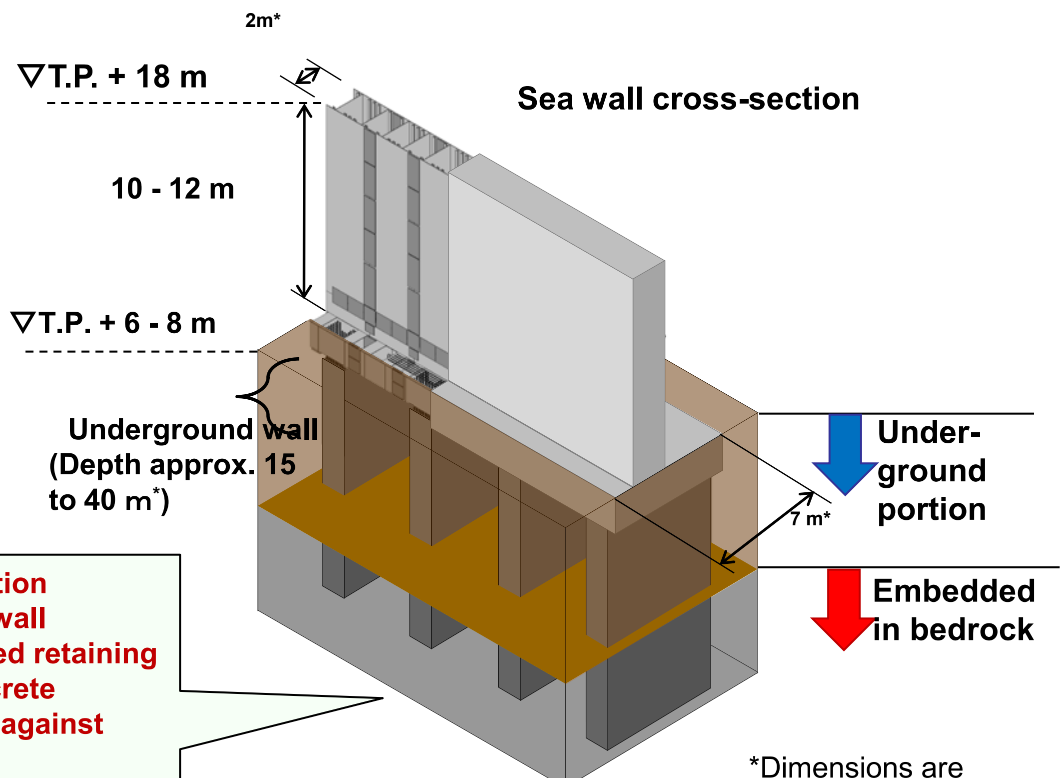
## Foundation structure: Underground wall (reinforced concrete wall embedded in bedrock)

## Wall structure: L-shaped retaining wall of steel and a complex structure of steel and reinforced concrete



◆The plan is to build a sea wall that has a foundation consisting of a reinforced concrete underground wall sufficiently embedded in bedrock, plus an L-shaped retaining wall of a combined steel and steel reinforced concrete structure; this structure will be sufficiently strong against earthquakes and tsunami.

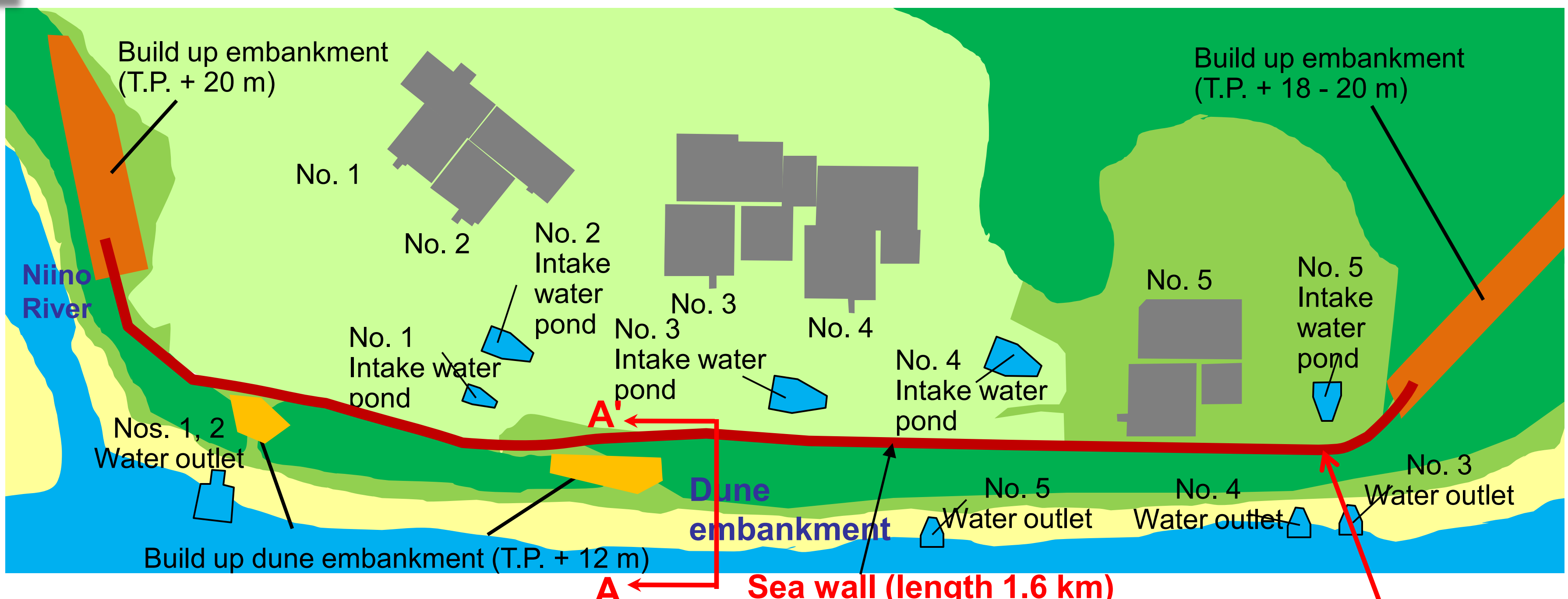
Sea wall image

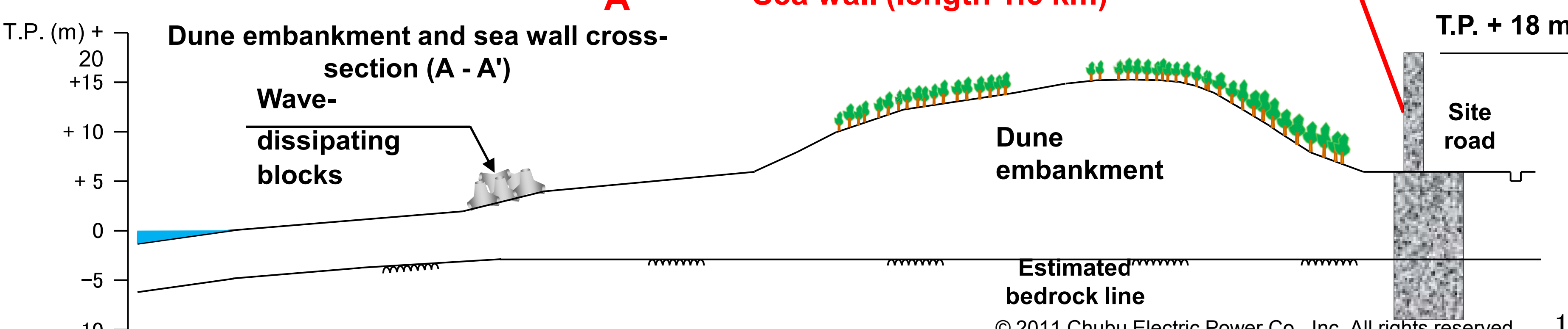



*Dimensions are provisional values

# Flooding Prevention (Arrangement of Sea wall, Etc.)

- The sea wall will be built along the shore of the site of Reactors No. 1-5 and will have a total length of about 1.6 km. At each end there will be an **embankment of T.P. + 18 - 20 m**, so that it will **connect to ground that is similarly T.P. + 20 m or higher**. This will prevent tsunami from penetrating from the front or side of the site and also avoid damage from water getting in from behind.
- To prevent tsunami from concentrating locally, we will build up the dune embankment so it has a height of at least T.P. + 12 m.

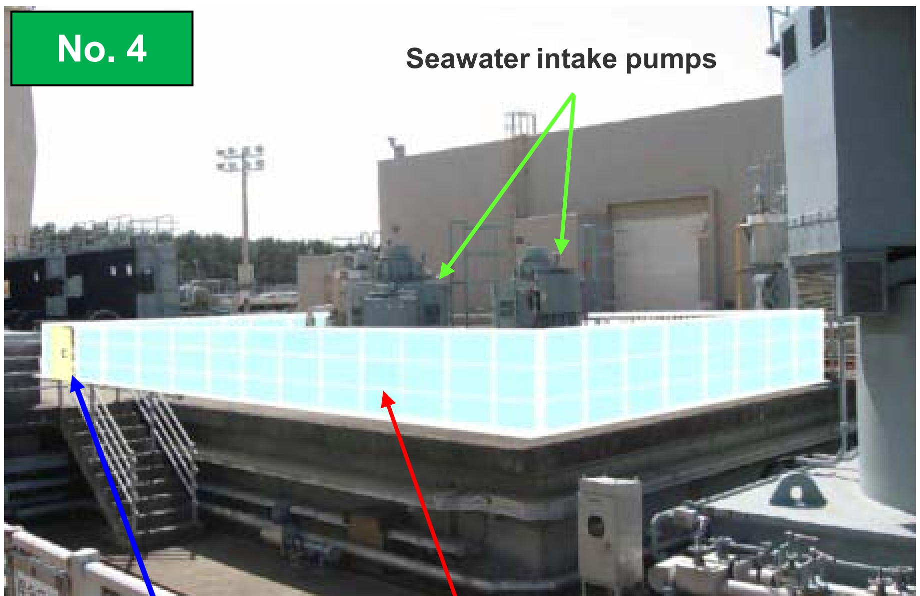


Flooding prevention measures 1

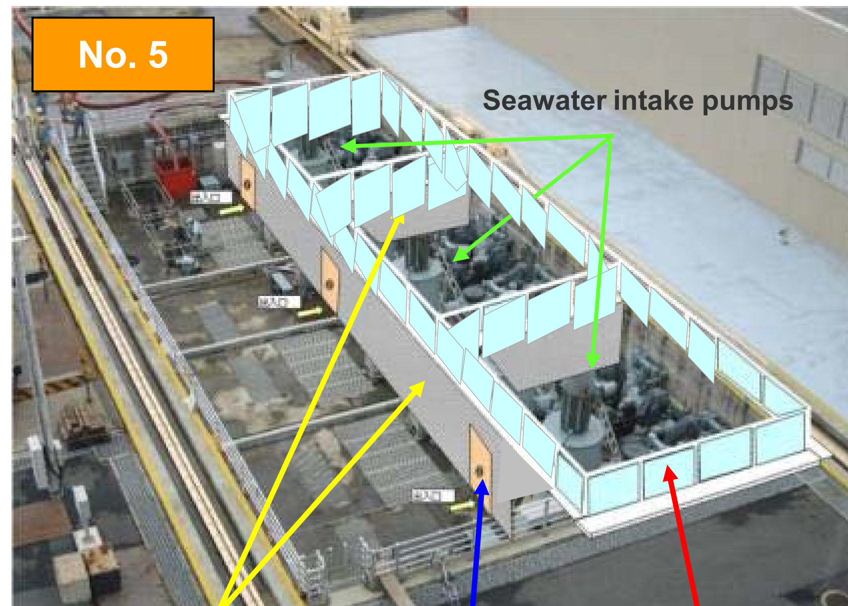
# Overflow Countermeasures (Placing Water Barriers in the Seawater Intake Pump Area)

- **Water barriers 1.5 m high will be built** around seawater intake pumps, so that during a tsunami there will not be an overflow of water on the site from spots connected to the sea (such as intake water ponds) and the seawater intake pumps needed to cool reactor facilities will not be flooded. (Flooding depth was about 0.5 m in the calculated results based on a virtual M9 tsunami runup height of T.P. + 10 m.)




Water-proof access door

Water barrier (metal panel)




Partition wall (concrete)

Water-proof access door

Water barrier (metal panel)

**Water barrier construction image**

# Prevent Flooding in Buildings (Flooding Prevention Measures 2)

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## Maintain seawater cooling function and prevent flooding in buildings even if the site is flooded.

◆ **This scenario assumes that a tsunami would overtop the sea wall and the site would be flooded.**

(Flooding depth was about 2 - 3 m in the calculated results based on a tsunami with runup height T.P. + 20 m overtopping the sea wall.)

- **Because seawater intake pumps are located outdoors, they would be flooded with water and stop working. As a result, the reactor facilities' cooling function using seawater would be lost ("loss of seawater cooling function").**
- **There is also concern that there could be much flooding in buildings.**

◆ **Based on the above, we are taking three types of measures as flooding prevention measures 2.**

**We will take measures to (1) maintain seawater cooling function, (2) prevent flooding in buildings, and (3) prevent flooding in equipment rooms.**

**(1) Maintain seawater cooling function**

① Install emergency seawater intake system (EWS) (as alternative to reactor cooling water system (RCWS))

② Take measures to keep flotsam out of intake water ponds

**(3) Equipment room flooding prevention**

⑧ Strengthen building drainage measures (install drainage pumps)

⑨ Install new watertight doors and reinforce existing ones

⑤ Take measures to prevent flooding from through-ways in equipment rooms (i.e., improve their seals)

**(2) Prevent flooding in buildings**

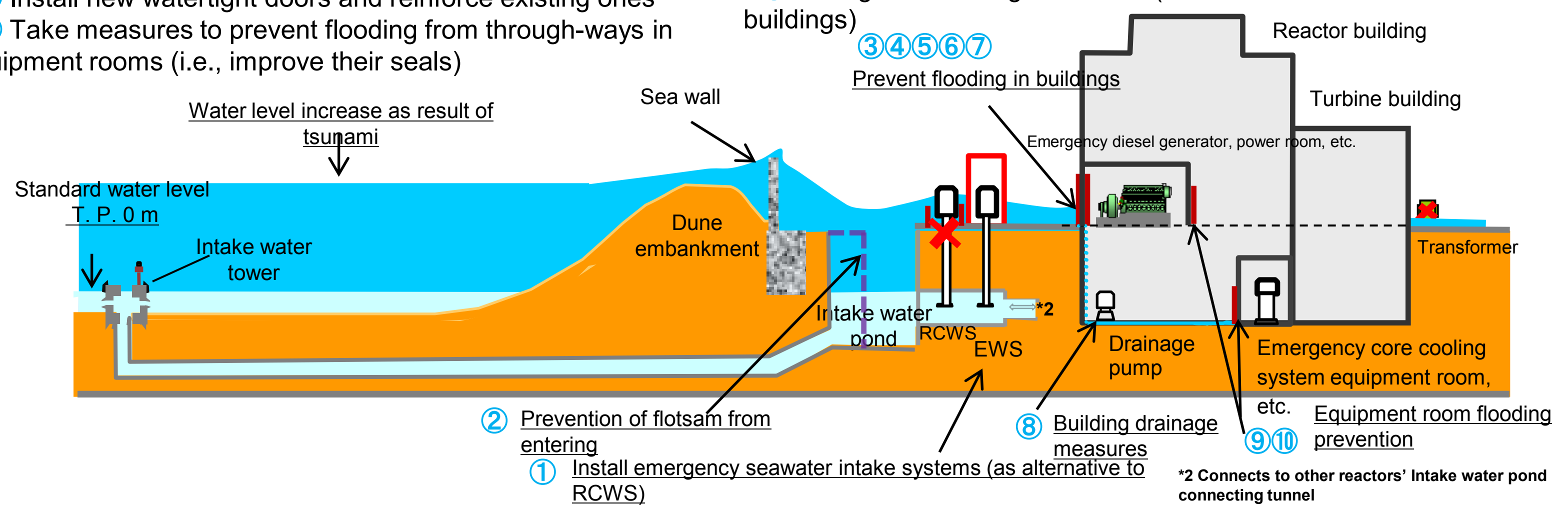
③ Increase the reliability of waterproof doors in outer walls of buildings

④ Take measures to prevent flooding from air intakes/vents (openings) in outer walls of buildings

⑤ Take measures to prevent flooding from through-ways in buildings (i.e., improve their seals)

⑥ Close underground pipe and duct inspection openings, entry doors, etc.

⑦ Strengthen building structures (Nos. 4 and 5 seawater heat exchanger buildings)



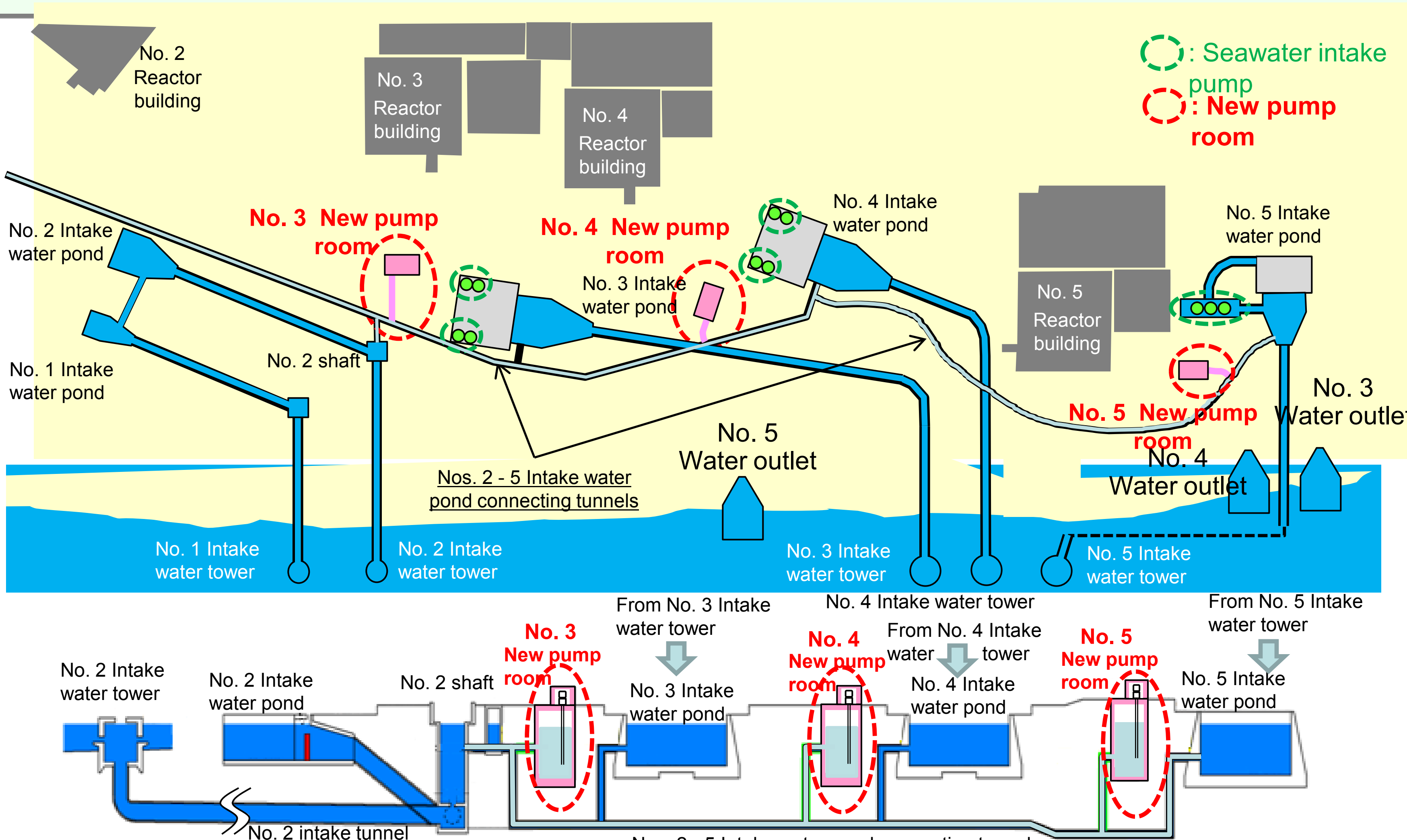

*2 Connects to other reactors' Intake water pond connecting tunnel

Flooding prevention measures 2

# Maintain Seawater Cooling Function

## (install emergency seawater intake systems (EWS))

- Construct waterproof buildings and install new seawater intake pumps in them. This measure will make it possible to maintain the seawater cooling function even if there is flooding on the station site.
- We will diversify our water intake sources by connecting newly installed seawater intake pumps to tunnels connecting intake water ponds in Reactors No. 2 - 5, so that water can be drawn from the intake water ponds of all reactors.



Flooding prevention measures 2

# Prevent Flooding in Buildings

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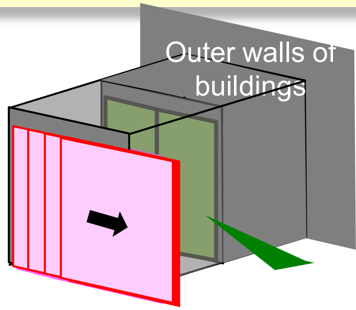
Measures we are taking to **"prevent flooding in buildings"** include:

- ◆We will replace doors with watertight ones, and double up doors by adding new reinforced doors.
- ◆The reliability of large cargo receiving dock doors against tsunami will be increased by installing sliding flood walls.
- ◆We will change air intakes/vents to a snorkel-like form.

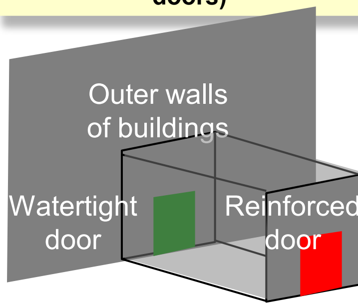
**Large cargo receiving dock doors**




Sliding flood wall


**(Image of measures)**

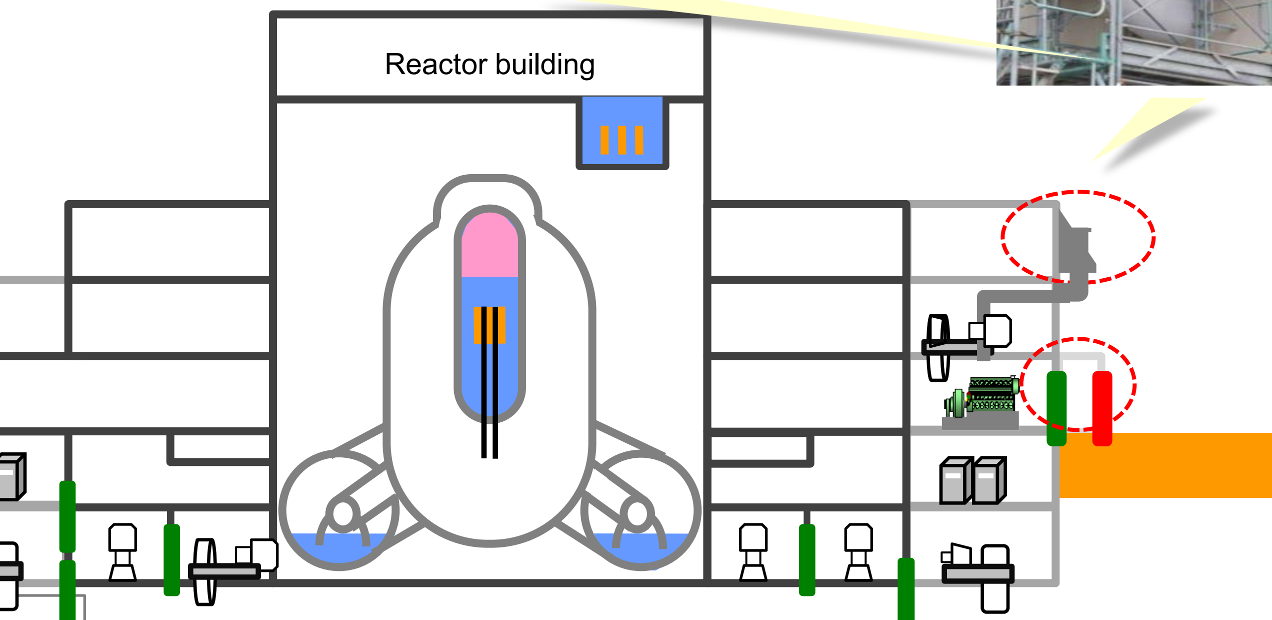
**Reinforced doors (ordinary doors)**




**(Image of measures)**



**Measures to prevent flooding from air intakes/vents in outer walls of buildings**




: Inside radiation control area
: Outside radiation control area

Flooding prevention measures 2

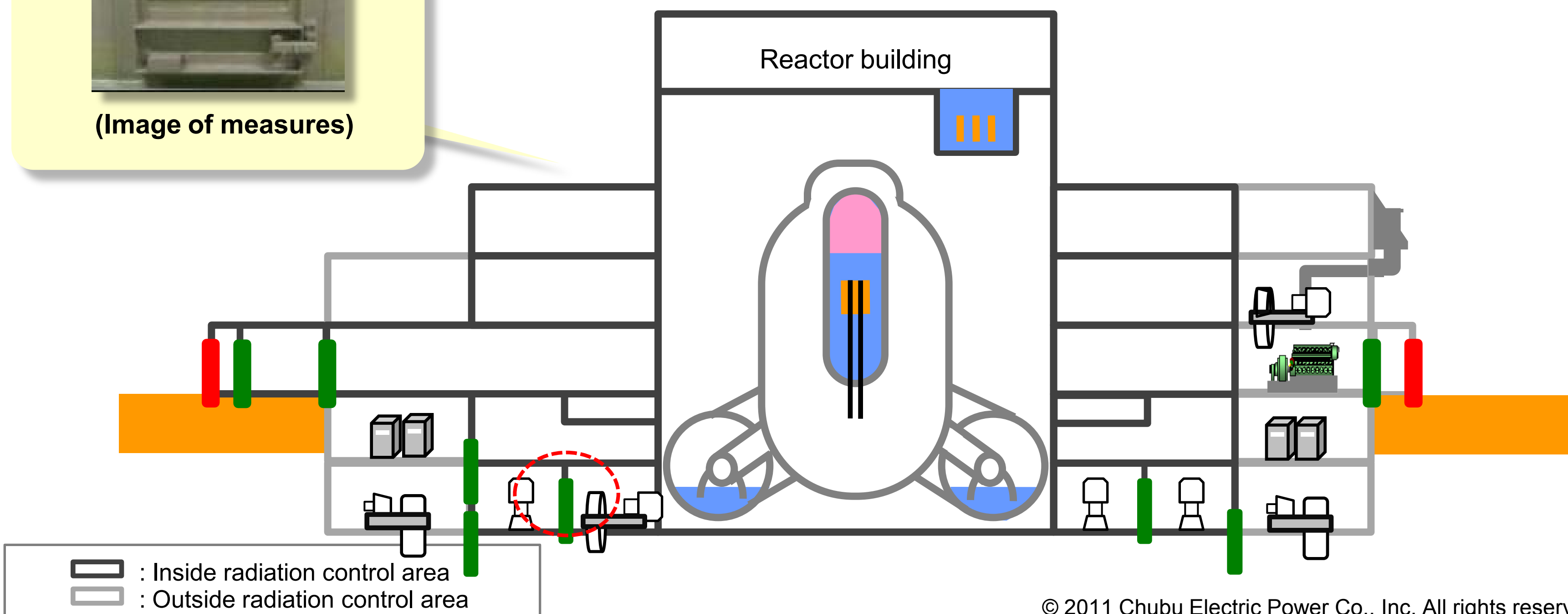
# Equipment Room Flooding Prevention

**Prevent flooding in equipment rooms**

**(Image of measures)**

◆Furthermore, equipment related to "cooling" and other important equipment such as for the power supply are located in separate equipment rooms inside buildings, and therefore we will take measures to "prevent flooding in buildings" and also "prevent flooding in equipment rooms."

◆Specifically, we will "reinforce already installed watertight doors and add new ones" and take "measures to prevent flooding from equipment room through-ways," and we will "strengthen drainage measures in buildings" by installing drainage pumps and through other means.



# Stance on Ensuring the Cooling Function (Strengthening Emergency Measures)

◆This explains how we will "ensure the cooling function" as a way of "strengthening emergency measures."

**We will take multiple and diverse measures to "ensure the cooling function" so that reactors can be reliably and safely brought to cold shutdown even in the event of "loss of all AC power" and "loss of seawater cooling function," problems that occurred at the Fukushima Daiichi Nuclear Power Station.**

**<Assumed conditions>**

◆ "Loss of all AC power"
Existing emergency diesel generators and switch panels would stop functioning and would be unable to supply power.

◆"Loss of seawater cooling function"
In addition to existing seawater intake pumps, the "emergency seawater intake system" we are newly installing would also stop functioning, making it impossible to cool the reactor by heat exchange with seawater.

**We will use alternative means to ensure the core and fuel pool cooling function even in this situation.**

**Take alternative means to:**

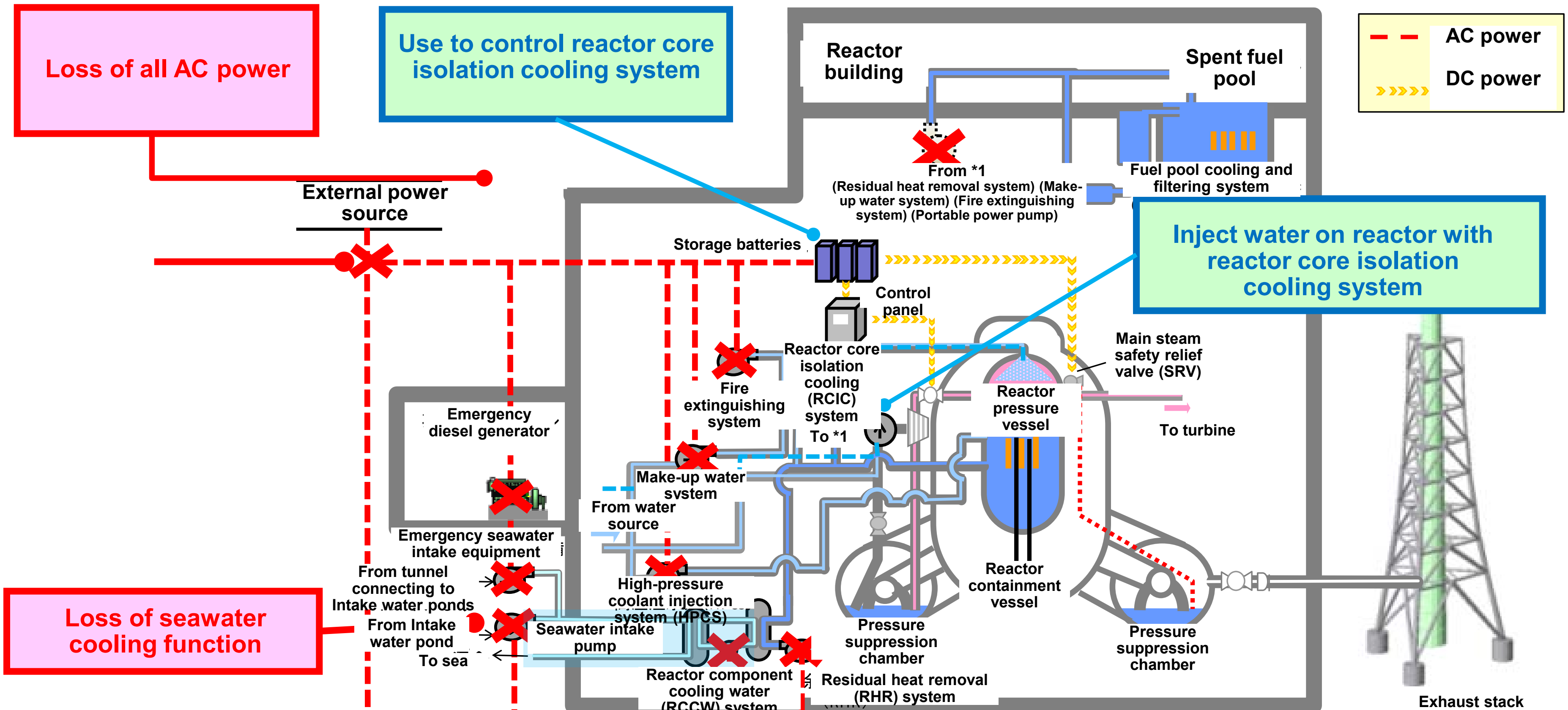
- Ensure water injection function
- Ensure heat removal function
- Ensure power supply

**Bring reactors reliably and safely to cold shutdown**

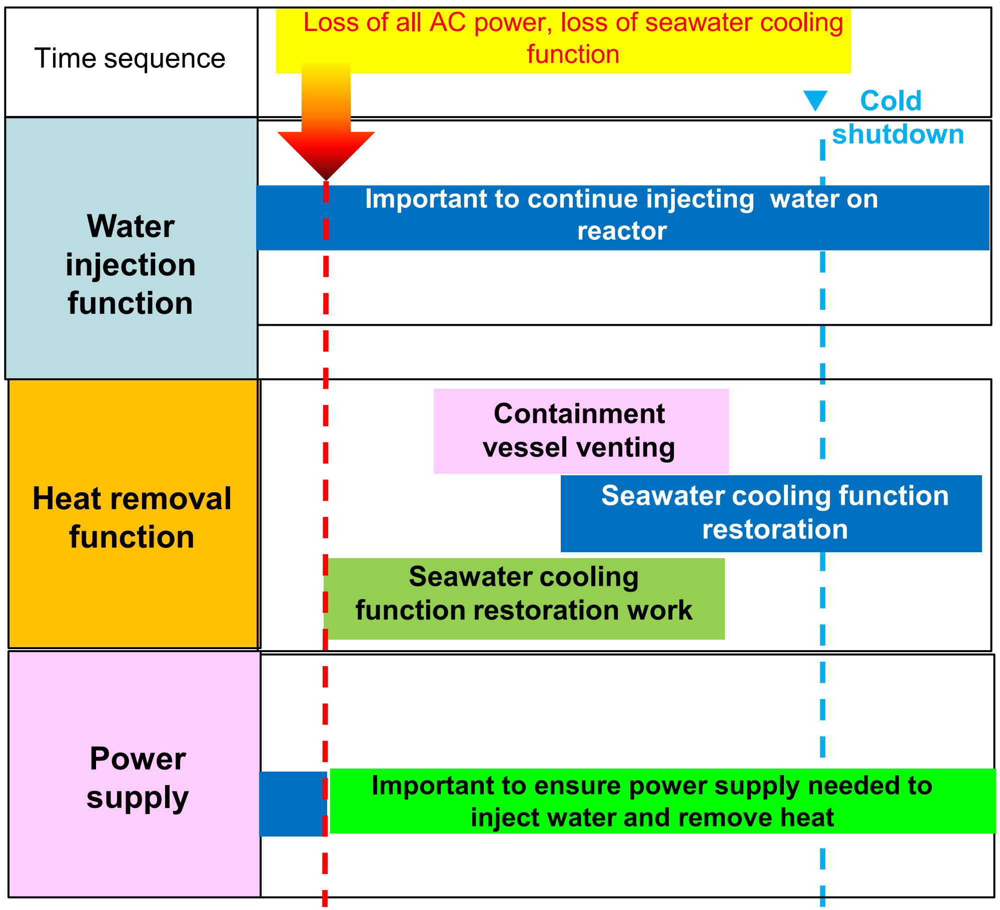
# Overview of "Loss of All AC Power" and "Loss of Seawater Cooling Function"

◆A loss of all AC power would cause the pumps that inject water to cool the reactor and the systems that remove reactor heat to stop operating.
◆A loss of seawater cooling function would make it impossible to cool the reactors, injection equipment, etc., by heat exchange with seawater.
→ Injection of water on reactor is driven by steam from the reactor, and we will inject water with a reactor core isolation cooling system capable of this function.

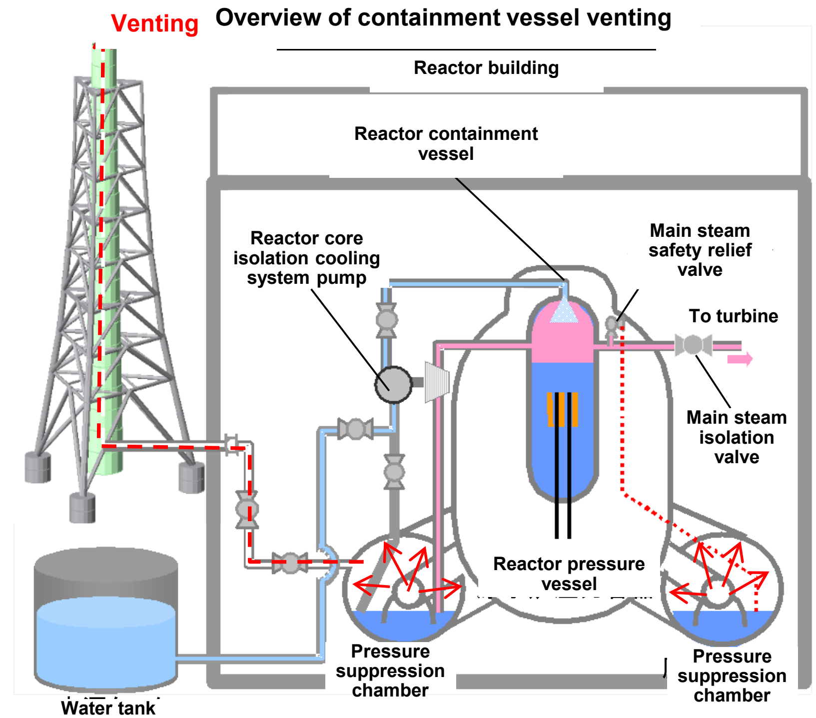


# Flow of Processes Leading to Cold Shutdown of Reactor

- To cool the reactor, it is important to ensure the "water injection function."
  By continuing to inject water on the reactor to cool it and using containment vessel venting to reduce pressure, it is possible to maintain the reactor in a hot but stable state.
- Quickly restoring the seawater cooling function is an important requirement for bringing the reactor to cold shutdown.
  At the same time, it is important to driven by steam sources and power supply, which support water injection, containment vessel venting and other processes that bring the reactor to cold shutdown.




**Overview of containment vessel venting**




◆To control pressure increase in the reactor, steam in the reactor pressure vessel is vented into the pressure suppression chamber in the reactor containment vessel through the "main steam relief safety valve."
◆As a result, pressure in the reactor containment vessel gradually rises.
◆Therefore, to control pressure increase in the reactor containment vessel, it is important to do containment vessel venting (i.e., venting pressure to the outside of the reactor containment vessel) using the reactor containment vessel's vent hole piping.

Strengthen emergency countermeasures

# (1) Water injection Equipment Measures

Measures to strengthen "water injection function"--diversify water injection means

◇The reactor core isolation cooling system and high-pressure coolant injection system are two systems with a high-pressure coolant injection function.

◇The reactor core isolation cooling system can continue to operate for a fixed period of time "in the event of loss of all AC power" and "in the event of loss of seawater cooling function."

◇We will strengthen the high-pressure coolant injection function by ① newly adding an **alternative cooling function (air-cooling)** in pumps, and ②, regarding power supply, receiving power from an **emergency AC power supply system** we are newly installing, so that the high-pressure coolant injection system can operate even "in the event of loss of all AC power" and "in the event of loss of seawater cooling function."

“Loss of all AC power”
"Loss of seawater cooling function"

↓

High-pressure coolant injection system **cannot operate**

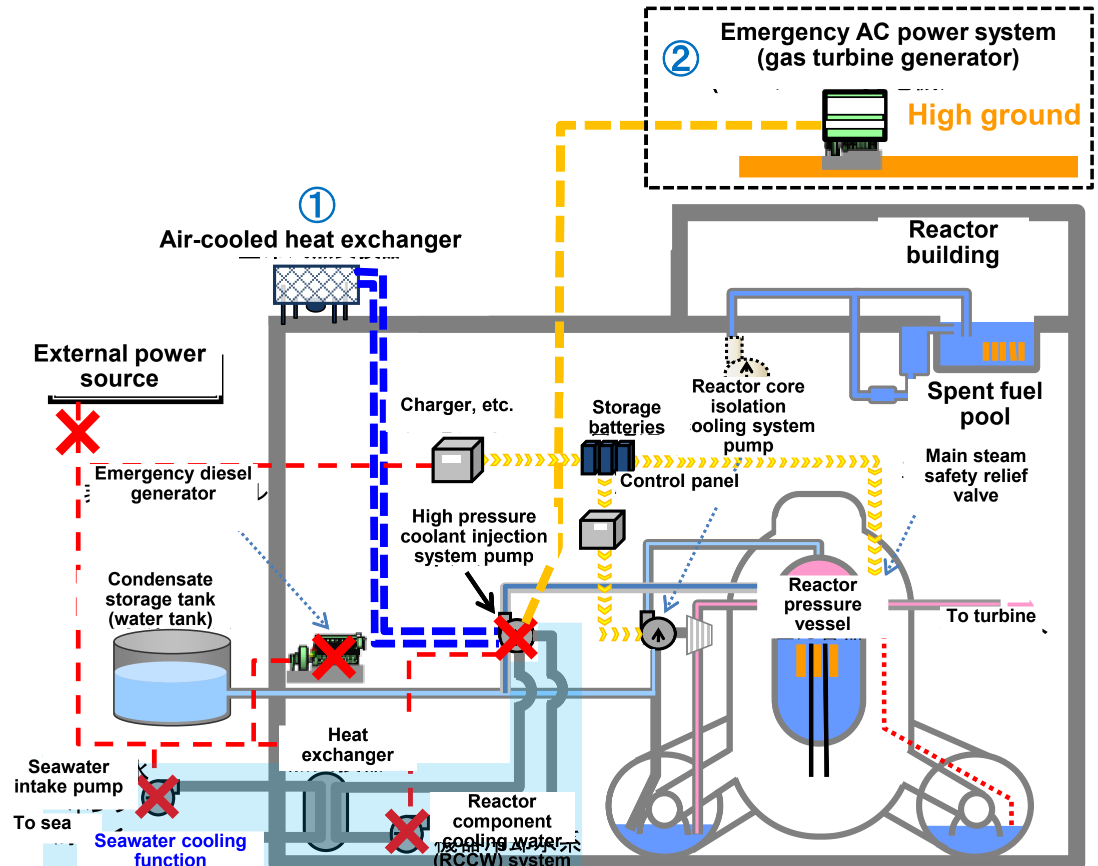
Reactor core isolation cooling system **can operate**

↓

① **Ensure cooling** with air-cooled heat exchanger
② **Ensure power supply** with emergency AC power supply equipment

↓

High-pressure coolant injection system **can operate**



Strengthen emergency countermeasures

# Power Supply Equipment Measures ⑪⑫⑬
## Diversify and increase reliability of power supply

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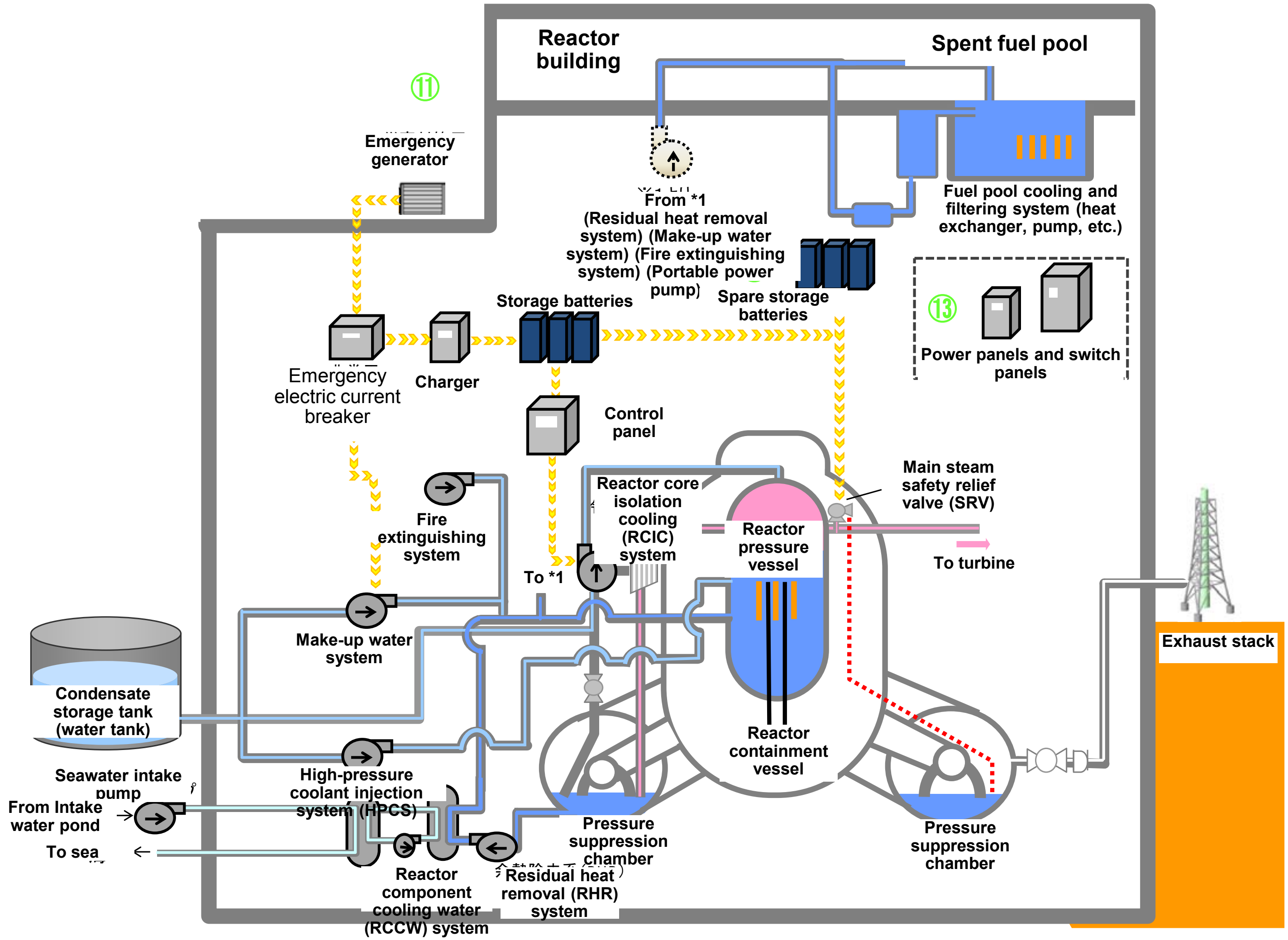
- Install emergency generators on rooftops
- Ensure availability of spare storage batteries



Strengthen emergency countermeasures

# Power Supply Equipment Measures ⑩⑬

## Diversify and increase reliability of power supply

## ●Install emergency AC power supply equipment (gas turbine generators)

Install emergency AC power supply equipment on high ground on the station site where it will not be affected by tsunami.

●To prepare for situations where the external power supply and emergency diesel generators cannot be used, install emergency AC power supply equipment on high ground on the station site where it will not be affected by tsunami, and promptly supply power to "cooling" equipment, including high-pressure coolant injection system.

## ●Install power panels and switch panels on upper floors or high ground

Power panels and switch panels that provide electric power to equipment will be installed on upper floors or high ground.

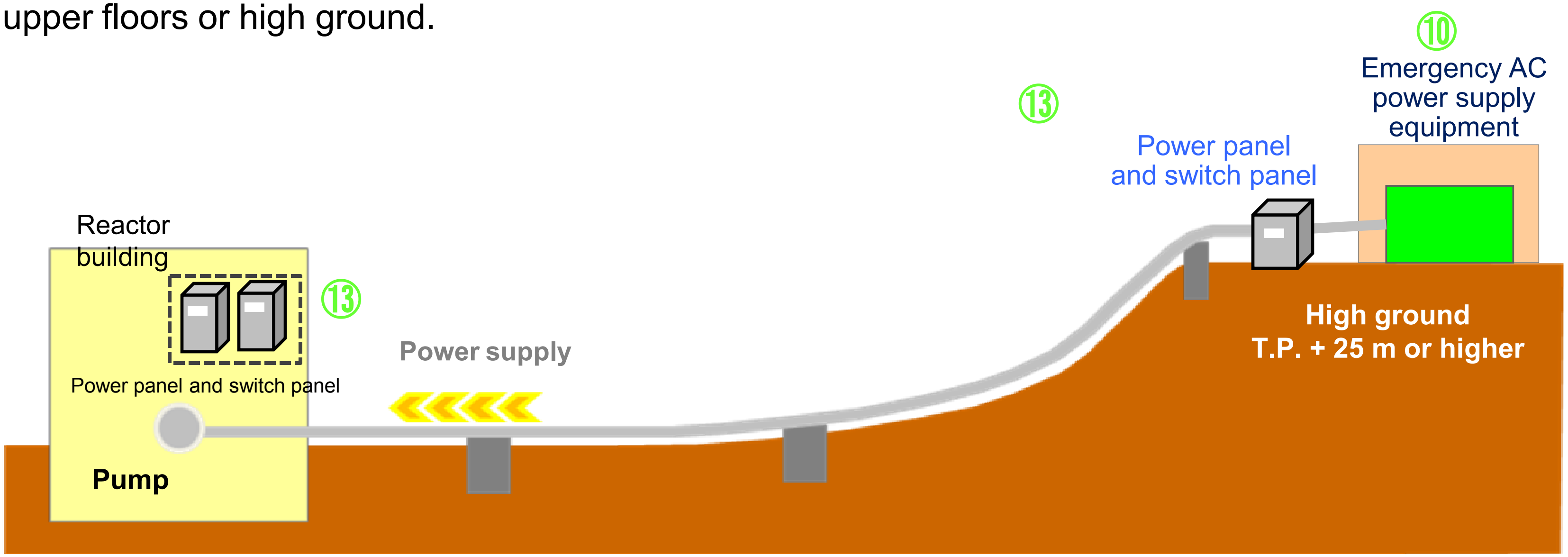



Image of supplying power with emergency AC power supply equipment

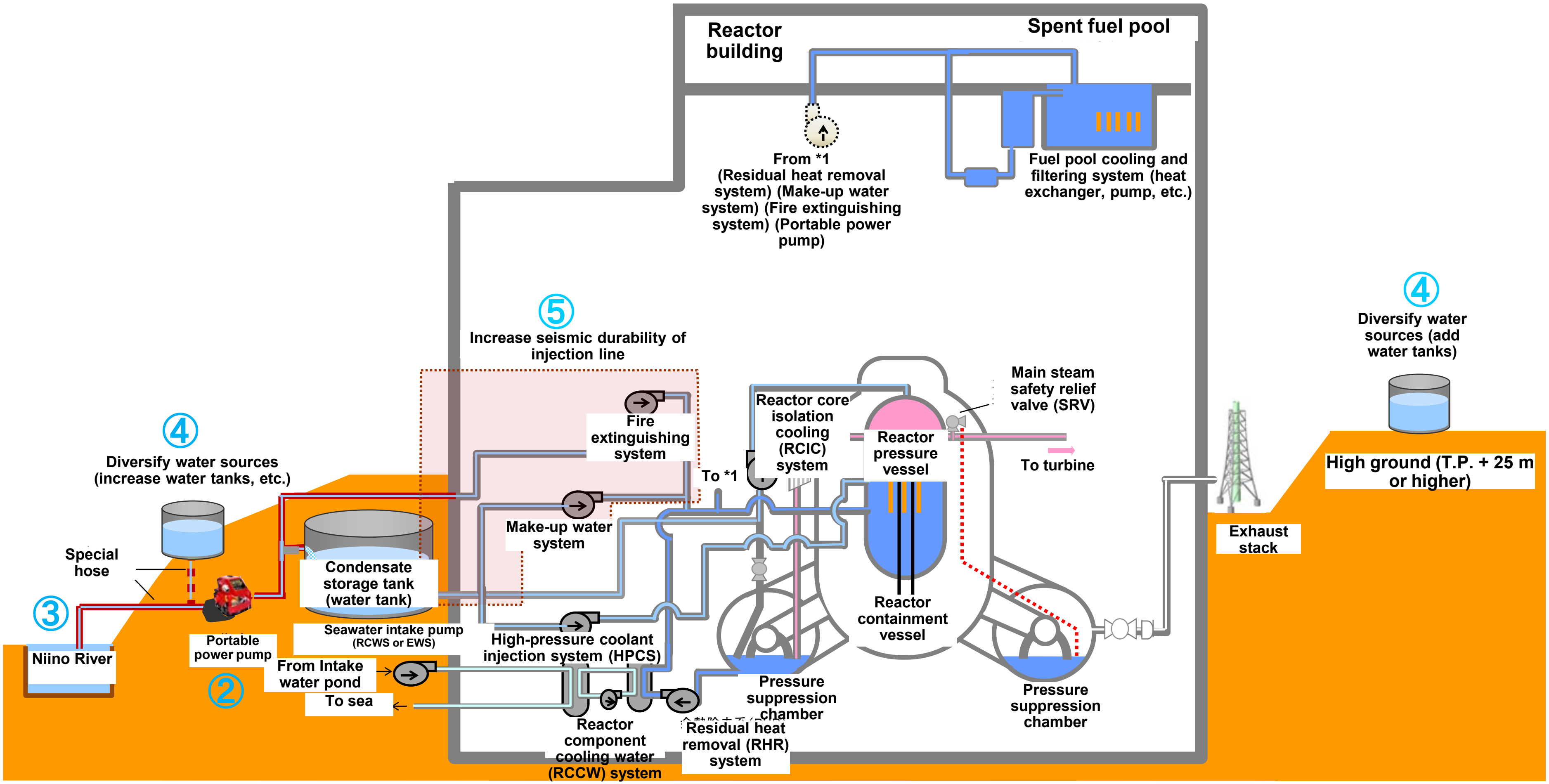
Strengthen emergency countermeasures

# Water Injection Equipment ②③④⑤

## Diversify water sources and supply methods and increase seismic reliability of supply lines

### ●Add water tanks, increase seismic reliability of supply lines

**We will add water tanks used to inject water into the reactor and spent fuel pool, and either increase the seismic durability of existing supply lines or install new supply pipes of S class seismic durability.**



Strengthen emergency countermeasures

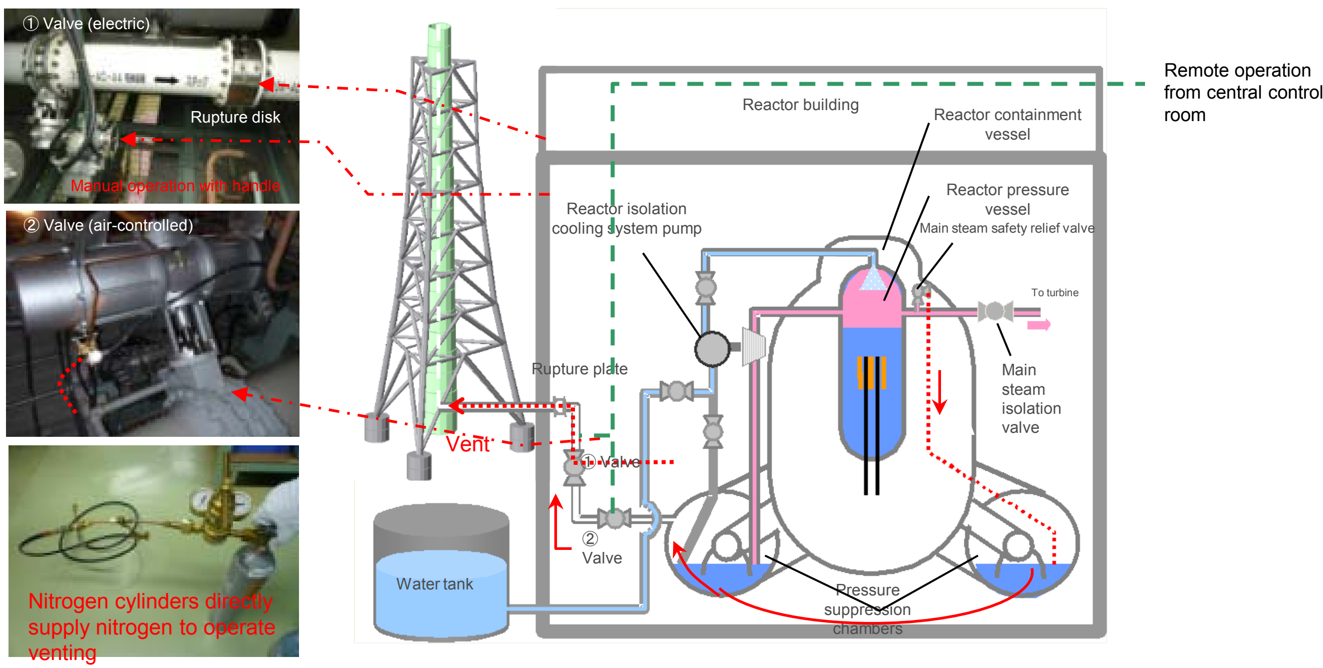
# Heat Removal Equipment Measures ⑥⑦
## Strengthen containment vessel venting system

### ●Use remote operation of reactor containment vessel venting

Use remote operation so that venting will be operated promptly.

### ●Install nitrogen cylinders for operating reactor containment vessel venting valves

Deploy equipment such as nitrogen cylinders so that we can respond promptly if it is necessary to vent the reactor containment vessel in the event all AC power supply is lost.




Steam from the core causes pressure to rise in the reactor containment vessel. Venting is therefore done to release reactor containment vessel pressure.

Strengthen emergency countermeasures

# Heat Removal Equipment Measures ⑧

## Prompt restoration of seawater cooling function

●Ensure spare equipment for reactor cooling water system, etc.

To prepare for breakdowns of equipment needed to cool reactor, we will ensure the necessary spare equipment.


Seawater intake pump (No. 4 reactor cooling water system pump)

Restoring the seawater cooling function while continuing to inject water on the reactor and fuel pool will make it possible to bring the reactor to cold shutdown within about one week.

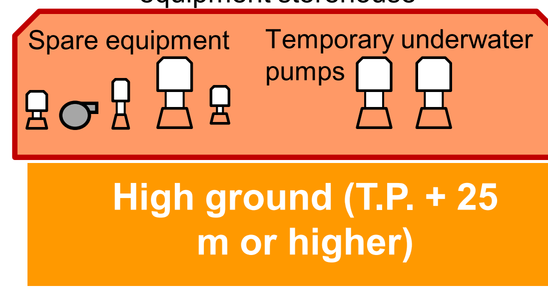
# Other ⑭⑮

## ●Put emergency materials and equipment storehouse in place

Put emergency materials and equipment storehouse on high ground on the station site where it will not be affected by tsunami.

●Prepare an emergency materials and equipment storehouse so that materials and equipment such as spare equipment can be used promptly in emergencies.

●Emergency materials and equipment storehouse




## ●Deploy heavy equipment such as bulldozers

Deploy heavy equipment to ensure the working environment, e.g., to remove flotsam from tsunami and transport spare equipment.


Wheel loader


Bulldozer


Crawler carrier


Hydraulic shovel
(with changeable arm end)

# Summary of "Strengthen Emergency Countermeasures"

As described above, even if a very serious situation occurred, namely "loss of all AC power" and "loss of seawater cooling function," strengthening our emergency measures by providing multiple and diverse measures will allow us to do the following:

① We will be able to **maintain the reactor in a stable hot shutdown state** by strengthening the water injection function, heat removal function and the power supply that supports these.

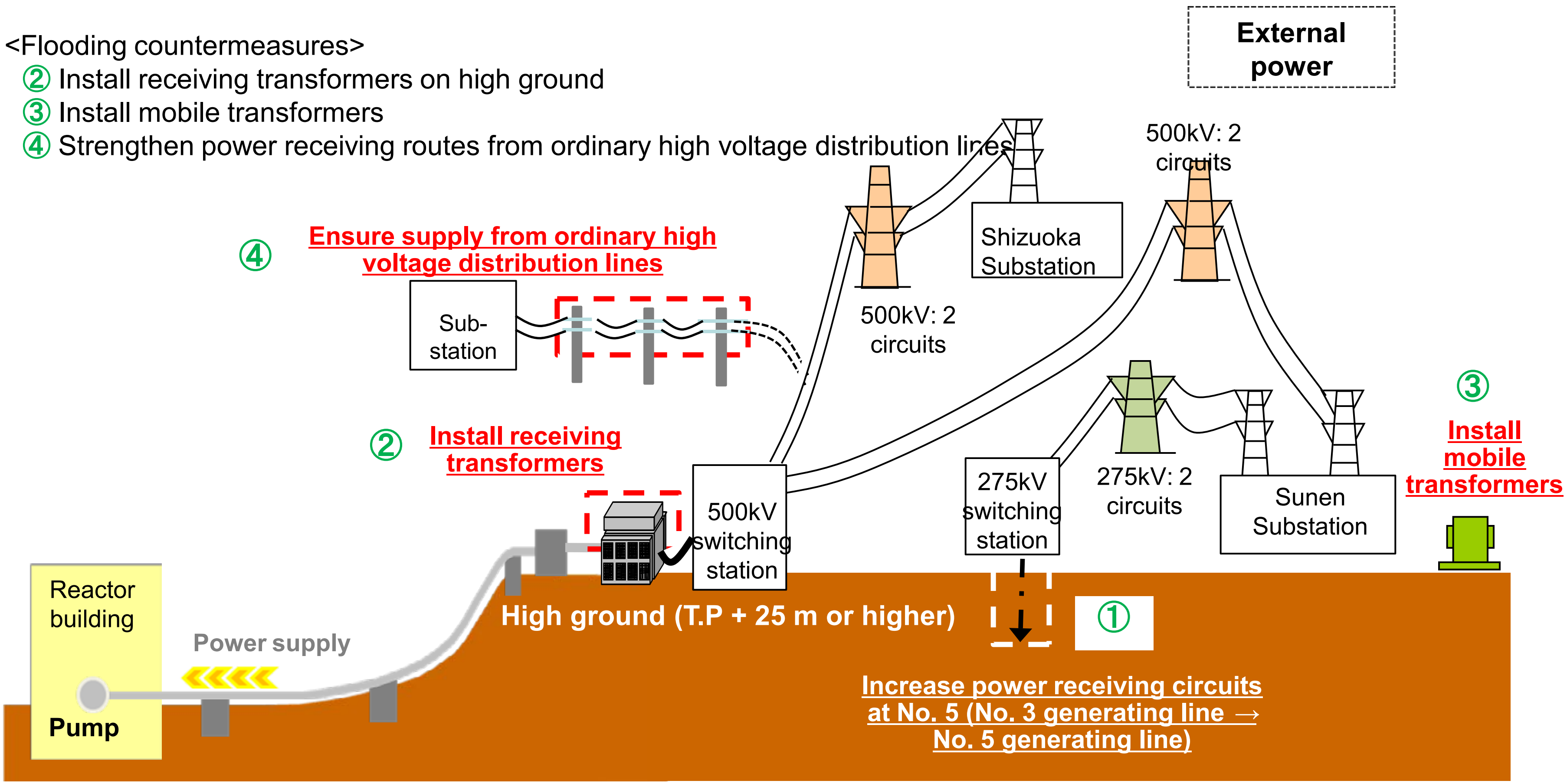
② Together with this, we will be able to promptly **bring the reactor to cold shutdown** by promptly restoring the seawater cooling function.

# Ensure Reliability of External Power Supply

**Given the importance of the power supply, we consider a prompt restoration of the external power supply to be crucial and are therefore taking measures to increase reliability.**

<Strengthen reliability of external power supply>
① Increase power receiving circuits at No. 5 (from two circuits to three)
*Three circuits already ensured at Nos. 3 and 4

<Flooding countermeasures>
② Install receiving transformers on high ground
③ Install mobile transformers
④ Strengthen power receiving routes from ordinary high voltage distribution lines



# Revise Disaster Management System

◆We have begun to revise our disaster management system into one that anticipates a combined disaster with the simultaneous occurrence of earthquake, tsunami and nuclear accident.

◆We will not just prepare an accident prevention system, but also strengthen our disaster prevention system that anticipates major accidents actually happening.

<Specific responses>

- Prepare system for responding to combined accidents and deploy the necessary materials and equipment
- Conduct training that anticipates combined accidents
- Enhance radiation control staff, prepare radiation control equipment, etc.

◆Respond to information announced by national and local governments to local people, and respond to needs of evacuees

<Specific responses>

- Work closely with local governments, etc., to respond appropriately
- Actively cooperate with local governments' regional disaster prevention plan revision efforts, etc.

# Conclusion

◆Chubu Electric Power aims to complete the tsunami countermeasures announced today by December 2012.

◆We will make every effort to increase safety at the Hamaoka Nuclear Power Station and explain these measures thoroughly so that the local community and the rest of society can feel reassured.