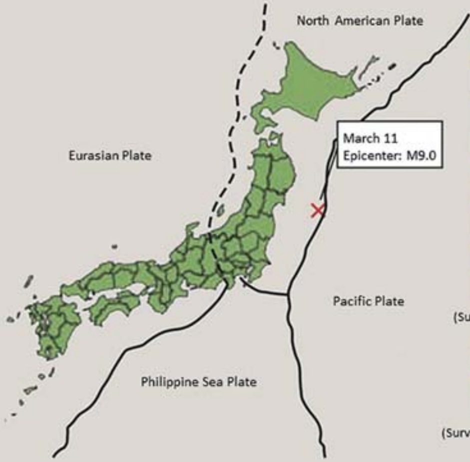
Fukushima Daiichi Nuclear Power Station (NPS) Accident

Damage due to the Great East Japan Earthquake

- ○ A 9.0-magnitude earthquake occurred off the coast of Sanriku at 14:46 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	15,899
Missing	2,526
Injured	6,167

Damage to buildings	
Completely destroyed	122,000
Half destroyed	283,117
Partially destroyed	731,573

(Surveyed by the National Police Agency; as of March 10, 2021)

Disaster victim support	
Evacuees nationwide	38,882

(Surveyed by the Reconstruction Agency; as of December 9, 2021)

A big earthquake centered off the coast of Sanriku occurred, at 14:46 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, 2022

Fukushima Daiichi Nuclear Power Station (NPS) Accident

Accident at the Nuclear Power Station

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
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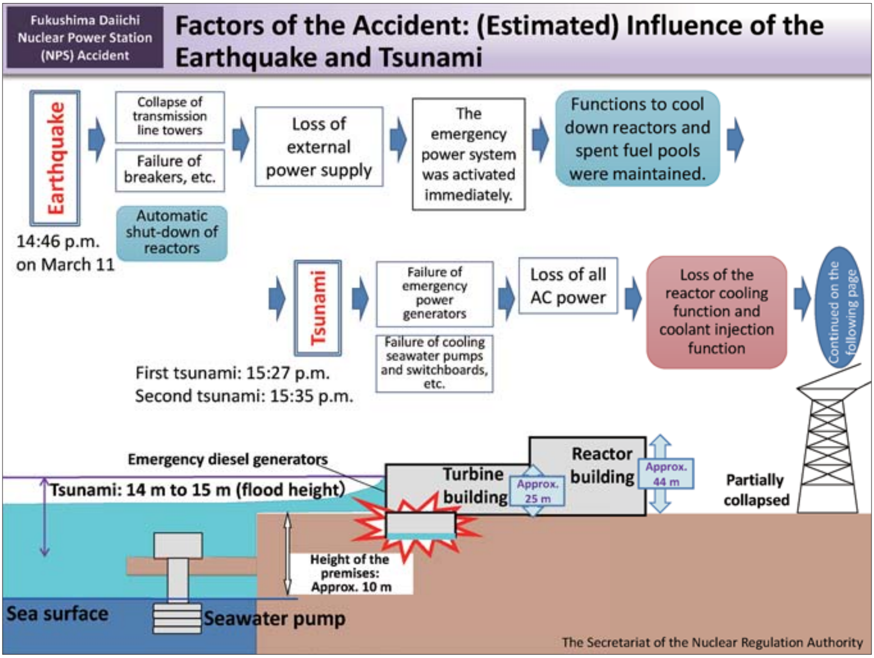

Immediately after the earthquake, at Units 1, 2 and 3 at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, which were in operation, all reactors were shut down automatically.

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
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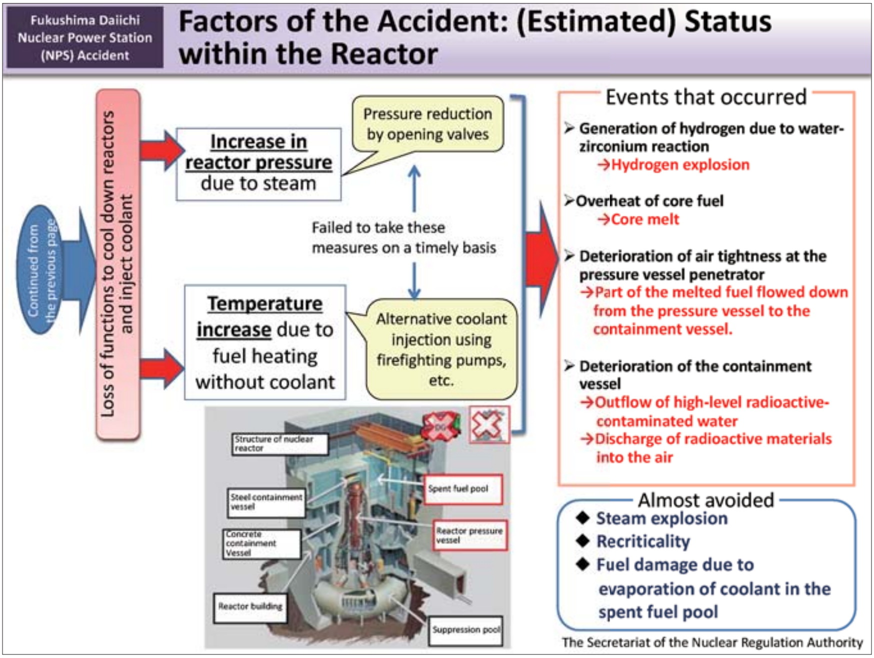

As coolant injection to the reactor core was suspended, the water level in the reactor declined and the fuel was exposed. This caused overheating of core fuel, triggered core melt and damaged a part of the pressure vessel. Melted fuel leaked from the pressure vessel into the inside of the containment 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	Aftershocks with seismic intensity 5 upper or less occurred several times. (15:42 – 18:25)	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.

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.

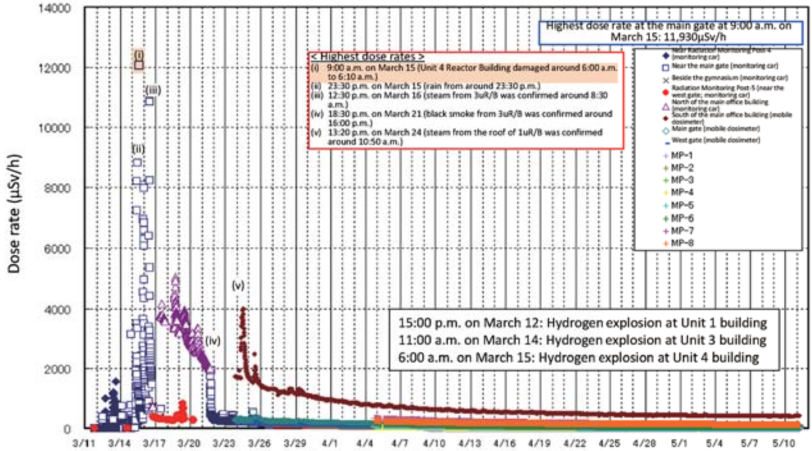
(Related to p.106 of Vol. 2, "Designation of Areas under Evacuation Orders," and p.107 of Vol. 2, "Designation of Restricted Areas and Areas under Evacuation Orders and Removal Thereof")

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

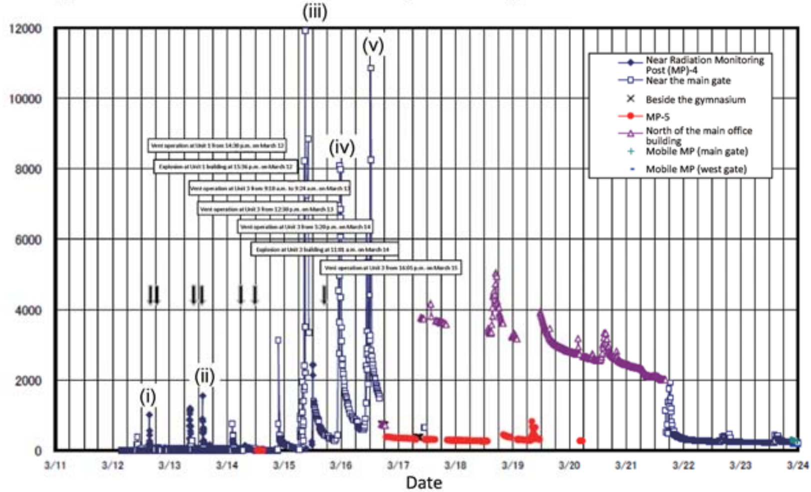
In the early morning of March 12, 2011, monitoring cars measured higher ambient dose rates within the premises of Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS and the discharge of radioactive materials was first confirmed after the earthquake. At Unit 1, after an abnormal pressure rise 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
Updated on March 31, 2022

Outline of the Accident

International Nuclear and Radiological Event Scale(INES)

	Level	Accident examples
Accident	7 Major accident	Former Soviet Union: Chernobyl Nuclear Power Plant accident (1986) Japan: Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi Nuclear Power Station (NPS) accident (2011)
Accident	6 Serious accident	Provisionally evaluated as Level 7 on April 12, 2011
Accident	5 Accident with wider consequences	UK: Windscale Nuclear Power Plant fire accident (1957) US: Three Mile Island Nuclear Power Plant accident (1979)
Accident	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)
Abnormal incident	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)
Abnormal incident	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)
Below scale	Not covered	(Events unrelated to safety)

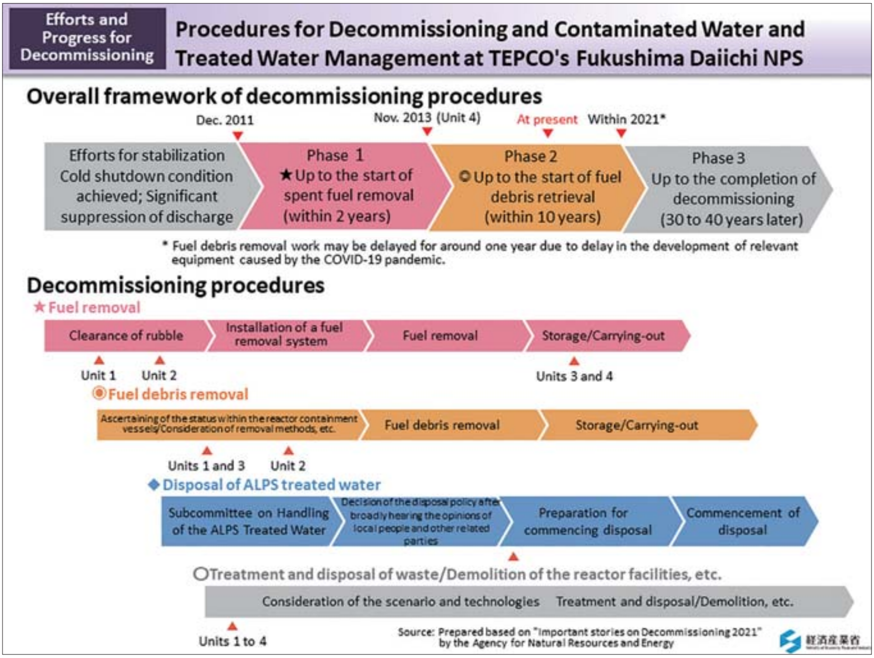
Prepared based on "The International Nuclear and Radiological Event Scale User's Manual" (IAEA) and "Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety" (June 2011; Nuclear Emergency Response Headquarters)

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 Chernobyl NPS Accident.

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

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



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

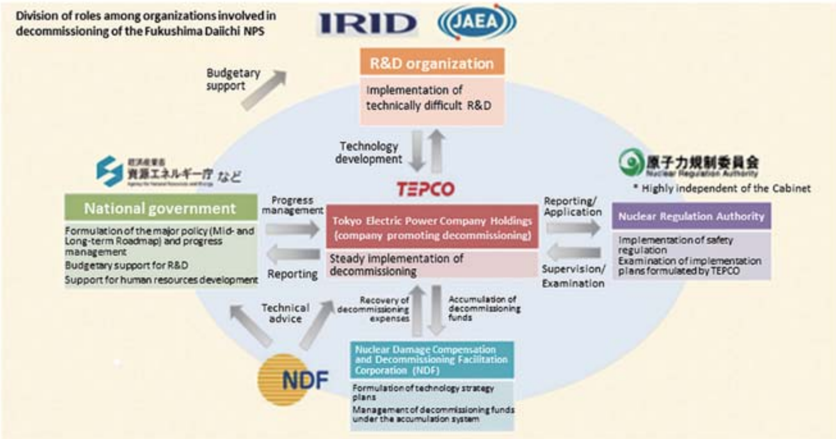
*1: Fuel debris removal work may be delayed for around one year due to delay in the development of relevant equipment caused by the COVID-19 pandemic.

Included in this reference material on February 28, 2018
Updated on March 31, 2022

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.

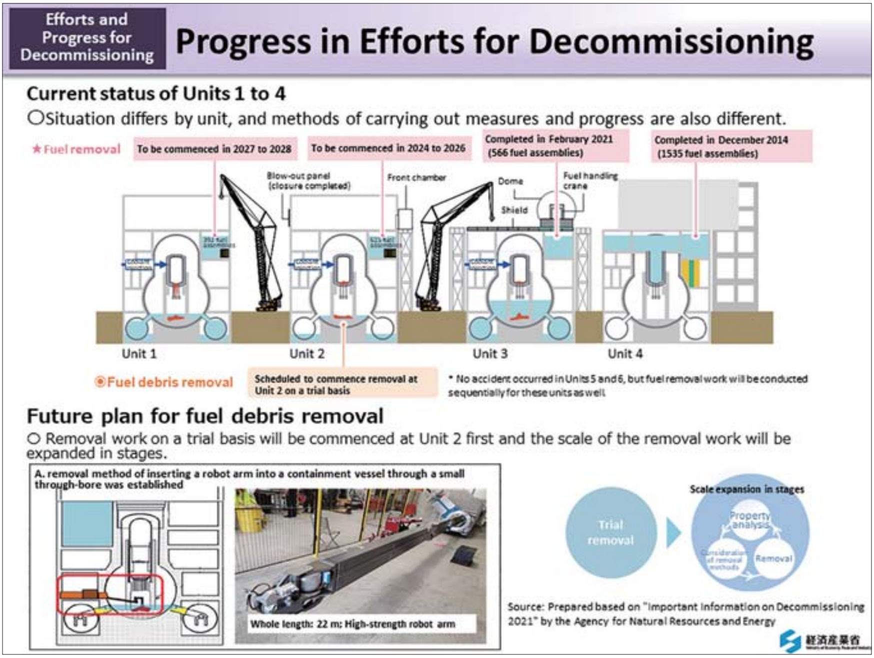


Source: Prepared based on "Important Information on Decommissioning 2021" by the Agency for Natural Resources and Energy

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



< Removal of spent fuel >
Removal of all 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 through installing large covers at working sites in order to further suppress scattering of dust at the time of clearing rubble.

< Removal of fuel debris >
The Mid- and Long-term Roadmap revised in December 2019 decides the method of removing fuel debris at the first Unit (a Unit for which removal is commenced first). The removal 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 removal (such as robot arms), and systems to analyze property of fuel debris and to confine radioactive materials.

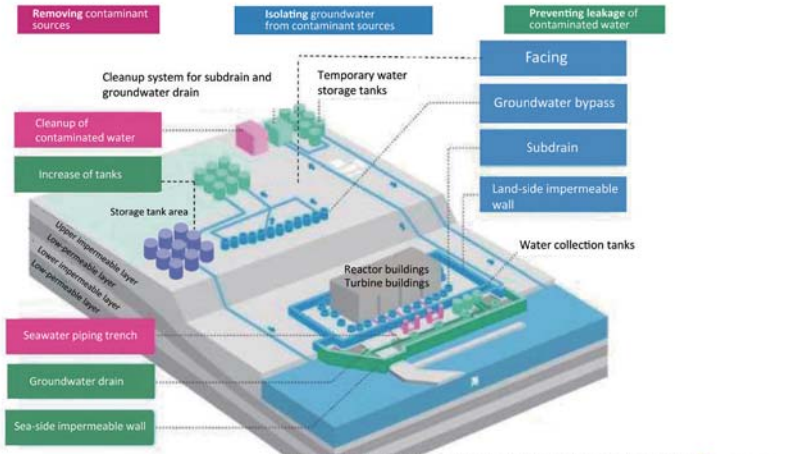
*1: Fuel debris removal work may be delayed for around one year due to delay in the development of relevant equipment caused by the COVID-19 pandemic.

Included in this reference material on February 28, 2018
Updated on March 31, 2022

Efforts and Progress for Decommissioning

Measures against Contaminated Water

Preventive and multi-layered measures are being taken against contaminated water based on policies of (i) removing contaminant sources, (ii) isolating groundwater from contaminant sources, and (iii) preventing leakage of contaminated water.



Prepared by the Ministry of Economy, Trade and Industry based on the materials of Tokyo Electric Power Company

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

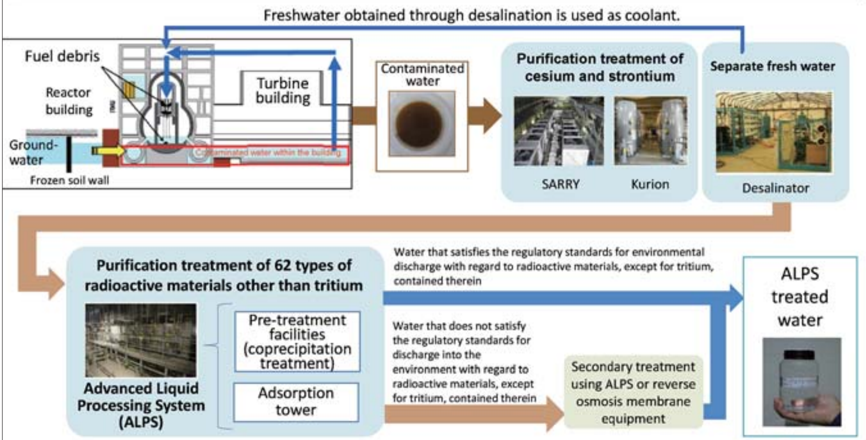
These efforts have brought about the following outcomes:
- The amount of newly generated contaminated water decreased from approx. 540m^3/day in May 2014 to approx. 140m^3/day in 2020, and the goal of approx. 150m^3/day set in the Mid- and Long-term Roadmap has been achieved.
- Treatment of the accumulated 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.

Included in this reference material on February 28, 2018
Updated on March 31, 2022

Efforts and Progress for Decommissioning

ALPS Treated Water
– Purification of Contaminated Water –

■ Contaminated water with radioactive materials is being generated after the accident at 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 contained radioactive materials, except for tritium, satisfy the regulatory standards for discharge into the environment.



(Source) Prepared based on "Fukushima Daiichi Nuclear Power Station: Contaminated water management: What is 'slurry'? Why is it generated? How is it stored?" by the Agency for Natural Resources and Energy (https://www.enecho.meti.go.jp/en/category/special/article/detail_157.html)

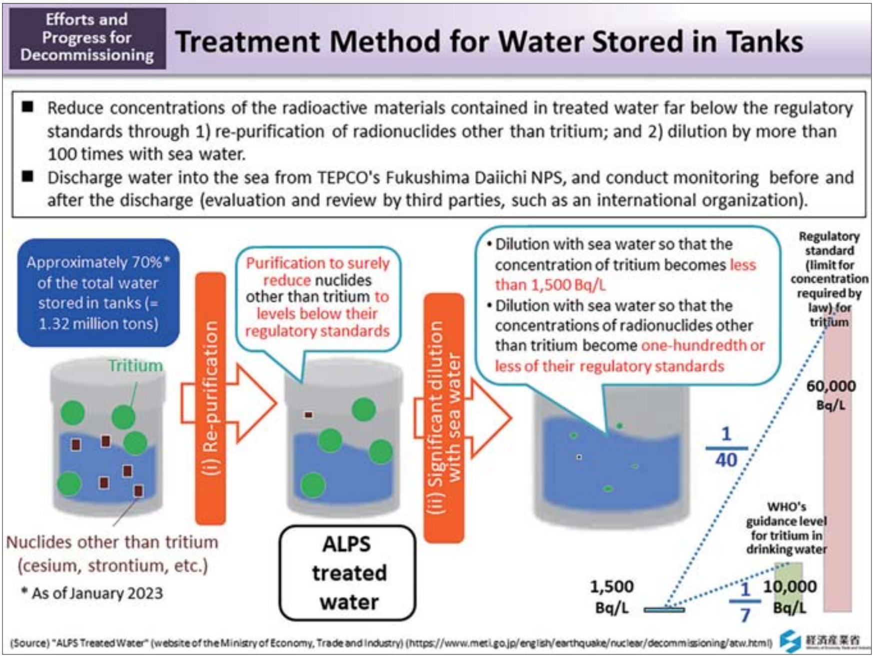
Contaminated water with radioactive materials is being generated after the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS. "ALPS treated water" refers to the water that has been treated by the Advanced Liquid Processing System (ALPS) and other equipment and has been purified repeatedly 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 2023, 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")

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



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. 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 0.01 in terms 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 2023, 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 function 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, for 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) so as 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, revealed the fact that nuclides other than tritium can be purified to levels below the regulatory standards for environmental discharge.

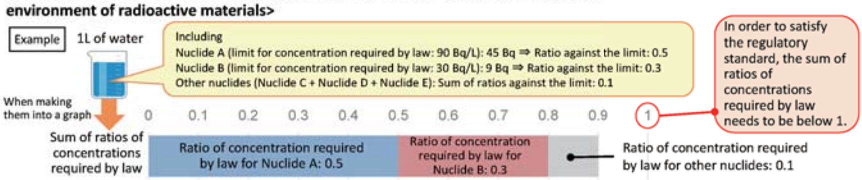
Included in this reference material on March 31, 2022
Updated on March 31, 2023

Efforts and Progress for Decommissioning

Regulatory Standards for Discharging Radioactive Materials into the Environment

- Whether the regulatory standard is satisfied or not is evaluated based on the sum of radiation effects caused by all types of contained nuclides, irrespective of whether the reactor is an operating one or a damaged one (based on the sum of effects converted to those on human beings, not based on types or numbers of nuclides).
- Contaminated water at TEPCO's Fukushima Daiichi NPS contains radioactive nuclides unique to the broken-down reactors (such as cesium and strontium), but these are surely removed to levels below the regulatory standards by the use of the Advanced Liquid Processing System (ALPS) and other equipment.

< Concept of the sum of ratios of concentrations required by law, the regulatory standard for discharge into the environment of radioactive materials>



[Reference] Results of the performance test regarding re-purification by the use of ALPS and other equipment (sum of ratios of concentrations required by law and ratios against the limits for major nuclides)

	Cobalt 60	Cesium 137	Strontium 90	Iodine 129	Other nuclides	Sum for nuclides other than tritium (sum of ratios of concentrations required by law)
Ratio against the limit for concentration required by law	0.0017	0.0021	0.0012	0.13	0.215	0.35

Dilution by more than 100 times so that the sum of the ratios of concentrations required by law for all radioactive materials including tritium becomes less than 1

(Source) Prepared based on "First priority is given to safety and security; Measures related to contaminated water in Fukushima (iv): Regulatory standards for radioactive materials" (https://www.enecho.meti.go.jp/about/special/johoteikyo/osensuitaisaku04.html) (in Japanese) and "Safe and secured disposal of treated water for reconstruction and decommissioning (ii): Secondary treatment and other nuclides contained in treated water" (https://www.enecho.meti.go.jp/about/special/johoteikyo/shorisui02.html) (in Japanese) by the Agency for Natural Resources and Energy, and "Performance test regarding secondary treatment of ALPS treated water" by Tokyo Electric Power Company Holdings

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 in light of the recommendations of the International Commission on Radiological Protection (ICRP) on the basis that an annual public exposure dose additionally caused by discharged radioactive materials (effects on human bodies) will not exceed 1 mSv. 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 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 excluding tritium but including those unique to the damaged reactors (such as cesium and strontium) so that their concentrations do not exceed the regulatory standards. The performance test on repurification using ALPS and other equipment, which Tokyo Electric Power Company Holdings conducted from September 2020, revealed that the sum of ratios of concentrations required by law for nuclides other than tritium was 0.35.

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. 1/100,000 of the exposure doses (2.1 mSv/y) of Japanese people from natural radiation (assessment results as of November 2022). (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
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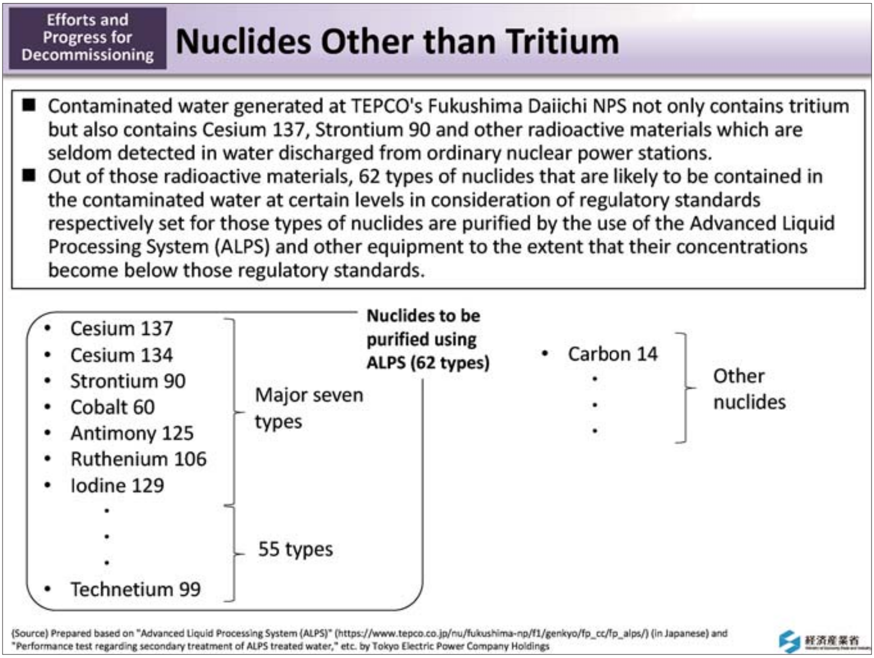


Contaminated water generated at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS contains not only tritium but also Cesium 137, Strontium 90 and other radioactive materials. These types of radioactive materials normally remain in nuclear fuel rods at ordinary nuclear power stations and are 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.

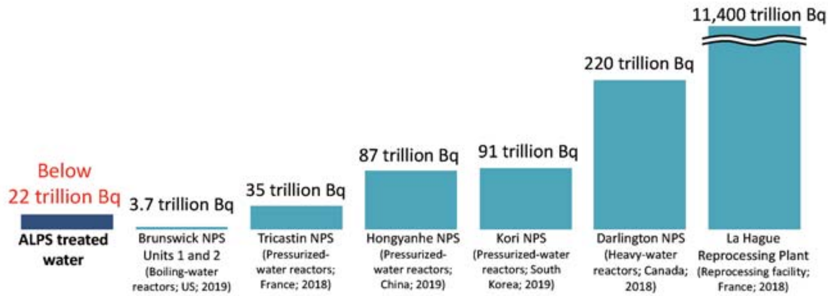
Regulatory standards for radioactive materials contained in liquid and gaseous waste that are discharged into the environment from nuclear power stations, etc. in Japan are set based on the total effects by all radioactive materials contained in waste, not based on the types of contained nuclides, and 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.

Included in this reference material on March 31, 2022

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)

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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.

Included in this reference material on March 31, 2022

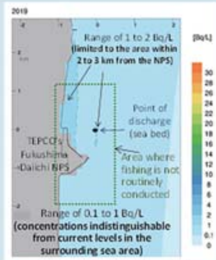
Efforts and Progress for Decommissioning

Assessment of the Radiological Impact of Discharge of ALPS Treated Water into the Sea

■ When discharging ALPS treated water into the sea, dilution is to be surely conducted and the diffusion and potential radiological impacts on humans and marine environment are to be scientifically assessed. Monitoring before and after the discharge will also be strengthened and enhanced.

< Assessment of potential impact on the marine environment>

- Results of the dispersion simulation
  The surrounding sea area where the tritium concentration was assessed to increase from the current level (0.1 to 1 Bq/L) is limited to the area within 2 to 3 km from the NPS. Even in this sea area, the sea water sufficiently satisfies the regulatory standard for tritium in Japan and the WHO's guideline for drinking-water quality.
- Assessment on exposure doses of the general public
  The impact on humans is assessed to be approx. 1/1,000,000 to 1/100,000 of the exposure doses (2.1 mSv/y) of Japanese people from natural radiation.



Around the NPS [Enlarged]
(Largest value in scale at 30Bq/L)

< Environmental monitoring>

- The Government of Japan and relevant sectors will strengthen and enhance sea area monitoring before and after the discharge so that concentrations of tritium etc. in the sea can be compared.
- The credibility of analysis is to be secured by obtaining cooperation from the IAEA.

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

Following the basic policy, which the Government of Japan announced in April 2021, Tokyo Electric Power Company Holdings conducted assessment on the radiological 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 meteorological and hydrological 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 point of discharge, 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 November 2022)
- The impact on humans was assessed to be approx. 1/1,000,000 to 1/100,000 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. 1/2,000,000 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. 1/25,000,000 to 1/10,000,000)

Furthermore, the Government of Japan and other related agencies decided to strengthen and enhance sea area monitoring even before the discharge of ALPS treated water into the sea so that concentrations of tritium and other substances in the sea area can be compared before and after the discharge. In conducting sea area monitoring, the credibility of analysis capabilities is to be secured by obtaining cooperation from the IAEA.

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

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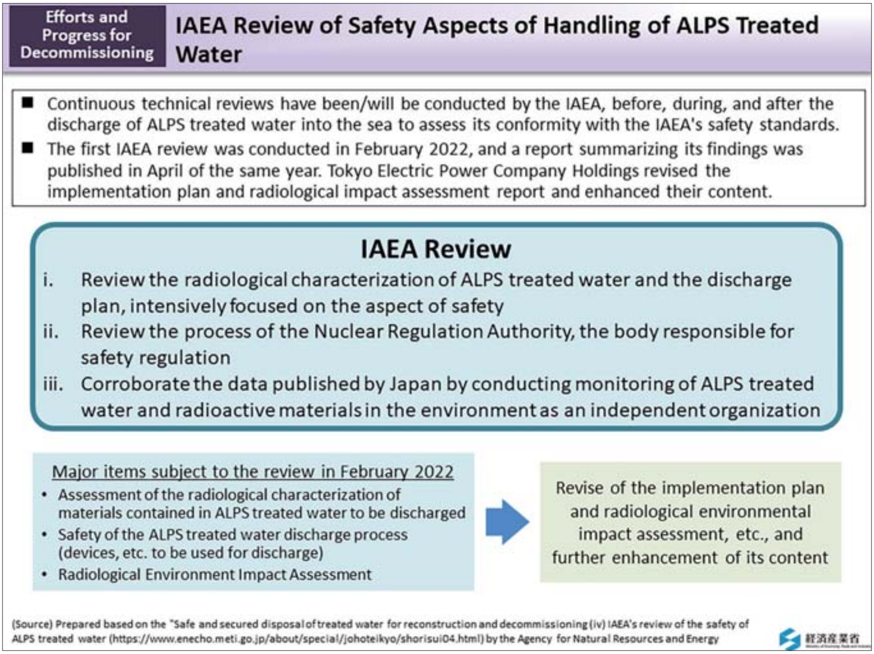


Regarding the discharge of ALPS treated water, Government of Japan has requested assistance from the International Atomic Energy Agency (IAEA) to review its plan and activities for the discharge of ALPS treated water to ensure that the discharge can be conducted in a safe and transparent manner in conformity with the IAEA Safety Standards. The IAEA has accepted Japan's request and conducted a technical review to ensure that the discharge of ALPS treated water over the coming decades is conducted in conformity with the IAEA Safety Standards. The technical review consists of multiple missions, and a progress report is to be published after each review mission. Before the discharge of ALPS treated water, a comprehensive report including conclusions of the review will be published.

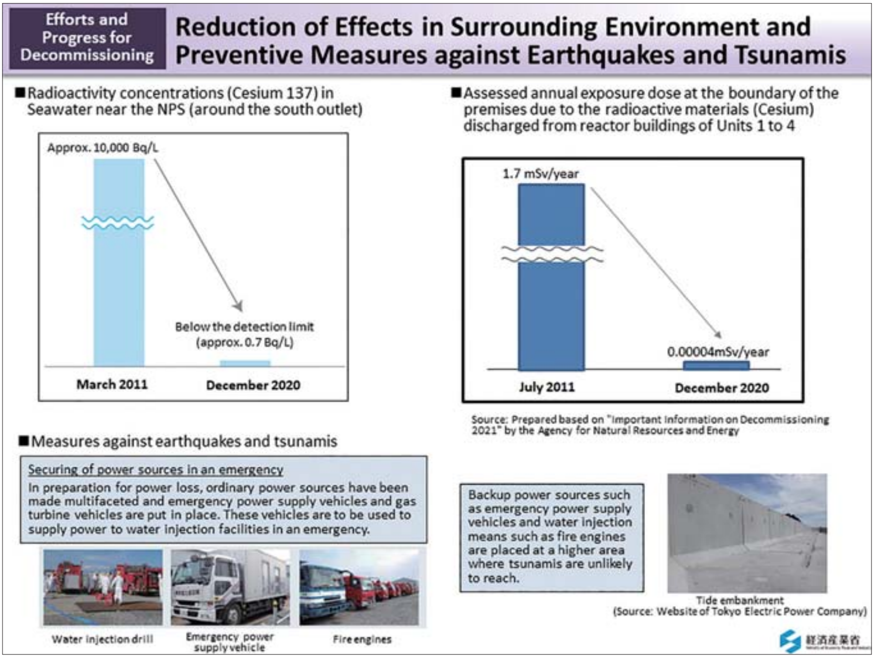
The IAEA conducted the first review from February 14 to 18, 2022, and published a report summarizing the findings through the review on April 29. In relation to the safety of related facilities which is the main content of the implementation plan, it was recognized that an enormous amount of analysis was performed by TEPCO for the conduct of the safety assessment, the level of detail, its comprehensive approach, as well as the fact that a large number of potential single failure events were taken into consideration for the development of the design criteria for the discharge of ALPS treated water. Regarding the radiological impact assessment, it was acknowledged that a comprehensive and detailed analysis was conducted and it was also noted that the radiological impact on the public was expected to be very low and significantly below the level set by the Japanese regulatory body. The IAEA Task Force noted that a significant amount of work and analysis has been performed to discharge the ALPS treated water, but the results need to be clearly described in writing to demonstrate compliance with relevant requirements in the context of IAEA safety standards so that the details of the radiological impact assessment can be fully understood.

Considering the points raised by the Task Force in the IAEA review, TEPCO revised the implementation plan and the report of assessment of radiological impact on the public and the environment and further enhanced its content.

(Source) Prepared based on the following:

- "IAEA Review of Safety Related Aspects of Handling ALPS-Treated Water at TEPCO's Fukushima Daiichi Nuclear Power Station: Report 1: Review Mission to TEPCO and METI" (February 2022) by the IAEA https://www.iaea.org/sites/default/files/report_1_review_mission_to_tepco_and_meti.pdf
- The news release titled "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) by the Ministry of Economy, Trade and Industry https://www.meti.go.jp/english/press/2022/0429_001.html

Included in this reference material on March 31, 2023



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 tide embankment against the Chishima-trench Tsunami was installed in September 2020. Measures against Japan-trench Tsunami, which is expected to be larger, have also been deliberated. While the work to block openings of the buildings has been underway to prevent inflow of seawater in the event of a tsunami. Additionally, preparing backup power sources such as emergency power supply vehicles and water injection means such as fire engines are placed at a higher area where tsunamis are unlikely to reach.

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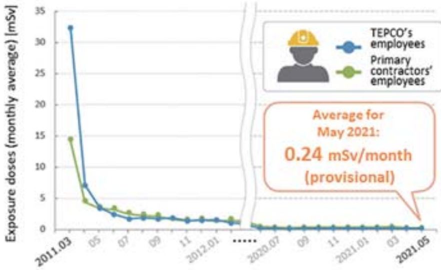
Efforts and Progress for Decommissioning

Improvement of Working Environment at TEPCO's Fukushima Daiichi NPS

■Changes in occupational workers' monthly personal exposure doses



Source (upper): Prepared based on the website of the Tokyo Electric Power Company (https://www.tepco.co.jp/decommission/progress/environment/)
Source (lower): Prepared based on "Important Information on Decommissioning 2021" by the Agency for Natural Resources and Energy

Workers' working environment

The large rest house has a dining room and a convenience store.

Emergency physicians are stationed at all hours.

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 May 2021 was 0.24 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
Updated on March 31, 2022