Fukushima Daiichi Nuclear Power Station (NPS) Accident

Damage due to the Great East Japan Earthquake

- A 9.0-magnitude earthquake occurred off the coast of Sanriku at 2:46 p.m. on Friday, March 11, 2011. The earthquake and subsequent tsunami caused severe damage mainly to the Tohoku region.
- The earthquake was the largest ever recorded in Japan and the fourth biggest in the world since 1900.

Human damage	
Dead	15,900
Missing	2,523
Injured	6,242

(Numbers of dead and missing people: surveyed by the National Police Agency as of the end of February 2022; Number of injured people: surveyed by the Fire and Disaster Management Agency as of March 1, 2022)

Damage to buildings	
Completely destroyed	122,006
Half destroyed	283,160
Partially destroyed	749,934

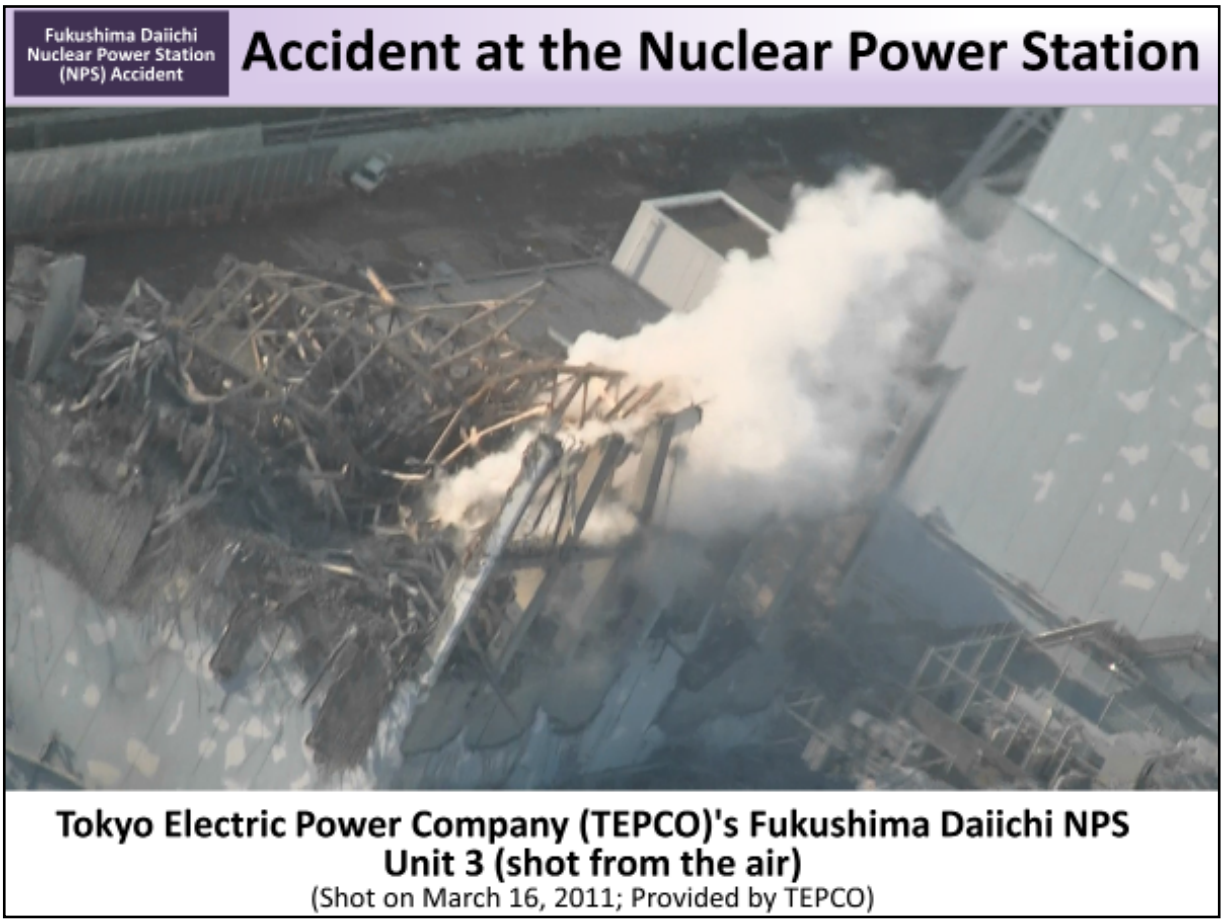
(Surveyed by the Fire and Disaster Management Agency; as of March 1, 2022)

Affected people support	
Evacuees nationwide	31,438

(Surveyed by the Reconstruction Agency; as of November 1, 2022)

A large earthquake centered off the coast of Sanriku occurred, at 2:46 p.m. on Friday, March 11, 2011. The seismic intensity of 7 on the Japanese earthquake scale was measured in Kurihara City, Miyagi Prefecture. This 9.0-magnitude earthquake was the biggest recorded in Japan since 1923 and the highest level in the world, equivalent to the 2010 Chili Earthquake (M8.8).

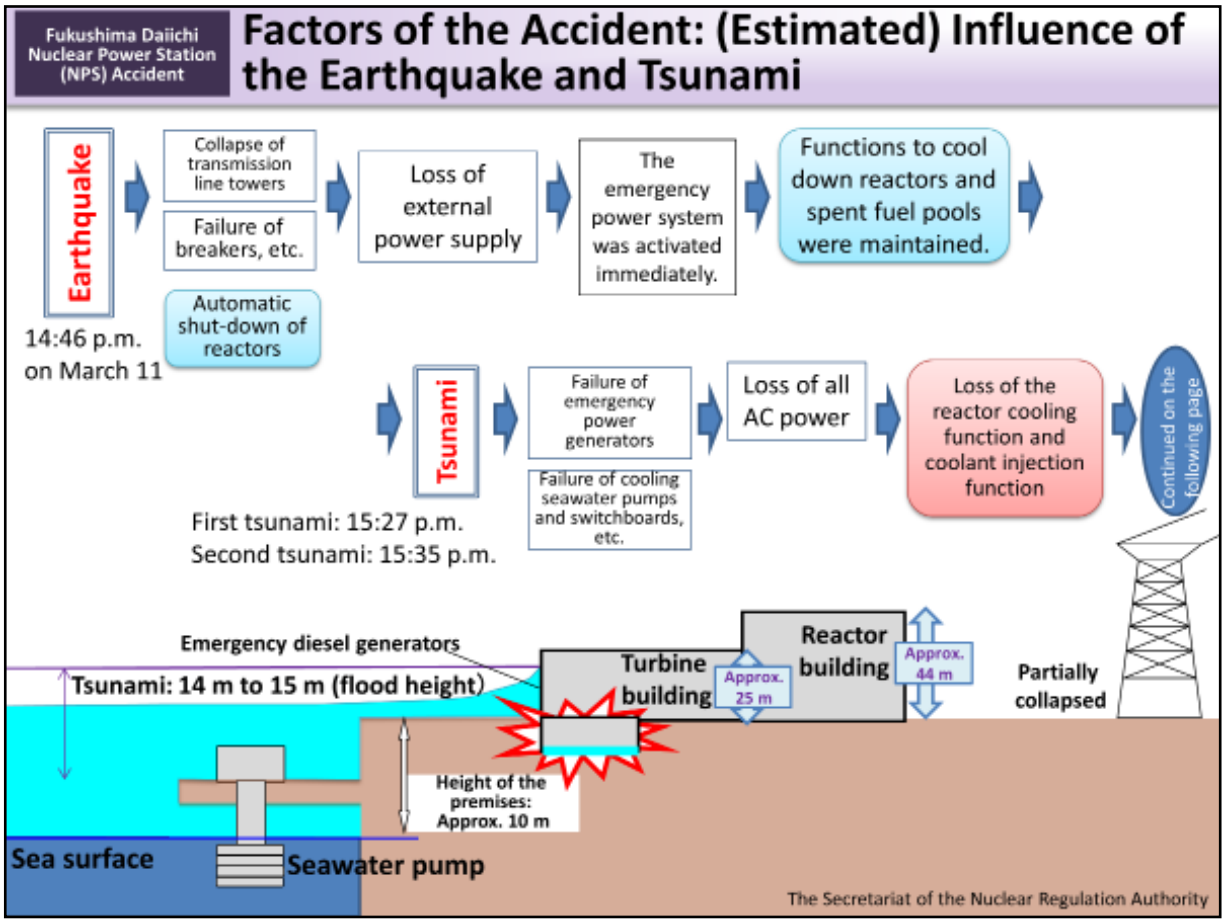
Included in this reference material on March 31, 2013
Updated on March 31, 2023



Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS Unit 3 (shot from the air)
(Shot on March 16, 2011; Provided by TEPCO)

Tokyo Electric Power Company (TEPCO)’s Fukushima Daiichi NPS Unit 1, 2 and 3, which were in operation at the time of the earthquake, lost all AC power due to the earthquake and subsequent tsunami. This led to the stop of the cooling system and loss of means to cool down nuclear fuels, eventually resulting in the melt of nuclear fuel. In the process of the melt, hydrogen gas was generated, and hydrogen gas accumulated in reactor buildings caused an explosion at Unit 1 on March 12 and at Unit 3 on March 14. Additionally, at Unit 4 adjacent to Unit 3, a hydrogen explosion occurred due to hydrogen gas that is considered to have flowed into it from Unit 3.

Included in this reference material on March 31, 2013
Updated on March 31, 2022



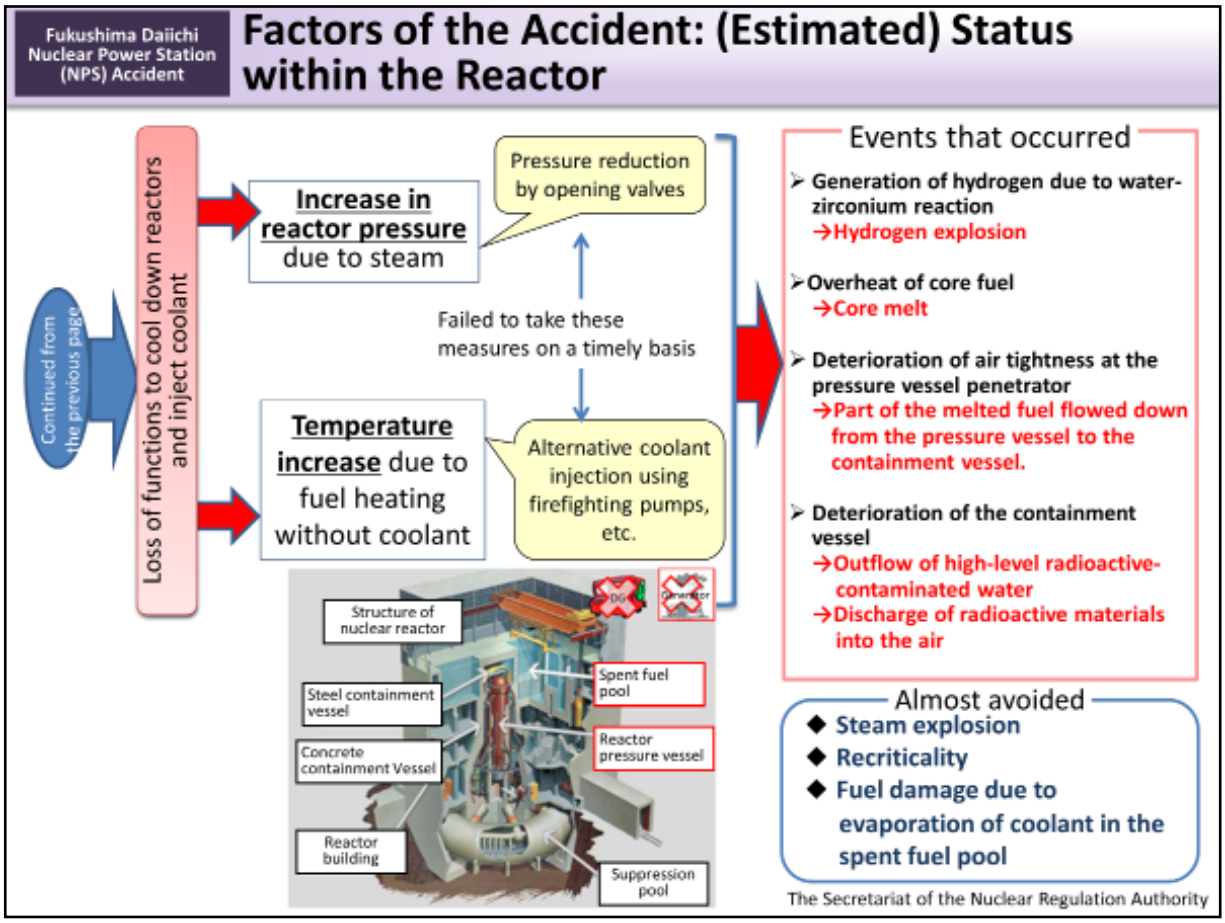
Immediately after the earthquake, at Units 1, 2 and 3 at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, which were in operation, all reactors were shut down automatically.

Even after reactors are shut down, it is necessary to remove the decay heat of core fuel. At the NPS, after external electrical power supply was lost due to the collapse of transmission line towers, etc., emergency diesel generators were automatically activated and procedures for normal cold shutdown were commenced.

However, the subsequent tsunamis hit the NPS and flooded those emergency diesel generators, switchboards and other equipment. All Units except for Unit 6 lost all AC power and cooling seawater pumps stopped functioning. Unit 1 thus lost all functions to cool down the reactor. While Units 2 and 3 continued cooling reactors for some time using the Reactor Core Isolation Cooling System (RCIC) and the High Pressure Coolant Injection System (HPCI), respectively, which can work without AC power, these systems also stopped soon and both Units eventually lost the means to remove the decay heat of core fuel.

Under such circumstances, NPS staff worked to activate alternative coolant injection routes using fire pumps or other equipment at Units 1, 2 and 3, but partly due to the possibility of another tsunami hitting, until those alternative measures were commenced, reactor cores were left uncooled. Coolant injection is considered to have been suspended for around 14 hours at Unit 1 and for around 6.5 hours at Units 2 and 3. Additionally, many hidden bypasses in the alternative coolant injection system made it difficult to supply injected water effectively to the reactor cores for cooling, and the reactors went into meltdown.

Included in this reference material on March 31, 2013
Updated on March 31, 2022



As coolant injection to the reactor core was suspended, the water level in the reactor declined and the fuel was exposed. This caused overheating of core fuel, triggered core melt and damaged a part of the pressure vessel. Melted fuel leaked from the pressure vessel into the inside of the containment vessel, and at the same time, cesium and other radioactive materials discharged from the fuel assembly was discharged within the containment vessel. Additionally, under high temperature due to core damage, steam and zirconium of the fuel cladding reacted to generate hydrogen, which was discharged within the containment vessel from the damaged part of the pressure vessel together with steam.

In the meantime, core damage increased the temperature and pressure in the containment vessel and deteriorated its confinement function, causing gaps in such parts as the penetrator that extends to the outside of the containment vessel. Radioactive materials discharged from such gaps to the outside of the containment vessel and diffused into the environment. Hydrogen generated due to the reaction of the steam and metal of the fuel cladding leaked through the gaps into the reactor building and accumulated there, and led to a hydrogen explosion.

Coolant injected into the reactor leaked from the pressure vessel and containment vessel and high-level radioactive-contaminated water accumulated underground below the reactor building and turbine building and partially flowed out into the ocean.

The damage to the pressure vessel and deterioration of the confinement function of the containment vessel caused a leak of steam containing radioactive materials. In addition, radioactive materials were also discharged into the air due to containment vessel vent operations, etc.

In this manner, radioactive materials were discharged into the environment in the forms of outflow of high-level contaminated water into the ocean and discharge of radioactive materials into the air.

Included in this reference material on March 31, 2013
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Outline of the Accident — Responses Immediately after the Accident

Time	Event	Responses by Tokyo Electric Power Company (TEPCO)	Responses by the national government (Nuclear and Industrial Safety Agency)
March 11 14:46	The Great East Japan Earthquake occurred. (Seismic intensity 6 upper at Fukushima Daiichi Nuclear Power Station (NPS))	Fukushima Daiichi NPS Unit 1, Unit 2 and Unit 3 are automatically shut down by earth quake. Unit 4, Unit 5 and Unit 6 were under suspension due to periodic inspection.	The government established the Headquarters for Emergency Disaster Control, assembled officials at the Emergency Response Center, and dispatched officials to disaster-stricken areas by helicopter.
15:15			The Nuclear and Industrial Safety Agency held a press conference and provided information online.
15:27 15:35	The first tsunami (4m in height) arrived. The second tsunami (15m in height) arrived.		
15:42		Report under Article 10 of the Act on Special Measures Concerning Nuclear Emergency (Emergency generators activated at Units 1 to 5, which had lost all AC power, were damaged due to the tsunami.)	The government established the Nuclear Accident Vigilance Headquarters.
16:36		TEPCO judged that the events fall under Article 15 of the Act on Special Measures Concerning Nuclear Emergency.	
19:03			The government issued a Declaration of a Nuclear Emergency Situation and established the Nuclear Emergency Response Headquarters.
21:23			The government issued an evacuation order to residents within a 3-km radius of the NPS and ordered those within a 10-km radius to shelter indoors.
March 12 5:44			The government issued an evacuation order to residents within a 10-km radius of the NPS.
18:25			The government issued an evacuation order to residents within a 20-km radius of the NPS.

Aftershocks with seismic intensity 5 upper or less occurred several times.

From the report by the Aomori Prefecture Nuclear Safety Measure Verification Committee
Prepared by the Nuclear and Industrial Safety Agency

The Secretariat of the Nuclear Regulation Authority

As the emergency core cooling system stopped at Unit 1 and Unit 2 of Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, the government issued, based on the Act on Special Measures Concerning Nuclear Emergency, a Declaration of a Nuclear Emergency Situation and established the Nuclear Emergency Response Headquarters at 19:03 p.m. on March 11, 2011.

At 21:23 p.m. on the same day, based on the same Act, the government issued an evacuation order to residents within a 3-km radius of the NPS and ordered those within a 10-km radius to shelter indoors.

Thereafter, the government expanded the coverage of the evacuation order, which was targeted to residents within a 3-km radius of the NPS, to cover those within a 10-km radius. As a result, a total of 51,207 residents in four towns within a 10-km radius were placed under the evacuation order.

As a hydrogen explosion occurred within the reactor building at Unit 1 at 15:36 p.m. on March 12, the coverage of the evacuation order was further expanded from residents within a 10-km radius to those within a 20-km radius of the NPS.

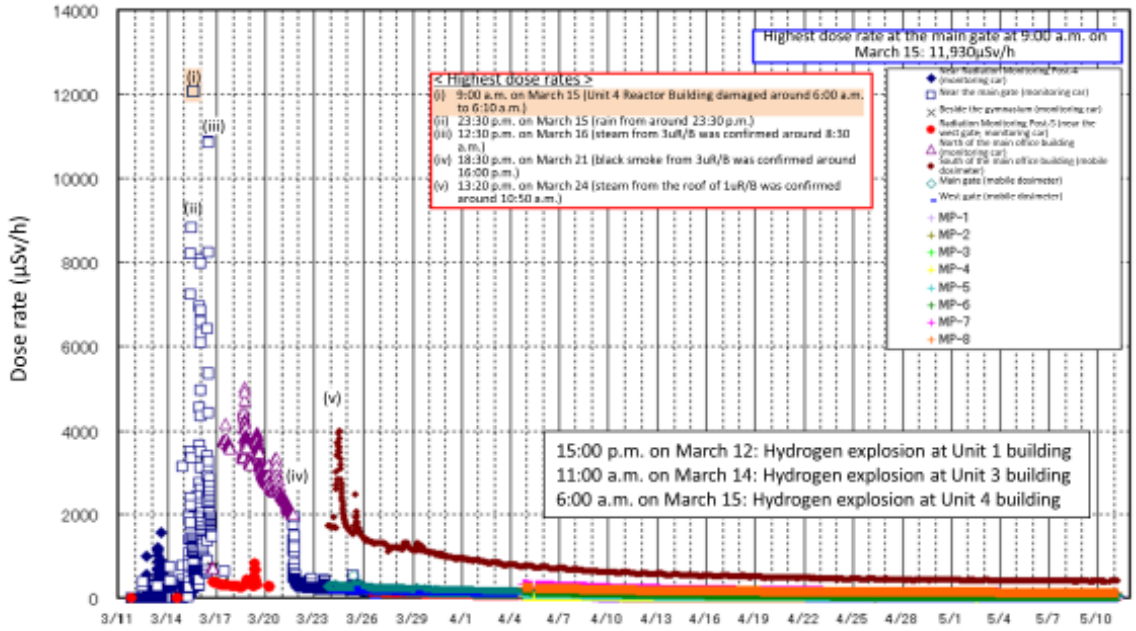
(Related to p.109 of Vol. 2, "Designation of Areas under Evacuation Orders," and p.110 of Vol. 2, "Designation of Restricted Areas and Areas under Evacuation Orders and Removal Thereof")

Included in this reference material on March 31, 2013
Updated on March 31, 2019

Outline of the Accident

Ambient Dose Rates during Two Months after the Accident (Within and around of the premises of TEPCO's Fukushima Daiichi NPS)

Hydrogen explosions occurred at buildings, etc. at Unit 1 to Unit 4 and the highest dose rates were measured in the morning of March 15.



Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety, June 2011
Nuclear Emergency Response Headquarters, Attachment V-9

μSv/h: micro sievert per hour, u: unit, R/B: Reactor Building

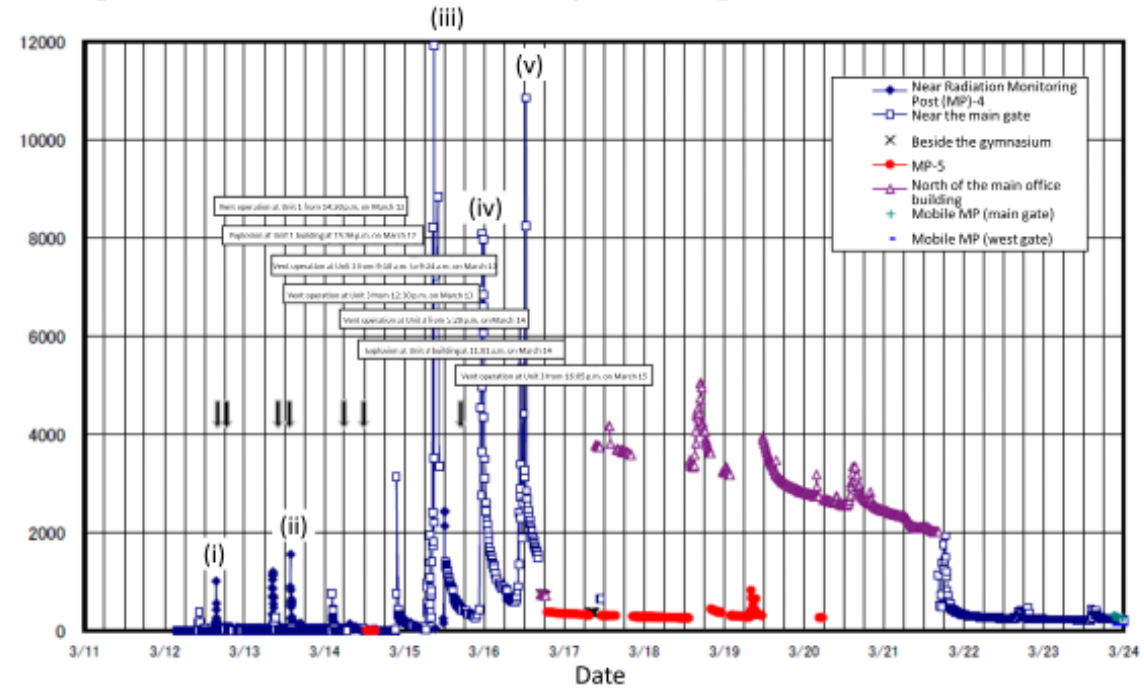
The Secretariat of the Nuclear Regulation Authority

In the early morning of March 12, 2011, monitoring cars measured higher ambient dose rates within the premises of Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS and the discharge of radioactive materials was first confirmed after the earthquake. At Unit 1, after an abnormal pressure rise in the containment vessel was observed, the pressure declined slightly. Therefore, it is considered that radioactive materials discharged from the containment vessel at Unit 1 and were discharged into the air. Thereafter, temporary rises of ambient dose rates were observed several times after the vent operations and explosions at the buildings. The highest ambient dose rate was measured at 9:00 a.m. on March 15. A monitoring car near the main gate measured the highest rate of approx. 12 mSv/h.

Included in this reference material on March 31, 2013
Updated on March 31, 2019

Outline of the Accident **Ambient Dose Rates during Two Weeks after the Accident (Within and around of the premises of TEPCO's Fukushima Daiichi NPS)**

● **Changes in ambient dose rates measured by monitoring cars within and around the NPS**



Additional Report of the Japanese Government to the IAEA - The Accident at TEPCO's Fukushima Nuclear Power Stations - (Second Report)

μSv/h: micro sievert per hour

The Secretariat of the Nuclear Regulation Authority

In accordance with the progress of events, fuel melted and radioactive materials was discharged from the pressure vessel to outside of the reactor. As a result of containment vessel vent operations and damage to reactor buildings, radioactive materials were discharged from the reactor core into the air. Vent operation at Unit 1 was considered to be successful as the pressure in the containment vessel declined at 14:30 p.m. on March 12. Due to the radioactive plume discharged at that time, an ambient dose rate of approx. 1 mSv/h was detected [(i) in the figure]. On March 13, the following day, the ambient dose rate clearly increased again [(ii) in the figure]. This is considered to have been caused by vent operation at Unit 3 conducted after the water level in the reactor declined and the fuel was exposed from cooling water. At 9:00 a.m. on March 15, the highest rate of approx. 12 mSv/h was observed [(iii) in the figure]. Early in the morning at around 6:00 a.m. of that day, the pressure of the pressure suppression chamber declined at Unit 2 with the sound of an explosion. Therefore, the high dose rate on March 15 is considered to have been caused by the discharge of radioactive materials from Unit 2.

Ambient dose rate increases were also measured at 23:00 p.m. on March 15 and at 12:00 p.m. on March 16 [(iv) and (v) in the figure]. Pressure decline in the containment vessel was observed in Unit 3 and Unit 2, respectively, and these ambient dose rate increases are considered to have been caused by the discharge of radioactive materials from Unit 3 and Unit 2.

Included in this reference material on March 31, 2013
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Outline of the Accident — International Nuclear and Radiological Event Scale(INES)

	Level	Accident examples
Accident	7 Major accident	Former Soviet Union: Chornobyl Nuclear Power Plant accident (1986) Japan: Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi Nuclear Power Station (NPS) accident (2011)
	6 Serious accident	Provisionally evaluated as Level 7 on April 12, 2011
	5 Accident with wider consequences	UK: Windscale Nuclear Power Plant fire accident (1957) US: Three Mile Island Nuclear Power Plant accident (1979)
	4 Accident with local consequences	Japan: JCO criticality accident (1999) France: Saint-Laurent Nuclear Power Plant accident (1980)
Abnormal incident	3 Serious incident	Spain: Fire at Vandellos Nuclear Power Plant (1989)
	2 Incident	Japan: Damage to steam generator heat exchanger tube at Unit 2, Mihama NPS (1991) Japan: Workers' radiation exposure due to an accident of scattering nuclear fuel materials at the Fuel Research Building, Oarai Research & Development Institute (2017)
	1 Anomaly	Japan: Sodium leak accident at Monju (1995) Japan: Primary coolant leak at Unit 2, Tsuruga NPS (1999) Japan: Pipe rupture in the residual heat removal system at Unit 1, Hamaoka NPS (2001) Japan: Pipe failure in the secondary system at Unit 3, Mihama NPS (2004)
Below scale	0 Below scale	(No safety significance)
	Not covered	(Events unrelated to safety)

Prepared based on "The International Nuclear and Radiological Event Scale User's Manual" (IAEA) and "Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety" (June 2011; Nuclear Emergency Response Headquarters)

The International Nuclear and Radiological Event Scale (INES) is the international indicator to show the level of the seriousness in terms of safety of accidents or trouble at nuclear power plants.

The accident at TEPCO's Fukushima Daiichi NPS was evaluated as Level 7 (radiation impact converted to the amount of I-131 exceeds several tens of thousands TBq (10^{16} Bq)), equivalent to the level of the Chornobyl NPS Accident.

(Related to p.28 of Vol. 1, "International Nuclear and Radiological Event Scale")

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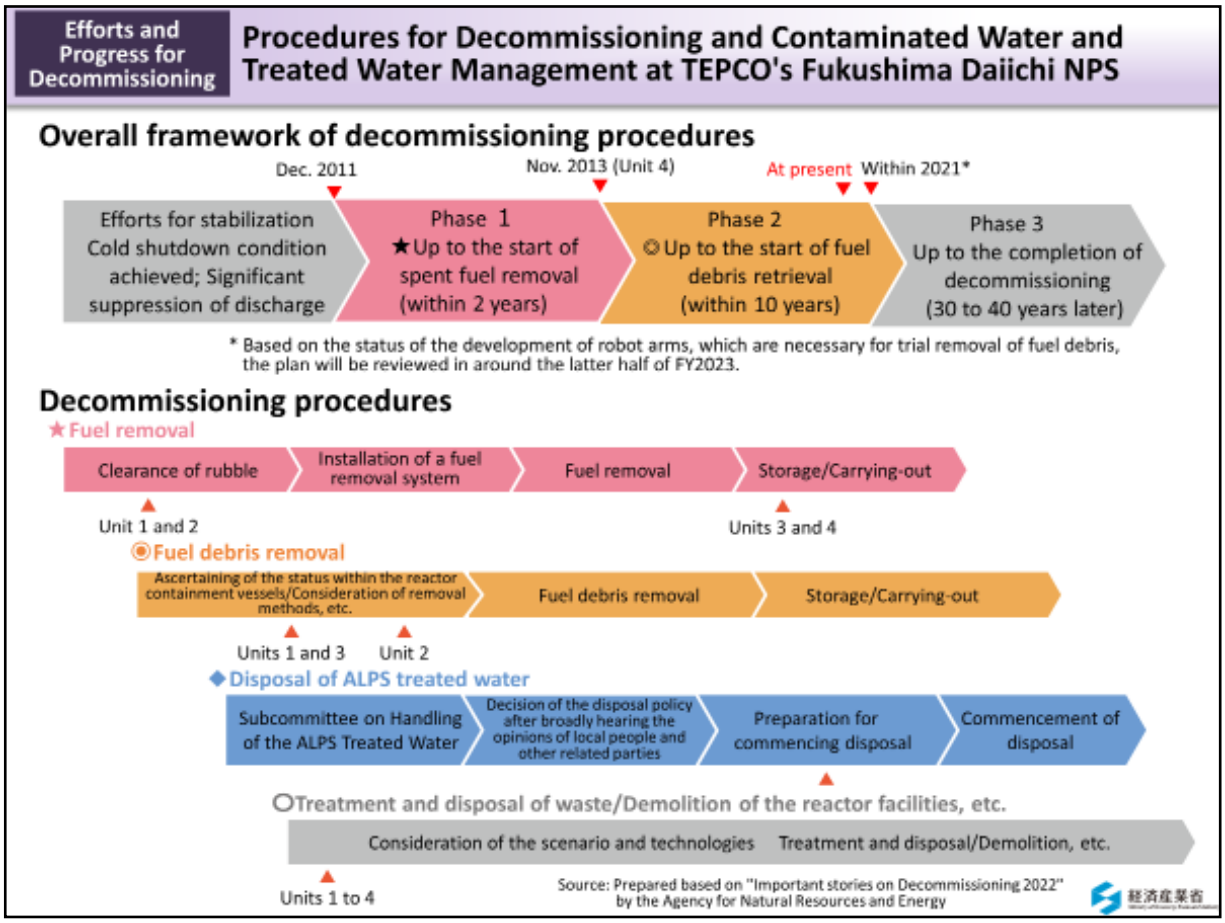


Efforts to decommission damaged nuclear reactors have been continued at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS. Since all units achieved cold shutdown condition in December 2011, the units have all remained stable and under control up until now.

Procedures for decommissioning Fukushima Daiichi NPS are unprecedentedly challenging. The Government of Japan takes the initiative to carry out measures stably and steadily in line with the Mid- and Long-term Roadmap towards the Decommissioning of Tokyo Electric Power Company Holdings' Fukushima Daiichi NPS (Mid- and Long-term Roadmap). Specifically, efforts have been made for the removal of fuel from spent fuel pools, fuel debris removal, measures for contaminated water, disposal of the ALPS treated water, treatment and disposal of waste, and demolition of reactor facilities, etc.

In December 2019, the Mid- and Long-term Roadmap was revised and the method of removing fuel debris for the first unit was finalized. The finalized plan is to commence with trial removal of the fuel debris from Unit 2 first, and then expand the scale of the removal work in stages. For completing the decommissioning by 2041 to 2051, decommissioning procedures will continuously be implemented while placing top priority on ensuring safety.[1]

1. Based on the status of the development, etc. of robot arms, which are necessary for trial retrieval of fuel debris, the plan will be reviewed in around the latter half of FY2023.

Included in this reference material on February 28, 2018
Updated on March 31, 2023

Efforts and Progress for Decommissioning

Organizations and Tasks

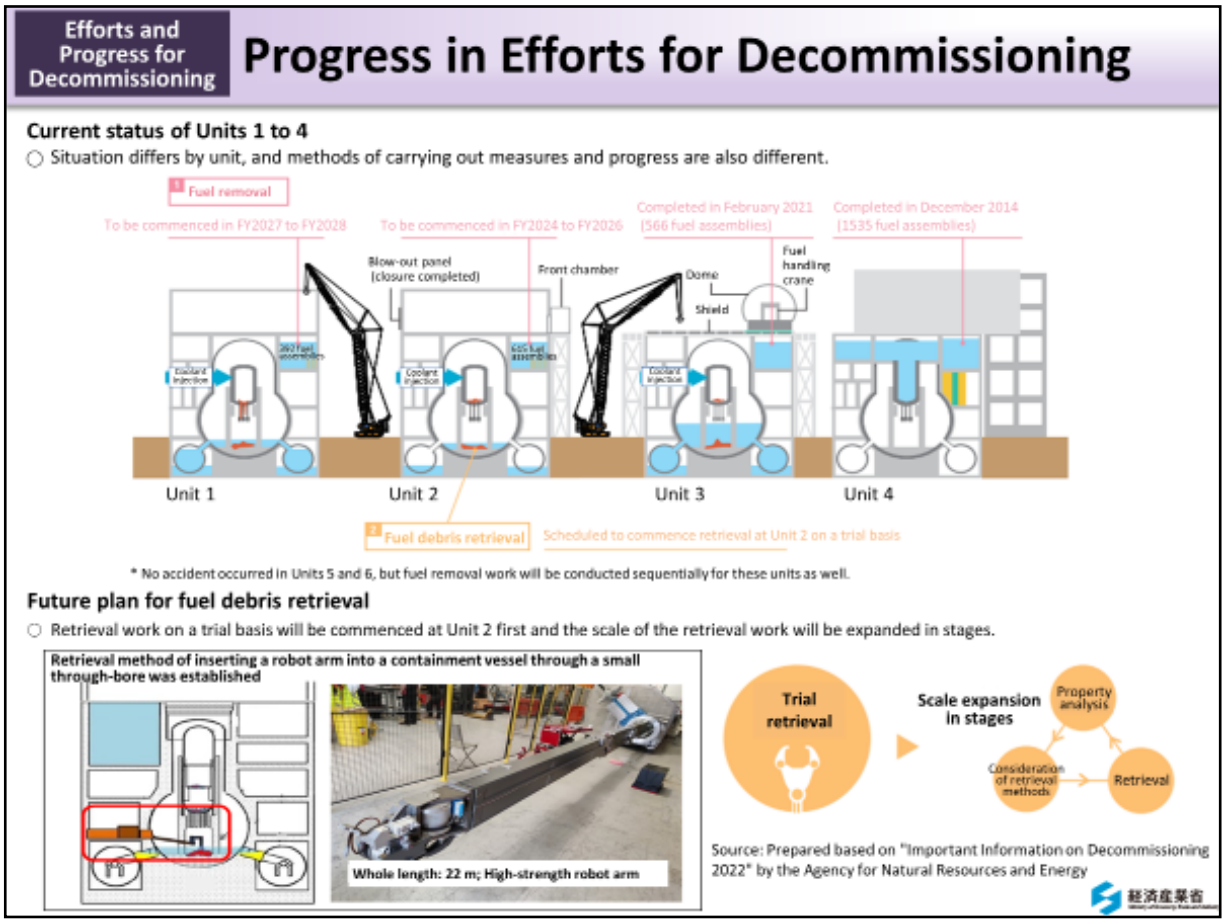
Decommissioning work is being carried out in cooperation with local companies and other organizations, as well as with the collective wisdom from Japan and abroad.

Source: Prepared based on "Important Information on Decommissioning 2022" by the Agency for Natural Resources and Energy

In proceeding with decommissioning, the national government first established a policy (Mid-and-Long-Term Roadmap towards the Decommissioning of the Tokyo Electric Power Company Holdings' Fukushima Daiichi NPS), and a system has been developed to ensure that TEPCO will steadily implement decommissioning under supervision and examination by the Nuclear Regulation Authority. In addition, the Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF) provides technical advice to TEPCO and the national government, and manages decommissioning funds under an accumulation system.

Decommissioning is an unprecedented challenge around the world. To consolidate the wisdom from Japan and abroad, in addition to the national government and TEPCO, various universities, the International Research Institute for Nuclear Decommissioning (IRID), the Japan Atomic Energy Agency (JAEA), other R&D organizations, and foreign companies are working together. Additionally, cooperation has been sought from local companies and residents in Fukushima with the aim of achieving revitalization of the local community based on technological capabilities, etc. accumulated through decommissioning work and ensuring well-balanced progress of decommissioning and reconstruction of Fukushima.

Included in this reference material on March 31, 2022
Updated on March 31, 2023



< Fuel removal from the spent fuel pool >

Removal of all fuel assemblies from the spent fuel pool was completed at Unit 4 in December 2014 and at Unit 3 in February 2021, and the risk of discharge of radioactive materials caused by the breaking down of spent fuel due to failure to cool it down was significantly reduced.

At present, at Units 1 and 2, preparatory work is being carried out while placing top priority on ensuring safety, such as the installation of large covers for further suppressing the scattering of dust at the time of clearing rubble at Unit 1 and the installation of a working platform for removing fuel at Unit 2.

< Fuel debris retrieval >

The retrieval works are scheduled to be commenced at Unit 2 first on a trial basis, and the scale will be sequentially expanded in stages.[1]

Investigations of the inside of containment vessels by using robots that were developed based on cutting-edge technologies have been conducted so far. Efforts will be continued to develop technologies necessary for those investigations and fuel debris retrieval (such as robot arms), and systems to analyze property of fuel debris and to confine radioactive materials.

1. Based on the status of the development, etc. of robot arms, which are necessary for trial retrieval of fuel debris, the plan will be reviewed in around the latter half of FY2023.

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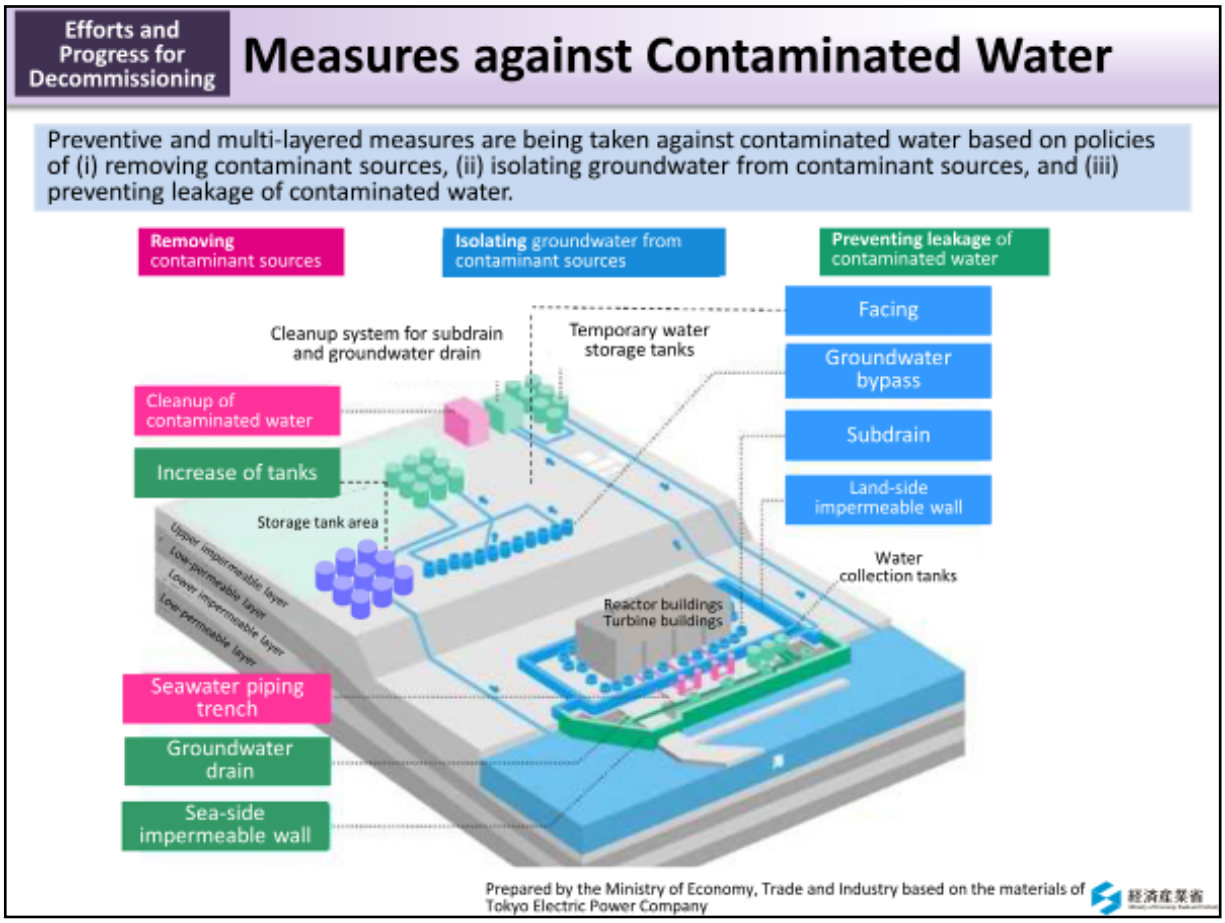
Updated on March 31, 2023



Water contaminated with radioactive materials has been treated based on the following three basic policies.

< Basic Policy 1: Removing contaminant sources >

(i) Clean up contaminated water by removing 62 types of radionuclides therefrom

(ii) Remove highly contaminated water that remains in the trench, etc.

< Basic Policy 2: Isolating water from contaminant sources >

(i) Pump up groundwater on the mountain side of the buildings to suppress inflow of groundwater around the buildings

(ii) Pump up groundwater using the well near the buildings (subdrain) to lower the groundwater level, thereby suppressing inflow of groundwater into the buildings

(iii) Construct a frozen soil wall around the buildings to suppress inflow of groundwater into the buildings

(iv) Suppress infiltration of rainwater into soil by paving the surface (facing)

< Basic Policy 3: Preventing leakage of contaminated water >

(i) Construct a sea-side impermeable wall made of steel pipes to reduce outflow of groundwater containing radioactive materials into the sea

(ii) Construct a groundwater drain in the area between the sea-side impermeable wall and the land-side impermeable wall and pump up groundwater to reduce the outflow of groundwater into the sea

(iii) In order to ensure safe storage of water after purification using ALPS and other equipment, promote storage in welded tanks with lower leakage risks

These efforts have brought about the following outcomes:

- The amount of newly generated contaminated water decreased from approx. 540 m^3/day in May 2014 to approx. 130 m^3/day in FY2021, and the goal of approx. 150 m^3/day set in the Mid- and Long-term Roadmap has been achieved.
- Treatment of the accumulated water in the buildings, except for reactor buildings, etc. for Unit 1 to Unit 3, was completed and the goal set in the Mid- and Long-term Roadmap has been achieved.
- Concentrations of radioactive materials in the port decreased significantly.

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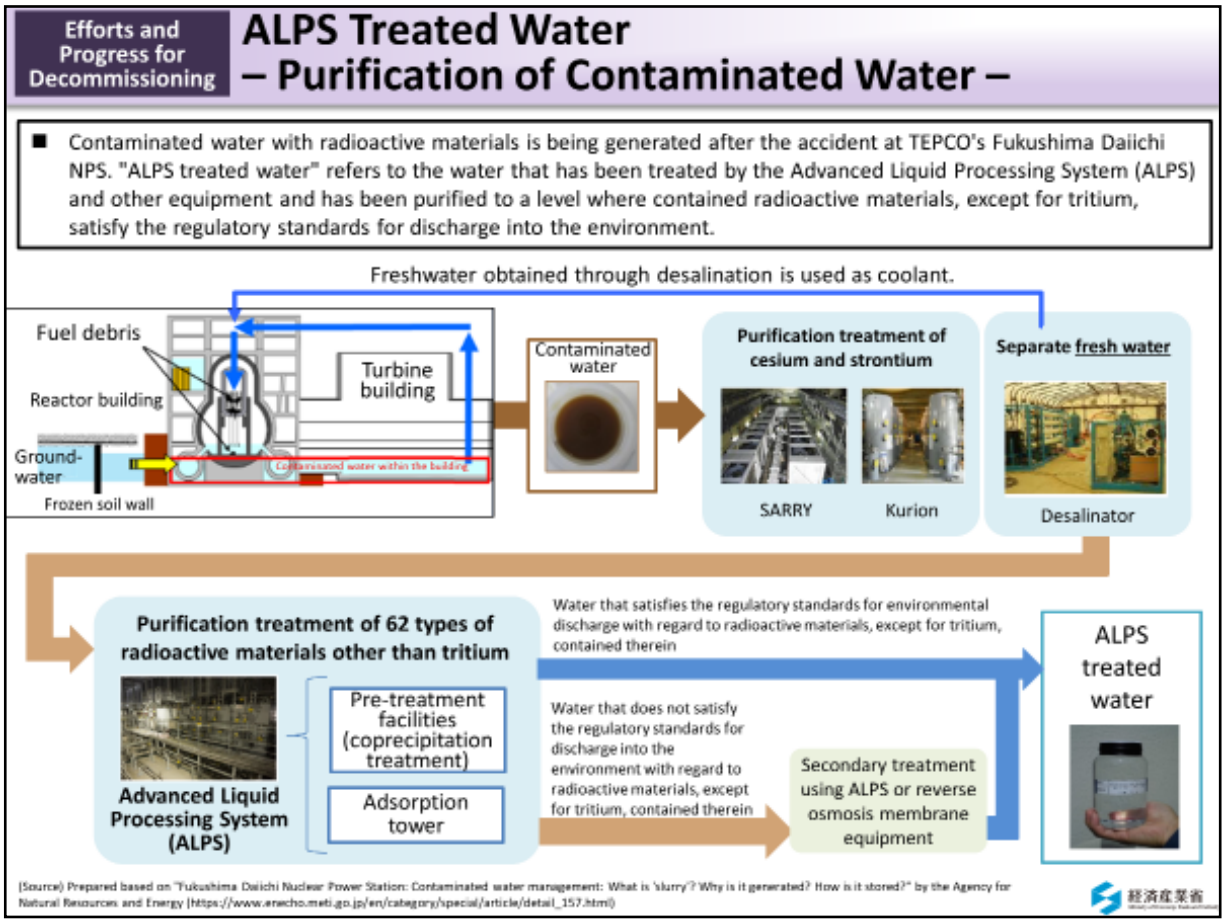

Contaminated water with radioactive materials is being generated after the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS. "ALPS treated water" refers to the water that has been treated by the Advanced Liquid Processing System (ALPS) and other equipment and has been purified to a level where contaminated radioactive materials, except for tritium, satisfy the regulatory standards for discharge into the environment.

At the NPS, as water is being injected continuously in order to cool melted and solidified fuel left within the reactor (fuel debris) and due to the inflow of rainwater and groundwater into the reactor building, water containing radioactive materials at high concentrations continues to be generated.

For such contaminated water, purification is conducted to remove radioactive materials using multiple types of equipment for the purpose of reducing the risks posed thereby. First, cesium and strontium are purified by the use of devices called SARRY and Kurion. Then, the water goes through a desalinator and clean water is separated and later used for cooling the reactor. The concentrated water is purified using ALPS to a level where the targeted 62 types of radioactive materials, except for tritium, satisfy their regulatory standards. Radioactive materials such as cesium, strontium, iodine, and cobalt are purified by ALPS through co-precipitation treatment using solutions and adsorption on activated carbon and adsorbents. Almost all radioactive materials are removed through repeated treatment by ALPS, but tritium, which is a radioisotope of hydrogen, exists as a part of the water molecule and cannot be removed through treatment by ALPS and other equipment.

Water treated in this manner has been stored in tanks installed within the premises of TEPCO's Fukushima Daiichi NPS. However, as of January 2024, approximately 70% of the water stored in tanks still contained radioactive materials at concentrations exceeding the regulatory standards, in addition to tritium, due to such reasons as failures in purification equipment that occurred in the past and emergency purification treatment prioritizing the treatment amount in order to promptly reduce the impact of contaminated water on the surrounding areas. For such approximately 70% of the stored water, further treatment is to be conducted using ALPS or using reverse osmosis membrane equipment till it meet the definition of "ALPS treated water" which satisfies the regulatory standards for discharge into the environment other than tritium. (Related to p.14 of Vol. 2, "Treatment Method for Water Stored in Tanks")

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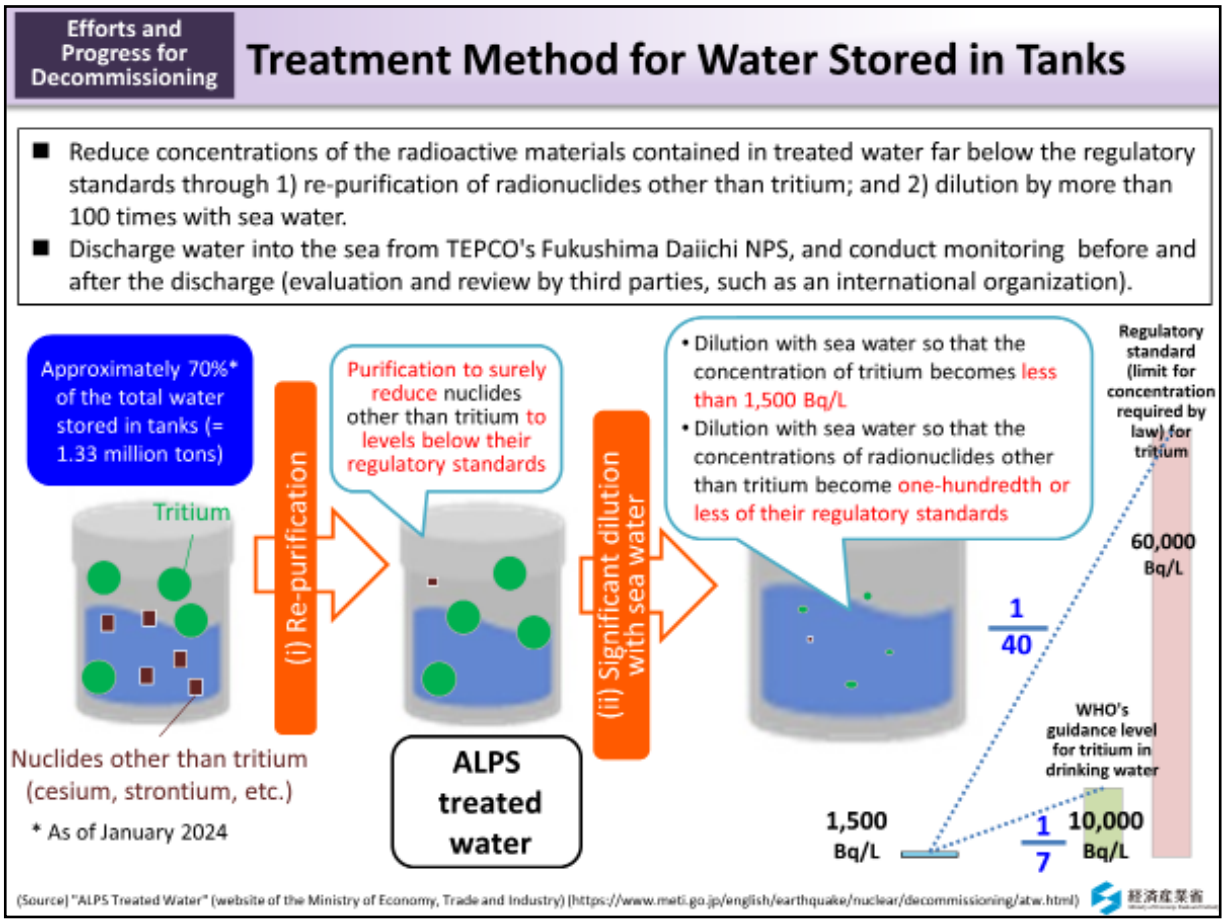

On April 13, 2021, the Government of Japan defined “ALPS treated water” as water wherein radionuclides other than tritium satisfy “their regulatory standards for discharge into the environment”, and announced its basic policy to discharge ALPS treated water into the sea. On August 22, 2023, the Government of Japan decided to commence the discharge of ALPS treated water into the sea as presented in the basic policy, and the discharge was commenced on August 24, 2023. The basic policy provides that ALPS treated water is to be discharged into the sea after diluting it by more than 100 times with sea water to reduce the concentration of tritium contained therein to less than 1,500 Bq/L. This value of 1,500 Bq/L is one-fortieth of the regulatory standard (limit for concentration required by law) for tritium that is applied to NPSs under operation and is around one-seventh of the WHO’s guidance level for tritium in drinking water (Guidelines for Drinking-Water Quality). Through this dilution, nuclides other than tritium are also diluted to below one hundredth of the regulatory standards for discharge into the environment (the sum of ratios of concentrations required by law). (Related to p.15 of Vol. 2, “Regulatory Standards for Discharging Radioactive Materials into the Environment”)

Water treated by ALPS and other equipment has been stored in tanks installed within the premises of Tokyo Electric Power Company (TEPCO)’s Fukushima Daiichi NPS after the accident. However, as of January 2024, approximately 70% of the water stored in tanks still contained radioactive materials at concentrations exceeding the regulatory standards, in addition to tritium. Such water does not meet the definition of “ALPS treated water.” This is because in around 2013, when the operation of ALPS commenced, (i) its purification capacity was inferior, and (ii) as an enormous amount of contaminated water was generated, the priority was placed on first satisfying the regulatory standards for the storage within the NPS premises in order to reduce radiation risks as promptly as possible.

Accordingly, in line with the basic policy, before discharging the water stored in tanks into the sea, purification by using ALPS or reverse osmosis membrane equipment is to be conducted again (secondary treatment) to satisfy the regulatory standards for environmental discharge, which are stricter than the regulatory standards for the storage within the NPS premises. The performance test on secondary treatment, which Tokyo Electric Power Company Holdings conducted from September 2020, confirmed that nuclides other than tritium can be purified to levels below the regulatory standards for environmental discharge.

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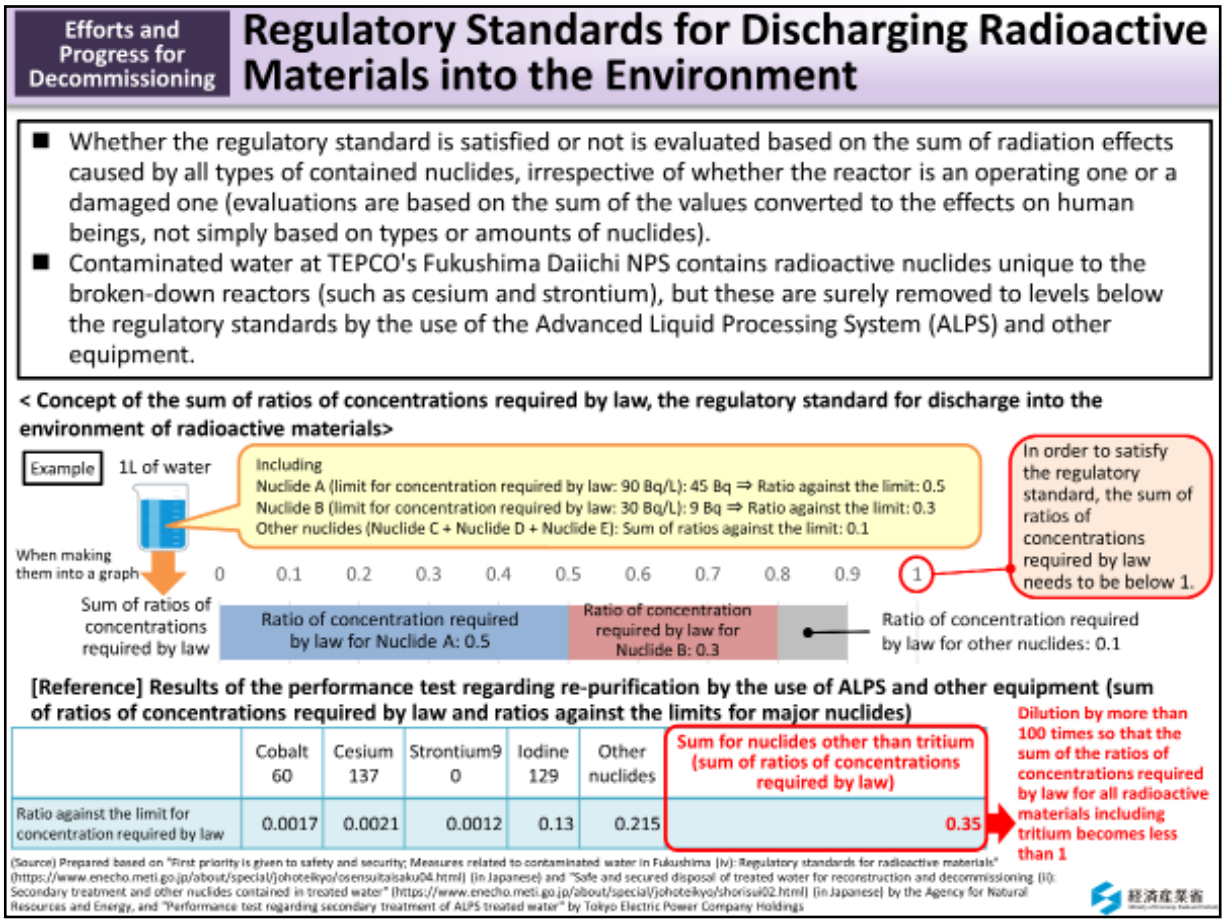


Regulatory standards for radioactive materials contained in liquid and gaseous waste that are discharged into the environment from nuclear power stations, etc. in Japan are set on the basis that an annual public exposure dose additionally caused by discharged radioactive materials (effects on human bodies) will not exceed 1 mSv, according to the recommendations of the International Commission on Radiological Protection (ICRP). More specifically, the maximum concentration for a radioactive material is set so that, supposing that a person continues to drink 2L of water containing that type of radioactive material every day from birth until becoming 70 years old, the resulting dose rate becomes 1 mSv per year on average. The limit thus set for each radioactive material is called the "limit for concentration required by law."

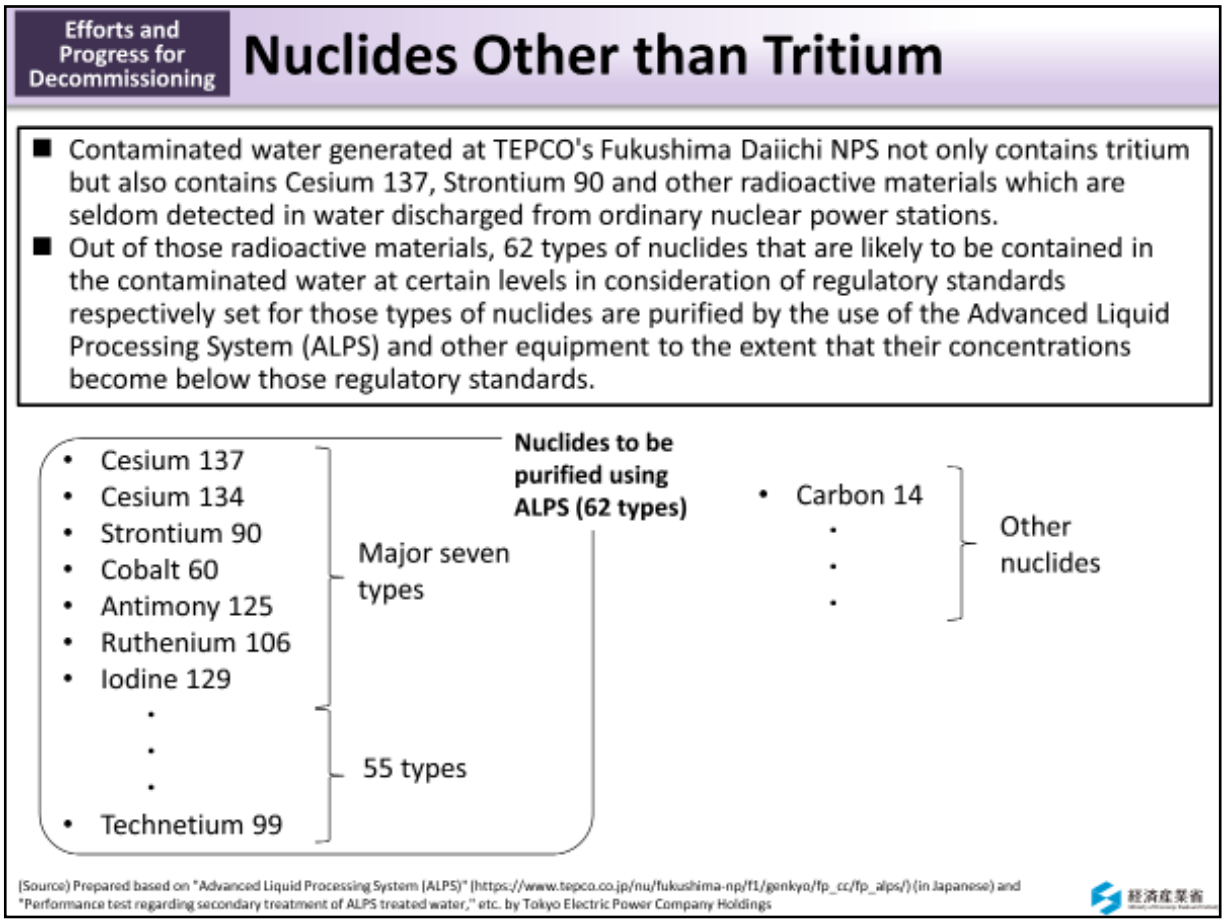
Generally, liquid and gaseous waste discharged from a nuclear power station, etc. contains multiple radionuclides. Therefore, when effects of multiple radionuclides are supposed, the concept of *the sum of ratios of concentrations required by law* as described in Ministerial Notice is adopted in comprehensive consideration of the effects of all radionuclides contained in the waste. Concentration levels are regulated so that the sum does not exceed 1.

When disposing of ALPS treated water, whether *the sum of ratios of concentrations required by law* thus obtained is below 1 is to be checked in the same manner as for other nuclear power stations, etc. currently under operation. At Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, treatment using ALPS and other equipment is conducted to reduce concentrations of radioactive materials other than tritium, including those unique to the damaged reactors (such as cesium and strontium), so that their concentrations do not exceed the regulatory standards. ALPS treated water which started to be discharged on August 24, 2023, revealed that *the sum of ratios of concentrations required by law* for nuclides other than tritium was 0.28.

Also with regard to tritium, which is difficult to remove by ALPS or other equipment, dilution for reducing its concentration (by 100 times or more with sea water) is conducted in order to ensure that the sum of ratios of concentrations required by law for all radioactive materials, including tritium, remains below 1. Through the dilution, concentrations of nuclides contained in ALPS treated water other than tritium, which are already reduced to below their regulatory standards, are also reduced by 100 times or more and safety can be further ensured.

Annual radiation effects when discharging ALPS treated water into the sea after dilution were assessed to be approx. 1/1,000,000 to approx. 1/70,000 of the exposure doses (2.1 mSv/y) of Japanese people from natural radiation (assessment results as of February 2023). (Related to p.18 of Vol. 2, "Assessment of the Radiological Impact of Discharge of ALPS Treated Water into the Sea")

Included in this reference material on March 31, 2022
Updated on March 31, 2023



Contaminated water generated at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS contains not only tritium but also Cesium 137, Strontium 90 and other radioactive materials. These types of radioactive materials normally remain in nuclear fuel rods at ordinary nuclear power stations and are seldom detected in water discharged therefrom. (Related to p.30 of Vol. 1, "Products in Nuclear Reactors")

Regarding these radioactive materials, purification using the Advanced Liquid Processing System (ALPS) and other equipment is conducted prior to discharge into the sea to reduce their concentrations to levels below their regulatory standards, and then, dilution by 100 times or more is conducted together with tritium. Through these procedures, concentrations of radioactive materials that were contained in contaminated water are reduced to less than 1/100 of the regulatory standards when the water is actually discharged.

In ALPS treated water after purification using ALPS and other equipment but before dilution, concentrations of many of the contained nuclides other than tritium are reduced to levels below detection limits. There remains the possibility that Cesium 134/137, Cobalt 60, Ruthenium 106, Antimony 125, Strontium 90, Iodine 129, Technetium 99, Carbon 14, etc., may be detected but at concentrations below the regulatory standards.

Regulatory standards for radioactive materials contained in liquid and gaseous waste that are discharged into the environment from nuclear power stations, etc. in Japan are set based on the total effects by all radioactive materials contained in waste, not based on the types of contained nuclides, and even if some types of these nuclides are detected, they do not necessarily have effects on human bodies and the environment. Incidentally, other nuclear power stations and reprocessing facilities inside and outside Japan also discharge waste containing radioactive materials into the sea or rivers or into the air through ventilation, etc. in compliance with the laws and regulations of respective countries.

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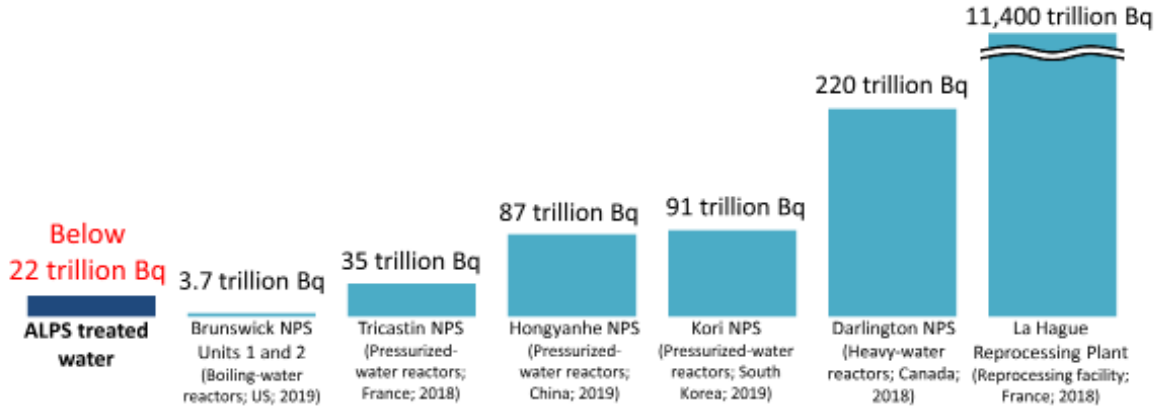
Efforts and Progress for Decommissioning

Annual Discharge Amounts of Tritium - International Comparison -

- The total amount of tritium at the time of discharge of ALPS treated water is below 22 trillion Bq per year (operational target value prior to the accident).
- Tritium is discharged as liquid waste into the sea or rivers or into the air through ventilation, etc. also at other nuclear power stations and reprocessing facilities inside and outside Japan in compliance with the laws and regulations of respective countries.



Annual discharge amounts of tritium (liquid) from ALPS treated water and at nuclear facilities around the world

(Source) Prepared based on "ALPS Treated Water" on the website of the Ministry of Economy, Trade and Industry (https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/atw.html)

For discharging ALPS treated water into the sea, the Government of Japan has published the policy of maintaining the annual total discharge of tritium at a level below the operational target value that was adopted at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS prior to the accident (22 trillion Bq per year).

Tritium is also generated at other nuclear power stations and reprocessing facilities inside and outside Japan and is discharged as liquid waste into the sea or rivers or into the air through ventilation, etc. in compliance with laws and regulations of respective countries.

As shown in the graph above, the limit for the total annual discharge of tritium upon discharge of ALPS treated water, 22 trillion Bq or lower, is at a low level, compared with the amounts discharged from many of the nuclear power stations, etc. outside Japan.

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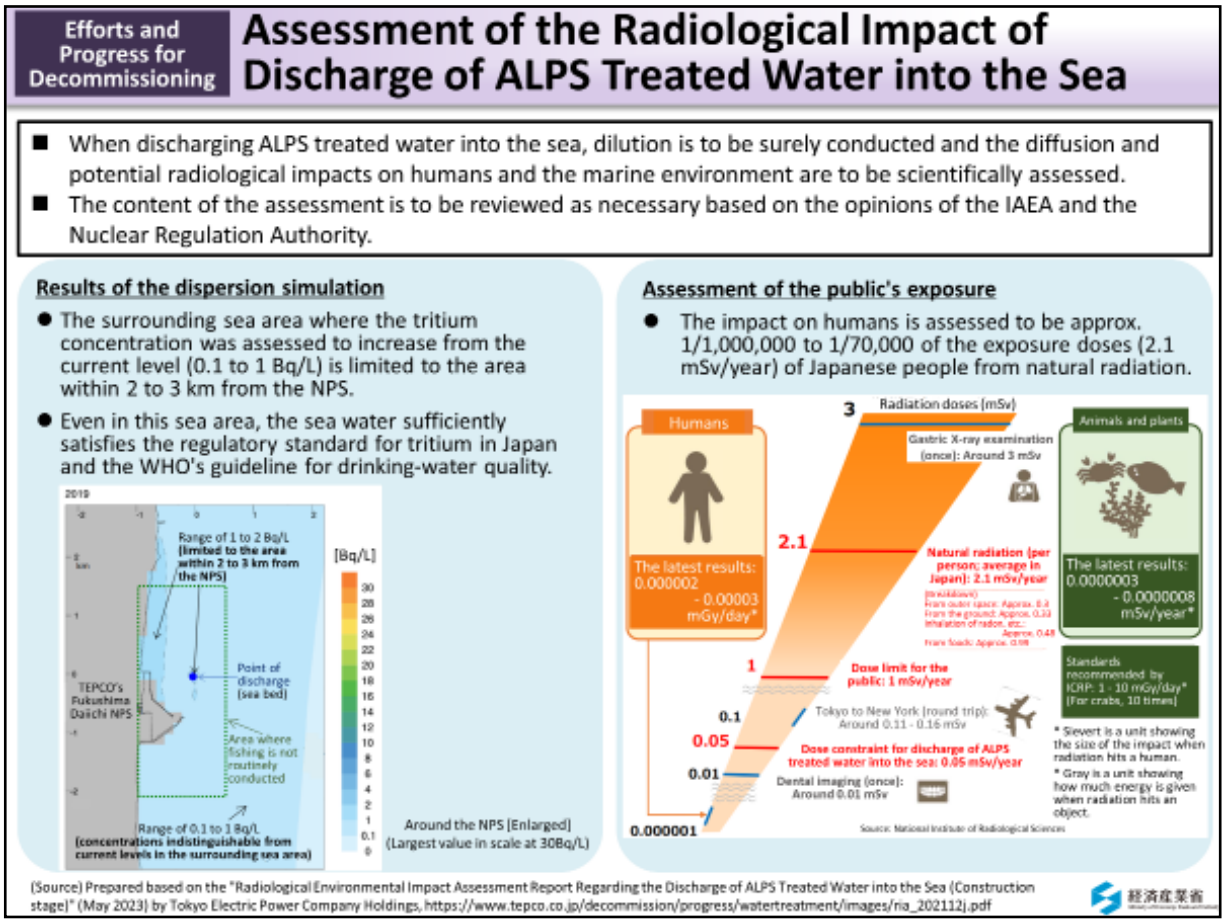

Following the basic policy, which the Government of Japan announced in April 2021, Tokyo Electric Power Company Holdings conducted assessment on the radiological environmental impact when discharging ALPS treated water into the sea in accordance with internationally recognized methods (as found in the International Atomic Energy Agency (IAEA) Safety Standard documents and International Commission on Radiological Protection (ICRP) recommendations). The assessment was revised based on opinions received from Japan and abroad through a public comment procedure, observations in IAEA reviews and discussions with Nuclear Regulation Authority. The assessment result indicated that the impact on humans and the environment is minimal.

■ Results of the dispersion simulation in the sea (using the atmospheric and hydrographic data for 2019; annual average)

- The area where the concentration of tritium was assessed to be higher than that in seawater (0.1 to 1 Bq/L) in the current surrounding sea area is limited to the area within 2 to 3 km around the NPS.
- Tritium concentration assessed to be around 30 Bq/L was observed in some areas near the discharge outlet, but the concentration decreased rapidly in the vicinity of those areas. Even the tritium concentration of 30 Bq/L is sufficiently lower than 10,000 Bq/L, which is the standard level specified in the WHO Guidelines for Drinking Water Quality.

■ Results of radiological impact assessment on humans and the environment (assessment results as of February 2023)

- The impact on humans was assessed to be approx. 1/1,000,000 to 1/70,000 of the exposure doses (2.1 mSv/y) of Japanese people from natural radiation.
- The impact on plants and animals (flatfish, crabs, and brown algae) was assessed to be approx. 1/3,000,000 to 1/1,000,000 of the standard values at which impact could occur in living organisms as specified by ICRP. (Result of the assessment regarding crabs was approx. 1/30,000,000 to 1/10,000,000)

(Source)
Prepared based on the “Radiological Environmental Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (Construction stage/Revised version)” (February 2023) by Tokyo Electric Power Company Holdings
https://www.tepco.co.jp/press/release/2022/pdf4/221114j0101.pdf#page=289

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Efforts and Progress for Decommissioning

Sea Area Monitoring in Relation to ALPS Treated Water

- Since 2022, before commencing the discharge, relevant ministries and agencies, the nuclear operator, and others have conducted sea area monitoring in relation to ALPS treated water. Immediately after commencing the discharge in August 2023, they strengthened and expanded the structure for sea area monitoring by such means as increasing analysis frequencies and locations.
- The reliability of the analyses is being ensured with the assistance of the IAEA.
- As of December 2023, it was confirmed that tritium concentrations were sufficiently low and would have no adverse impact on human health and the environment.

< Monitoring of sea water, marine biota and fishery products regarding ALPS treated water >

Extract of monitoring plan for FY2023 (immediately after commencing the discharge)

[Sea water (conducted by the Ministry of the Environment and the Nuclear Regulation Authority)]

(i) Precise analysis of tritium
- Conduct analysis basically four times a year
- For the time being after commencing the discharge, additionally conduct analysis at three locations once a month
- Also conduct analysis at six bathing beaches close to the outlet

(ii) Rapid analysis of tritium
- For the time being after commencing the discharge, conduct analysis at 11 locations once a week

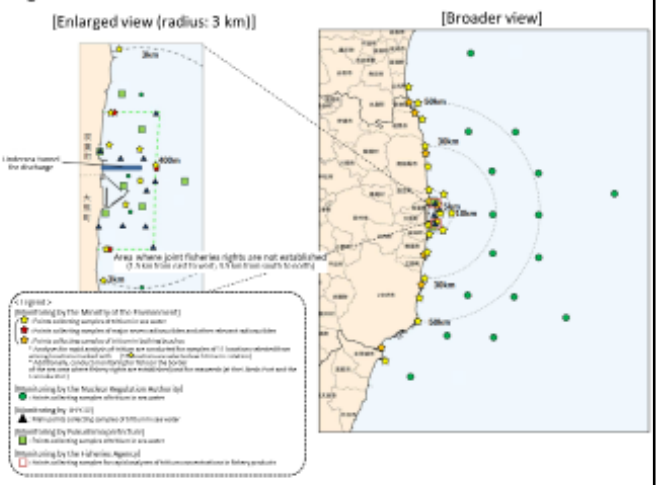
(iii) Analysis of radionuclides other than tritium
- Conduct analysis for relevant radionuclides other than tritium basically four times a year
- For the time being after commencing the discharge, additionally conduct analysis at three locations once a week

[Marine biota (conducted by the Ministry of the Environment)]

(i) Fish
- Conduct analysis for fish collected at three locations closest to the outlet in the sea area where fisheries are conducted ordinarily
- Analyze the concentrations of tritium and Carbon-14 four times a year

(ii) Seaweeds
- Conduct analysis for seaweeds collected at two locations close to the outlet
- Analyze the concentrations of Iodine-129 four times a year

[Fisheries products (conducted by the Fisheries Agency)]
- Measure the concentration of tritium for approx. 380 samples per year



Points collecting samples for sea area monitoring by the relevant organizations

(Source) Prepared based on "Comprehensive Radiation Monitoring Plan (revised on March 16, 2023)" (Monitoring Coordination Meeting) (https://radioactivity.nra.go.jp/en/contents/17000/16273/24/274_20230412.pdf), and "Status of Monitoring by MOE" (MOE's website) (https://www.env.go.jp/content/000183685.pdf) (in Japanese), and "Sea Area Monitoring regarding ALPS Treated Water" (NRA) (https://www.nra.go.jp/data/000457798.pdf) (in Japanese)

From the perspective of securing safety and thoroughly ensuring measures against reputational damage upon the discharge of ALPS treated water, the national government and other relevant organizations have been conducting sea area monitoring. The monitoring has been conducted while ensuring the reliability of the relevant organizations' analytical abilities with the assistance of the IAEA.

Since FY2022 before commencing the discharge, monitoring has been conducted, and after the commencement, the structure for monitoring was strengthened and expanded. Specifically, sampling locations and analysis frequencies were increased, and rapid analyses came to be conducted in addition to conventional precise analyses.

When monitoring detects any incident, such as a radioactive concentration exceeding the discharge suspension level, TEPCO is committed to making responses appropriately, including the immediate suspension of the discharge based on the Implementation Plan it had formulated.

Results of monitoring concerning tritium, etc. conducted by relevant ministries and agencies are published on the webpage titled "ALPS Treated Water Sea Area Monitoring Information. The government of Japan will continue making efforts to provide information domestically and internationally in a transparent and easy-to-understand manner.

ALPS Treated Water Marine Monitoring Information
https://shorisui-monitoring.env.go.jp/en/

(Source) Prepared based on "Comprehensive Radiation Monitoring Plan (revised on March 16, 2023)" (Monitoring Coordination Meeting) (https://radioactivity.nra.go.jp/en/contents/17000/16273/24/274_20230412.pdf),
and "Status of Monitoring by MOE" (MOE's website) (https://www.env.go.jp/content/000183685.pdf) (in Japanese),
and "Sea Area Monitoring regarding ALPS Treated Water" (NRA) (https://www.nra.go.jp/data/000457798.pdf) (in Japanese)

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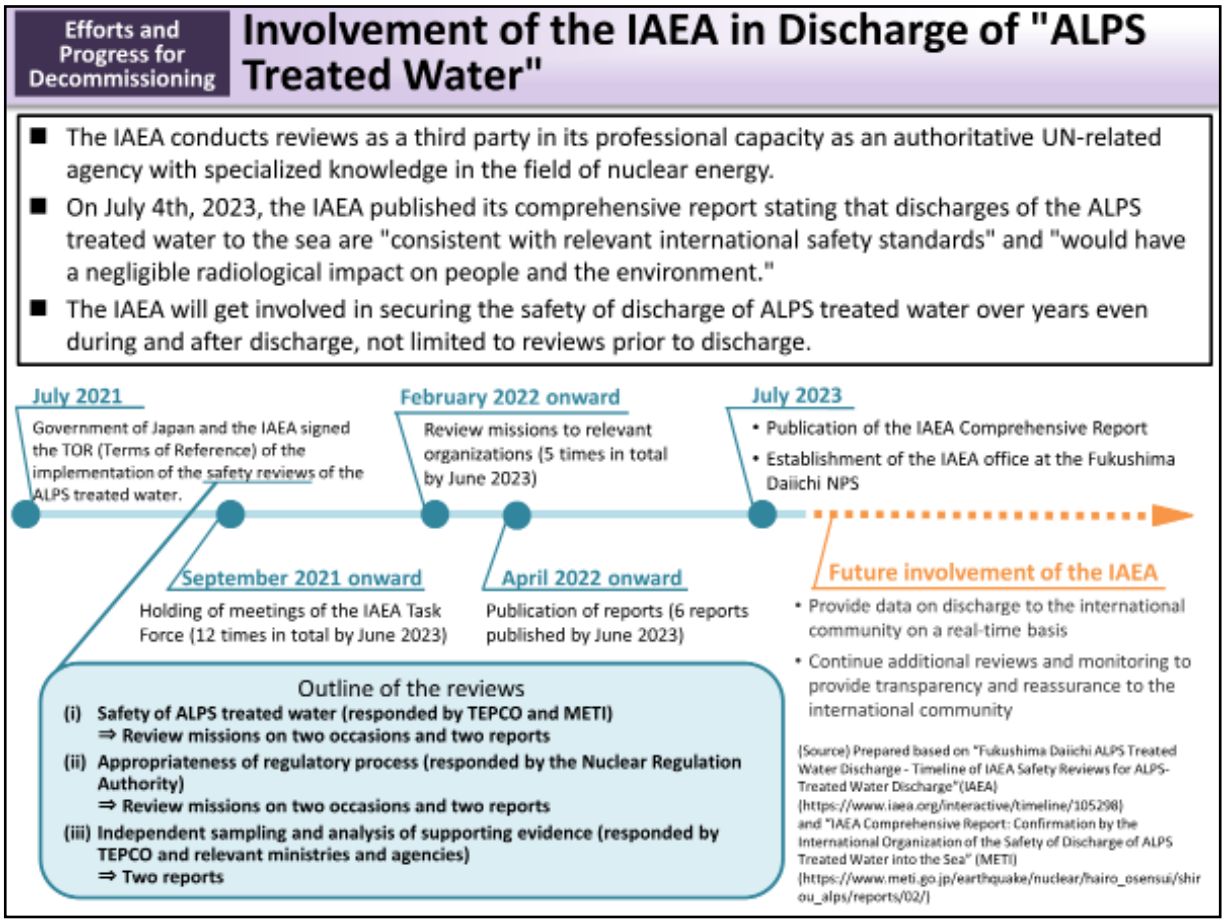

The government of Japan has asked the IAEA for support to review Japan's plans and activities for the discharge of ALPS treated water so that the treated water can be discharged in a safe and highly-transparent manner in compliance with the IAEA international safety standards. Accepting this request of the government of Japan, the IAEA will conduct technical reviews as to whether ALPS treated water is discharged in compliance with the IAEA international safety standards over the coming several decades. In order to sufficiently secure key elements regarding safety, the reviews consist of the following three major items.

1. Intensively evaluate the property of ALPS treated water and discharge plans, especially focused on safety
2. Check responses of the Nuclear Regulation Authority, which is responsible for nuclear safety regulations
3. Corroborate the data published by the government of Japan by independently conducting monitoring of radioactive materials in ALPS treated water and the environment

From February 2022 to June 2023, the IAEA conducted multiple review missions and published reports for the purpose of publicizing the progress. Based on the observations by the Task Force, TEPCO revised the Implementation Plan and reports on the assessment of radiological impacts on humans and the environment to further improve the content thereof.

In July 2023, the IAEA published its comprehensive report, which concludes that discharges of the ALPS treated water into the sea are "consistent with relevant international safety standards" and "would have a negligible radiological impact on people and the environment" (p.21 of Vol. 2, "IAEA Comprehensive Report on the Safety of 'ALPS Treated Water'"). This report states as follows.

- The IAEA will maintain an onsite presence at Fukushima Daiichi NPS throughout its review and will provide real-time and near real-time monitoring data on discharges to the international community.
- Additional review and monitoring activities will be continued to provide additional transparency and reassurance to the international community.

The report presents the IAEA's commitment to engaging with Japan on the discharge of ALPS treated water not only before, but also during, and after the treated water discharges occur, aiming to secure the safety of discharge over years.

The IAEA's reports are published on the following website:
IAEA Fukushima Daiichi ALPS Treated Water Discharge - Reports
https://www.iaea.org/topics/response/fukushima-daiichi-nuclear-accident/fukushima-daiichi-alps-treated-water-discharge/reports

(Source)
Prepared based on

- "The IAEA confirmed the safety of discharge of ALPS treated water into the sea" (July 2023)
  https://www.meti.go.jp/earthquake/nuclear/hairo_osensui/shirou_alps/reports/02/ (in Japanese)
- "The IAEA Published a Report on Its February Review Mission of Safety Aspects of Handling of ALPS Treated Water at Fukushima Daiichi Nuclear Power Station" (April 2022)
  https://www.meti.go.jp/english/press/2022/0429_001.html

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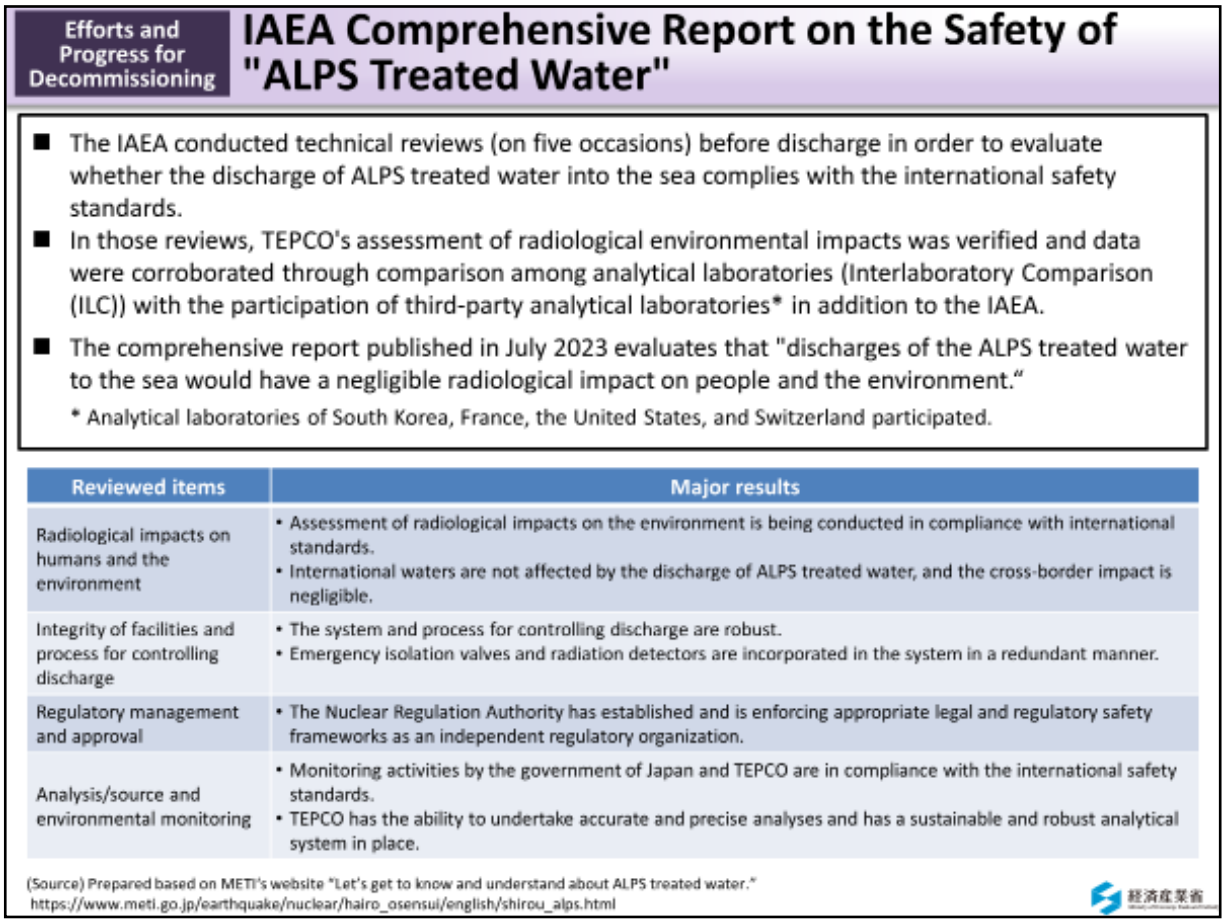

Efforts and Progress for Decommissioning

IAEA Comprehensive Report on the Safety of "ALPS Treated Water"

- The IAEA conducted technical reviews (on five occasions) before discharge in order to evaluate whether the discharge of ALPS treated water into the sea complies with the international safety standards.
- In those reviews, TEPCO's assessment of radiological environmental impacts was verified and data were corroborated through comparison among analytical laboratories (Interlaboratory Comparison (ILC)) with the participation of third-party analytical laboratories* in addition to the IAEA.
- The comprehensive report published in July 2023 evaluates that "discharges of the ALPS treated water to the sea would have a negligible radiological impact on people and the environment."

* Analytical laboratories of South Korea, France, the United States, and Switzerland participated.

Reviewed items	Major results
Radiological impacts on humans and the environment	• Assessment of radiological impacts on the environment is being conducted in compliance with international standards. • International waters are not affected by the discharge of ALPS treated water, and the cross-border impact is negligible.
Integrity of facilities and process for controlling discharge	• The system and process for controlling discharge are robust. • Emergency isolation valves and radiation detectors are incorporated in the system in a redundant manner.
Regulatory management and approval	• The Nuclear Regulation Authority has established and is enforcing appropriate legal and regulatory safety frameworks as an independent regulatory organization.
Analysis/source and environmental monitoring	• Monitoring activities by the government of Japan and TEPCO are in compliance with the international safety standards. • TEPCO has the ability to undertake accurate and precise analyses and has a sustainable and robust analytical system in place.

(Source) Prepared based on METI's website "Let's get to know and understand about ALPS treated water."
https://www.meti.go.jp/earthquake/nuclear/hairo_osensui/english/shirou_alps.html

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In response to the request of the government of Japan, the IAEA conducted reviews in and after February 2022 from the viewpoints of (i) safety of ALPS treated water, (ii) appropriateness of the regulatory process, and (iii) independent sampling and analysis of supporting evidence. The results of the reviews were published as reports in and after April 2022, and the comprehensive report summarizing the reviews was published on July 4, 2023. International experts from 11 countries participated in the reviews, in addition to the experts of the IAEA.

In the review concerning (i), data provided by TEPCO and the Ministry of Economy, Trade and Industry (METI) concerning eight technical matters, including TEPCO's radiological environmental impacts assessment, were verified. In the review concerning (ii), the details of the examinations and inspections being conducted by the Nuclear Regulation Authority were checked. In the review concerning (iii), the IAEA conducted independent monitoring of radioactive materials in ALPS treated water and the environment and verified data published by the Japan side.

The comprehensive report summarizing the results of these reviews concludes that the approach to and activities for the discharge of ALPS treated water taken by TEPCO, the Nuclear Regulation Authority, and the government of Japan are consistent with relevant international safety standards. Additionally, it concludes that discharges of the ALPS treated water to the sea would have a negligible radiological impact on people and the environment. On the other hand, the report points out the necessity to assess the consistency of activities during the operation of the ALPS treated water discharges with relevant international safety standards at various times. Given these, the IAEA presents its commitment to being involved even after the commencement of ALPS treated water discharges to secure the safety thereof.

(Source)
Prepared based on
- IAEA, "IAEA COMPREHENSIVE REPORT ON THE SAFETY REVIEW OF THE ALPS-TREATED WATER AT THE FUKUSHIMA DAIICHI NUCLEAR POWER STATION" (July 2023)
  https://www.iaea.org/sites/default/files/iaea_comprehensive_alps_report.pdf
- METI's website "Let's get to know and understand about ALPS treated water."
  https://www.meti.go.jp/earthquake/nuclear/hairo_osensui/english/shirou_alps.html

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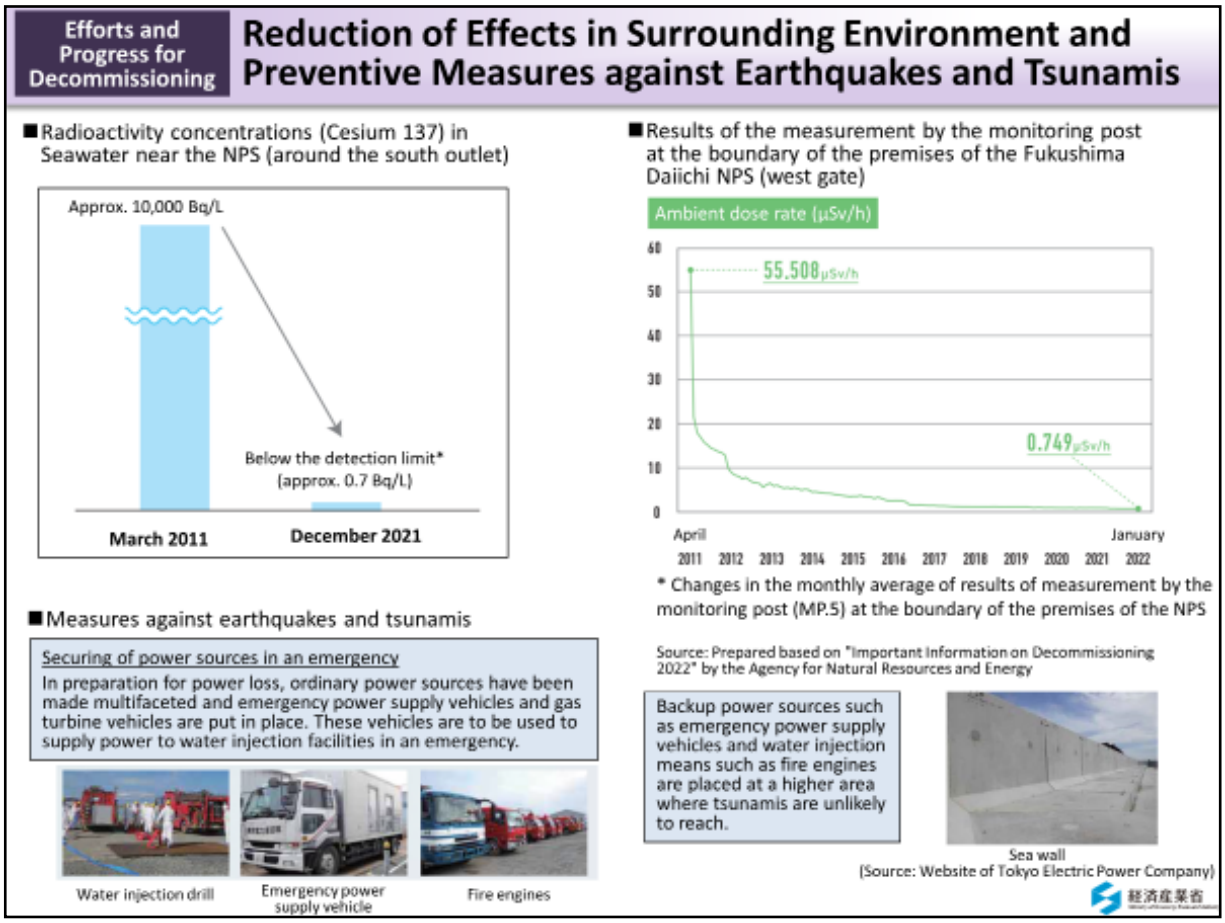

During work, the monitoring of changes in radiation doses at work sites and the monitoring of water and air at the boundary of the premises of the NPS have simultaneously been conducted regularly. In preparation for any event of an abnormal increase in ambient dose rates or concentrations of radioactive materials in dust, a system for promptly reporting the incident has been put in place.

As measures against earthquakes and tsunamis, computer analysis has confirmed that important buildings will not collapse even in the event of an earthquake of the same magnitude as the Great East Japan Earthquake. In addition, a sea wall against a Chishima-trench Tsunami was installed in September 2020. Additionally, a sea wall against a Japan-trench Tsunami, which is expected to be larger, is being constructed at present. While the work to block the openings of the buildings to prevent the inflow of seawater in the event of a tsunami has been completed, backup power sources such as emergency power supply vehicles have been provided and water injection means such as fire engines are placed at a higher area where tsunamis are unlikely to reach.

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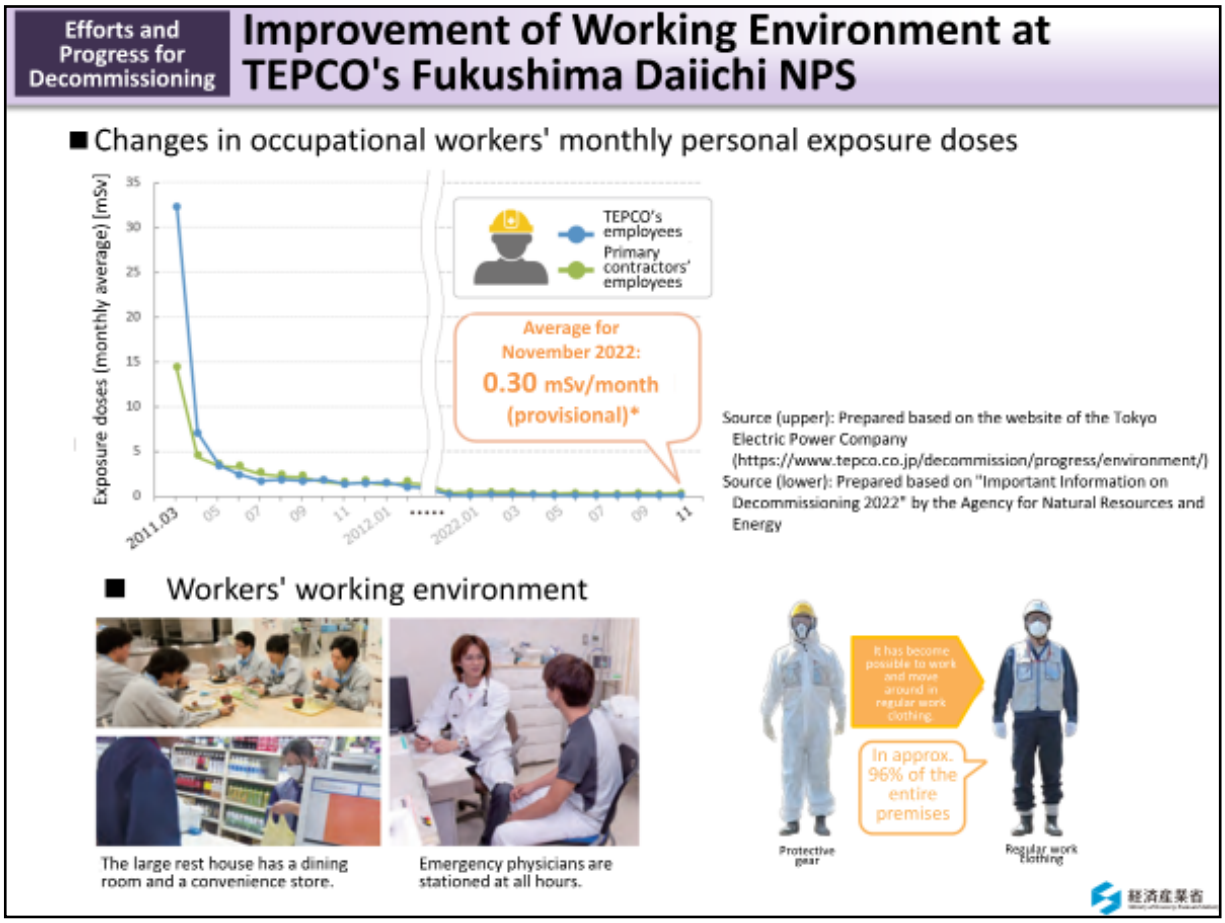

In order to improve safety and workability by reducing workers' load, efforts to improve the working environment for such work as rubble removal and covering of slopes and sites, etc. with mortar have been made at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS. As a result, areas where workers can work in regular work clothing expanded to approx. 96% of the entire premises in June 2018.

Furthermore, in November 2018 onward, it became possible for residents to attend a tour of the NPS and observe Units 1 to 4 from a height in ordinary clothing without wearing a mask.

Along with efforts to improve the working environment, etc., reduction of exposure doses has been implemented. The average exposure dose in November 2023 was 0.30 mSv/month, which is sufficiently low compared to the value of 1.67 mSv/month, calculated from the dose limit of 100 mSv per 5 years (p.169 of Vol. 1, "Application of Dose Limits"). Not only radiation control but also comprehensive occupational health management, including countermeasures against heatstroke and infectious diseases, are conducted to ensure the health and safety of workers. Additionally, long-term health management has also been implemented for emergency workers, etc.

In May 2015, a large rest house was opened, and workers are served hot meals prepared at the food service center and can take a shower and buy things at a convenience store. They can thus work under normal working conditions, except for a certain zone, at present.

The facility that manages access to and from the Fukushima Daiichi NPS is equipped to provide emergency medical care 24 hours a day in case of any accident. A heliport has also been constructed so as to ensure prompt transportations to external medical facilities in an emergency.

Included in this reference material on February 28, 2018
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