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	2,527
Injured	6,157

Damage to buildings	
Completely destroyed	121,992
Half destroyed	282,920
Partially destroyed	730,392

(Surveyed by the National Police Agency; as of December 10, 2020)

Disaster victim support	
Evacuees nationwide	41,781

(Surveyed by the Reconstruction Agency; as of January 29, 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, 2021

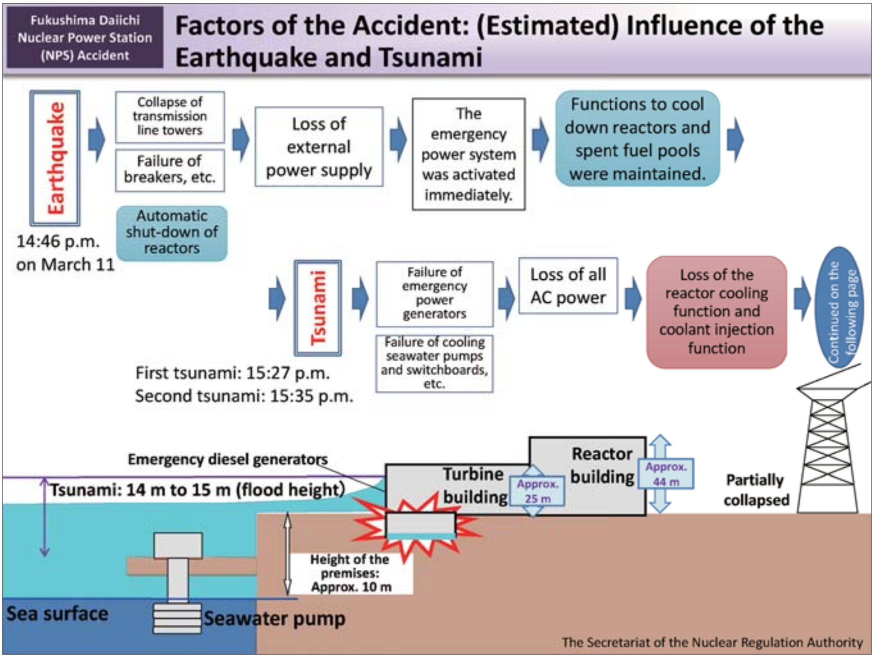
Fukushima Daiichi Nuclear Power Station (NPS) Accident

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, a large amount of 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



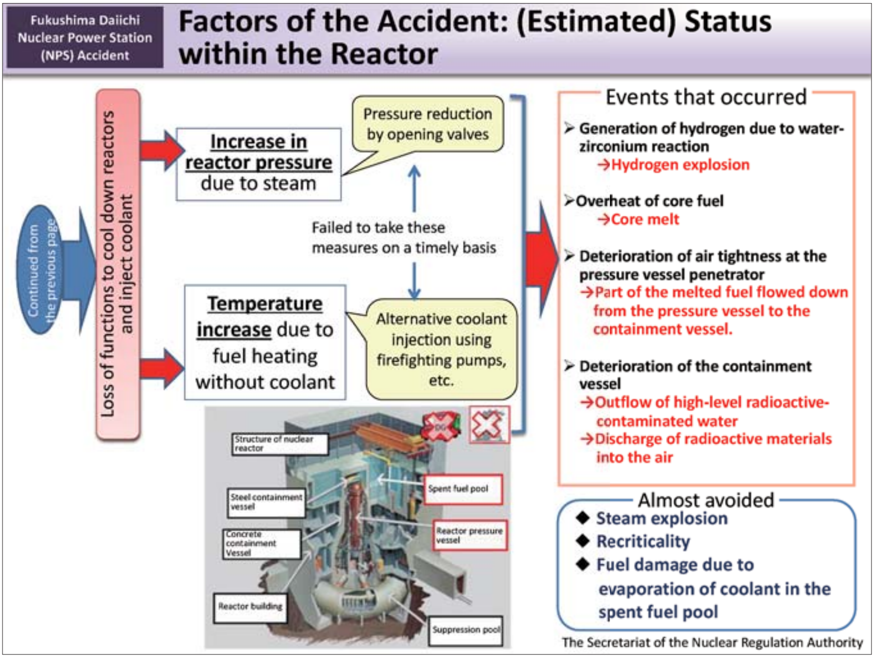
Immediately after the earthquake, at Units 1, 2 and 3 at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, which were in operation, all reactors were shut down automatically.

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, 2019



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 a large amount of 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
Updated on March 31, 2019

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.	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.

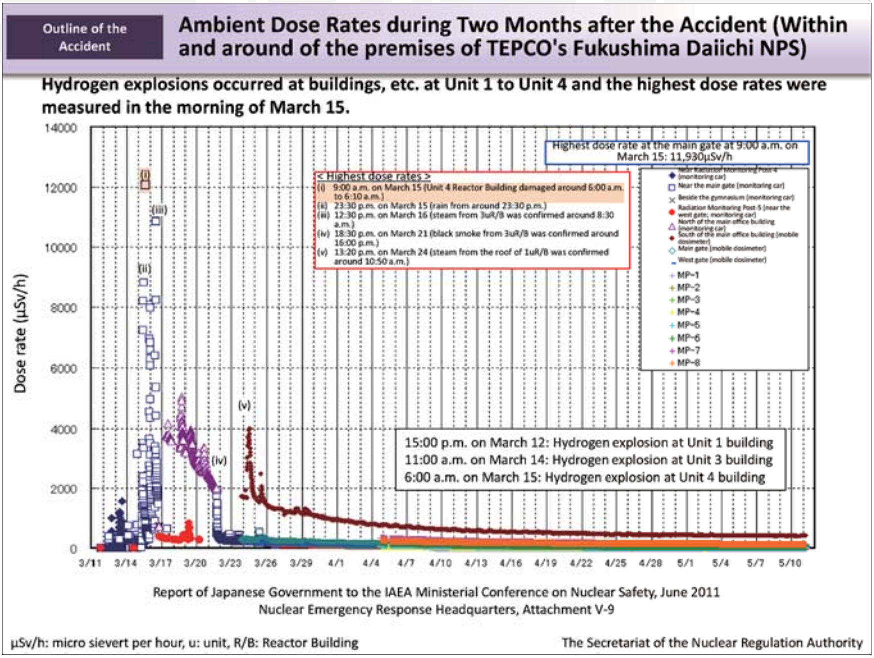
At 21:23 p.m. on the same day, based on the same Act, the government issued an evacuation order to residents within a 3-km radius of the NPS and ordered those within a 10-km radius to shelter indoors.

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.107 of Vol. 2, "Designation of Areas under Evacuation Orders," and p.108 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

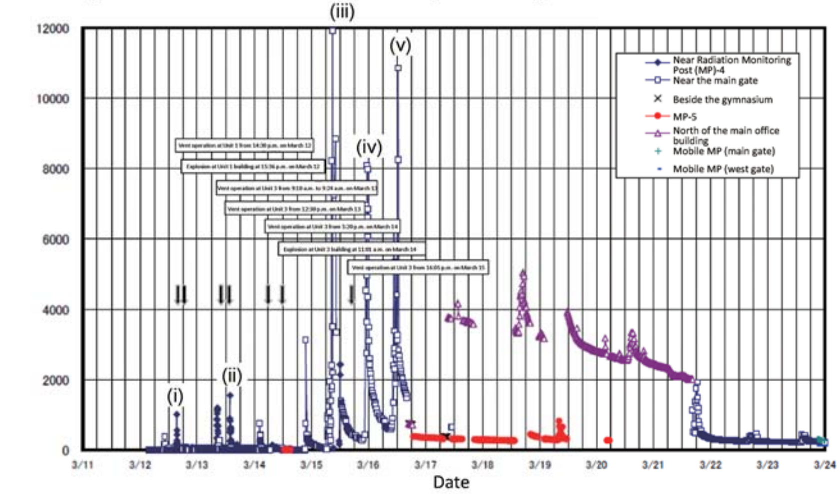


In the early morning of March 12, 2011, monitoring cars measured higher ambient dose rates within the premises of Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS and the discharge of radioactive materials was first confirmed after the earthquake. At Unit 1, after an abnormal pressure rise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

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 a large amount of 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, part of the melted fuel and 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)]. On March 13, the following day, the ambient dose rate clearly increased again [(ii)]. 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)]. 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)]. 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, 2019

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)

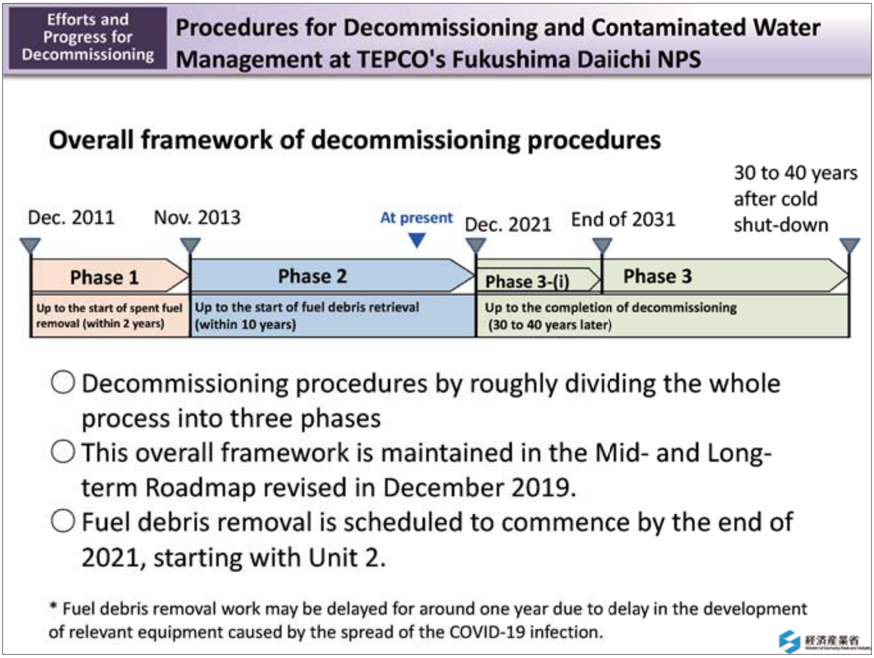
Prepared based on "The International Nuclear and Radiological Event Scale User's Manual" (IAEA) and "Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety" (June 2011; Nuclear Emergency Response Headquarters)

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



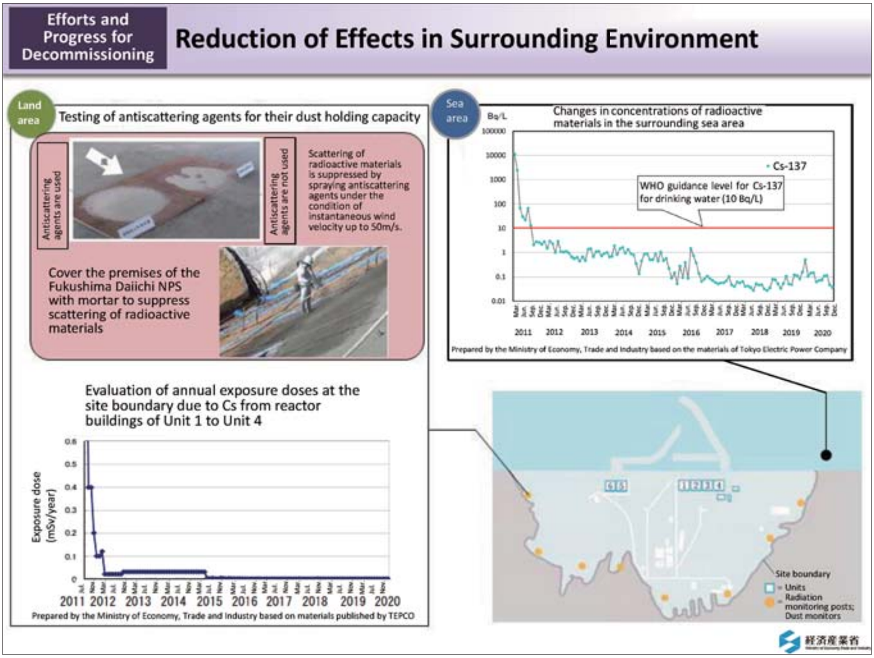
Efforts to decommission damaged nuclear reactors have been continued at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS. At present, cooling of reactors is continued at all Units and they are all being kept stable and under control.

Procedures for decommissioning Fukushima Daiichi NPS are unprecedentedly challenging and 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).

In December 2019, the Mid- and Long-term Roadmap was revised and it was decided to commence with taking out the fuel debris of Unit 2 first, and the method was also determined. For completing the decommissioning in 30 to 40 years, decommissioning procedures will continuously be implemented while placing top priority on ensuring safety. (Note 1)

(Note 1) Fuel debris removal work may be delayed for around one year due to delay in the development of relevant equipment caused by the spread of the COVID-19 infection.

Included in this reference material on February 28, 2018
Updated on March 31, 2021



During work, not only monitoring of changes in radiation doses at work sites but also monitoring of water and air around the premises of the NPS has been conducted regularly and it has been confirmed that influence on people's lives is sufficiently low. In preparation for any event of an abnormal increase in ambient dose rates or concentrations of radioactive materials in dust, a system for prompt reporting and responses has been put in place.

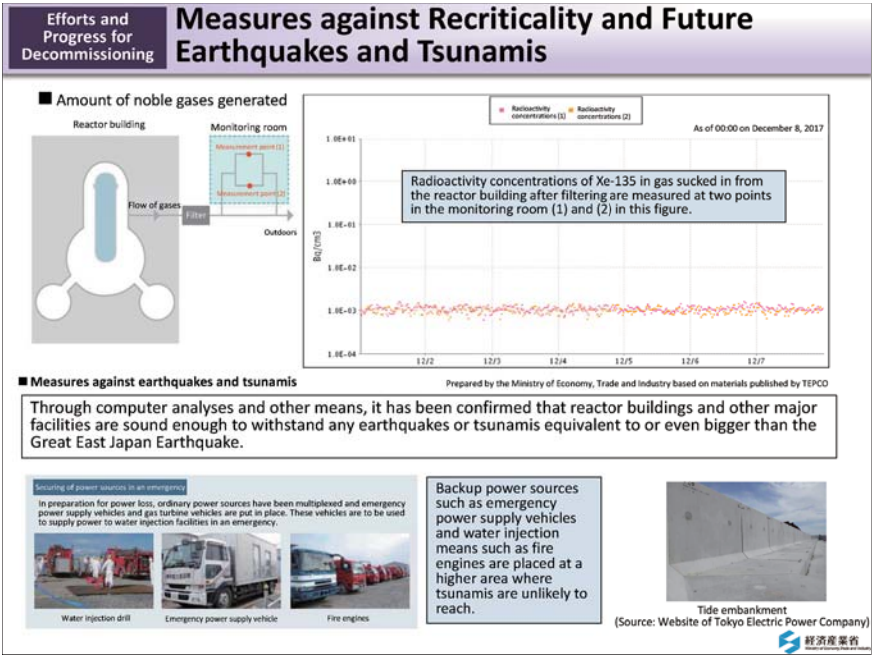
< Sea area monitoring >

By the sea-side impermeable wall consisting of driven steel piles, which was completed in October 2015, and other various measures (for details, see p.13 of Vol. 2, "Measures against Contaminated Water"), concentrations of radioactive materials in the surrounding sea area were reduced and have maintained levels far below the World Health Organization (WHO)'s guidance level for drinking water quality.

< Surrounding area monitoring >

At Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, various measures are taken to prevent scattering of radioactive materials to outside of its premises. Representative measures being taken are spraying of antiscattering agents and covering the ground with mortar. These measures have worked to reduce dose rates, compared with those immediately after the accident, and to stabilize the rates at radiation monitoring posts installed at the boundary of the premises.

Included in this reference material on February 28, 2018
Updated on March 31, 2021



< Recriticality >
When criticality occurs (a status where chain fission reaction occurs and continues), Xe-135 and other noble gases increase in an unexpected fashion. At Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, generation of noble gases is being monitored at all hours. At present, the amount of noble gases generated has been stable, which suggests that recriticality has not occurred. However, in preparation for any risks of recriticality, a boric acid water system to suppress nuclear fission in the event of criticality has been installed.

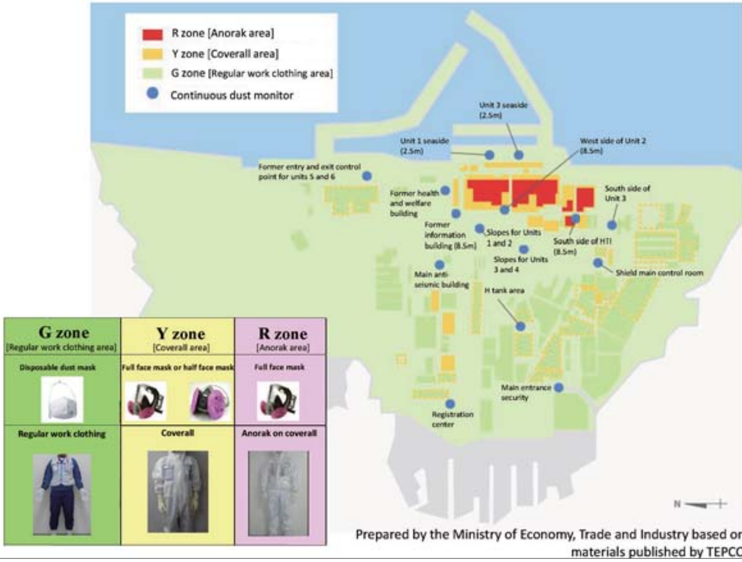
< Measures against earthquakes and tsunamis >
■ Measures against earthquakes
It has been confirmed that important buildings in the premises are sound enough not to fall down even in the event of an earthquake of the same level as the Great East Japan Earthquake. For securing a seismic safety margin, the demolition of the upper part (approximately 60 m) of the common exhausted stack for Units 1 and 2 was implemented in May 2020.

■ Measures against tsunamis
As measures against earthquakes and tsunamis, a tide embankment against 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, 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.

Included in this reference material on February 28, 2018
Updated on March 31, 2021

Efforts and Progress for Decommissioning

Improvement of Working Environment at TEPCO's Fukushima Daiichi NPS



Prepared by the Ministry of Economy, Trade and Industry based on materials published by TEPCO

In order to improve safety and workability by reducing workers' load, efforts to improve the working environment, for such work as debris removal and paving of roads, 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 October 2018 onward, it became possible to move around in some areas without wearing specific protective gear.

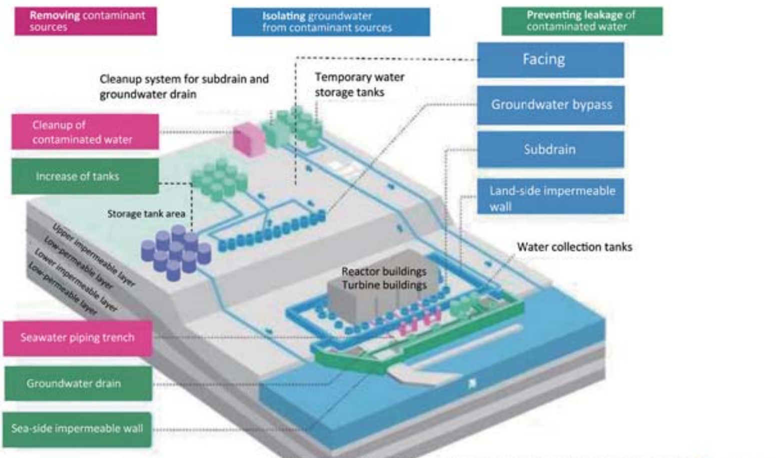
In May 2015, a large rest house was opened and workers are served with hot meals prepared at the food service center and can take a shower and buy things at a convenience store. They can thus work under normal working conditions, except for a certain zone, at present.

Included in this reference material on February 28, 2018
Updated on March 31, 2021

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 policies.

< 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.

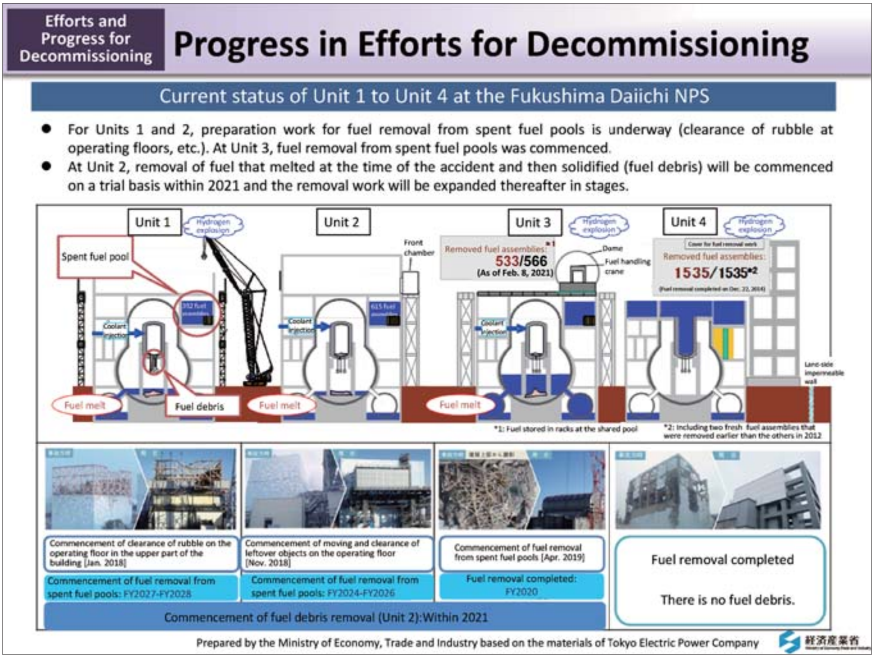
< Policy 2: Isolating water from contaminant sources >
(i) Pump up groundwater on the mountain side of the buildings to suppress inflow of groundwater around the buildings
(ii) Pump up groundwater using the well near the buildings (subdrain) to lower the groundwater level, thereby suppressing inflow 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)

< 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 suppress outflow of groundwater into the sea
(iii) Secure tanks in a planned manner to store highly contaminated water and decontaminated water newly generated every day

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.

As a remaining challenge, the amount of the decontaminated water that still contains tritium is increasing in storage tanks, and some countermeasures are being required.

Included in this reference material on February 28, 2018
Updated on March 31, 2021



< Removal of spent fuel >

Removal of all 1,535 fuel assemblies from the spent fuel pool was completed at Unit 4 in December 2014 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 Unit 3, removal of fuel was commenced in April 2019 and removal work was continued steadily and safely, aiming to achieve completion within FY2020.

At present, preparations are being steadily progressed at Units 1 and 2 for clearance of rubble. From now on, preparatory work will be carried out while placing top priority on ensuring safety, such as through adopting new methods of installing large covers at working sites in order to further suppress scattering of dust.

< Removal of fuel debris >

The Mid- and Long-term Roadmap revised in December 2019 decides the method of removing fuel debris. The removal work will be commenced at Unit 2 first on a trial basis, and the scale will be sequentially expanded in stages.(Note 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, and systems to confine radioactive materials.

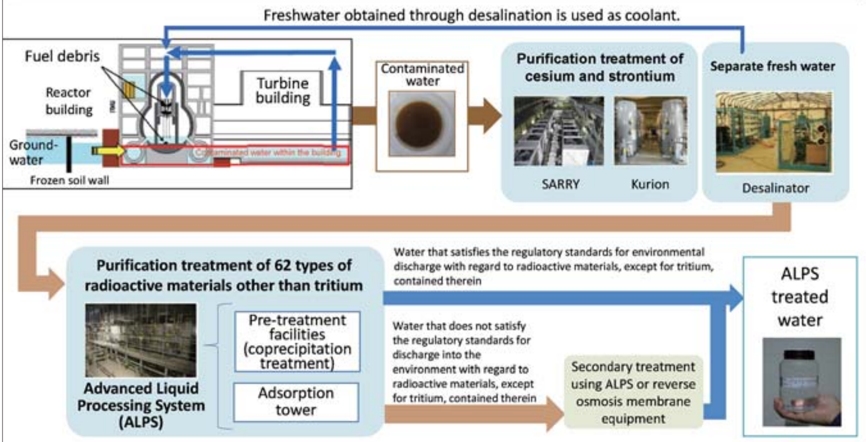
(Note 1) Trial removal work may be delayed for around one year (initially scheduled to be commenced within 2021) due to delay in the development of relevant equipment caused by the spread of the COVID-19 infection.

Included in this reference material on February 28, 2018
Updated on March 31, 2021

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.

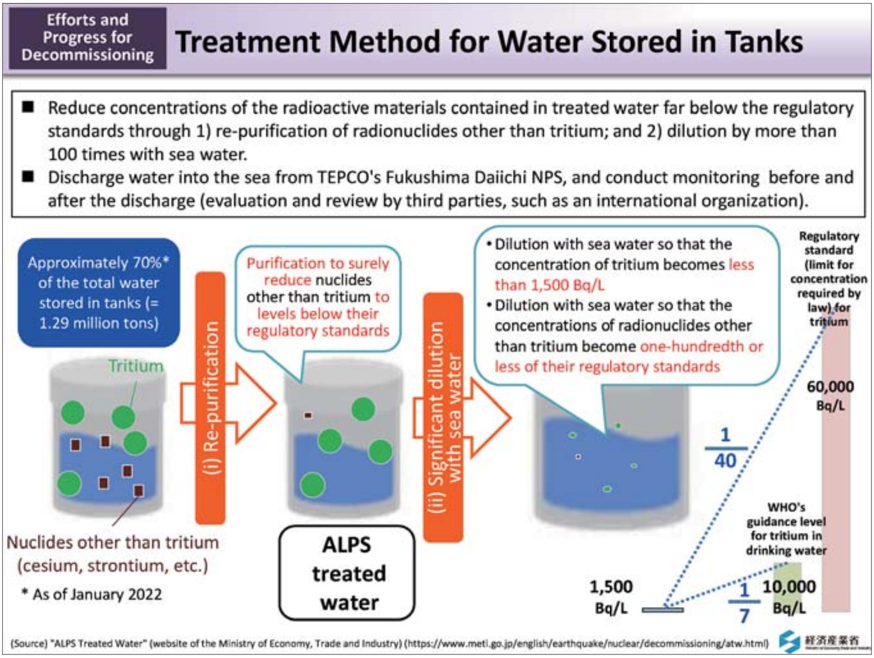
At the NPS, as water is being injected continuously in order to cool melted and solidified fuel left within the reactor (fuel debris) and due to the inflow of rainwater and groundwater into the reactor building, water containing radioactive materials at high concentrations continues to be generated.

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, and iodine 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 2022, 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.16 of Vol. 2, "Treatment Method for Water Stored in Tanks")

Included in this reference material on March 31, 2022



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.17 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 2022, 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.

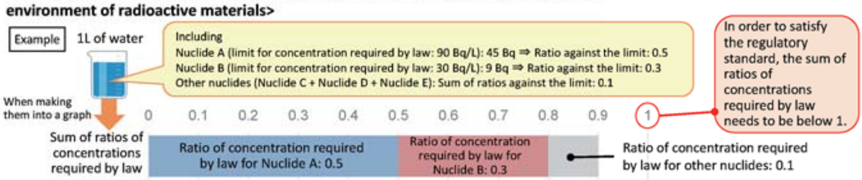
Accordingly, in line with the basic policy, for discharging the water stored in tanks into the sea, purification by using ALPS or reverse osmosis membrane equipment is to be conducted again (secondary treatment) so as to satisfy the regulatory standards for environmental discharge, which are stricter 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

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

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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 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."

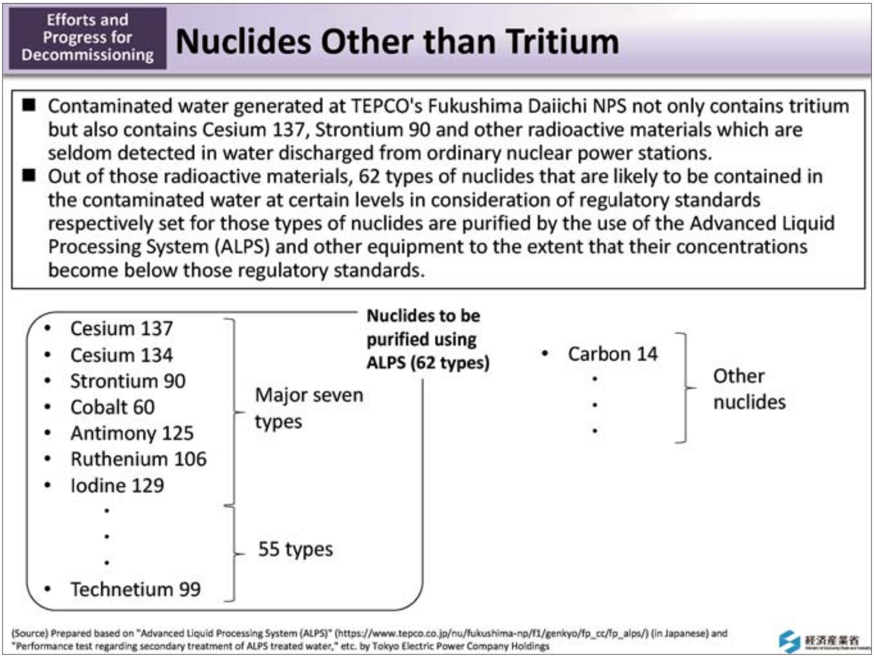
Generally, liquid and gaseous waste discharged from a nuclear power station, etc. contains multiple radionuclides. Therefore, when effects of multiple radionuclides are supposed, the concept of the sum of ratios of concentrations required by law as described in Ministerial Notice is adopted in comprehensive 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. 1/120,000 to approx. 1/1,000 of the radiation effects that Japanese people receive from nature for one year. (Related to p.20 of Vol. 2, "Assessment of the Potential Radiological Impact of Discharge of ALPS Treated Water into the Sea")

Included in this reference material on March 31, 2022



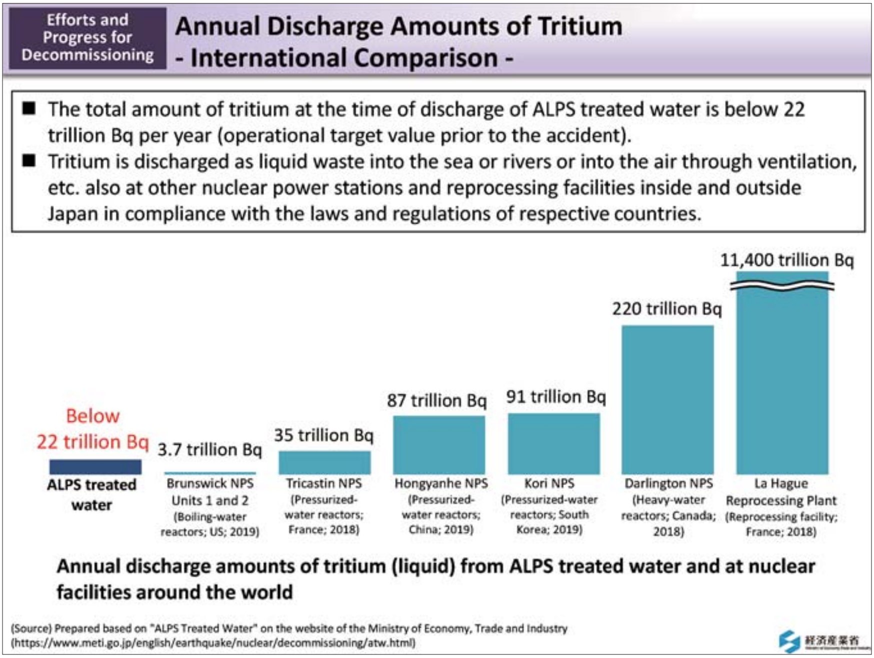
Contaminated water generated at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS contains not only tritium but also Cesium 137, Strontium 90 and other radioactive materials. These types of radioactive materials normally remain in nuclear fuel rods at ordinary nuclear power stations and are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



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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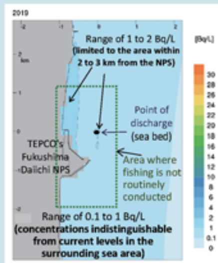
Efforts and Progress for Decommissioning

Assessment of the Potential 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 people who consume marine products at the national average was assessed to be approx. 1/120,000 to approx. 1/1,000 of the average annual exposure doses of Japanese people due to natural radiation (2.1 mSv/y).



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 "Announcement of the Basic Policy on Handling of the ALPS Treated Water at TEPCO's Fukushima Daiichi Nuclear Power Station (FDNPS)" (https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/pdf/pr_bpalps.pdf) by the Agency for Natural Resources and Energy and the "Radiological Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (Design stage)" (November 2021) (https://www.tepco.co.jp/press/release/2021/1657175_8711.html) by Tokyo Electric Power Company Holdings

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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 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). As a result, it was found that the impact on humans and marine environment will be negligible enough.

■ Results of the dispersion simulation in the sea (using the meteorological and hydrological data for 2019; annual average)
・The area where the tritium concentration in seawater in the surrounding area 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.
・There were some points near the point of discharge where the tritium concentration was assessed to be around 30 Bq/L, but the concentration would decrease promptly in and around those points. The tritium concentration of 30 Bq/L is still far below 10,000 Bq/L, the WHO Guidelines for drinking-water quality.
■ Results of potential radiological impact on human and plants and animals
・The impact on persons who consume marine products at the national average was assessed to be approx. 1/120,000 to approx. 1/1,000 of the average annual exposure doses of Japanese people due to natural radiation (2.1 mSv/y).
・The impact on plants and animals (flatfish, crabs, and brown algae) was assessed to be approx. 1/60,000 to approx. 1/120 of the standard values that may cause an impact on living organisms as specified by ICRP.

The Government of Japan and relevant sectors will strengthen and enhance sea area monitoring before and after the discharge of ALPS treated water into the sea, so that concentrations of tritium etc. can be compared. 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 Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (Design stage)" (November 2021) (https://www.tepco.co.jp/press/release/2021/1657175_8711.html) by Tokyo Electric Power Company Holdings

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