Where Japan Is and Where Japan Will Go: Update of the Fukushima Accident and the Deliberation of Post-Fukushima Nuclear Energy Policy in Japan

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March 11 Event

- The Great East-Japan Earthquake and the resulting tsunamis struck the Fukushima Daiichi Nuclear Power Plant of TEPCO on March 11, 2011.
- This caused a nuclear accident that was unprecedented: the simultaneous progression of severe accidents at multiple units and the continuation of accident over an extended period of time.
- The fact that this accident has raised concerns around the world about the safety of nuclear power generation is a matter which Japan takes with the utmost seriousness and remorse.
- In the face of this hardship, Japan has received supports and expressions of solidarity from around the world. I would like to express Japan's sincere gratitude to you.

Presentation Topics

- Accident Progression
- On-site Management: Activities and Future Plan
- Off-site Management: Activities and Future Plan
- Root Causes of the Accident
- Compensation of Damage Caused by the Accident
- Deliberation of Nuclear Energy Policy
- Conclusion

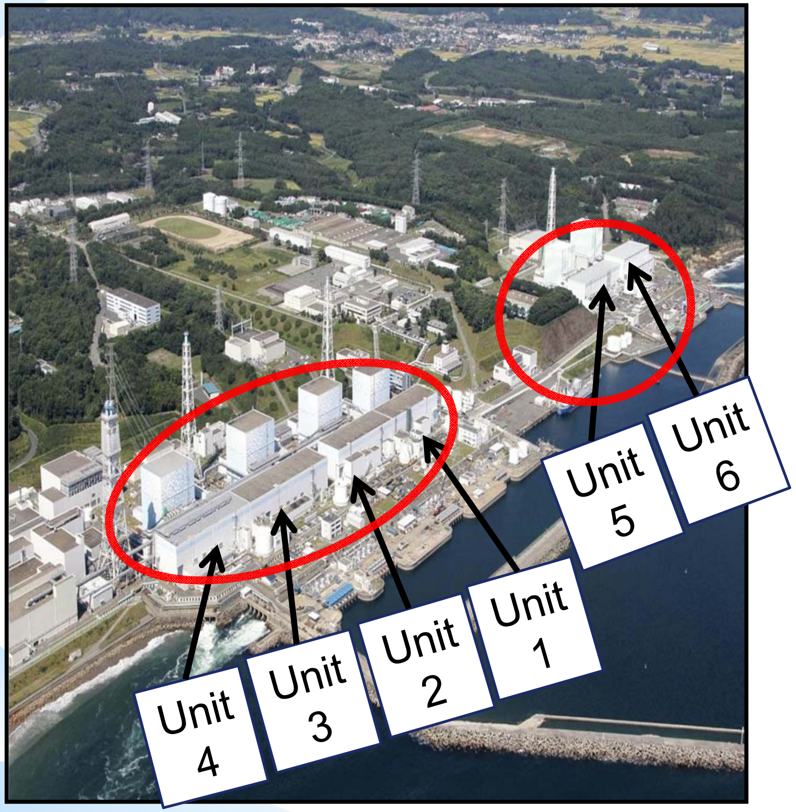
Fukushima Daiichi Nuclear Power Station

* The Fukushima Daiichi nuclear power station, which is operated by TEPCO, is located in the Fukushima prefecture, approximately 260 km from Tokyo, on the northeast coast of Japan. It consists of six BWRs capable of generating 5,480 MWe total.
* The units are designed such that units 1 and 2, 3 and 4, and 5 and 6 share common facilities and structures, such as a shared control room and turbine building. The station also has a common spent fuel pool and dry cask storage facility.
* The original design basis tsunami for Fukushima Daiichi was based on the Chilean tsunami of 1960 which resulted in a historic high water level of 3.1 m at the Onahama port, just north of the plant, as it was common practice to adopt historical tsunami records as the design basis tsunami height. The design included a breakwater, which ranged in height from 5.5 m to as high as 10 m.

Fukushima Daiichi Nuclear Power Plant

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Reactor Type	BWR-3	BWR-4	BWR-4	BWR-4	BWR-4	BWR-5
PCV Model	Mark-I	Mark-I	Mark-I	Mark-I	Mark-I	Mark-II
Electric Output (MWe)	460	784	784	784	784	1100
Commercial Operation	1971,3	1974,7	1976,3	1978,10	1978,4	1979,10

Before the Earthquake and Tsunamis



(Source: TEPCO)

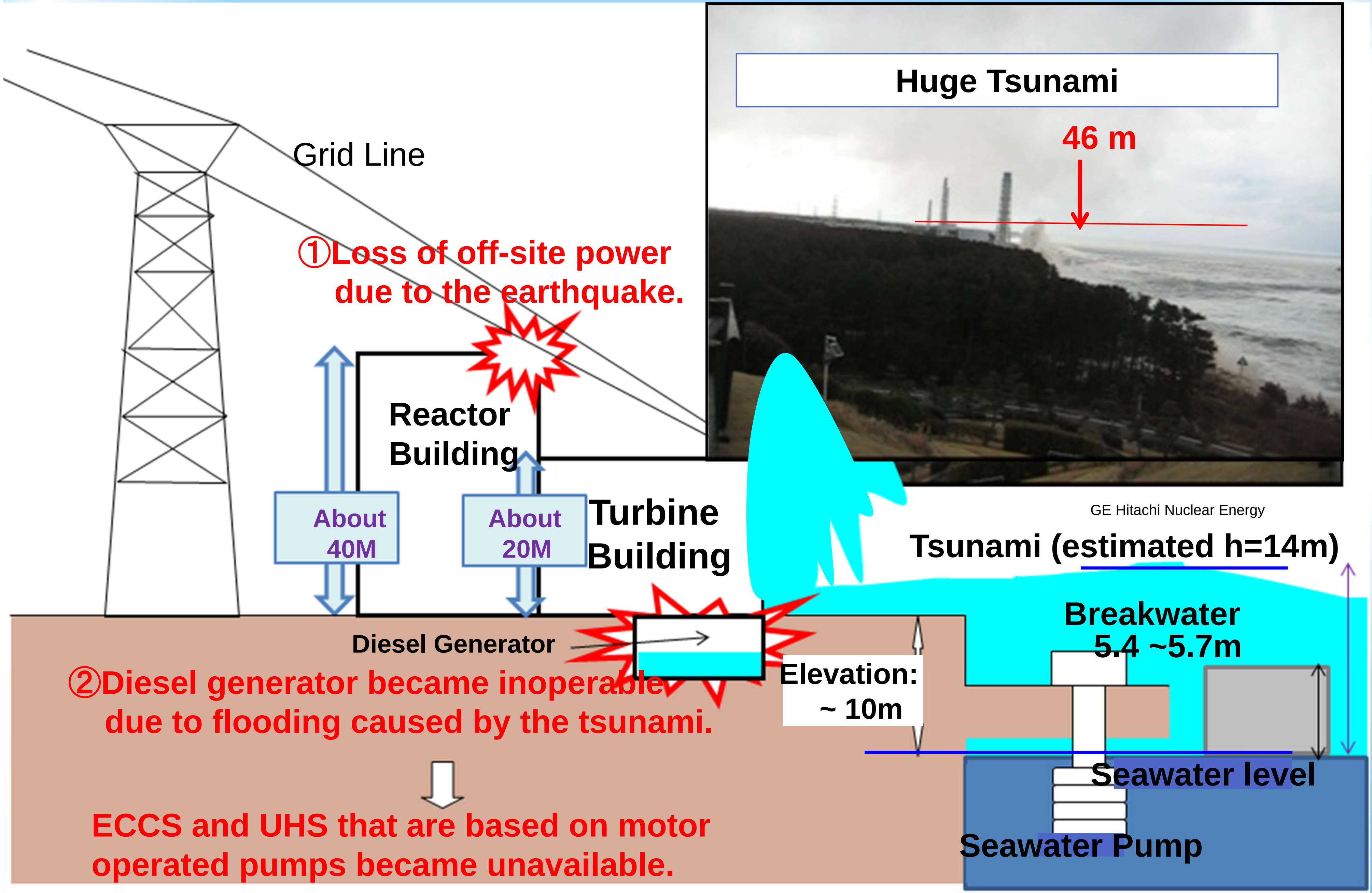
After the Earthquake and Tsunamis

(Source: Air Photo Service Inc (Myoko, Niigata Japan))

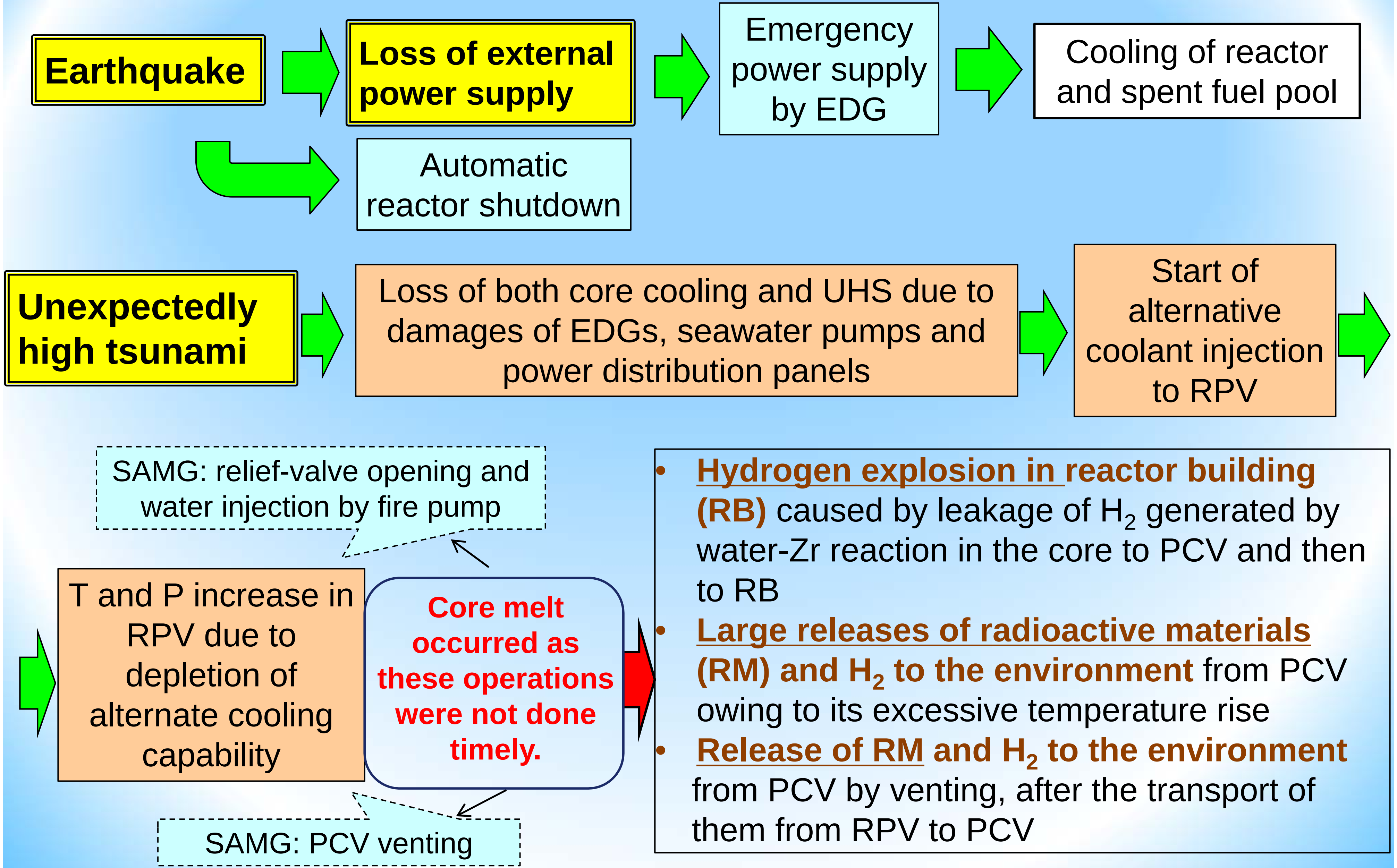
Earthquakes and Tsunamis hit the Fukushima Daiichi Nuclear Power Station

* The earthquake caused a loss of all off-site power to units 1 through 6. Therefore all emergency diesel generators that were operable started and loaded as expected, and each emergency core cooling system the operators used appeared to function as designed. Reactor pressure, reactor water level, and containment pressure indications for units 1, 2, and 3 appeared as expected following a scram and did not indicate any potential breach of the reactor coolant system from the earthquake.
* The earthquake generated a series of tsunamis that arrived at the site starting at 1527, 41 minutes after the earthquake, which inundated the area surrounding units 1□4 to a depth of 4 to 5 meters and flooded the turbine and reactor buildings. Intake structures at all six units were unavailable because the tsunamis and debris heavily damaged the pumps, strainers, and equipment, and the flooding caused electrical faults.

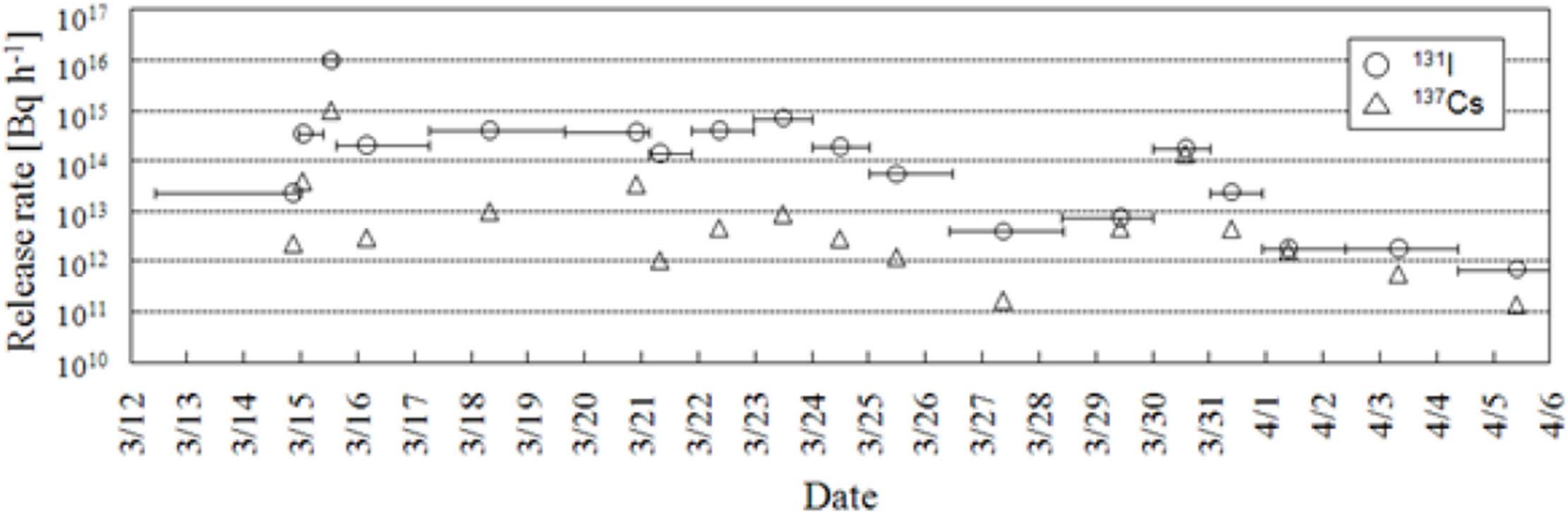
Damages Caused by Earthquake and Tsunami



Accident Sequences



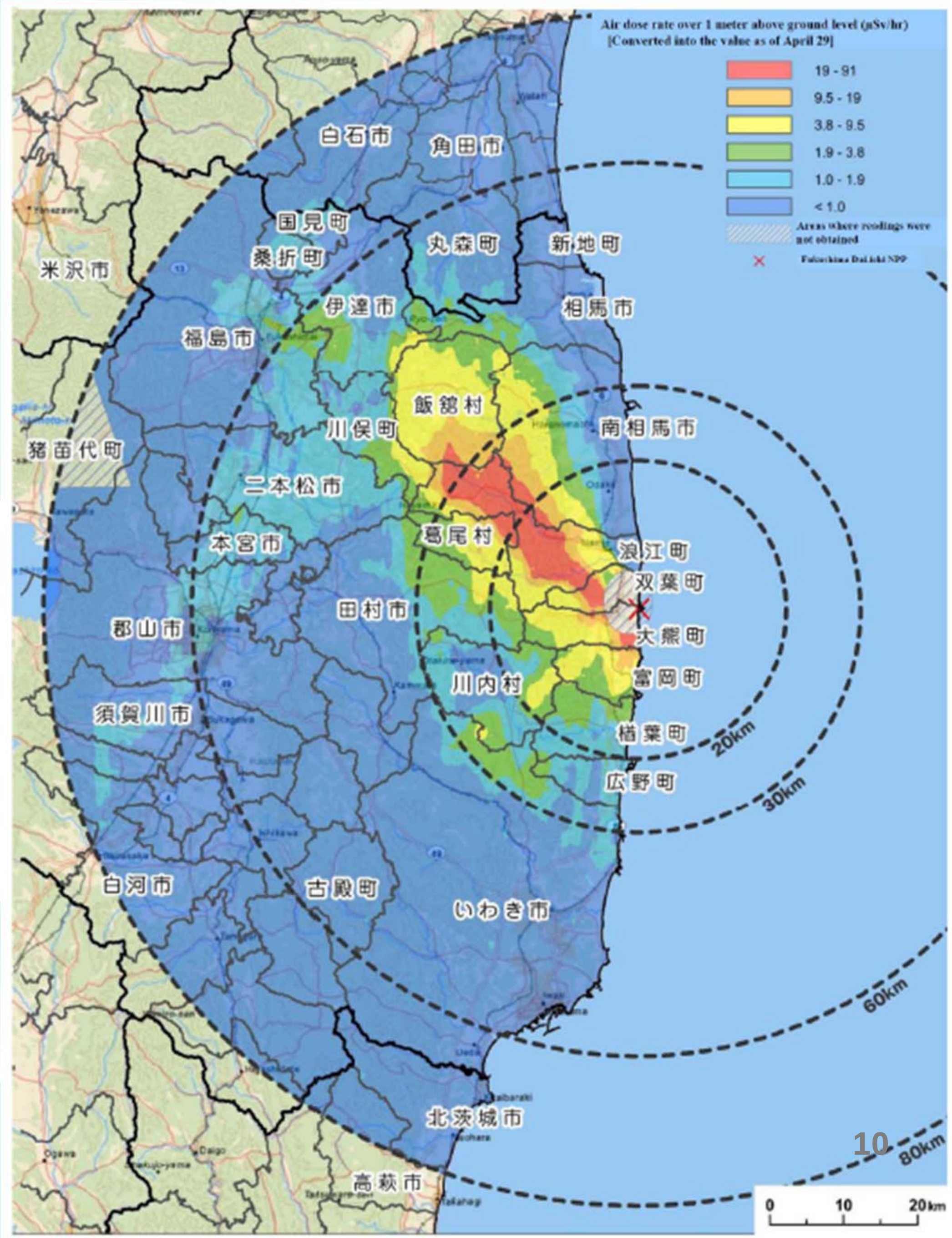
Release Rates of Iodine-131 and Cesium-137:Estimation by SPEEDI



Horizontal bar denotes the duration of the discharge estimated. The maximum release rate occurred on March 15. The release from Unit 1 on March 12 is not included in this figure.

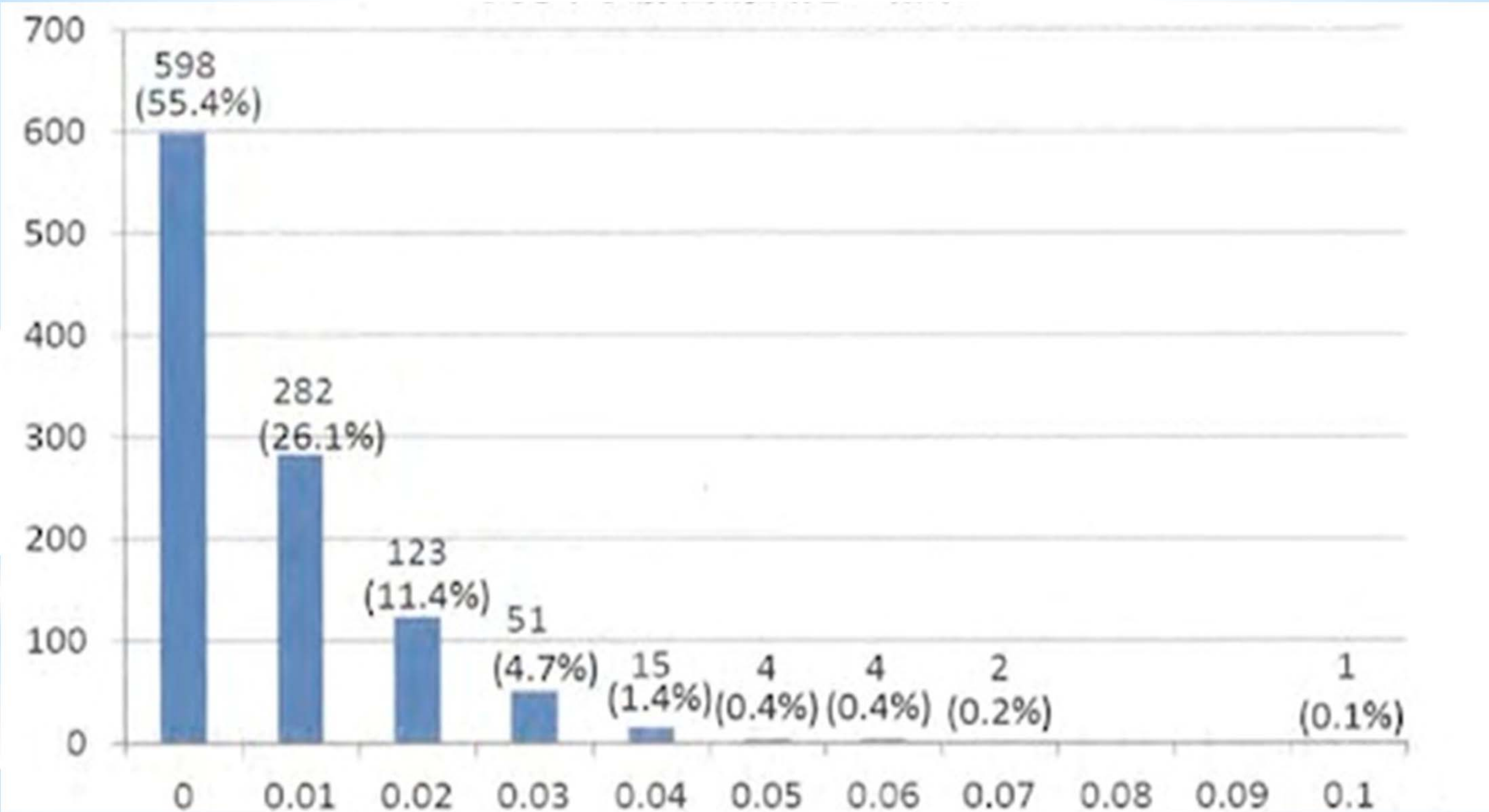
Source: Material 4-2 for 31th NSC held on May 12, 2011

Results of Airborne Monitoring By MEXT and USDOE



On March 15, radioactivity in the air flew to the northwest by wind, and then it fell down due to rain & snow and high radioactivity remained in that direction.

Distribution of Dose Rate (μSv/h) of Children's Thyroid Glands: the Maximum Dose was Estimated to be 35mSv.



Estimation of Radioactive Materials Released to the Environment

- To the air

  Estimation by SPEEDI Code: the JAEA team estimated the source term by reconstructing the radioactive materials concentration in the environment measured (The results of dust samplings) by SPEEDI code that can simulate radioactivity diffusion.

  - ✓Iodine 131: approx. 1.5×10^{17}Bq
  - ✓Cesium 137: approx. 1.3×10^{16}Bq

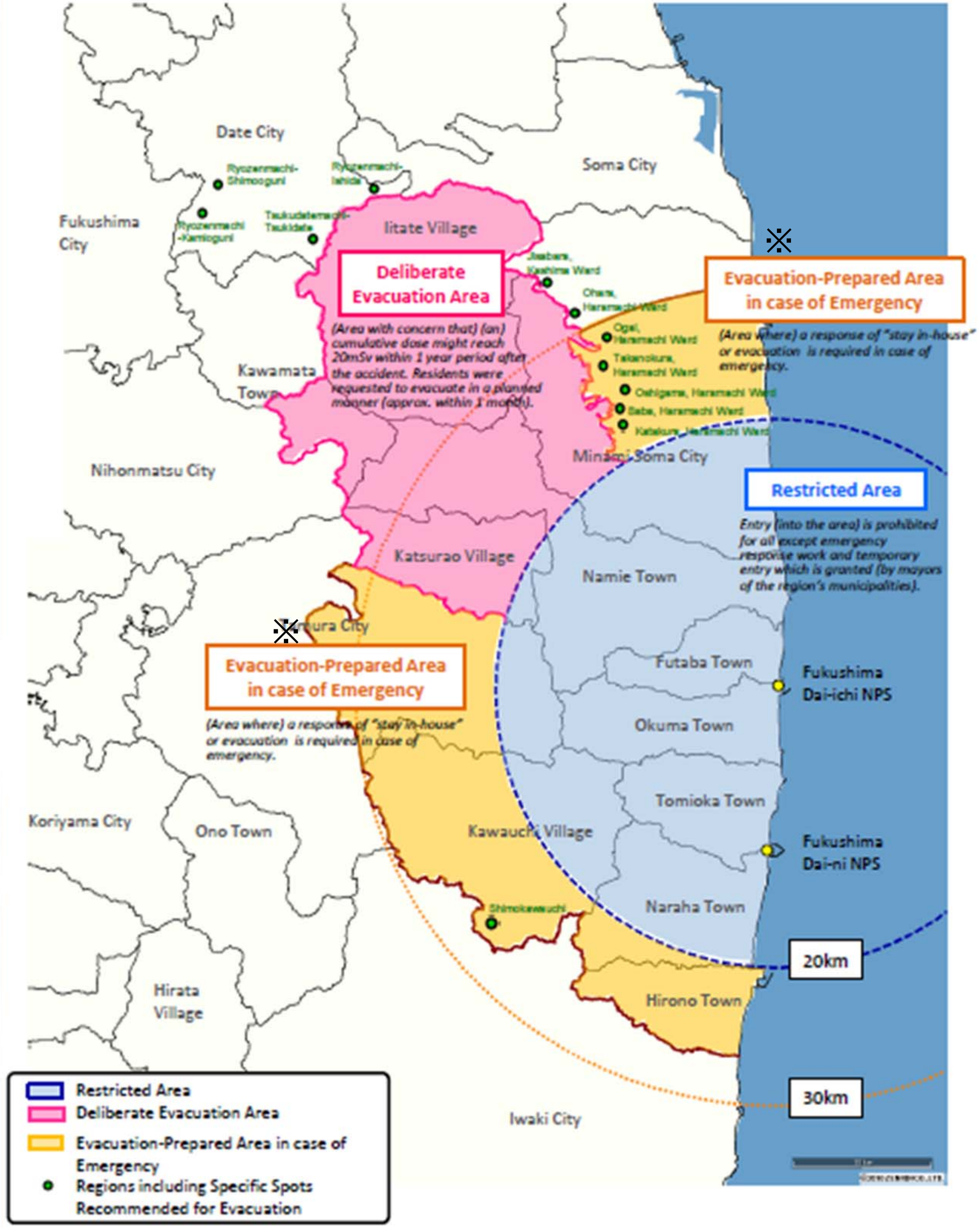
- To the sea

  Estimation based on the observation of water flowing from the electric cable-pit to the sea discovered and the contamination level of the water

  - ✓Iodine 131: approx. 2.8×10^{15}Bq
  - ✓Cesium 137: approx. 9.4×10^{14}Bq


Silt fence to block the releases

Various Evacuation Areas (As of August 3, 2011)



- Restricted Area
- Deliberate Evacuation Area
- Evacuation Prepared Area, which was annulled on September 30.

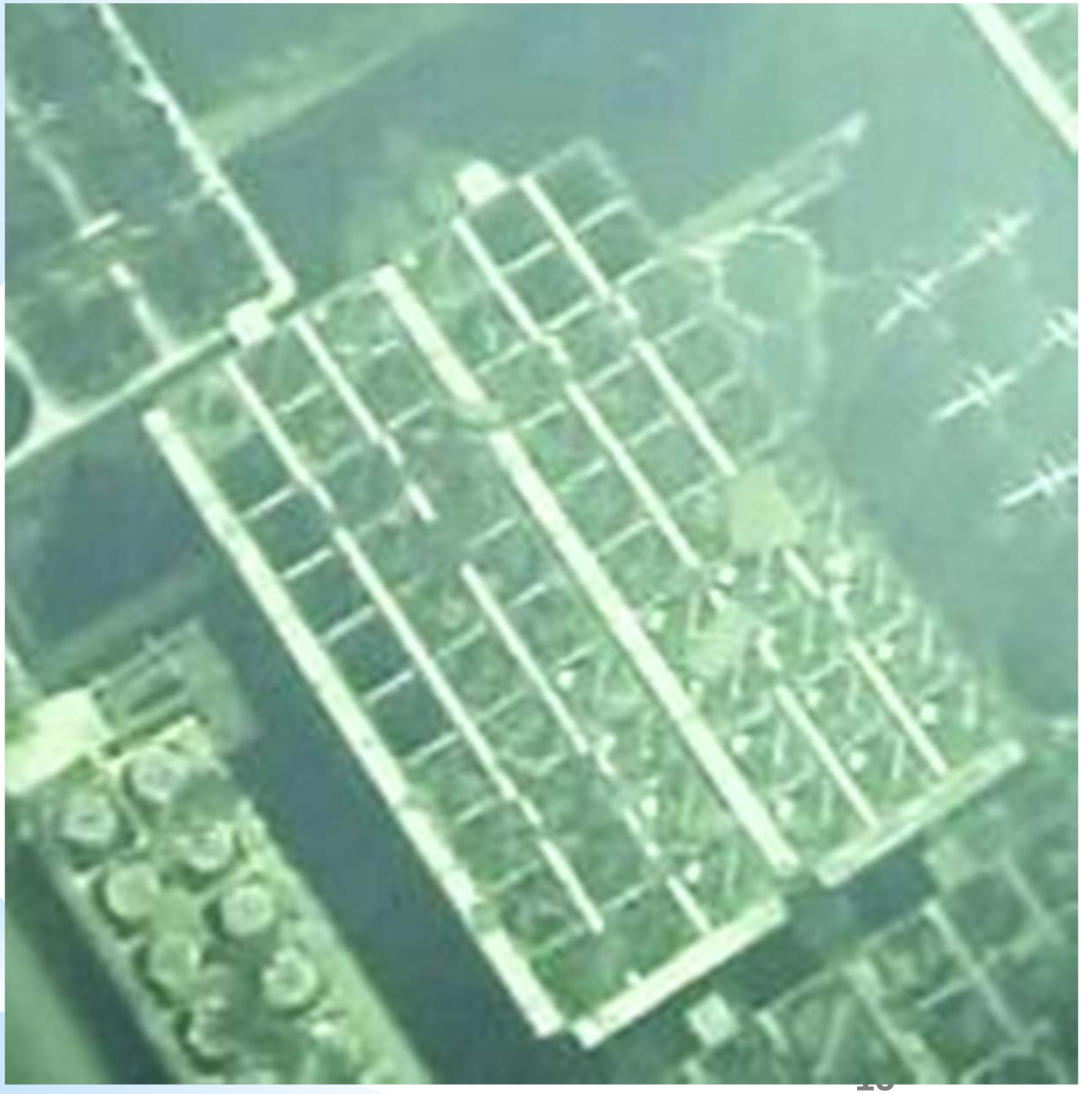
More than ten municipalities with hundreds of thousands people in a radius of 30 km have been evacuated from these areas.

Spent Fuel Storage: Pools and Dry Casks

		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Number of fuel assemblies	In the reactor	400	548	548	0*	548	764
	In the spent fuel pool	292	587	514	1,331	946	876
	New ones in the pool	100	28	52	204	48	64
	Capacity of pool	900	1240	1240	1590	1590	2030

- A **common spent fuel pool in a separate building** contained 6,375 fuel assemblies of which heat load was very low because the assemblies were stored in their respective units' SFPs for 19 months or longer before being set in this pool. The capacity of the pool is 6840.
- The pool uses fans and air for cooling. AC power is required to power the fan motors and circulating pumps.
- Nine **dry casks** containing 408 spent fuel assemblies were in the dry cask storage facility.

Photo of Spent Fuel Pool of Unit 4 Taken by Underwater Camera



It was confirmed radiologically and visually that fuels had not melted, though some of fuels in SFP were mechanically damaged by falling rubbles,

On-site Management

Roadmap towards Restoration from the Accident Developed on April 17 and revised it on May 17

- **Mar.11**
- **Apr.17** Step 1 started.
- **July.19** **Completion of Step 1 declared**

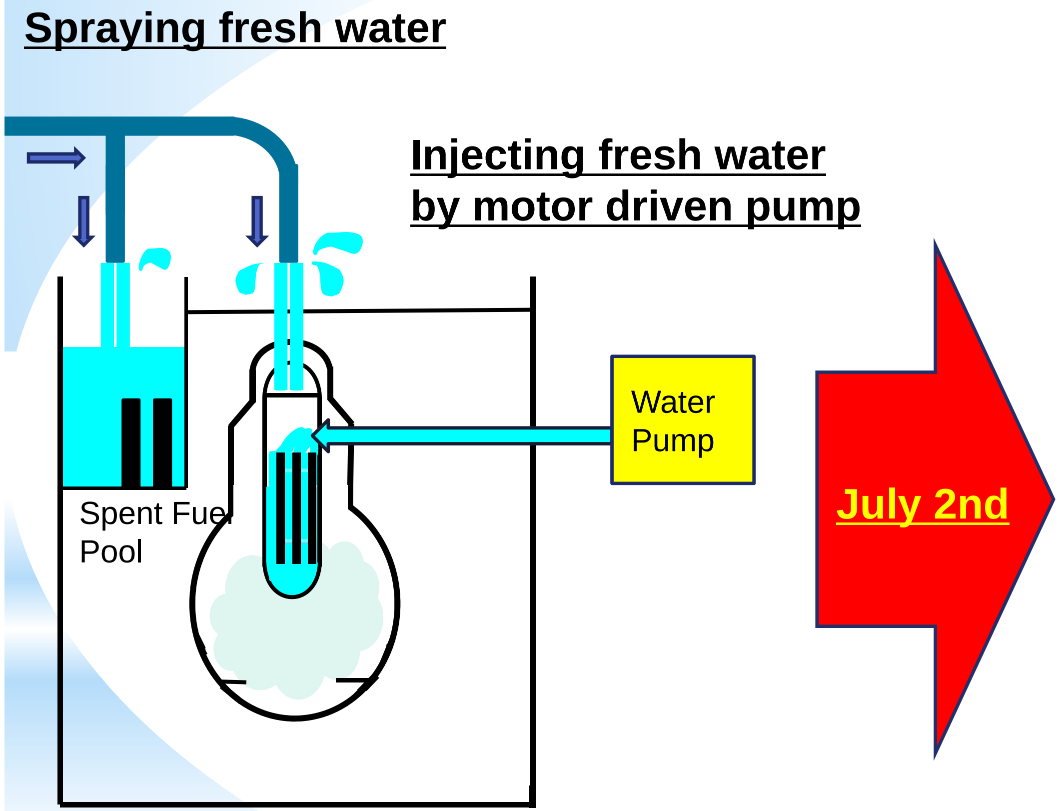
✓ ・・targets completed

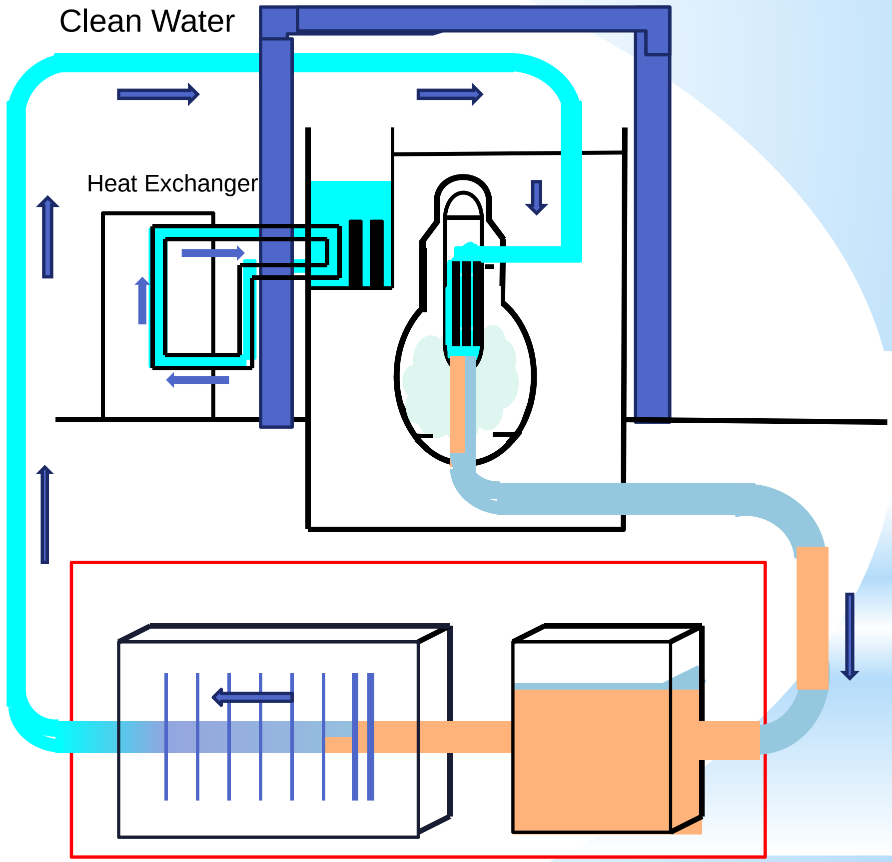
Target	Step 1 (Around 3 months) ✓	Step 2 (before the end of this year)	Mid-and Long-term Measures
Reactors	✓ **Stable cooling** - Prevention of hydrogen explosion - Injection of water	**Cold shutdown state** -Cooling by injection of circulating water	Protection against corrosion/cracking of structural materials
Spent fuel pools	✓ **Stable cooling** - Remote-control operation - Circulating cooling system	**More stable cooling**	**Removal of fuels**
Accumulated contaminated water	✓ **Secure storage** - Installation of storage facilities/decontamination processing	**Reduction of total amount of contaminated water** - Expansion of processing capacity - Mitigation of ocean contamination	**Full-scale water treatment facility** Waste management
Radioactivity release	✓ **Decrease by cooling fuel**	**Introduction of CV atmosphere control**	**Confine and control radioactivity releases**

Cool Down of the Reactor Core
- Sustainable Reactor Cooling System -

Provisional Cooling by Spraying/Injecting Fresh Water

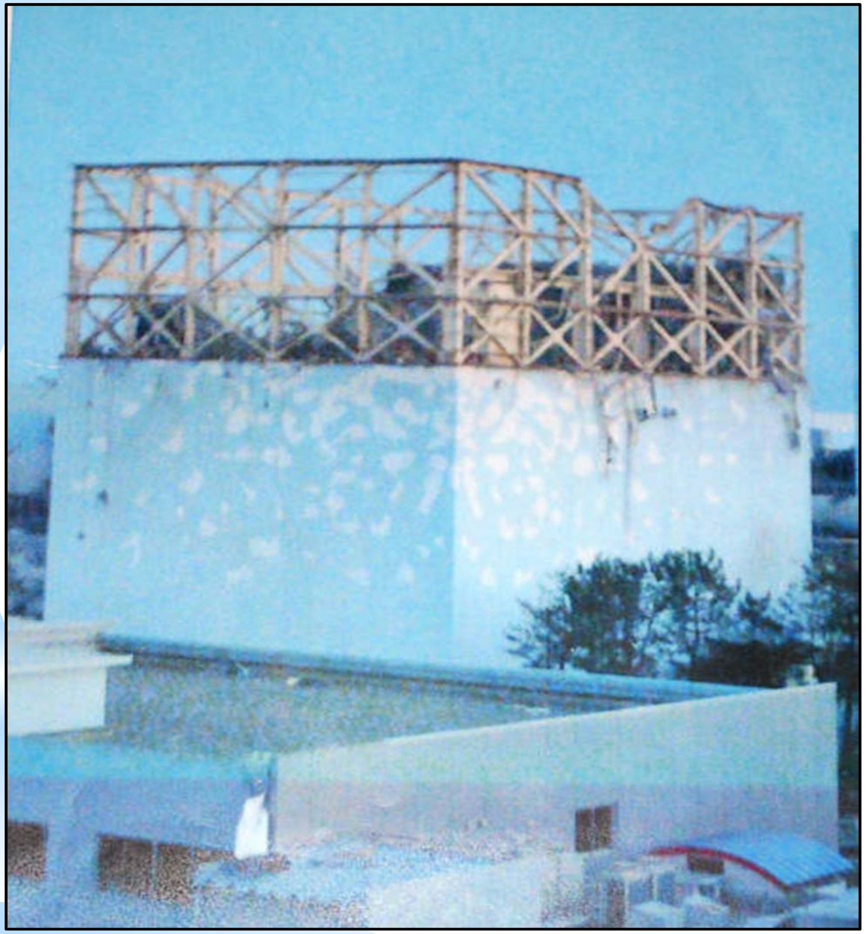
Steady and Sustainable Cooling by Injecting Circulating water





Water Purification System

Installation of Reactor Building Cover: Unit 1



TEPCO

TEPCO

Mid and Long-term Activities Beyond Stabilization: Cleanup Program

- Maintain the reactors in a safe condition, by protecting against corrosion/cracking of structural materials and treat contaminated water and wastes in a comprehensive manner.
- Start removal of spent fuel from the spent fuel pools within three years.
- Decontaminate the reactor buildings and recover leak-tightness of CV and RPV.
- Start removal of core debris from RPVs and CVs in ten years.
- Complete decommissioning of the plant and dispose generated wastes at final disposal facilities.

Deliberation of Arrangement to Remove SFs and Core Debris and Technology R&D Programs necessary

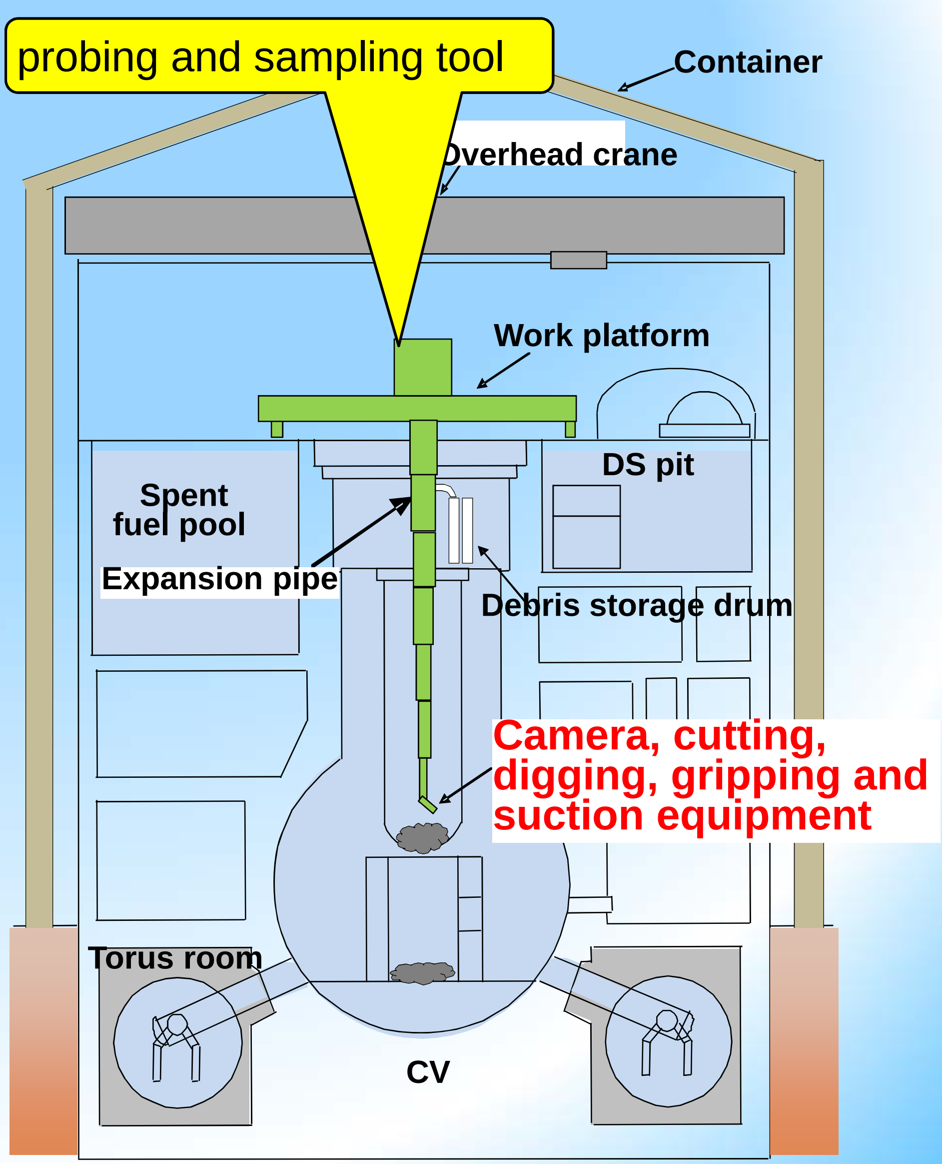
Example

Activity

* Probing the inside of RPV and taking samples

Necessary Technology R&D

* Decontaminate the building
* Reestablish leak tightness
* Remotely probe and take samples in high radiation area
* Clarify properties of debris/material
* Treat contaminated water and waste



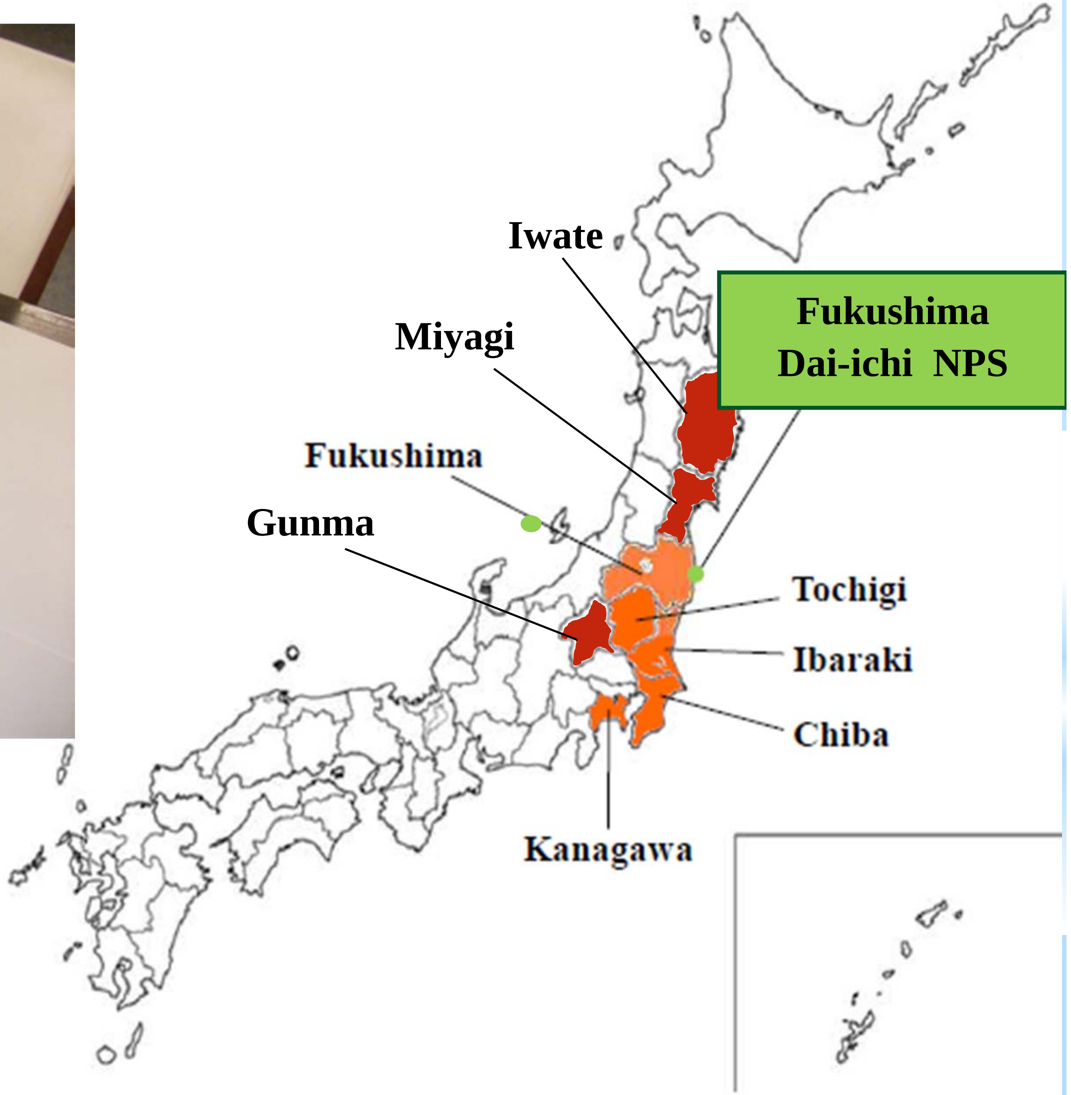
Off-site Management: Remediation of Contaminated Environment

Measures for Off-site Remediation

- To decrease existing and potential annual exposures, we should pursue;
  - Reducing the number of exposed people
  - Modifying pathways of contaminant to a people
  - Removing existing sources by decontamination.
- The priority choices the Government is pursuing are
  - A) Restriction of inhabiting in the area where expected annual additional dose is larger than 20 mSv;
  - B) Strict shipping control for agricultural products, animal products and marine products through radiological surveys
  - C) Step-by-step decontamination of the land.

Ensure the Safety ~Farm Produce: Vegetable

Japan inspects radioactivity in food every day, and restricts distribution of food that fails to meet provisional regulation values taking into consideration the spread of contamination.



Ensure the Safety ~Farm Produce: Beef

Radioactive cesium which exceeded provisional regulation values (500Bq/kg) was detected in Beef. Using the traceability system established in Japan, Japanese Government determined location and status of all the meat concerned. Testing systems for food safety have been introduced and shipment restriction was lifted by August 25.

Contamination was caused by feeding contaminated rice straw inadvertently.

Tokyo University

Blanket testing has been introduced by prefectures and prefectural JAs (Japan Agricultural Cooperatives).

Matsuzaka Shokuniku Public Corporation

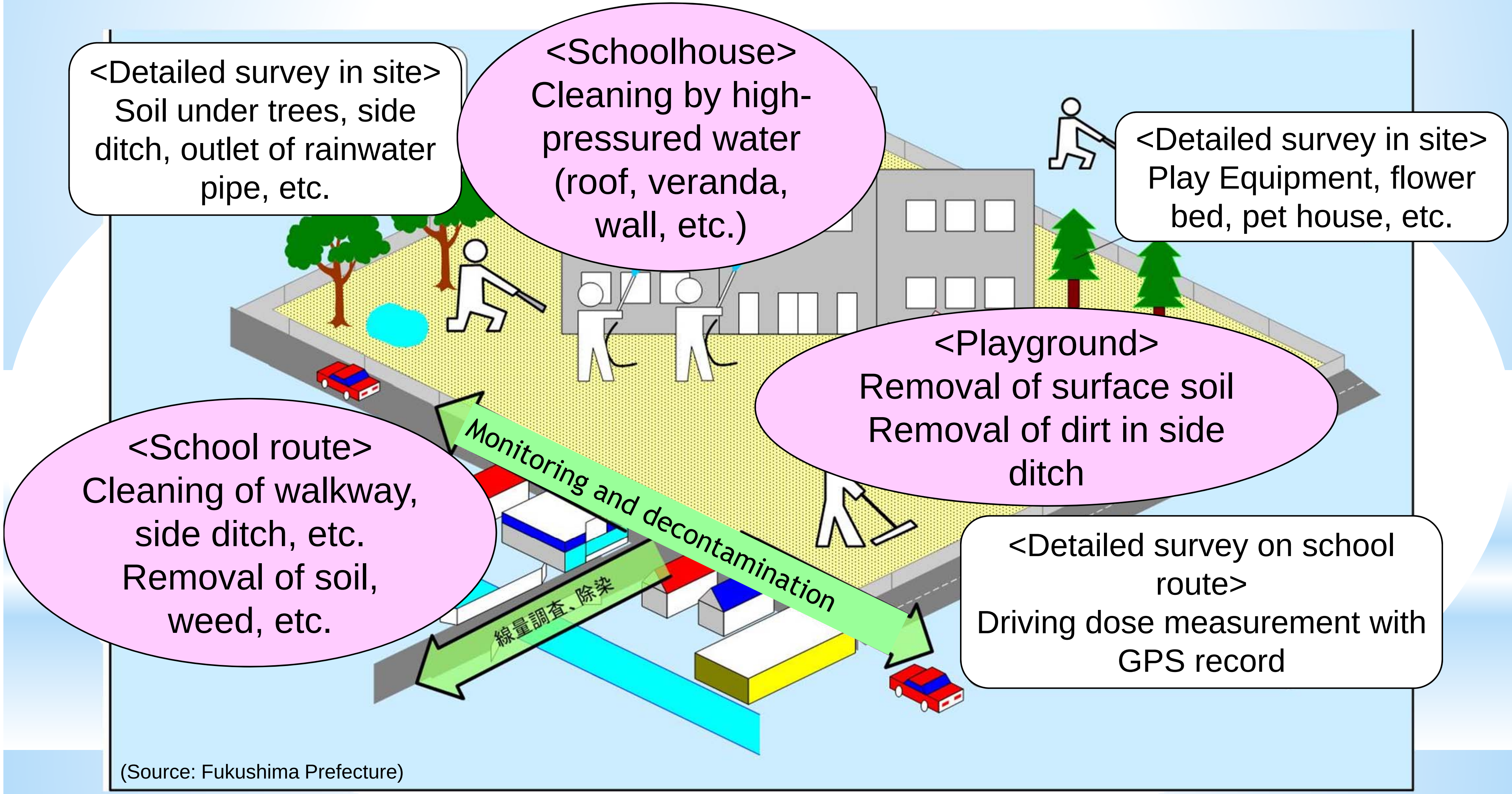
The individual history of all beef can be traced by identification numbers given to each cattle for meat in entire Japan.

Individual Identification Numbers

Strategy for Decontamination

- Reduce the additional annual exposure below 1 mSv on a long term basis in non-restricted areas where it is currently below 20 mSv but above 1 mSv. Municipalities are leading the execution:
  - Pursuing wide area decontamination activities in highly contaminated areas and localized decontamination in relatively low contamination areas, identifying hot spots such as those locations where sludge in the drains or gutters has collected.
  - Pursuing exhaustive decontamination of children's’ environment (schools, play grounds, etc.), aiming at reducing the annual additional exposure to 1 mSv as soon as possible and pursue further reduction incessantly.
- Reduce the size of the areas where estimated additional annual exposure is larger than 20 mSv and residents have been already evacuated through step by step decontamination activities.

Activities to Reduce Dose-Rate in School and School Route

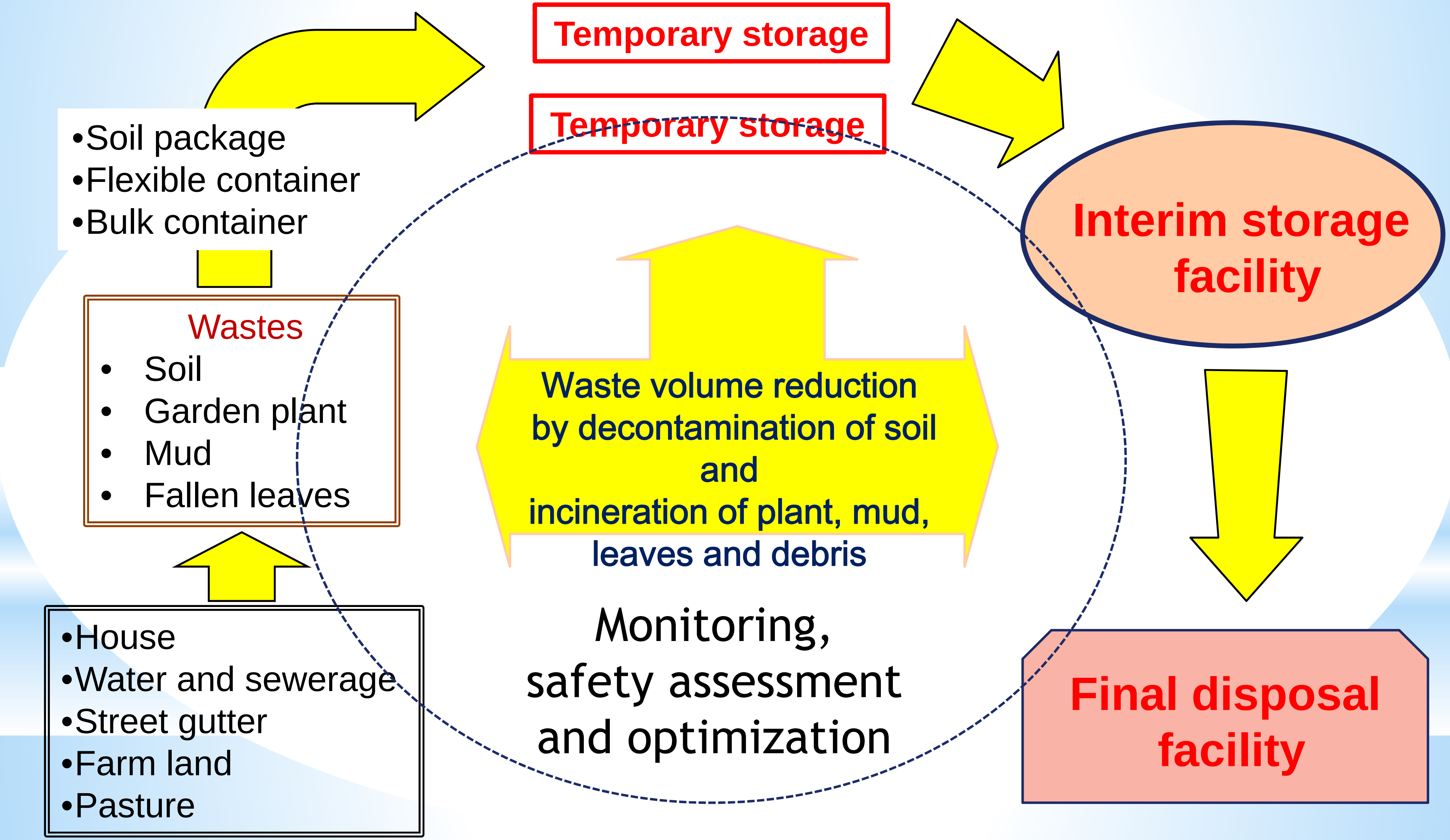


(Source: Fukushima Prefecture)

Plans for Evacuation Area

- The Government has started one demonstration decontamination project in every municipal area to try various approaches and establish the guideline for their widespread implementation.
- As for agricultural land, the Ministry of Agriculture, Forestry and Fisheries has promoted activities to verify the effectiveness of various decontamination technologies to be applied to contaminate agricultural fields.
- Based on the results of such projects, the Government will start a full-scale decontamination activity before the end of the year in cooperation with the municipal governments so that displaced people can return home as soon as possible, though it will be necessary to restore the operation of public services essential for living before removing the restriction of entrance.

Concept of Managing Waste from Decontamination Activities



Root Causes of the Event

Root Causes of the Accident

- Japanese nuclear safety people should have been more keen to the prevention of soil contamination due to large releases, after witnessing the tragedy caused by the Chernobyl. The regulators have not promoted the IPEEE and lost the opportunity to identify the weaknesses of plant that contribute to large releases of I and Cs and the huge liability cost accompanied with such releases.
- Japanese nuclear regulator and operators, who were shy with probabilistic analysis, failed to let the experts of tsunami know the necessity of having information about a tsunami that has a frequency of exceedance of less than 1 in 10,000 years.
- Before 2000 or so the experts of tsunami had been interested in finding the historical maximum tsunami height at a given site with limited resources available and nuclear people had utilized it as a design basis without paying due attention to the limitation.

Root Causes of the Accident

- They have not vigilantly reviewed the contents of the debate held in the academic circles related with earthquake and tsunami, based on questioning attitude and a commitment to excellence.
- Nuclear regulator and operators have tended to limit their attention to the prevention of accidents within deterministically-set design basis and have failed to satisfy the internationally recognized need for defense-in-depth features that will prevent a disproportionate increase in radiological consequences from an appropriate range of events which are more severe than the design basis event (cliff-edge).
- This tendency has come from their shallow understanding of the huge hazard potential of nuclear reactors and their weak concentration on the objective to assure the extreme rarity of land contamination.

Nuclear Safety and Security Agency

- The Cabinet decided to create "Nuclear Safety and Security Agency (NSSA) (tentative)" next April as an affiliated organization of the Ministry of Environment, separating the nuclear safety regulation section of the Nuclear and Industry Safety Agency (NISA) from the Ministry of Economy, Trade and Industry (METI) and integrating the function of the Nuclear Safety Commission (NSC).
- The NSSA will be in charge of safety regulation on the use of reactors and nuclear fuel materials, nuclear security, leading function in environmental monitoring and crisis management including emergency responses.

Compensation of Damage Caused by the Accident

Compensation of Damage Caused by the Accident

- Japan has two laws governing nuclear third party liability: the Law on Compensation for Nuclear Damage and Law on Contract for Liability Insurance for Nuclear Damage. These laws say that plant operator liability is exclusive and absolute, and power plant operators must provide a financial security amount of JPY 120 billion (US$ 1.4 billion). The government may relieve the operator of liability if it determines that damage results from "a grave natural disaster of an exceptional character". In any case, however, liability is unlimited.
- Judging that the Fukushima accident was a man-made disaster（to be precise, TEPCO asked the Government to postpone the legal decision of the applicability of the relief clause related with a grave natural disaster to expedite the damage compensation), the government set up **Nuclear Damage Liability Facilitation Fund;** a new state-backed institution to expedite payments to those affected. The Fund is to receive financial contributions from electric power companies with nuclear power plants in Japan, and from the government through special bonds that can be cashed whenever necessary. The government bonds total JPY 5 trillion ($62 billion). The provision for contributions from other nuclear operators is similar to that in the USA.
- The TEPCO will pay an annual fee for the government support, maintaining adequate power supplies and ensuring plant safety.

Compensation of Damage Caused by the Accident

- As Government decided recently that the decontamination activity should be done in the area where annual additional radiation dose will be higher than 1 mSv/year without delay, TEPCO will have to pay compensation far more than JPY 5 trillion.
- At the same time unlimited operator liability necessitates NPP operators to assure the public that the likelihood of a catastrophic accident at a NPP that takes into consideration of the emergency measures specified by NISA is exceedingly remote.
- They have not yet completed a Probabilistic Risk Assessment (PRA) of their plants that takes into consideration of the tsunami hazard curve (relation between tsunami height and its return period), however, as they have not yet obtained a reliable estimation of it for their plants.
- Therefore they may be forced to accept a high risk premium for nuclear power generation in the discussion of desirable energy supply mix in the future.

Post-Fukushima Nuclear Energy Policy

Energy Supply- Demand Structure and Policy Issues in Japan

- A major energy consuming and importing country in the world
  - 5th largest energy consumer, 3rd oil importer and 1st LNG importer
  - Fossil fuels are dominant in primary energy mix: oil 46%, coal 22%, gas 18%, nuclear 11%, hydro and other renewables 4%.
- Low self-sufficiency; about 4% but 15% if nuclear is included.
- Most of fossil fuels supply depends on imports: 90% of crude oil supply are imported from the Middle East.
- Unfailing policy issues:
  - Volatility in global energy prices
  - Security of supply: growing energy demand in Asia
  - Combat to global warming

Challenges in Energy Sphere After March 11th

- Top priority: stabilization of Fukushima Daiichi & Restoration and reconstruction of energy-related facilities and infrastructure
- Electric power shortage: sudden shutdown of 10 fossil fuel power plants and 9 nuclear power plants due to the earthquake and tsunami
  - Assure power supply capacity by restoration of standstill power plants, securing fossil fuel for such plants.
  - Enhance power saving and efficiency improvement
- Political leadership and national consensus making for establishing mid- and long-term energy strategy in the strong anti-nuclear social environment triggered by the accident.

Post-Fukushima Nuclear Energy Policy: Near-term

- Goals: pursue best use of existing facilities, making them safe against tsunami based on the lessons learned from the accident at Fukushima and restoring the public trust in nuclear safety.
- In reality, the number of nuclear power plant in operation has reduced from 26 (9 units affected and16 units in the state of scheduled maintenance outage requested after every 13 months operation.) in March to 10 in October due to the difficulty in obtaining the consent of central and local government to restart after the completion of the outage.

Restart of NPPs that Completed Scheduled Maintenance Outage

- Just after the accident at Fukushima, the NISA, nuclear safety regulator of Japan asked every operator of nuclear power plants to implement emergency safety measure for preventing the occurrence of severe core damage in the case they are hit by beyond design basis tsunami.
- On May 6, the NISA confirmed that as all NPP had properly implemented the measure and established a plan to further improve the safety of their plants against external hazards, they were eligible to resume operation after completing their scheduled outage.
- The Government requested the Chubu Electric Power Company to shut down the Hamaoka NPPs for the reason of a high occurrence probability of a magnitude 8-level earthquake that should trigger major tsunamis in the region, until permanent measures against tsunami such as 20m breakwater and the improvement of water-tightness of important buildings are completed.

Restart of NPPs after Completion of Scheduled Maintenance Outage

- Prime Minister expressed his view that the NPP should pass a "stress test" before the restart.
- The NISA deliberated under the guidance of the Nuclear Safety Commission the content of the test called "comprehensive safety assessment (CSA) that clarifies the beyond design basis margin or distance between design basis event and the threshold of events beyond which severe accident will be inevitable.
- Currently plant operators are submitting the result of their preliminary CSA for restarting the plants in outage state: the evaluation of the result is still in preliminary state and no decision has yet been made on restarting any units.
- The regulators and operators should work hard for restoring the public trust in their activities, as number of operating units will dwindle away to nothing by mid-2012 if no reactor restart approvals are given in due time.

Mid- and Long-term Energy Policies

- The Energy and Environment Council of the government, that is a ministerial committee in the cabinet, has initiated the work to formulate mid- and long-term energy policy.
- They set the goals of energy policy as stability of supply, economy, friendliness to environment and safety & peace of mind, based on the deep reflection on the March 11 event at Fukushima.
- The Council will start from the beginning of 2012 the discussion about the best mix of fossil, renewable, nuclear and efficient use of energy for the attainment of these goals.

Mid-and Long-term Nuclear Energy Policy

We are deliberating;

- The ways to make nuclear power system trustworthy to the public in a rage by improving the merit and reducing the demerit as a way to attain the specified energy policy goals under possible new condition for competition.
- How we can continue to promote bilateral, multilateral and international cooperation and joint activities for nuclear safety, security, safeguards, R&D of nuclear technology and so on, as a responsible country.
- How we can continue to assure the safety, security and proliferation resistance of our nuclear energy supply system, building human resources enthusiastic about these tasks.

Conclusions

- The accident at Fukushima was caused by tsunami of unprepared violence and contaminated a wide area around the plant.
- The root cause of this accident seems to be the weak recognition by the operators and regulators of the paramount importance of the establishment of a safety culture, the prime responsibility of the operating organization, and the independent regulatory control and verification of safety related activities that implement defense-in-depth concept.
- To recover the life of suffered people and society by way of the on-site and off-site activities should be a prime task for the Government and nuclear community: we are still in the crisis. The recovery will cost a huge sum of resources and extend over a long period of time.
- The deliberation of future energy policy has been started, searching the possibility to reduce the dependence on nuclear in future: the nuclear community is asked to rectify the defect and talk to the public its merit and demerit to recover the credibility.

Backup Slides