NRA
Nuclear Regulation Authority

Nuclear Safety Regulation System and Safety Standard of Japan

26 March 2013

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The Secretariat of Nuclear Regulation Authority (NRA)

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- The accident at TEPCO's Fukushima Dai-ichi NPS
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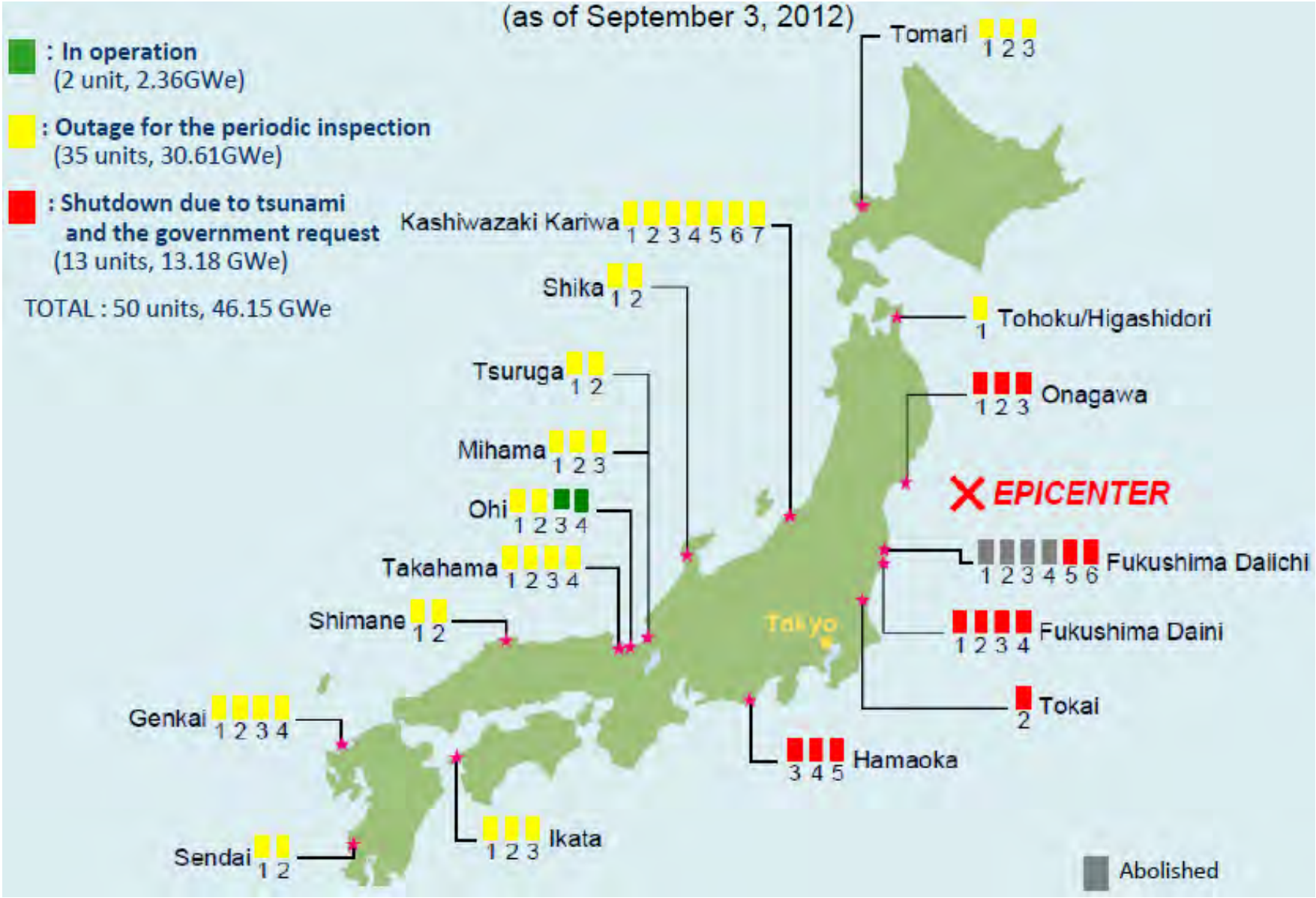
Current Status of Nuclear Power Plants in Japan



Picture: JAIF

The accident at TEPCO's Fukushima Dai-ichi NPS

TEPCO's Fukushima Dai-ichi NPS Accident

- The accident rated at INES Level 7 still forcing evacuation.
- Major causes:
  - Long lasting complete power loss due to the loss of off-site power and flooding in electrical equipment following tsunami,
  - Insufficient provision against severe accidents, and
  - Lack of the regulator's competence to properly address the above mentioned issues.

The moment when tsunami attacked Fukushima Dai-ichi NPS (Source: TEPCO)

The severely damaged RB of U3 due to the hydrogen explosion (Source: TEPCO)

- Specified as Disaster-experienced Nuclear Power Plant on 7 Nov. 2012.

  Ensuring safety of the decommissioning of reactors.

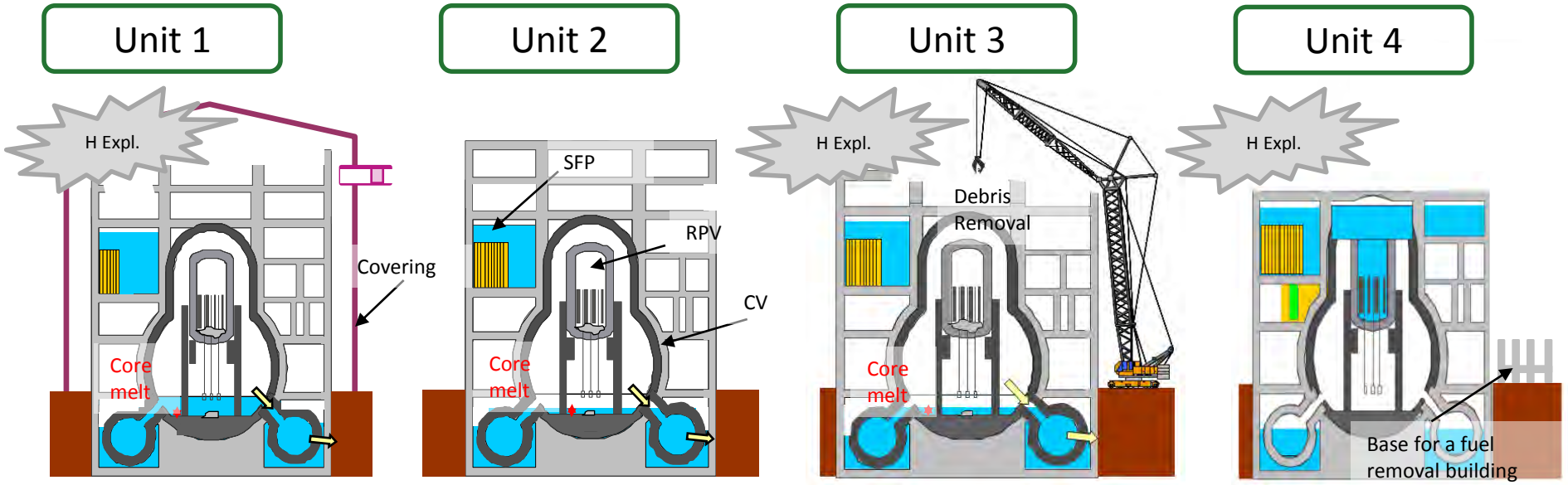
- Continuing investigation of the accident cause.

  Full cooperation for IAEA report.

- Experts groups on radiation emergency medicine and on health care administration.

  To recommend measures to control radiation pollution and reduce long-term anxiety to human health.

Current State of the Damaged Reactors



	Unit 1	Unit 2	Unit 3	Unit 4
Reactor	17℃ (RPV) 19℃ (CV)	31℃ (RPV) 32℃ (CV)	31℃ (RPV) 29℃ (CV)	No fuel
	Circulated cooling water injection N2 gas injection CV gas control including sampling			
SFP	9.5℃	11.0℃	7.9℃	19℃
	Circulated cooling water injection		Circulated cooling water inj. Desalination	Cooling water circulation Ion exchanger
notes			Debris removal from RB	RB covering work

As of 25 Feb. 2013.

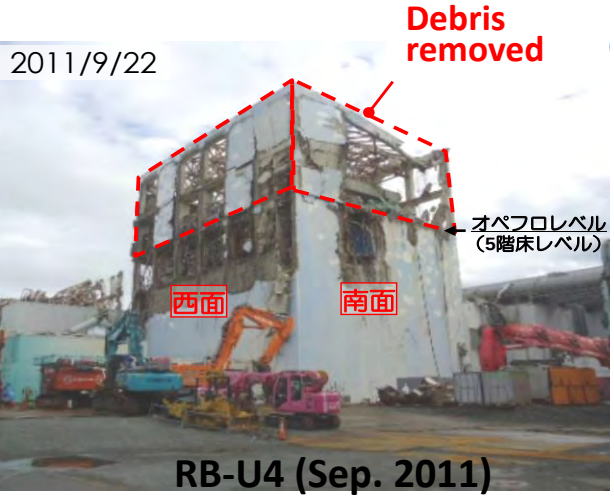
Immediate issues in the accident site:

#1 Fuel removal
#2 Contaminated water management

Immediate Issue #1: Fuel Removal

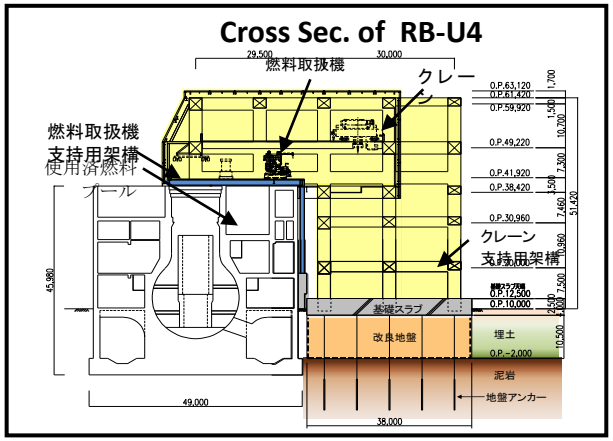
(1) Debris removal from the top of R/B of U4 was completed. Covering structure is being built.

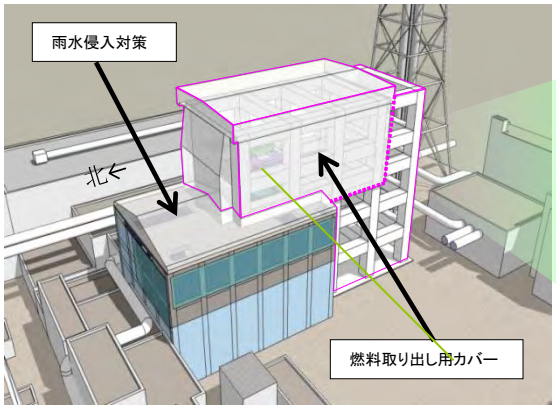
- **Aiming at early completion of fuel removal from the U4 SFP (planned from Nov. 2013 to the end of 2014).** (For U3, the removal work is planned to be initiated at the end of 2014)



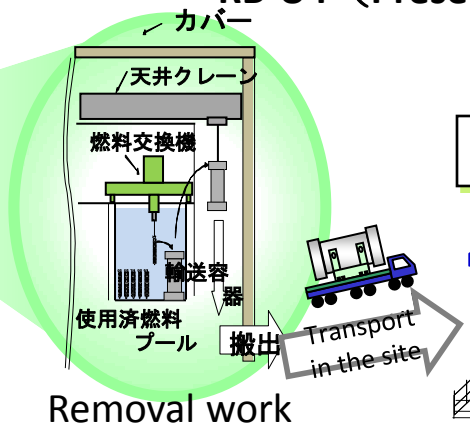
RB-U4 (Sep. 2011)

RB-U4（Present）



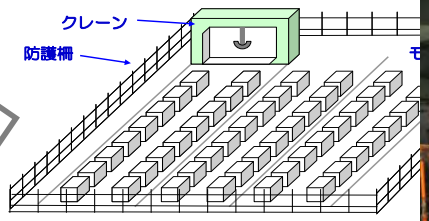


Planned covering structure for fuel removal work



Removal work

Dry cask storage facility



Air-cooling

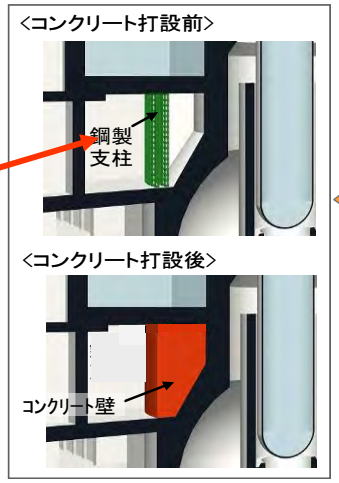
Dry casks

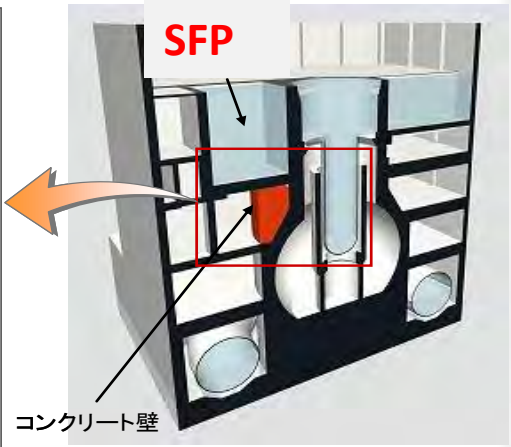
Immediate Issue #1 (cont'd)

(2) Structural reinforcement of U4-SFP and integrity assessment of U4-RB

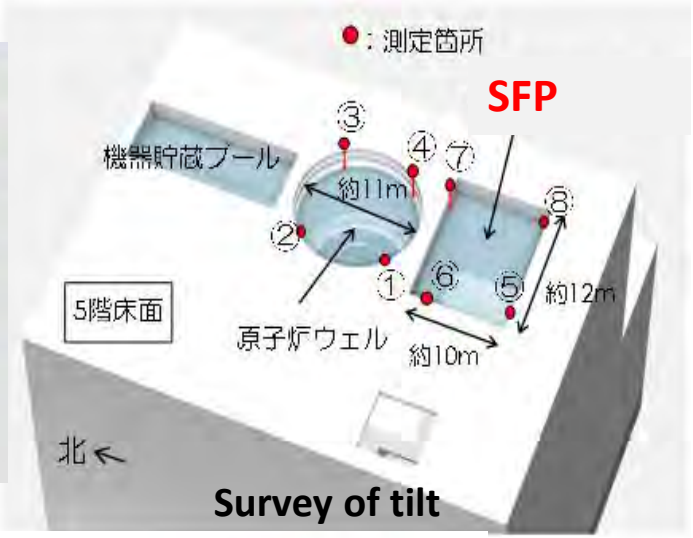
- Seismic margin has been increased by 20% after introducing steel pillars and concrete walls (Jul. 2011).
- No tilt has been identified through the periodic surveillance (May, Aug., Nov. 2012 and Feb.2013)

Steel pillars
(Before introducing concrete walls)



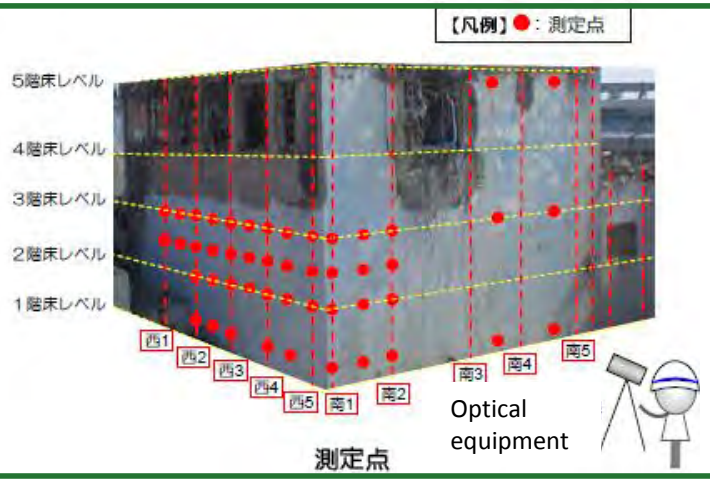


Concrete walls



<u>One of the methods used to assess the tilt</u>

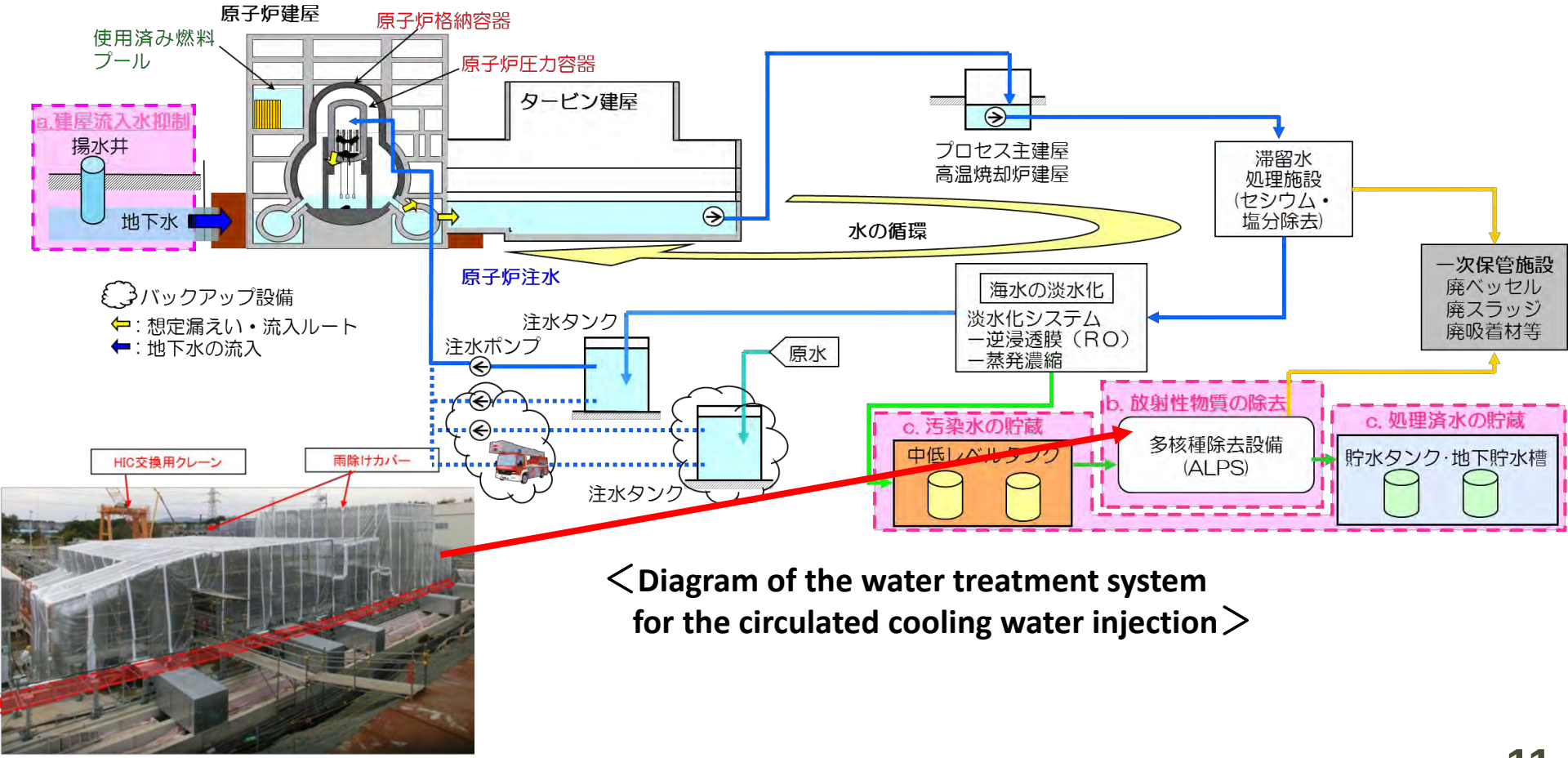
By precisely measuring position of fixed points on the outer surface of RB with optical equipment, distortion of the structure is closely monitored.



Immediate Issue #2: Contaminated Water Management

(1) Enhancing the function of the water treatment system to deal with multi-nuclides

- The new system can remove 62 nuclides while the present system can mainly remove Cesium, by which radioactivity of treated water can be controlled on a lower level.
- Toward the introduction of the new system, the safety and reliability of the system are being confirmed, and tests using water with radioactivity will be implemented.



多核種除去設備設置エリアの全景（H24.11.17）

＜Diagram of the water treatment system for the circulated cooling water injection＞

Immediate Issue #2 (cont'd)

(2) Preparing additional capacity for storing contaminated water

- **Additional tanks and an underground reservoir are being constructed.**
- The total capacity is approx. 310,000m^3 filled with approx. 260,000m^3 as of 20 Feb. 2013).
- By the end of April 2013, the capacity of 20,000m^3 will be added. Within 2 years and a half from now, additional capacity of approximately 300,000m^3 is planned (approx.700,000m^3 in total).

(1,000t per a tank)

Large cylindrical steel tanks

（before soil covering）

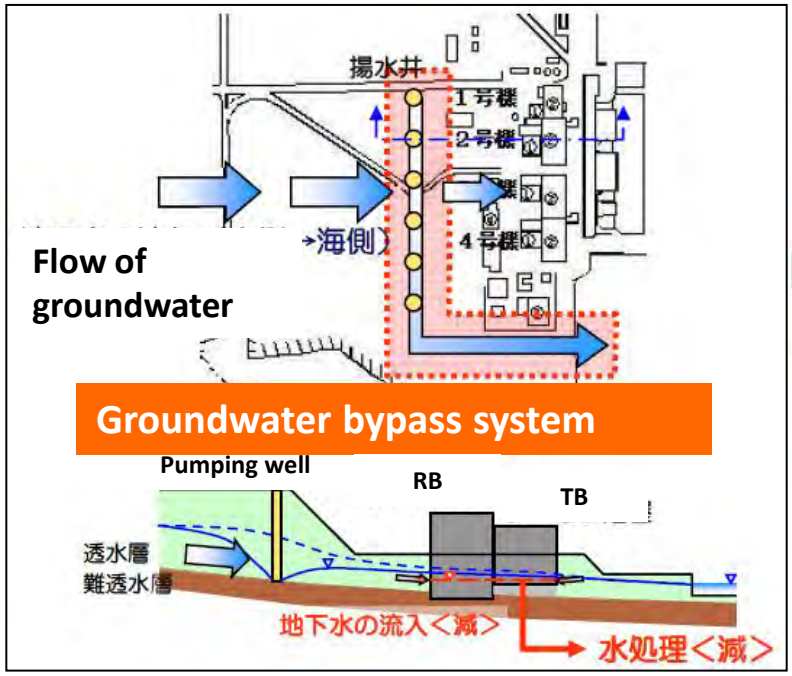
(Covered with soil)

Underground reservoir

Immediate Issue #2 (cont'd)

(3) Bypass of the groundwater flow

- To reduce ground water flow coming into the RB by lowering groundwater level around the RB, **facilities for groundwater bypass are being introduced.**
- As of the end of Jan. 2013, the construction work of 6 pumping wells has been completed. Now the other facilities including 6 pump wells and piping are being constructed aiming completion at the end of this March.



Establishment of Nuclear Regulation Authority (NRA)

Established in Sep. 2012

Commission

Secretariat

The Secretariat of the NRA
(About 500 staffs)

TSOs

JNES | JAEA | NIRS

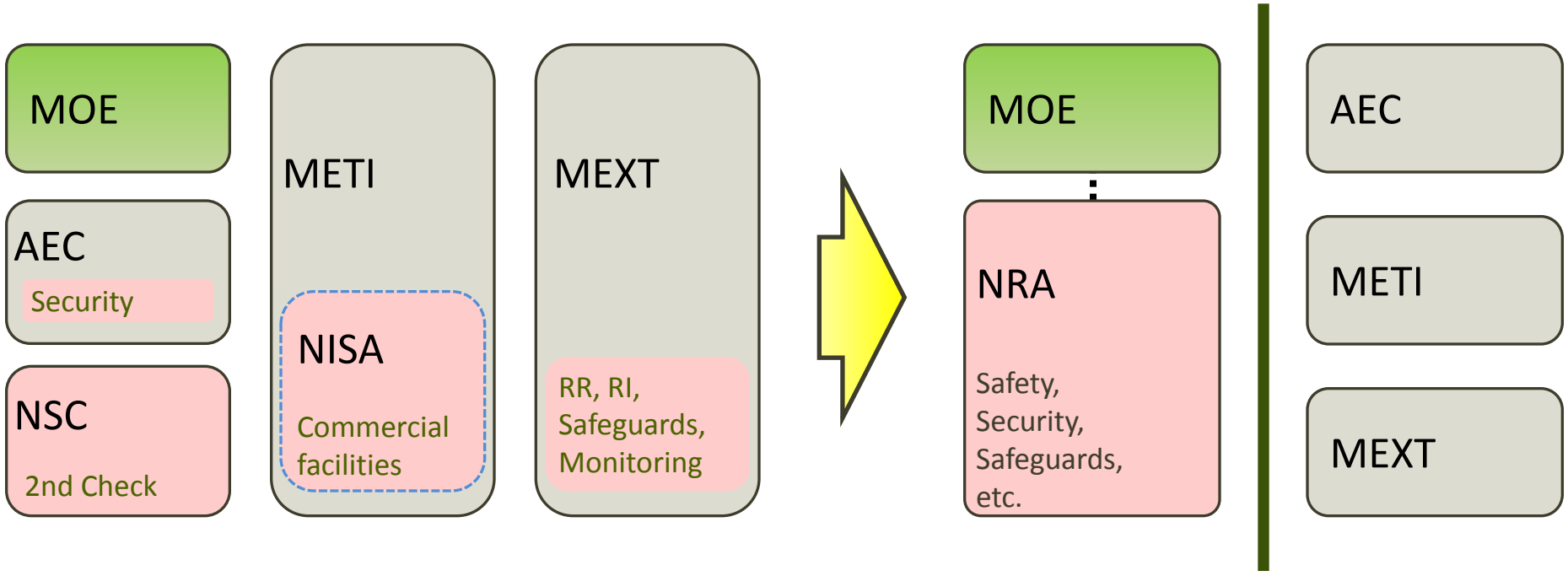
Independence

= Separating the functions for nuclear regulation and nuclear promotion.
Establishment of the Nuclear Regulation Authority (NRA) as an independent regulatory body.

Integration

= Integration of nuclear regulation functions regarding safety, security, safeguards, radiation monitoring and radioisotopes regulation into the NRA.

Independent and Integrated



AEC : Atomic Energy Commission
METI : Ministry of Economy, Trade and Industry
MEXT : Ministry of Education, Culture, Sports, Science and Technology
MOE : Ministry of the Environment
NISA : Nuclear and Industrial Safety Agency (abolished)
NSC : Nuclear Safety Commission (abolished)

Transparency

- NRA meetings are open to the public (streamed live on the Internet).
- Meeting records with licensees are open to the public.
- Criteria for appointing external experts
- Press conferences are held three times a week.

New Safety Standards for Nuclear Power Plants

- New regulation on **severe accidents**

  Legislative requirements on measures to prevent severe accident and to mitigate the consequences.

- Development of new regulatory standards and application to **the existing nuclear facilities (back-fitting)**.

- **40-years operational limit** for NPPs

  Legally defined limit to 40 years.

  NRA can permit an extension maximum 20 years.

- Safety measures against **external event risks**, including earthquakes, tsunamis, tornados, fire and terrorist attacks.

  Establishing new standards for earthquake and tsunami in particular.

First Draft Outline of New Safety Standards for Light Water Nuclear Power Plants

—Summary—

As of February, 2013

1. Strengthening of Design Basis
2. Severe Accident Measures
3. Enhanced Measures for Earthquake/Tsunami

Basic Policy of New Safety Standards

1）Thorough Application of Defense-in-Depth Concept

- Prepare multiple effective measures (multi-layered protective measures) and, for each layer, achieve the objective only in that layer regardless of the measures in the other layers.
- Assume the preceding layer be breached (denial of preceding layer) with no reliance on subsequent layer (denial of subsequent layer).

2）Enhancement of Reliability as the Bases for Safety

- Strengthening of fire protection, and of measures against inundation by tsunami.
- Reinforcement of SSCs important to safety (elimination of shared use of passive components if relied on for a long time).

3）More Conservative Postulation Associated with Common Cause Failures due to Natural Hazards and Enhanced Protective Measures

- More stringent approach for assessment of earthquake and tsunami, introduction of measures against tsunami inundation.
- Due consideration of diversity and independence (shift of emphasis from “redundancy centered”).

Basic Policy on Measures against SAs and Terrorism

1) Preparation of multi-layered protective measures for “prevention of core damage”, “maintaining containment integrity”, “controlled release by venting”, and “suppression of release / dispersion of radioactive materials”

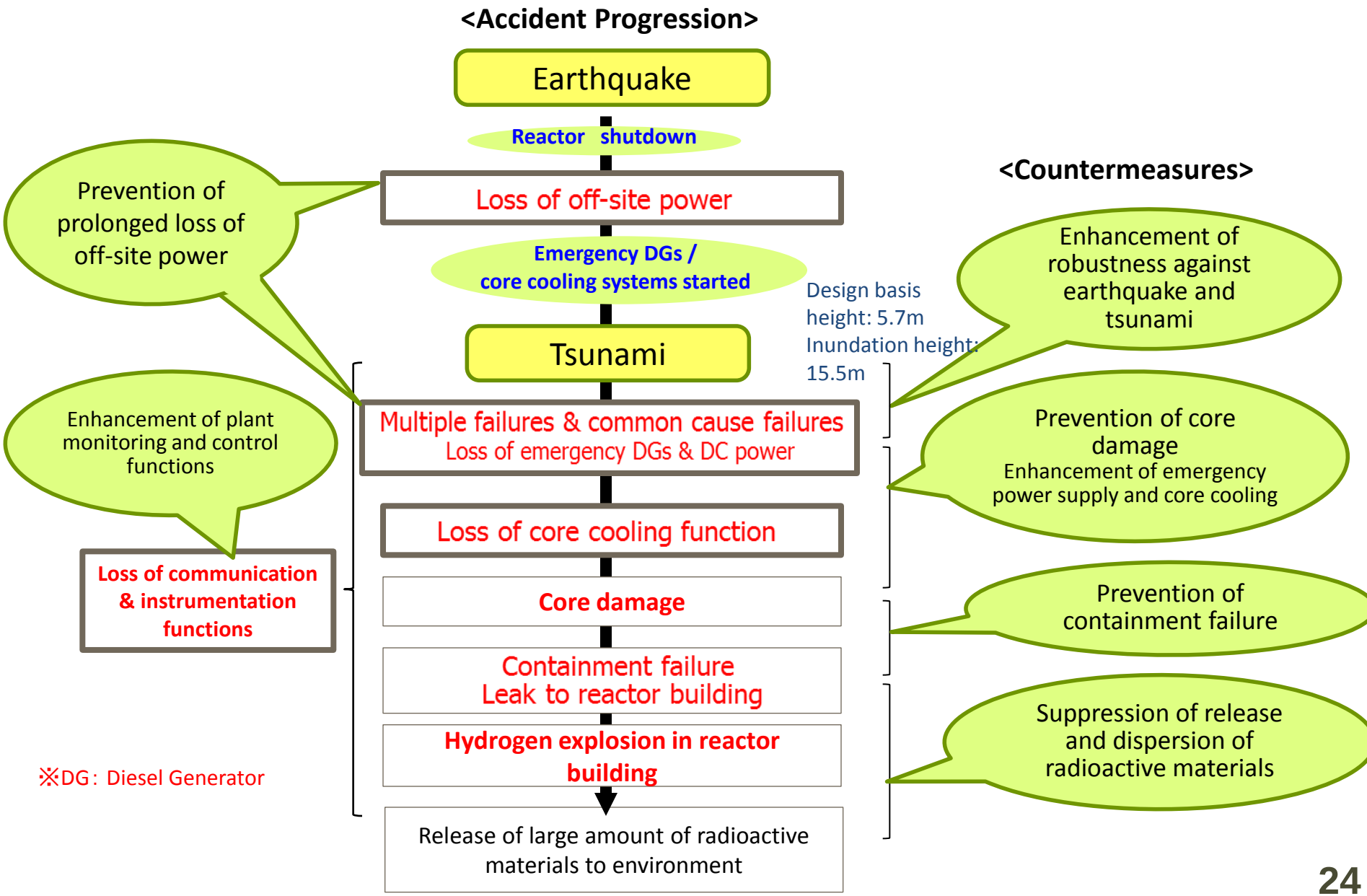
2) Use of mobile equipment as a base similar to U.S. etc. and further enhancement of reliability by combined use with permanently installed systems / equipment (Continuous improvement)

3) Enhancement of protective measures for SFP
(Water level measurement, Alternative water supply, Spray)

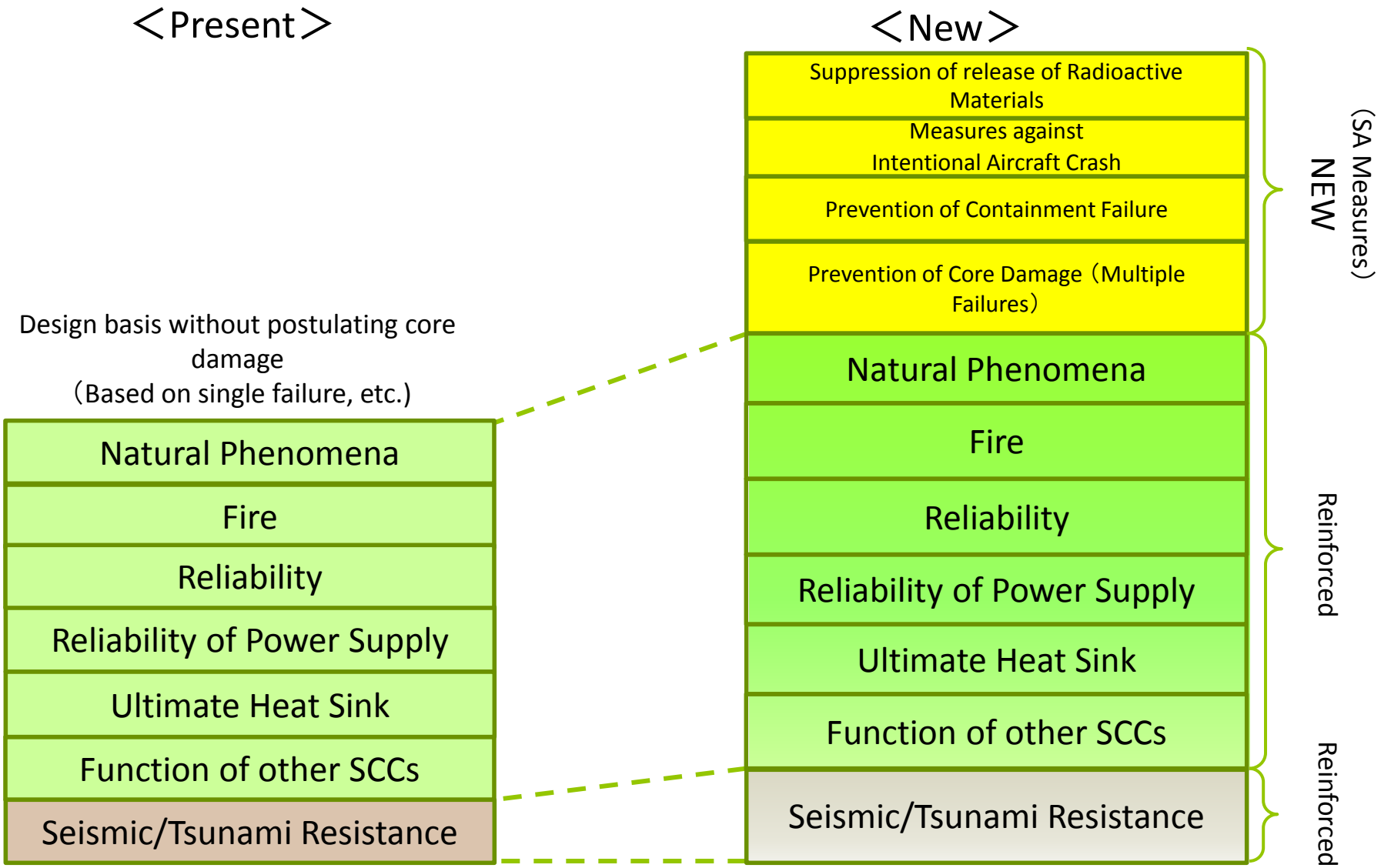
4) Reinforced seismic-resistance of on-site emergency response center, improved reliability / durability of communication system, enhanced instrumentation including SFP (enhancement of command communication and instrumentation)

5) Introduction of “Specialized Safety Facility” against intentional aircraft crash

Progression of the Fukushima Accident and Countermeasures



Structure of New Safety Standards



1-1. Strengthening of Design Basis

Revision of “Design basis without postulating core damage ”

1) Addition of natural phenomena to be considered such as tornado and forest fire

2) Reinforced fire protection measures

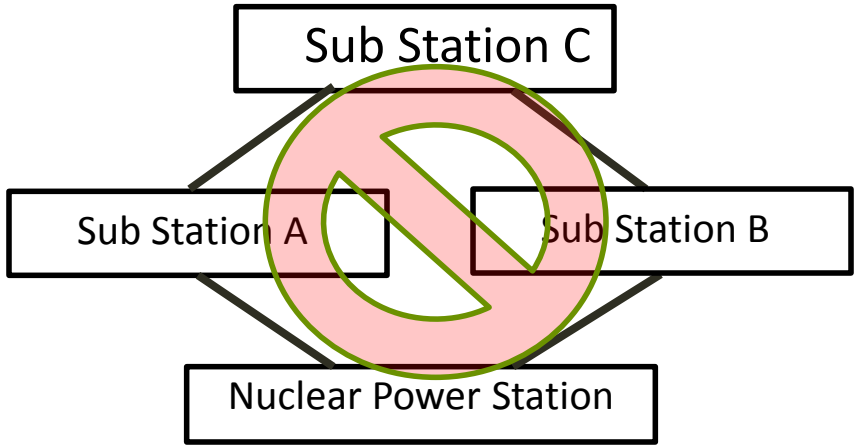
3) Enhanced reliability of SSCs important to safety (Redundancy of piping if relied on for a long time)

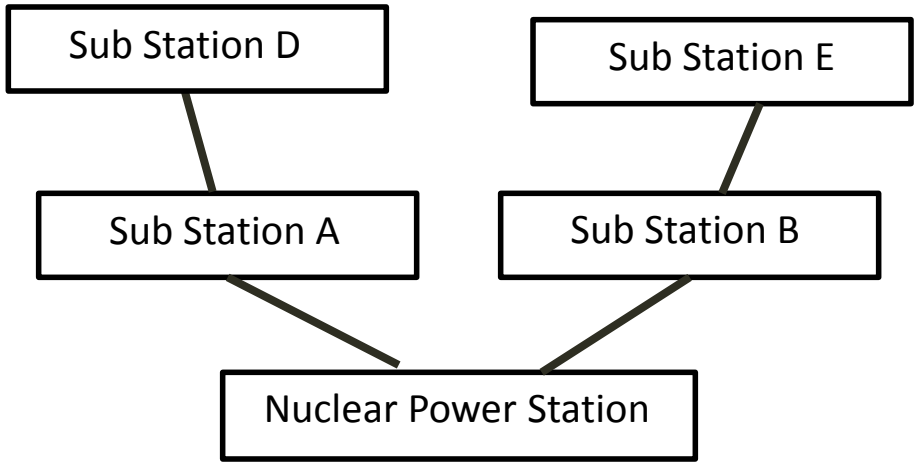
4) Reinforcement of off-site power supply (connection to different substations through multiple lines)

5) Protection of systems for Ultimate Heat Sink (Protection of seawater pumps, etc.)

1-2. Example of Strengthening of Design Basis

4) Reinforcement of off-site power supply (connection to different substations through multiple lines)





5) Protection of systems for Ultimate Heat Sink (Protection of seawater pumps, etc.)

2-1. SA Measures（Prevention of Core Damage)

New Requirements for Measures to Prevent Core Damage in case of assuming beyond Design Basis Accidents

Measures against the followings:

1) ATWS
2) Loss of reactor cooling function (at high pressure)
3) Loss of reactor depressurization function
4) Loss of reactor cooling function (at low pressure)
5) Loss of UHS System
6) Loss of support function (makeup water, power supply)

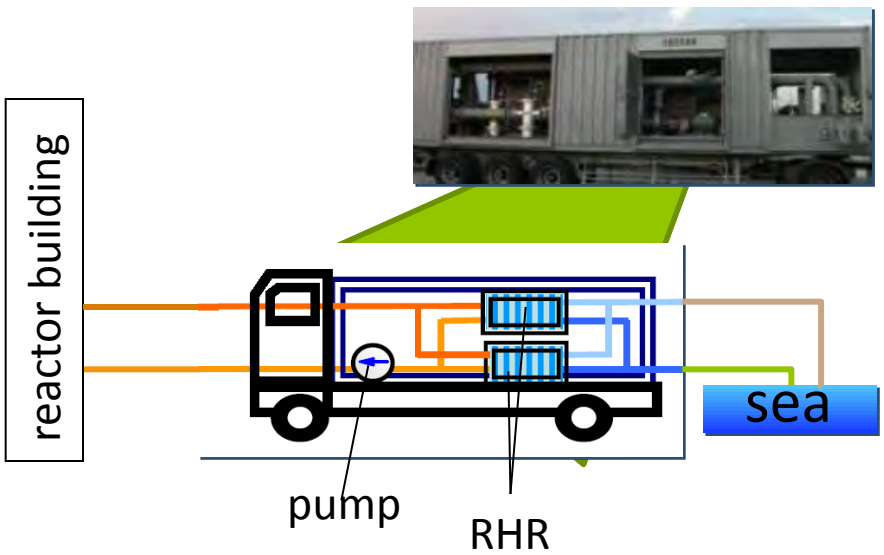
2-2. Example of Prevention of Core Damage

5) Loss of UHS System

Alterative UHS System

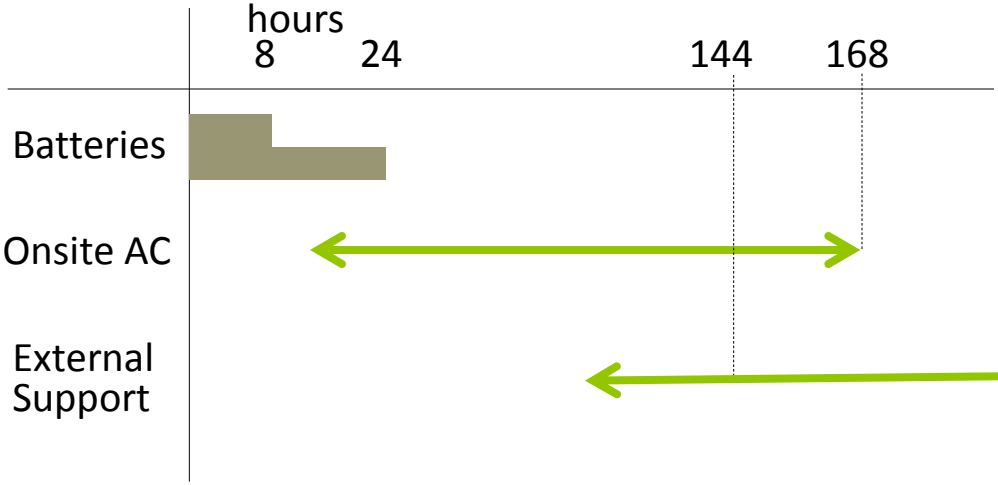
PWR
- ✓ Through main steam relief valves to the atmosphere
- ✓ Sea water injection to RHR-S

BWR
- ✓ Filtered venting system
- ✓ Mobile RHR



6) Loss of support function (SBO)

- ・Batteries(8hours without load shedding + 16hours with load shedding)
- ・Alternative onsite AC power for 7days
- ・External Support by the 6th day



Alternative onsite AC power (Power Vehicle)

2-3. SA Measures（Prevention of Containment Failure)

New requirements for measures to prevent containment failure postulating core damage

1) Cooling and depressurization of CV, reduction of release of radioactive materials (e.g., CV spray ）
2) Heat removal from CV and depressurization of CV （e.g., Filtered venting）
3) Cooling of molten core at the bottom of CV (e.g., water injection)
4) Prevention of hydrogen explosion inside CV (e.g., igniter)

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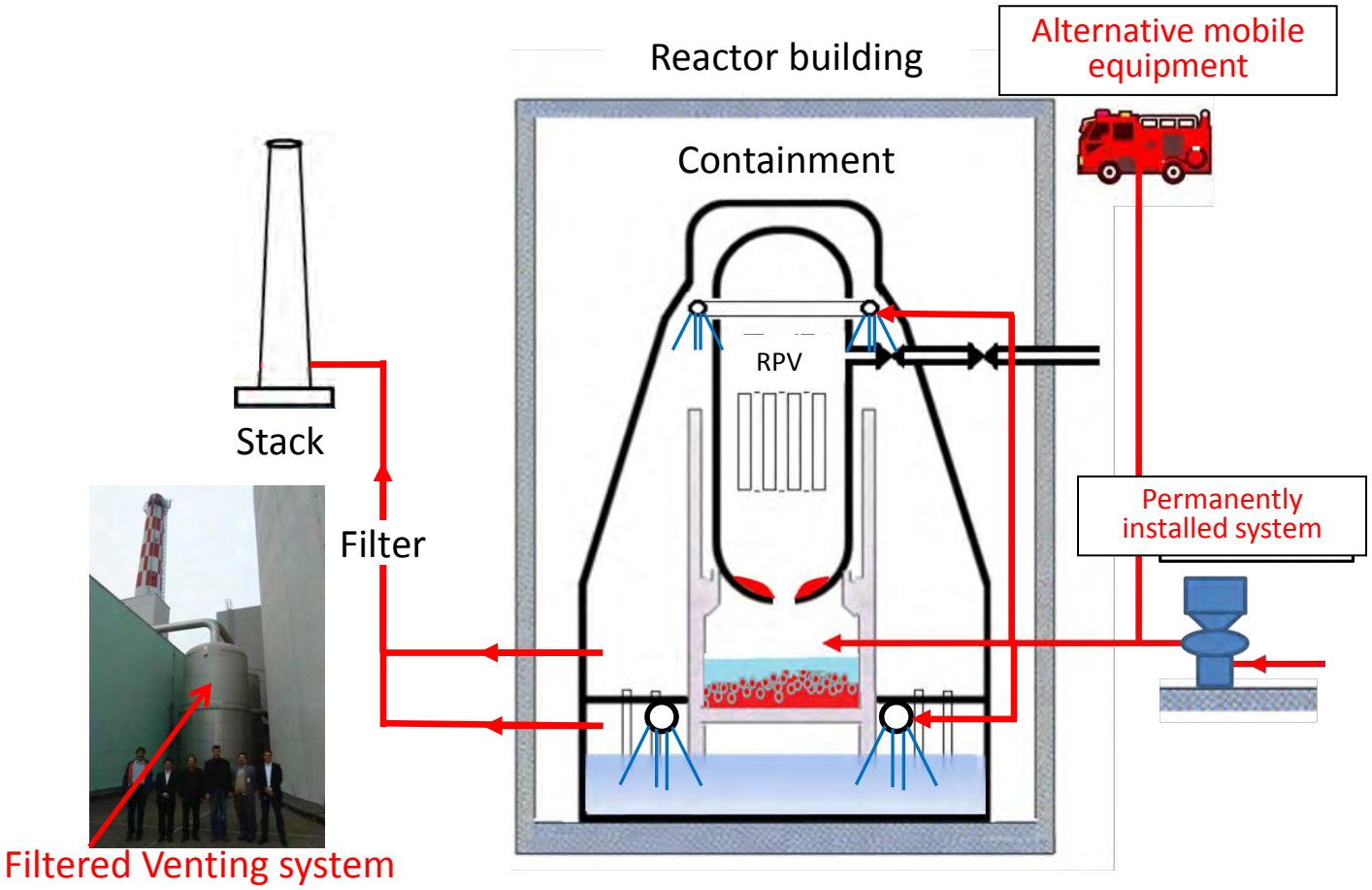
5) Prevention of hydrogen explosion at reactor building etc.
6) Cooling of SFP

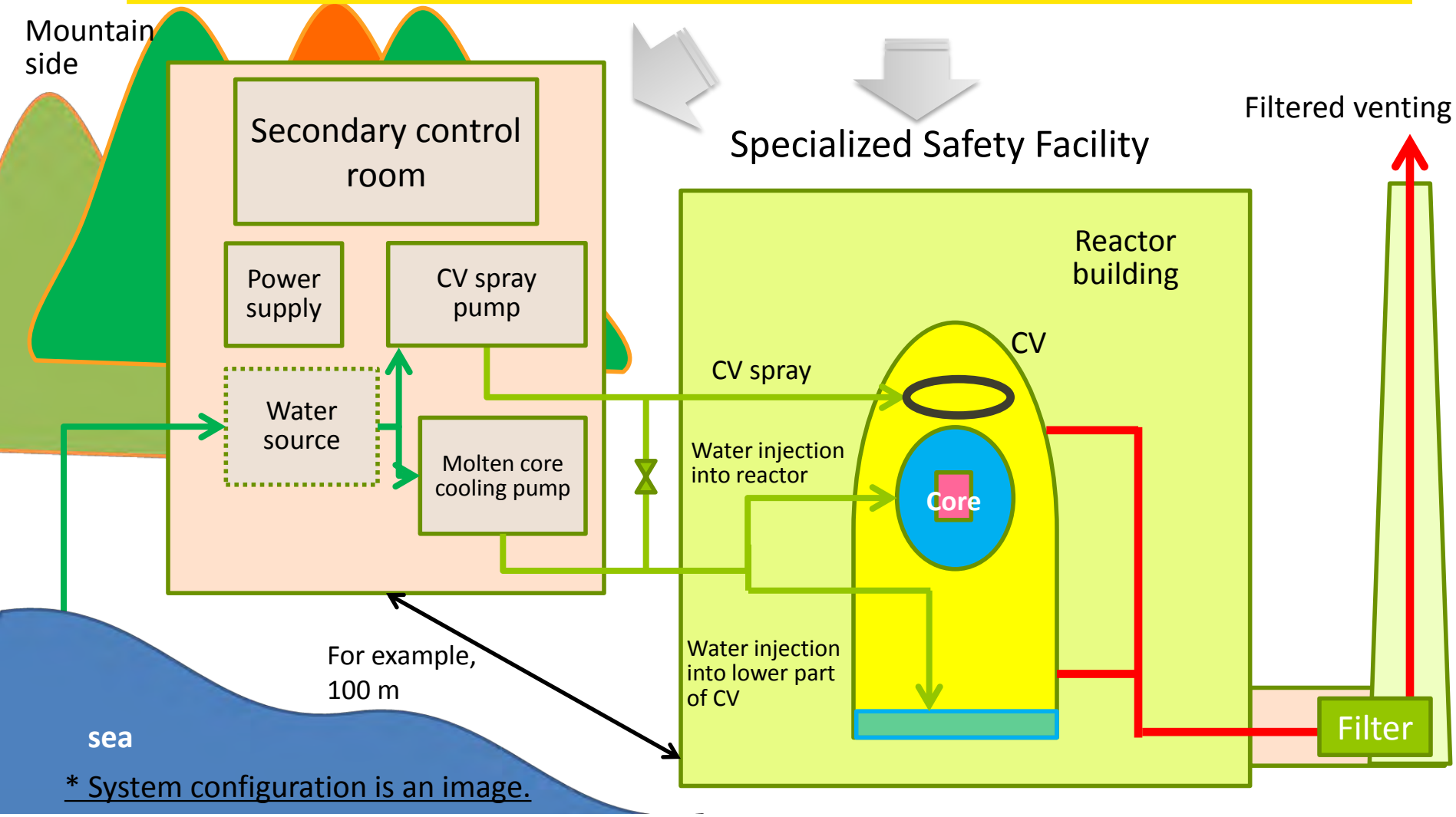
2-4. Example of Prevention of Containment Failure (BWR)

1) CV spray to cool and depressurize CV, and reduce release of radioactive materials.
2) Filtered venting to reduce the pressure and temperature inside CV in addition to reducing radioactive materials while exhausting.
3) Water injection system into lower part of CV to prevent CV failure due to molten core (mobile pumps, hoses etc.)



2-5. Measures against Intentional Aircraft Crash, etc.

New requirements on facilities (Specialized Safety Facilities) in case of core damage due to intentional aircraft crash



* System configuration is an image.

For BWR, one filtered venting for prevention of containment failure and another filtered venting of Specialized Safety Facility are required.

2-6. Measures for suppression of release / dispersion of radioactive materials

Assuming CV failure, it is newly required to install outdoor water spraying equipment, etc. (Suppression of dispersion of radioactive materials by water spraying to reactor building)

Water-spraying training with a large scale bubble water cannon system (Osaka and Wakayama wide area cooperative disaster prevention committee)

(Pictures cited)
Fire fighting white paper, 2011 edition, http://www.fdma.go.jp/html/hakusho/h23/h23/html/2-1-3b-3_2.html

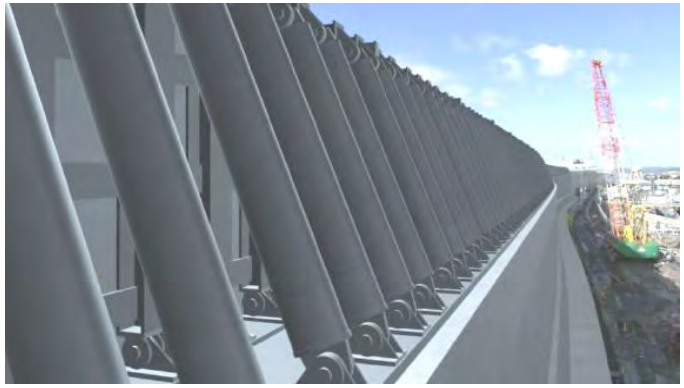
3-1. Enhanced Measures for Earthquake / Tsunami

Stringent Evaluation Method on Earthquake and Tsunami; Particularly Enhanced Tsunami Measures

More stringent Standards on Tsunami	Define “Design basis tsunami” that exceeds the largest in the historical records and require to take protective measures such as breakwater wall based on the design basis tsunami
Enlarged Application of Higher Seismic Resistance	SSCs for tsunami protective measures are classified as Class S equivalent to RPV etc. of seismic design importance classification

＜Example of tsunami measures（multiple protective measures）＞

○ Breakwater Wall
（prevent inundation to site）



○ Tsunami Gate
（prevent water penetration into the building）

More stringent criteria for active faults

Active faults with activities later than the Late Pleistocene (later than 120,000-130,000 years ago) be considered for seismic design

Activities in the Middle Pleistocene (later than 400,000 years ago) be further investigated if needed

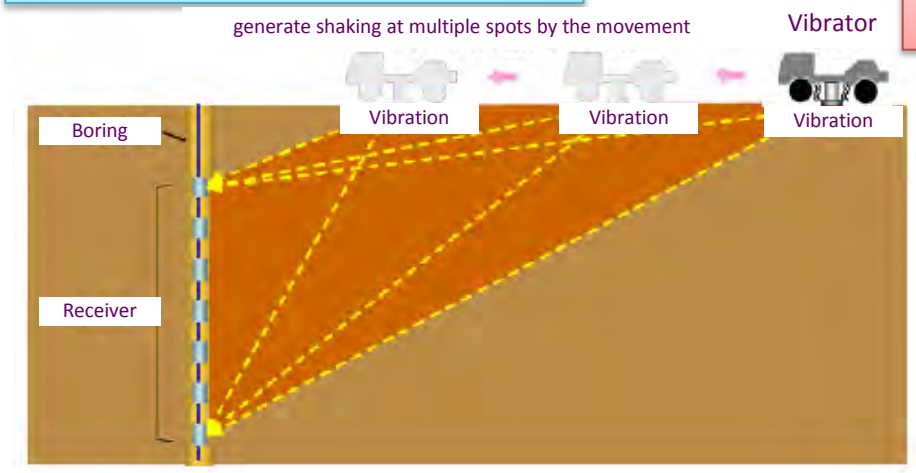
More precise methods to define design basis seismic ground motion

3D observation of underground structure of the site

Clarification of requirements for “displacement and deformation” in addition to the seismic ground motion

Class S buildings should not be constructed on the exposure of active faults

Example of geophysical exploration



The underground structure is explored by generating a vibration by vibrator and analyzing the signals received in a borehole.

Vibrator

Nuclear Emergency Response Guidelines

Emergency preparedness and response in off-site areas

- Nuclear Emergency Preparedness Guidelines were developed (October 31, 2012)
  - Expanded evacuation preparing zone
  - The area within about 5km radius from the site is designated as PAZ and that within about 30km radius as UPZ.
- An expert study on EAL and OIL went underway.

Reflecting the Nuclear Emergency Response Guidelines on the Regional Disaster Prevention Plan being revised by local governments.

Nuclear Emergency Response Guidelines

Technical and special matters of nuclear emergency measures

A document which was formulated after the occurrence of the nuclear accident at Three Mile Island, the United States, in 1979.

(Nuclear Disaster Prevention Guidelines →Nuclear Emergency Response Guidelines)

March 2011

◆TEPCO's Fukushima Dai-ichi NPS Accident

↓

◆New legislation requires NRA to compose Nuclear Emergency Response Guidelines.

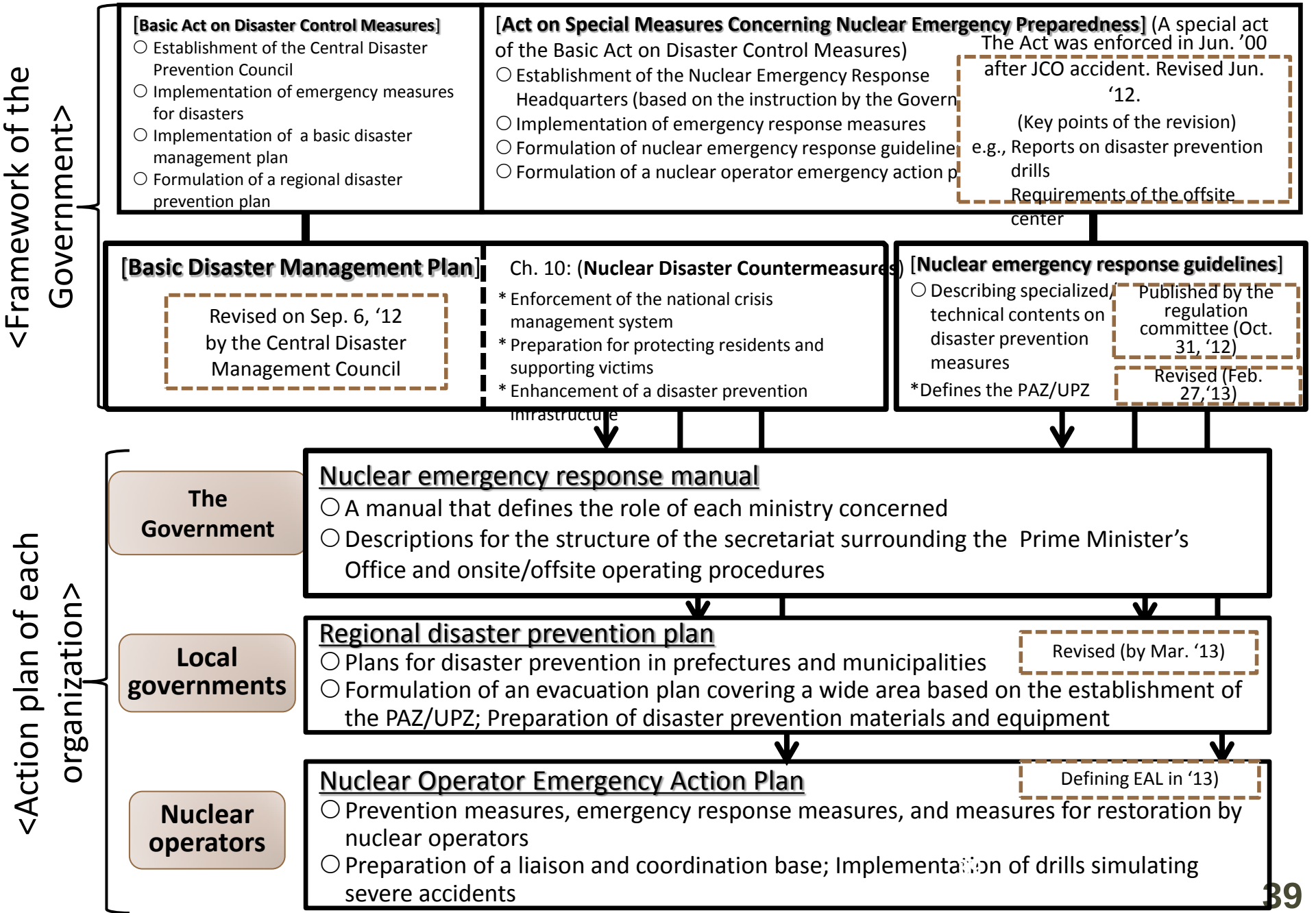
The Emergency Planning Zone (EPZ) of 10km set by Nuclear Disaster Prevention Guidelines (the former guideline) was not enough to respond to the accident.

↓

2013

◆The guidelines will be revised in light of international standards and the lessons learned from the accident.

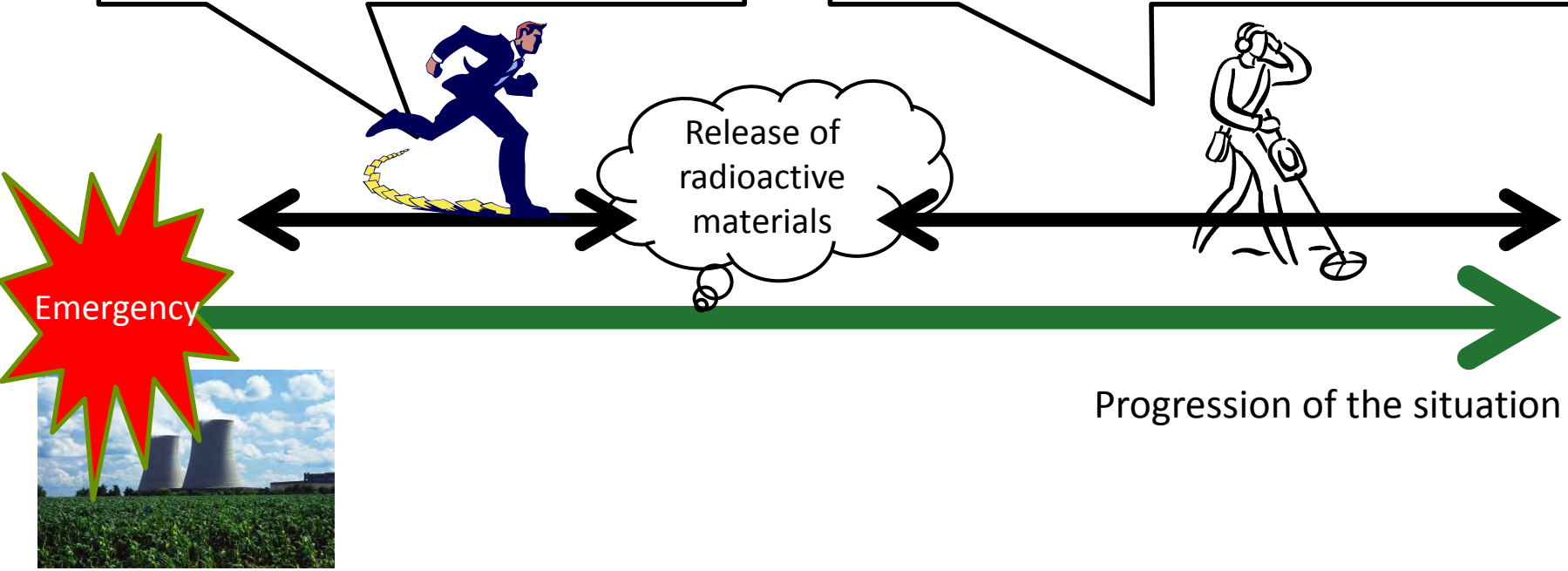
The Regulatory Framework for Nuclear Emergency Preparedness



New approach to the implementation of urgent protective actions at the time of emergency

Judge the situation based on the condition of the plant
(Emergency Action Level : EAL)
↓
Precautionary protective measures
(Avoiding deterministic effects)
Evacuation, iodine prophylaxis…

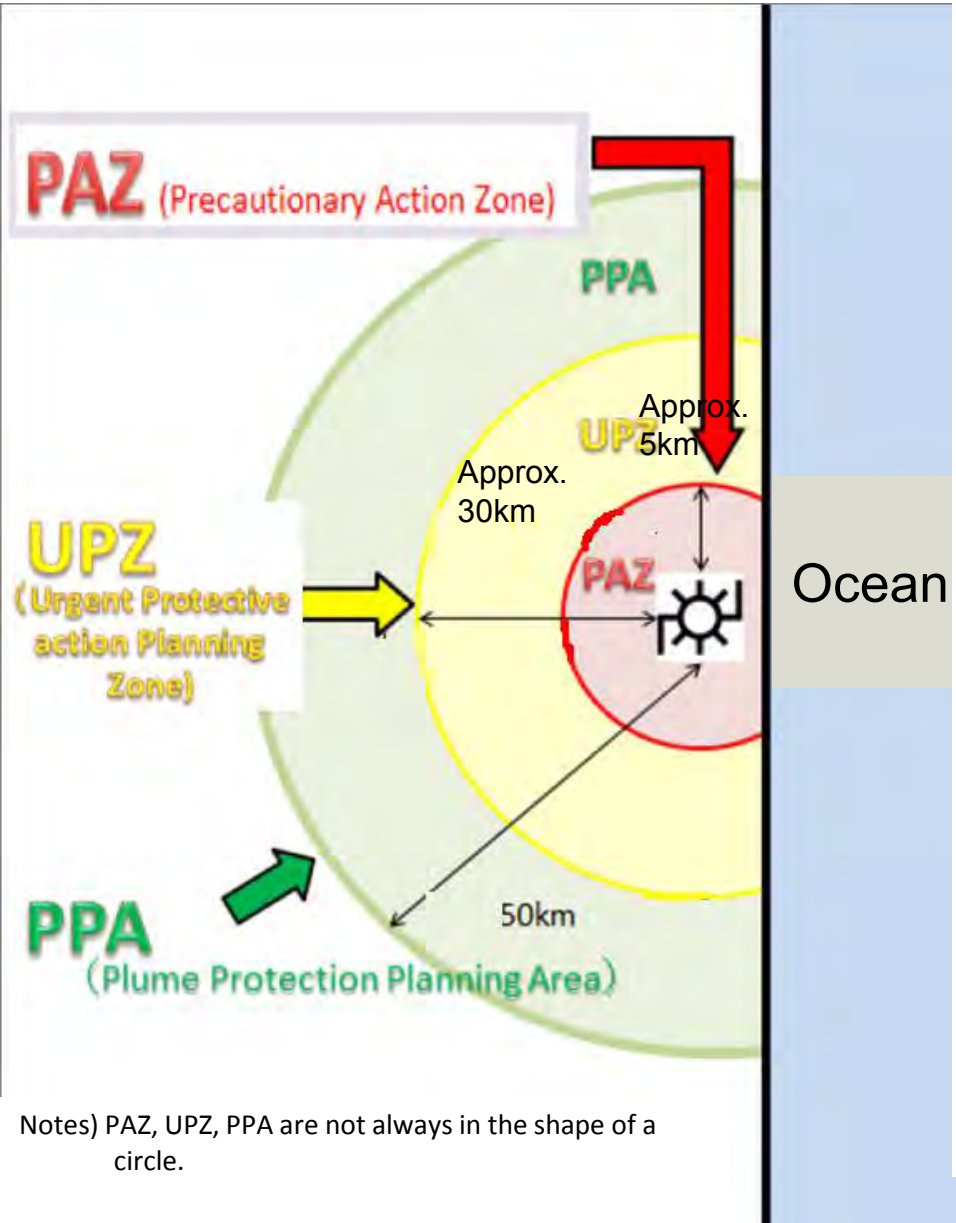
Judge the situation based on ambient dose rates
(Operational Intervention Level : OIL)
↓
Protective measures
(Reducing stochastic effects)
Evacuation, temporary relocation, restriction of food and drink intake



Response to Emergency

1) In the case of an emergency situation occurring at a nuclear facility, a class of emergency is determined based on the condition of the facility (EAL), and urgent protective actions are taken according to the emergency classification.
2) In General Emergency, precautionary protection measures are implemented in the Precautionary Action Zone (PAZ) before the release of radioactive material.
3) When the radioactive material is released, environmental measurements are carried out in the Urgent Protective action planning Zone (UPZ) (measurements may also be taken in areas beyond the UPZ as required), and urgent protective actions or early protective actions are implemented based on Operational Intervention Levels (OILs).

Illustration of Zones regarding Disaster Response Measures



Notes) PAZ, UPZ, PPA are not always in the shape of a circle.

PAZ：Precautionary Action Zone
(a zone approximately 5 km away from the plant)
An area where precautionary measures will be taken such as immediate evacuation prior to the release of radioactive materials to the environment based on emergency classification in order to avoid severe deterministic effects in the light of accidents that develop rapidly.

UPZ：Urgent Protective action planning Zone
(a zone approximately 30 km away from the plant)
In accordance with the international standards and other standards, to reduce the stochastic effects to residents within the zone as much as possible, arrangements need to be in place to evacuate, stay indoors, provide stable iodine in line with the levels based on the result of environmental monitoring, e.g., the Operational Intervention Level (OIL), the Emergency Action Level (EAL).

（to be considered in future）
PPA：Plume Protection planning Area
An area where protection measures will be implemented such as staying indoors for residents to reduce the exposure to plumes containing radioactive materials (a cloud of air containing radioactive materials in the form of gas or particles).

Source: Nuclear Safety Commission

Japan's Emergency Classification based on EAL

- Alert
- Site Area Emergency
- General Emergency

Japan's Emergency Classification (1)

Alert	**Special Vigilance phenomenon** **1) If, in prefectures where nuclear facilities are located, an earthquake more than 6 in Japanese seismic intensity grades occurred.** **2) If, in prefectures where nuclear facilities are located, large tsunami warning was issued.** **3) Others, such as when the chairman of the Nuclear Regulation Authority deems that the establishment of the headquarter is necessary.**

Japan's Emergency Classification (2)

Site Area Emergency

Article 10 of the Act on Special Measures Concerning Nuclear Emergency Preparedness

(1) Leakage of reactor coolant

(2) A breakdown of residual heat removal capabilities in addition to the breakdown of heat removal capabilities from the reactor via the main condenser

(3) Loss of all of the alternating-current power supply (for more than 5 minutes)

(4) The power sources that supply electricity to emergency direct-current generating lines were reduced to one, with the number of emergency direct-current generating lines also being reduced to one (for more than 5 minutes).

(5) A state in which a nuclear reactor's operations are suspended and the level of water in the reactor vessel lowers to the point at which the emergency core cooling system becomes activated

(6) all nuclear reactor cooling functions break down while the reactor is in an inactive state, etc.

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Japan's Emergency Classification (3)

General Emergency

Article 15 of the Act on Special Measures Concerning Nuclear Emergency Preparedness

(1-1) When the nuclear reactor needs to be shut down urgently, it cannot be done so by using a normal neutron absorber.

(1-2) When the nuclear reactor needs to be shut down urgently, all functions designed to stop the reactor break down.

(2) Unable to pour water into the nuclear reactor by any of the emergency core cooling system.

(3) The depressurizing function of the nuclear reactor vessel breaks down when the residual heat removing function from the reactor has broken down.

(4) All functions that cool the nuclear reactor break down.

(5) All of emergency direct-current power supplies break down (for more than 5 minutes).

(6) Detection of radiation doses or temperatures that indicate melting of the reactor

(7) Lowering of water levels to the point at which the residual heat removal function breaks down (for more than 1 hour)

(8) Lowering of liquid levels in the storage tank containing spent fuel assemblies to the point at which the assemblies are exposed above the liquid surface

(9) A dose rate measured at the nuclear facility site boundary of 5 μSv/h, etc.

Future Plans Regarding Japan's Emergency Classification

Examine the classification status (EAL) of plant emergency submitted by the nuclear operator. In addition, will be made a revision of Article 10 and Article 15 on Nuclear Disaster Special Measures Law.

Purpose of Operational Intervention Levels (OILs)

With reference to international standards and lessons learned from the Fukushima accident, to take actions below immediately is understood crucial:

- Determination of significantly affected areas.
- Prompt implementation of protective actions.
- Reduction of stochastic effects in accordance with the international standards.

Determination of the zones for which arrangements should be made for protective actions

- The area where immediate evacuation will be carried out before the release of radioactive material just after the declaration of General Emergency judged by EAL.

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Setting of PAZ (approx. 5 km)

- The area where protective measures such as evacuation or sheltering will be conducted based on the environmental measurements and criteria of OIL.

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Setting of UPZ (approx. 30 km)

Arrangements for prompt implementation of protective actions

Arrangements implemented by national and local governments and the nuclear operator:

- Development of monitoring system in an emergency.
- Centralized management of information obtained from monitoring posts and others.
- Wide-area monitoring using an aircraft.
- Provision of means to provide information to the public should be made prior to an accident.

Reduction of stochastic effects in accordance with the international standards

Based on lessons learned in the accident, OILs are suggested as below in Japan.

- OIL1: 500 μSv/h Evacuation or sheltering indoors (within hours)
- OIL2: 20 μSv/h Temporary relocation (within 1 week)
- (OIL3): 0.5 μSv/h Contamination screening of food and drink
- OIL4: 40,000 cpm Decontamination of the body (prompt action)
- OIL5: (Not applied) Screening level for assessment of food and drink using OIL6
- OIL6: (According to nuclide analysis) Restriction of food and drink intake

Japan's situations in defining OILs

- GM survey meters commonly used in Japan have larger diameter than that of IAEA.
- The criterion (OIL2) used for early protective actions of temporary relocation is defined to reflect the lessons learned from the Fukushima accident.
- In Japan, as radionuclides in environmental samples can be measured easily, screening levels for further assessment i.e., OIL5 was not defined.

Other Major Issues

Field Surveys of Fracture Zones

- Started additional field surveys at three NPP sites
  （Oi, Tsuruga and Higashidori)
- NRA organized experts' team to conduct field surveys.

International collaborations in the field of Nuclear Safety Regulation

- International collaborations with IAEA, OECD/NEA, and other countries.
- Sharing cutting-edge knowledge in the field of nuclear safety regulation
- Nuclear security
- Nuclear safeguards
- Development of human resources

Thank you for your attention !