Provisional translation

The Subcommittee on Handling of the ALPS Treated Water Report

February 10, 2020

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Introduction

The accident at Tokyo Electric Power Company Holdings' Fukushima Daiichi Nuclear Power Station (hereinafter referred to as "Fukushima Daiichi NPS") damaged the production bases of Fukushima's industries with radioactive materials, in addition to the damage caused by the earthquake and tsunamis. The impact of rumor-based reputational damage on Fukushima's industries still remains, especially in the agriculture, forestry, fishery and sightseeing industries. The committee expects that the Government of Japan will work on Fukushima's revitalization and reconstruction at the forefront, while recognizing the current situation of Fukushima's industrial sector.

While maintaining and managing the stable state of the Fukushima Daiichi NPS, the decommissioning is steadily progressing and includes the concrete plan of fuel debris retrieval. There has been gradual progress in the returning of residents and reconstruction efforts in the surrounding area. The Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station (hereinafter referred to as "Mid-and-Long-Term Roadmap") states that systematic risk reduction will be realized under the concept of "coexistence of reconstruction and decommissioning," with consideration for the site conditions, rationality, promptness and certainty while placing top priority on the safety of locals, the surrounding environment and workers

Needless to say, the realization of Fukushima's reconstruction is of the utmost importance. In order to ensure compatibility with Fukushima's reconstruction efforts, decommissioning and contaminated water management should be steadily implemented. It is necessary to complete the disposal of the water which is treated with multi-nuclide removal equipment and other equipment (hereinafter referred to as "ALPS" and "ALPS treated water[Note1]") while completing the decommissioning work at the same time, since the disposal of the ALPS treated water is one of the countermeasures for the contaminated water and one of the decommissioning tasks.

The topic of how to handle the ALPS treated water* is one of the most important decommissioning tasks which has been discussed since 2013. Due to the improved performance of ALPS, radionuclides other than tritium can be purified to levels that can be released into the environment complying with relevant regulations. However, the disposal of the ALPS treated water is considered to have a particularly large impact on reputation and is one of the issues of increased public interest, especially in the local community. As such, comprehensive consideration has been conducted at the Subcommittee of handling of the ALPS treated water (hereinafter referred to as "the ALPS subcommittee") not only from scientific aspects but also from social aspects, taking into account the impact on reputation.

As part of the decommissioning work, the disposal of the ALPS treated water may increase the problem of reputational damage. It is important to take into consideration that rushing the disposal of the ALPS treated water must not increase reputational damage, which could stagnate the reconstruction process. Consequently, it is important to dispose of the ALPS treated water as part of the decommissioning work in order to fully complete the decommissioning with necessary storage, as well as taking into account the reputational impact when the disposal method for the ALPS treated water is examined.

The intent of the examination at the ALPS subcommittee is not to coordinate opinions among the parties concerned, but rather to provide materials from a professional point of view for the Government of Japan to decide how to dispose of the ALPS treated water. The Government of Japan, while carefully listening to the opinions of a wide range of the parties concerned including local residents, is expected to decide upon a policy that not only includes the disposal method, but also counter-measures to deal with the problem of reputational damage.

Note1: ALPS has the ability to purify 62 kinds of radionuclides other than tritium to less than the regulatory standards for each radionuclides applicable to discharge. However, approximately 70%[Note2] of the ALPS treated water* stored in tanks contains radionuclides other than tritium at the concentration that exceeds the regulatory standards applicable for discharge into the environment (hereinafter referred to as "regulatory standards for discharge[Note3]").

The ALPS subcommittee, therefore, assumes that the water which has not been sufficiently purified (hereinafter referred to as "ALPS treated water (which needs to be re-purified)") will be re-purified and radionuclides other than tritium will be removed to the level to satisfy the regulatory standards for discharge, as a precondition of the examination. The ALPS subcommittee discussed how to handle the ALPS treated water (see Page 16).

Accordingly, **in this report, the ALPS treated water which meets the regulatory standards for discharge except for tritium is referred to as "ALPS treated water."** When it is disposed of, ALPS treated water will be disposed of with sufficient dilution to satisfy the regulatory standards including tritium for discharge.

By contrast, **the water currently stored in tanks is referred to as "ALPS treated water*."** When it is disposed of, part of the ALPS treated water* will be re-purified and then be disposed of with sufficient dilution to satisfy the regulatory standards including tritium for discharge.

Note2: As of December 31, 2019.

Note3: "The regulatory standards for discharge" is the limit value applicable to discharge the radioactive waste to the environment, which is stipulated in the ordinance of the Reactor Regulation Act. If the radioactive waste contains multiple radionuclides, the sum of the ratios of each radionuclides concentration to the regulatory standards for them should be less than 1.

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1. Summary of earlier discussion

(1) Discussion by the Tritiated Water Task Force

On December 10, 2013, the Committee on Countermeasures for Contaminated Water Treatment drafted a document entitled “Preventative and Multilayered Measures Utilizing Enhanced Comprehensive Risk Management for Contaminated Water Treatment at Tokyo Electric Power Company’s Fukushima Daiichi Nuclear Power Station.” The document identified that issues would remain unresolved concerning the handling of the ALPS treated water* even if various countermeasures were taken, including “removing” the contamination source, “redirecting” groundwater from the contamination source and “preventing leakage” of contaminated water due to the storage of the ALPS treated water* which would increase the number of tanks to be managed, resulting in the potential for more leakage events to occur.

In addition, on December 4, 2013, the International Atomic Energy Agency (hereinafter referred to as “IAEA”) Review Mission provided an advisory comment concerning the handling of the ALPS treated water, that “all options should be examined.”

Responding to such input, the “Additional Measures for Decommissioning and Contaminated Water Issues in Tokyo Electric Power Company’s Fukushima Daiichi Nuclear Power Station” were established by the Nuclear Emergency Response Headquarters on December 20, 2013, specifying that, “concerning the handling of the tritiated water [note] which will pose risks due to the scale in storage volume even after the implementation of the additional measures, a comprehensive assessment should be performed to examine all options.”

Note: refers to “the ALPS treated water*”

Accordingly, to assess a variety of options for the handling of the ALPS treated water, the Tritiated Water Task Force (hereinafter referred to as “the Task Force”) was established under the Committee on Countermeasures for Contaminated Water Treatment. As a result, the Task Force began a review on December 25, 2013 and published a report on June 3, 2016.

The Task Force compiled the scientific information on tritium as the basic data to determine how to handle the ALPS treated water over a long period of time at TEPCO’s Fukushima Daiichi NPS, and examined possible handling options including geosphere injection, discharge into the sea, vapor release, hydrogen release and underground burial, while at the same time checking the fundamental factors (regulatory feasibility and technical feasibility) and potential restraints (duration, cost, scale, secondary wastes, workers’ exposure to radiation and others) of each option.

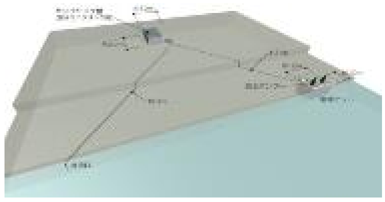
Regarding tritium separation technologies, a test project to verify tritium separation technology was conducted in FY2015, which concluded that “no technology was close to practical use (in consideration of the volume and concentration of the ALPS treated water*)," and subsequently, the details of the project were presented to the Task Force.

Table 1: Results of assessment at Tritiated Water Task Force (Basic requirements)

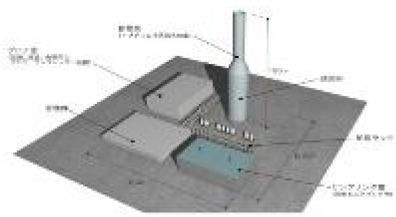
Method of disposal	Geosphere injection	Discharge into the sea	Vapor release	Hydrogen release	Underground burial
Technical feasibility	- If a suitable geosphere layer cannot be found, the treatment cannot be initiated. - There is no monitoring method established.	- There are examples of discharging into the sea of liquid radioactive waste containing tritium at other nuclear facilities.	- There is an example from TMI-2 of evaporation method using a boiler.	- To handle the ALPS treated water, R&D for pre-treatment and scale enlargement might be needed.	- Track records exist for concrete pit disposal sites and isolated-type disposal sites.
Regulatory feasibility	It is necessary to formulate new regulations and standards related to disposal concentration.	Feasible	Feasible	Feasible	New regulatory standards might be needed.

(1) Example of geosphere injection

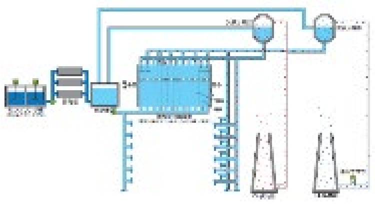
(2) Example of discharge into the sea



(3) Example of vapor release



(4) Example of hydrogen release



(5) Example of underground burial

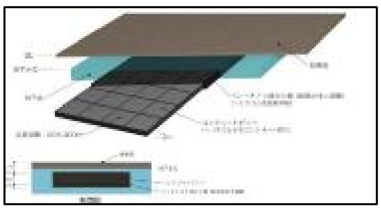


Figure 1. Image of five methods of disposal discussed at the Task Force

Table 2: Results of assessment of Tritiated water Task Force (Potential Constraints)

Method of disposal	Geosphere injection	Discharge into the sea	Vapor release	Hydrogen release	Underground burial
Duration [months]	104 + 20*n* 912 (for monitoring)	91	120	106	98 912 (for monitoring)
Cost [Yen]	(18＋0.65*n*) Billion ＋ Monitoring cost	3.4 Billion	34.9 Billion	100 Billion	243.1 Billion
Scale	380 m^2	400 m^2	2,000 m^2	2,000 m^2	285,000 m^2
Secondary Waste	None	None	Incinerator ash may be produced depending on components in the treated water.	Secondary waste in the form of residue may be produced.	None
Radiation Exposure to Workers	No points to consider in particular.	No points to consider in particular.	There are no points to consider in particular since the height of the exhaust pipe will be sufficiently high.	There are no points to consider in particular since the height of the exhaust pipe will be sufficiently high.	To prevent radiation exposure to workers during the burial operation, installing a cover etc. is needed.
Others	The costs and duration of the exploration will increase in the event that it is difficult to find a suitable geosphere layer.	In the case of using a divider between the intake water pit and the discharge port, the cost will increase.	The duration may be extended, in case the release operation needs to be suspended due to precipitation.	The duration may be extended, in case the release operation needs to be suspended due to precipitation.	A large amount of concrete and bentonite will be needed. Construction spoil will be produced.

Note: The duration, cost and scale are those obtained on the supposition that the ALPS treated water of a concentration of 4.2 MBq/L (MBq= Megabecquerel) and that of 0.5 MBq/L respectively in an amount of 0.4 million m^3 each (0.8 million m^3 in total) is disposed. The letter *n* refers to the number of geologic formation surveys conducted.

The Task Force report added a note that ". . . since handling of tritiated water can have a large influence on reputation, future discussions about the handling of tritiated water should advance in a comprehensive manner, touching upon both technical perspectives, such as feasibility, economical efficiency, and duration, as well as social perspectives, such as reputational damage," for further assessment.

(2) Status of discussion at the Subcommittee on Handling of the ALPS Treated Water

On September 27, 2016, the Committee on Countermeasures for Contaminated Water Treatment decided to establish ALPS subcommittee to discuss the handling of the ALPS treated water from all viewpoints, including social perspectives such as rumor-caused reputational damage, based on the knowledge presented in the Task Force Report. The ALPS subcommittee had its first meeting on November 11 in the same year.

The ALPS subcommittee held hearings on the mechanism and actual conditions of reputational damage as well as the measures taken by the national and prefectural governments and others to correspond such reputational damage. In addition, the subcommittee organized explanatory and public hearing meetings to hear opinions about the ALPS treated water disposal path and concerns that could arise after the actual disposal because it was discussed that reputational damage is not only associated with just Fukushima Prefecture, but Japan as a whole and that handling of the ALPS treated water should be examined after the thoughts and concerns from Japanese citizens are understood.

The explanatory and public hearing meetings were held in Tomioka Town on August 30，and Koriyama City, Fukushima and Chiyoda Ward, Tokyo, on August 31, 2018 where opinions were heard from a total of 44 people across all of the venues. The subcommittee also requested the public to submit opinions in writing, and received written opinions from 135 people. A major trend in the opinions collected, were various concerns about the disposal of the ALPS treated water, concerns about the safety of the ALPS treated water stored in tanks, and disapproval of discharging the ALPS treated water into the sea due to concerns about reputational damage.

After these explanatory and public hearing meetings, the ALPS subcommittee discussed the arguments presented at the meetings while also checking facts from a scientific point of view (see “Arguments presented at the explanatory and public hearing meetings and the developments of discussion”).

In addition, the ALPS subcommittee members visited the Fukushima Daiichi NPS in summer, 2017 (July and August), and in summer, 2019 (July and August), and conducted a review based on the on-site status of decommissioning activities.

All of the informational materials used in the review by the ALPS subcommittee were publicized both domestically and internationally, through the Internet, explanations provided to local the parties concerned through the Fukushima Advisory Board and other meetings, and through briefing sessions for all diplomatic missions in Tokyo and foreign press.

【Arguments presented at the explanatory and public hearing meetings and the developments of discussion】

(The parenthesized ordinal numbers indicate in what ALPS subcommittee meetings the issue was discussed.)

1) Disposal path (13th, 14th, 15th and 16th)
- Treated water's concentration for disposal, total emissions control, disposal location, etc.

2) Continuation of storage (13th, 14th, 15th and 16th)
- Review of long-term storage of treated water, treated water storage methods, etc.

3) Biological impact of tritium (11th)
- Hazards of tritium (especially organically bound tritium), etc.

4) Treatment of radionuclides other than tritium (10th)
- Characteristics and actual storage conditions of the ALPS treated water* (especially radionuclides other than tritium)
- Treatment and disposal of radionuclides other than tritium contained in the ALPS treated water*, etc.

5) Monitoring and other measures to be performed (11th and 12th)
- Tritium monitoring methods, difficulty in monitoring, validity of monitoring, etc.

6) Measures against reputational damage (12th, 13th, 14th and 15th)
- Concerns about reputational damage, etc.

7) Consensus making (14th and 15th)
- The necessity of considerate information output to national citizens, considerate communication and opinion exchange with locals in the region, etc.

(3) IAEA Review Mission

At the request of the Government of Japan, the IAEA Review Mission was implemented between November 5 and 13, 2018 in order to obtain an international review of the decommissioning of the Fukushima Daiichi NPS. The Government of Japan received various advisory comments for the Fukushima Daiichi NPS decommissioning efforts that are underway according to the Mid-and-Long-Term Roadmap.

The advisory comments for the ALPS treated water* are as follows: "The IAEA Review Mission holds that a decision on the disposal path for the stored ALPS treated water ... must be taken urgently, engaging all stakeholders, to ensure the sustainability of the decommissioning activities and of the safe and effective implementation of other risk reduction measures," "After the decision on the disposal path is made, Tokyo Electric Power Company should prepare and submit to the Nuclear Regulation Authority (hereafter called "NRA") for authorization a comprehensive proposal for its implementation in conformity with laws and regulations, supported by such items as a safety assessment and analysis of the environmental impacts," and "To support the implementation of the chosen disposal path, a robust comprehensive monitoring program ... supported by a communication plan ensuring a proactive and timely dissemination of information to stakeholders and general public are necessary."

2. Review of the current conditions of the ALPS treated water*

(1) Progress of contaminated water management and generation status of the ALPS treated water*

At the Fukushima Daiichi NPS, there has been continuous cooling, as water has been poured on the melted and solidified fuel in the reactors (hereafter referred to as “fuel debris”), resulting in a certain amount of contaminated water being stagnant at the basement of the buildings. Due to the explosions of reactor buildings and other incidents, rainwater has been entering the reactor buildings, while groundwater has been entering them through wall penetration by pipes, etc. The groundwater levels surrounding the buildings and contaminated water in the buildings are controlled to keep the groundwater level outside the buildings higher than the contaminated water level in the buildings, thus preventing contaminated water from leaking out of the buildings. Consequently, the amount of contaminated water is increasing continuously. However, the contaminated water generation rate decreased from about 540 m^3/day (May 2014) to about 170 m^3/day (average in FY2018) thanks to the implementation of a multi-layered approach, including the operation of sub-drain and various reliability improvement measures such as the enhancement of the capacity of purification systems and the reinforcement of existing pits, as well as the completion of the land-side frozen soil wall.

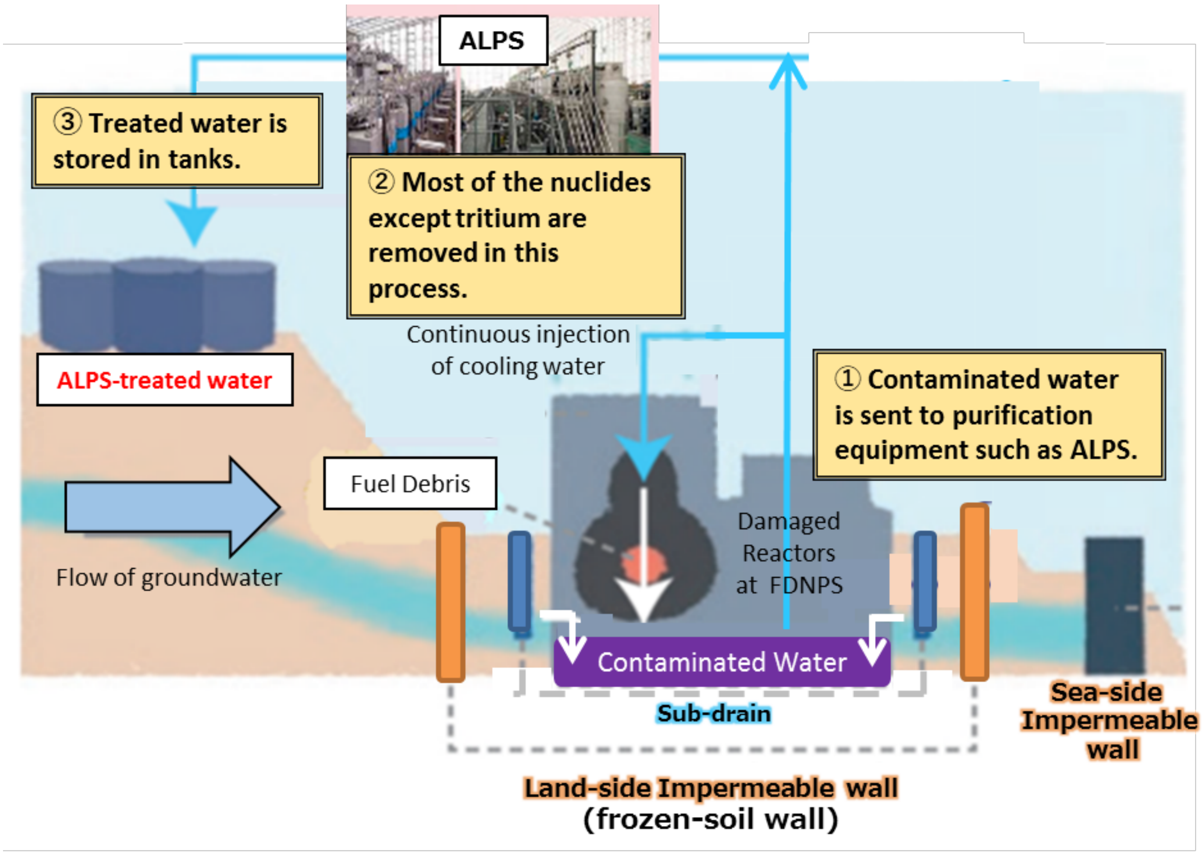


Figure 2. Contaminated water generation mechanism and the ALPS treated water*

The Mid-and-Long-Term Roadmap plans to reduce the contaminated water generation rate to around 150 m³/day in 2020 and to around 100 m³/day in 2025, and expects Tokyo Electric Power Company Holdings, Inc. (hereinafter referred to as "TEPCO") to make further efforts to reduce the generation rate. However, in order to fundamentally reduce the generation of contaminated water, it is necessary to proceed with the retrieval of fuel debris as well as the improvement of the surrounding environment including the reactor buildings, which would result in eventually stopping the injection of cooling water to the fuel debris.

(2) Status of the storage of the ALPS treated water* in tanks[1]

Contaminated water, which is generated continuously, is treated by purification systems[2] such as ALPS to remove as much radioactive material as possible, however tritium cannot be removed resulting in the handling of the ALPS treated water including residual tritium remaining an unresolved issue. Since the ALPS treated water has once been in contact with fuel debris and its handling may have an adverse impact on reputation, it is being stored for the time being within the site as it is still necessary not only to confirm the scientific safety, but also to discuss disposal methods keeping in mind the social influence, including reputational damage. The total volume of the ALPS treated water* and the strontium removed water that is waiting for the purification treatment by ALPS is, as of October 31, 2019, about 1.17 million m³, and the amount and concentration of tritium are, on average, about 856 TBq (TBq = Terabecquerel) and about 0.73 MBq/L (MBq = Megabecquerel) respectively.

The tanks storing the ALPS treated water* and strontium removed water were installed at the site of the Fukushima Daiichi NPS, where space was available. However, because it became necessary to install more tanks, the forested area on the southern side of the site was logged and additional tanks were installed on the newly developed land. To install those extra tanks, efforts were made for efficient installation; namely, larger tanks were used and were placed more efficiently (in a honeycomb layout). Even with the additional tanks, according to the current tank construction plan, which plans to install more tanks with a total capacity of about 1.37 million m³ before the end of 2020, the tanks are expected to be full around summer 2022, and additional space for installing more tanks than currently planned is restrained.

1 13th ALPS Subcommittee, Document 4-2

2 Referring to existing multi-nuclide removal equipment, additional multi-nuclide removal equipment, and high-performance multi-nuclide removal equipment as well as a mobile strontium removal system, RO-concentrated water treatment equipment, cesium adsorption system, second cesium adsorption system and third cesium adsorption system.

When the ALPS first started to operate, strontium removed water and concentrated saltwater[3] were also stored in the tanks in addition to the ALPS treated water*. At that time, bolted tanks, which were called flanged tanks, were used for storage, but the stored water was found to be leaking multiple times. Thereafter it was decided to reinforce the measures against the leakage of treated water: the purification of the concentrated saltwater by the ALPS and other facilities was hastened, and the strontium removed water and the ALPS treated water* were transferred to welded tanks with lower leakage risks. At present (since March 2019), the treatment of the concentrated saltwater has been completed, and all the strontium removed water and the ALPS treated water* have been stored in welded tanks. In addition, double dikes have been built to prevent water from flowing out to the external environment in case of leakage, while the water level in the tanks is perpetually monitored and tank leakage is visually observed through on-site touring.

(3) Increase in the capacity of tank storage (including tank replacement and storage off-site, and on-site land expansion)[4]

The ALPS subcommittee examined storage using large-capacity aboveground tanks, underground tanks and sea-surface tanks.

Compared with currently used standard tanks, large-capacity aboveground tanks are not significantly different in capacity efficiency per unit area, posing an issue that, while storage capacity would not increase significantly, the period of time required for installation, leakage inspection and others would be longer, and if a failure occurred, leakage would be vast. Likewise, large-capacity underground tanks would not provide a significantly greater storage capacity compared with the standard tanks, while posing the same issue as that of large-capacity aboveground tanks concerning leakage. The underground tanks would pose another issue that leakage could not be detected quickly because they are buried. In the case of sea-surface tanks, those of the size used in oil storage stations would not be easily installed in the Fukushima Daiichi NPS port, where water depth is shallow, and if a tsunami occurs, they might be wrecked and drift to the shore, possibly causing damage. In addition, if water leaks out of the sea-surface tanks, it will be difficult to collect the leakage water. In consideration of these issues, installing tanks, such as large-capacity tanks as mentioned above would not significantly increase the storage capacity compared with the standard tanks in the Fukushima Daiichi NPS and would not provide any benefits.

If the ALPS treated water* is transferred to an off-site location, legally compliant transfer facilities would be required and it would be necessary to obtain understanding

3 Concentrated saltwater refers to the water from which major cesium radionuclides have been removed by treatment systems (such as cesium absorption apparatus and secondary cesium absorption apparatus, etc.).

4 13rd ALPS subcommittee Document 4-2, 14th subcommittee Document 2 and 3, 15th subcommittee Document 2

from municipalities on transfer routes. More specifically, if pipelines are used for its transfer, it would be necessary to install physical protection facilities (fences, etc.) surrounding the pipelines. If vehicles or ships are used for the transfer, vehicles or ships would need to carry type L transport casks with a maximum volume of 4 m^3, and procedures for transportation outside the nuclear site should be needed. To transfer the water in a condition where regulatory standards for discharge is satisfied, the ALPS treated water* would need to be diluted several tens of times, which means that the amount of water to be transferred becomes far greater than the current amount, and it would still be necessary to obtain understanding from the municipalities on transfer routes and would necessitate building legally compliant transfer facilities. As having been discussed above, consultation and preparation of the transfer of large amounts of the ALPS treated water* to off-site locations would require significant time and a wide range of advance coordination.

If a new site were to be obtained separate from the Fukushima Daiichi NPS site to store the ALPS treated water*, understanding from the municipalities where storage facilities would be installed would be required. Additionally, as the storage of the ALPS treated water means the handling of radioactive material, it would be necessary to obtain business permission as radioactive waste storage facilities based on the “Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors” (hereinafter referred to as “Reactor Regulation Act”), as well as to implement radiation sickness prevention measures and take safety inspection and physical protection inspections among others, based on the Act. Installment of new radioactive material storage facilities will require proper equipment, a wide range of advanced coordination and an approval process, which will take a considerable amount of time.

Considering these conditions, the subcommittee reviewed the expansion of the site to the grounds prepared for the intermediate storage facility. The plan for the intermediate storage facility site located outside the Fukushima Daiichi NPS has been approved and land acquisition and preparation work have begun for the sake of revitalization of Fukushima after the national government explained to the local municipalities (prefecture and the two towns in which the site is located) with the condition that final disposal will be completed outside Fukushima Prefecture within 30 years after the start of intermediate storage. The landowners are requested to allow use of the land (including the establishment of property right) for the intermediate storage facility. Currently, land acquisition and facility preparation work are underway to receive, treat, and intermediately store the soil and other waste which was removed from across Fukushima Prefecture. To ensure the storage of the soil and other waste, including the soil removed from the zone designated for reconstruction and recovery, it is necessary to continue land acquisition and facility preparation work. Accordingly, it is deemed difficult to expand the area of the Fukushima Daiichi NPS site by using the land located outside the NPS for purposes other than intermediate storage, as this land has been allocated for the intermediate storage facility.

(4) Continuation of storage in tanks[5]

At the ALPS subcommittee, the continuation of storage has been examined, however, the subcommittee pointed out that ALPS treated water* remains. Furthermore, according to the Mid-and-Long-Term Roadmap, the decommissioning of the Fukushima Daiichi NPS aims to complete within 30 to 40 years after the achievement of the cold shutdown status in December 2011.The disposal of the ALPS treated water is equivalent to “the disposal of the material contaminated by nuclear fuel materials” stipulated as part of the decommissioning in the “Reactor Regulation Act.” The disposal of the ALPS treated water must be completed as a part of the decommissioning works when the decommissioning itself is completed with an important premise that Fukushima reconstruction and the decommissioning should be two major principles. Hence, it should be assumed that the continuation of storage will end at the completion of the decommissioning.

The decommissioning and contaminated water management are part of continuous risk reduction efforts, and as such, it is fundamental to proceed with the decommissioning works within the existing site area, as removing radioactive materials and placing them outside of the site area might entail increased risk. In addition, as mentioned previously above, the transfer of radioactive waste to an off-site location or the expansion of the site area for the continuation of storage in tanks, a substantial amount of coordination and time would be needed until implementation to acquire the understanding from local municipalities and others, to decide upon where storage facilities might be built, and to acquire an approval for radioactive waste storage facilities.

In light of these conditions, the only option to continue storage in tanks is to store the treated water on-site using standard tanks with an improved efficient installation arrangement. Space for installing additional tanks other than currently planned is limited. Therefore, to install as many tanks as possible while proceeding with decommissioning activities safely and consistently, the entire existing site area should be used effectively to the maximum extent in consideration of the limits of the site area.

To be more specific, according to TEPCO, vacant land may become available on the site premises due to improved efficiency in the stored-water tank area (through utilization of the space where flanged tanks used to be built) and progress in waste disposal efforts and other works. However, the ALPS treated water* storage tanks and temporary storage facilities for spent fuel and fuel debris, as well as other facilities necessary for use in the decommissioning project will be required as decommissioning proceeds, including analysis facilities for various samples, fuel debris retrieval material and equipment storage facilities, fuel debris retrieval mock-up facilities, fuel debris retrieval training facilities and waste recycling facilities.

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[5] 14th ALPS subcommittee, Document 3 and 4

For the effective utilization of the on-site premises, the subcommittee examined the possibility of using the yard currently used for soil disposal in an efficient manner, by relocating the soil there to a location outside of the site, while also including a comparison with the removed-soil recycling in accordance with the regulations given in the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials[6]. The substantial amount of coordination and time will be needed to relocate the soil off-site and there are many problems to be solved: while the soil on-site is required to be controlled properly according to the Reactor Regulation Act, the actual conditions regarding soil contamination in the Fukushima Daiichi NPS site are unknown; where to relocate the soil from the site and how to store it, etc. are not specifically clarified; and the final on-site soil disposal method has not been determined. Therefore, relocation of soil to off-site takes considerable amount of coordination and time.

(5) Characteristics of the ALPS treated water[7]

The ALPS treated water* is the water which has been treated by purification systems using ALPS to reduce its radioactive material concentration to about one-millionth that of the original contaminated water. Its characteristics are significantly different from that of contaminated water found in the damaged buildings of the Fukushima Daiichi NPS, however the water still includes tritium, which cannot be removed either physically or chemically.

ALPS has the ability to purify 62 kinds of radionuclides other than tritium to less than the regulatory standards for discharge into the environment[8]. However, as of December 31, 2019, about 70% of the ALPS treated water* stored in tanks contains[9] radionuclides other than tritium at the concentration that exceeds the regulatory standards for discharge. As described above, about 70% of the ALPS treated water* stored in tanks is not sufficiently purified, and it cannot be said that “the ALPS treated water that has been purified.”

This is because in FY2013, in the early period of ALPS operation, purification performance was still insufficient, and the treated water included radionuclides that exceeded the regulatory standards for discharge. Additionally, due to the influence of the highly-concentrated contaminated water stored in the tanks, additional exposure doses at the site boundary were far higher than the regulatory standard for storage.

[6] Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the NPS Accident Associated with the Tohoku District - Off the Pacific Ocean Earthquake That Occurred on March 11, 2011

[7] 10th subcommittee, Document 3

[8] “The regulatory standards for discharge” is the limit applicable to release the radioactive waste to the environment, which is stipulated in the ordinance of the Reactor Regulation Act. If the radioactive waste contains multiple radionuclides, the sum of the ratios of each radionuclides concentration to the regulatory standards for them should be 1 or less.

[9] 10th ALPS subcommittee, Document 3

Therefore, the throughput of ALPS had to be increased by lowering adsorbent replacement frequency to comply with the regulatory standards at the site boundary, instead of satisfying the standards for discharge. More specifically, from 2013 to the end of 2015, reducing additional exposure dose at the site boundary to lower than 1 mSv/year was prioritized and ALPS was operated with low adsorbent replacement frequency. Since FY2017, an additional exposure dose of lower than 1 mSv/year at the site boundary has been retained. But, to prioritize the treatment of strontium removed water and its transfer from flanged tanks that have high leakage risk to the welded tanks before the end of 2018, ALPS was operated with low adsorbent replacement frequency. Therefore some ALPS treated water* stored in tanks exceeds the standards for discharge.

Accordingly, the concentration of the ALPS treated water* stored in tanks varies depending on conditions of operation of ALPS (adsorbent replacement frequency, etc.) and on pre-treatment water quality. Figure 3 shows the concentration distribution, with more detailed data periodically disclosed and updated on the TEPCO’s website.[10]

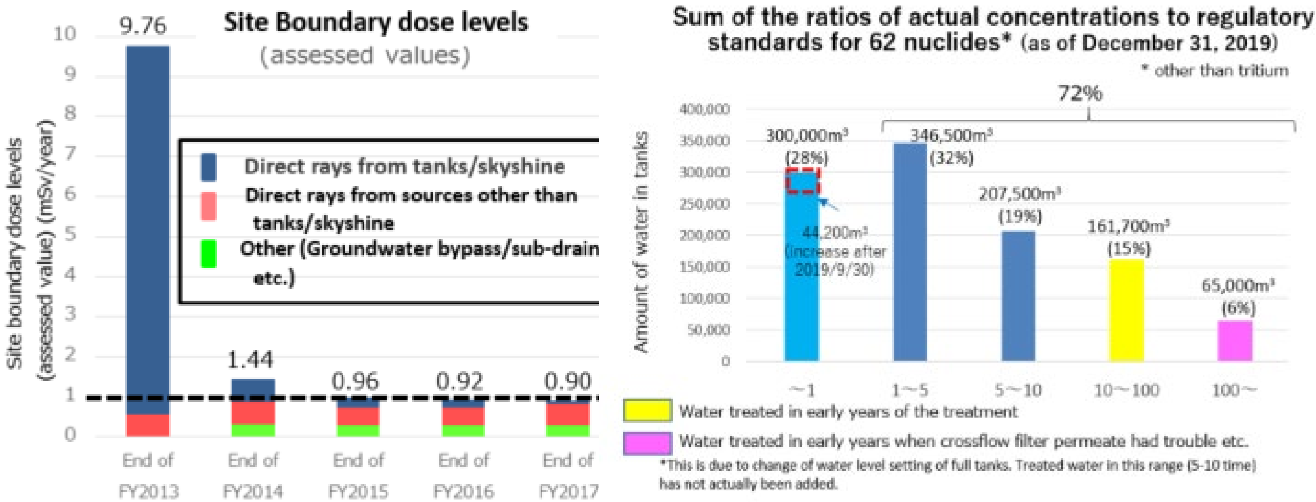

Figure 3. Estimated doses at the site boundary (left), and
Characteristics of the ALPS treated water* in tanks (right)

Under these circumstances, the subcommittee decided upon the following principles: to discharge the ALPS treated water stored in tanks (which needs to be re-purified) without normal purification process to the environment, secondary treatment[11] should be performed before dilution to satisfy the regulatory standards

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[10] Treated Water Portal Site (http://www.tepco.co.jp/en/decommission/progress/watertreatment/index-e.html).

[11] TEPCO states that it is examining a method that will use ALPS and/or other equipment, if secondary treatment is to be performed. Single-time treatment with ALPS can reduce radionuclides other than tritium to less than the regulatory standards for discharge as required by the Act, as seen in the track record of purification by ALPS

for discharge, instead of satisfying the regulatory standards for discharge by dilution alone, in consideration of social impact such as impact on reputation. While the regulatory standards must be satisfied as a matter of standard, building a system where a third party can check that the secondary treatment is performed properly will also provide assurance to locals and the parties concerned and is positioned as an important activity to neutralize the impact on reputation.

(6) Scientific characteristics of tritium[12]

Tritium, or hydrogen 3, is a radioisotope of hydrogen, which emits weak radiation (beta rays). In the natural environment, it is produced by cosmic rays and others on the Earth at about 70,000 TBq (TBq = Terabecquerel) per year. A major part of tritium exists as hydrogen that is comprised of water molecules, and is included in atmospheric vapor, rainwater, seawater and tap water. The amount of tritium in precipitated water in Japan is estimated to be about 223 TBq per year. Tritium is not concentrated in a specific creature or organ, because the water molecule containing tritium has similar characteristic to an ordinary water molecule. By drinking water, dozens of Becquerel of tritium are introduced into the human body. In addition, in the natural environment as well as in the human body, radioactive substances such as potassium 40 and polonium 210 already exist. The external and internal exposure doses of those naturally originated radionuclides are around 2.1 mSv/year in Japan. Tritium contained in water molecules has relatively low impacts on health, compared to other radioactive materials. The impact of the tritium per Becquerel is less than three hundredth of that of potassium 40. As has been discussed, radioactive materials or substances that are regarded as harmful are present in the human body to a certain extent, and it should be noted that the extent of impact on the human body is dependent on their concentration.

In addition, tritium is generated in nuclear power plants in and outside Japan as a results of their operation. Most of the tritium produced in these nuclear power plants is confined to the nuclear reactors, while some is removed from the reactors during maintenance activities such as fuel replacement, and is discharged into the sea, river, lake, and atmosphere in accordance with their country’s regulations.

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between the end of September 2019 and the end of December 2019 (see Figure 3).

12 8th ALPS subcommittee Documents 2-1, 2-2, 9th subcommittee, Document 4

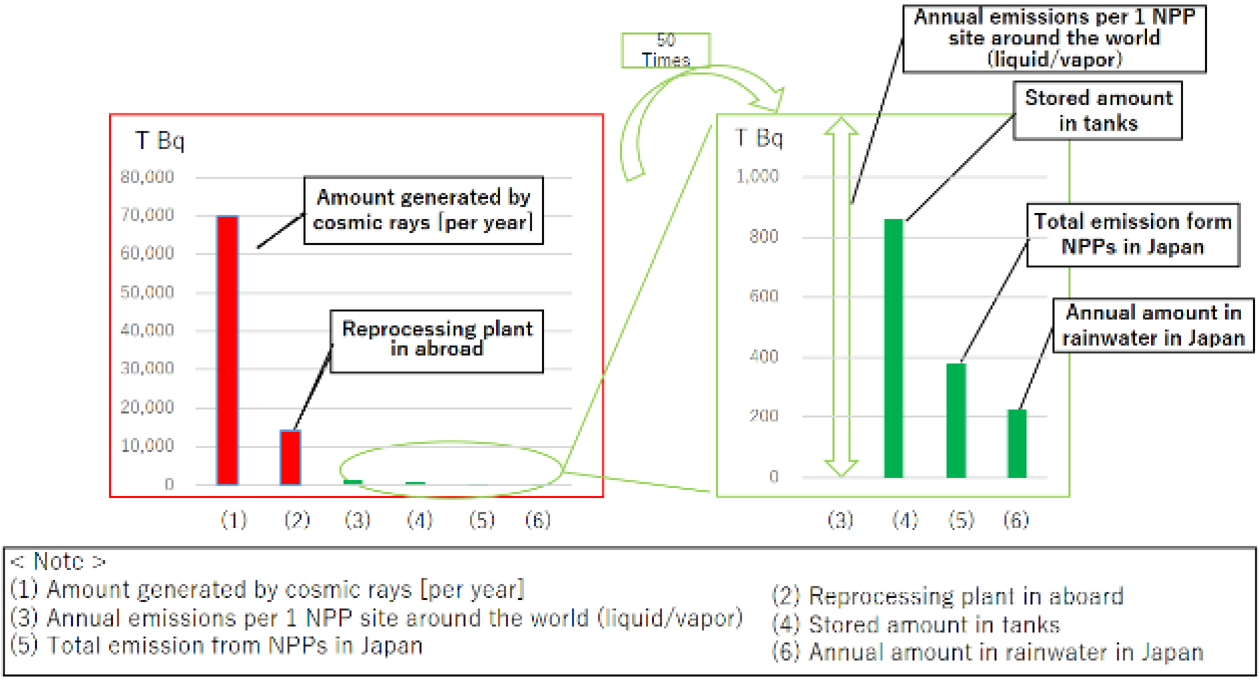

Figure 4. Status of tritium generation and discharge in and outside Japan

At the explanatory and public hearing meetings, opinions were voiced such as "organically bound tritium bioaccumulates in the body," and "compared to other radioactive materials, tritium is more hazardous". Based on these opinions, the ALPS subcommittee reviewed and summarized information based on research papers that employed reproducible data and the information carried by properly refereed scientific publications[13] in order to have discussions based on fairly evaluated scientific information.

[Biological impact of radiation]

● Unit *Sievert* (Sv) expresses the impact of radiation exposure on the human body.
→ Values are calculated based on physical radiation dose such that "the same level of impact will be expressed by the same value."

● Whether any biological impact from radiation exists or not and its extent, if any, is dependent on the exposure dose and dose rate.

● Deterministic effect is not induced when the dose is below a given value (threshold).

● The occurrence probability of a stochastic effect increases as dose increases, while below 100 mSv range, statistically significant increases are not seen (within the fluctuation range of natural occurrence probability).

[13] 11th ALPS subcommittee, Document 3-1, 3-2, 3-3

● Radiation damages DNA, although cells have a mechanism for repairing DNA damage.

● DNA is damaged routinely due to various causes, with most of the damage swiftly repaired.

→ When damage due to radiation is slight, the difference cannot be distinguished from damage caused by natural phenomena.

[Biological impact of tritium]

● Tritium releases weak beta rays only and may impact the body through internal exposure.

● Committed effective doses specified by the International Commission on Radiological Protection (ICRP) recommendations (50 years exposure for adults and until 70 years old for children)

Tritiated water (HTO): 0.000000018 mSv/Bq （1.8×10^{-8}mSv）*1

Organically bound tritium (OBT): 0.000000042 mSv/Bq（4.2×10^{-8}mSv）*2, 3

*1 : Of the tritiated water that enters the body, about 5% to 6% is converted into OBT, with the value taking into account the effect of the conversion.

*2 : The half-life of OBT in organisms comes in two forms: 40 days and about one year. Considering this, the impact of the OBT is two to five times as large compared to tritiated water.

*3 : The internal exposure dose from tritium compounds is no greater than three-hundredths, compared to water-soluble radioactive cesium (cesium 137) which shows a similar distribution in the human body.

● Animal tests and epidemiologic researches to date have not shown a far greater biological impact from tritium than other radiation or nuclides.

・Mouse carcinogenicity experiments showed that when the dose rate is 3.6 mGy/day (HTO concentration in drinkable water: about 140 million Bq/L) or lower, occurrence probability and quality are about the same as those due to natural cancer occurrence.

・According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), excess relative risk per 100 mSv[14] dose for cancer lethality of those engaged in nuclear power facilities work is about equivalent to the estimated value from atomic-bomb victims, and tritium has not been found to have a greater impact on health than other radiation and nuclides.

[14] Refers to the part the increment occupies by the risk factor (exposure radiation in this case) among relative risks.

- In addition, no examples of impact attributable to tritium have been commonly seen among nuclear power facilities.

● In the Japanese regulatory standards values for the emission of individual radioactive materials, the concentration of the pertinent radioactive material is specified such that, when water that includes the material is ingested daily for 70 years, the cumulative dose will be 70 mSv, namely, 1 mSv/year on average, which meets the yearly exposure limit for the public.[15]

(7) Tritium (isotope) separation technologies[16]

It is difficult to separate specific isotopes from isotope mixtures. Isotope separation work is to remove highly concentrated certain isotopes water from lowly concentrated isotope water. If the certain isotope is hazardous, the lowly concentrated isotope water is generally discharged to the environment complying with the regulations. The technology of tritium isotope separation is applied to through fuel-handling process at nuclear-fusion-reactor and others, which is designed to discharge the lowly concentrated tritiated water to the environment, whose tritium concentration is within the regulatory standards. It should be noted that the continuous storage of lowly concentrated tritiated water means that the large volume of treated water will be continuously stored. In that case, in addition to the highly concentrated ALPS treated water, the lowly concentrated ALPS treated water whose volume is equivalent to the water before isotope separation work should be continuously stored.

Concerning technologies of tritium isotope separation, the Task Force concluded that no technologies were close to practical use (in consideration of the volume and concentration of ALPS treated water) as described before. Concentration of tritium separation technologies in practical use is 10,000 times as high or higher when compared to the ALPS treated water at the Fukushima Daiichi NPS, while treatment throughput is tenths or lower (see Table 3 and Figure 5). From the viewpoint of engineering technology, even if there is a one-digit difference between the two technical challenges, the two challenges will be considered to be different challenges. As there are difference in digits both in the volume and concentration, technologies which have been already developed cannot be applied to the ALPS treated water as well. Accordingly, further research and development is required for utilizing separation technology at the Fukushima Daiichi NPS. Presently, no technologies have been judged as being close to practical use at the Fukushima Daiichi NPS. We decided to continue discussions on the condition that the separation of tritium will not be performed.

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15 The 2007 recommendations of the International Commission on Radiological Protection (ICRP) specify the annual effective dose limit for the public as 1 mSv.

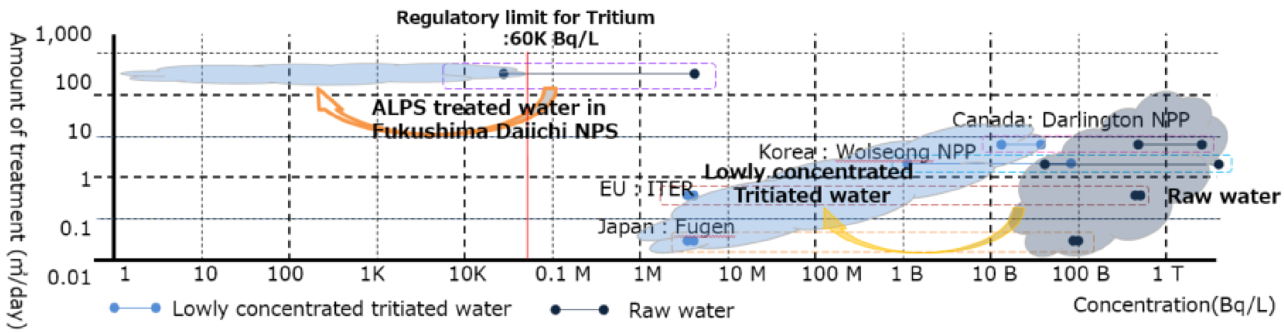
16 13rd subcommittee, Document 4-3

As research on new technologies is advancing, technological trends should be watched carefully and continuously.

Table 3: Tritium separation technologies in practical use

Track record in plants	Separation technologies	Start year of operation	Inlet concentration (TBq/L)	Separation factor	Amount of treatment (m^3/day)
Darlington Tritium Removal Facility (Canada)	Isotope exchange + Hydrogen distillation	1988	0.4～1.3	Around 10-100	8.6
Wolsong Tritium Removal Facility (Republic of Korea)	Isotope exchange + Hydrogen distillation	2007	0.04～2	About 35	2.1
Fugen Heavy Water Upgrader (Ⅱ) (Japan)	Isotope exchange	1987	0.1	25,000	0.03
ITER Tritiated Water Treatment Equipment (Design stage) (EU)	Isotope exchange* + Hydrogen distillation	2027(Planed)	0.4*	100,000*	0.48*

*Data shows only a part of the Isotope exchange.



* There is no practical separation technologies that can further reduce concentration of raw-water in large amount and low tritium concentration.
* Tritium concentration of Lowly concentrated tritiated water are the ones before dilution for discharge

Figure 5. Concentration of Raw water and Lowly concentrated tritiated water with tritium separation technologies in practical use

(8) Status of disposal of radioactive waste including tritium in and outside Japan

Waste generated at nuclear power facilities is classified into gaseous radioactive waste, liquid radioactive waste and solid radioactive waste. For gaseous and liquid radioactive waste, the concentration of the radioactive material is reduced as much as possible by filtering, adsorption, radioactivity attenuation with time, and dilution with a large amount of water or air, etc., to satisfy the regulatory standards of individual countries; thus complying with discharge requirements in a controlled manner, it is permitted that these wastes are discharged from the facilities handling radioactive material to the environment.

Each nuclear power site in Japan discharges radioactive waste containing tritium of tens of billions Becquerel to one hundred trillion Becquerel into the ocean. The three year average of the tritium emission records[17] before March 2011 is about 18 to 83 TBq/year for a power station with pressurized-water reactors[18]; about 0.0316 to 1.9 TBq/year for a power station with boiling-water reactors[19]; and about 360 TBq/year for all nuclear power stations in Japan. As a result, the concentration in the surrounding sea area ranges between below the minimum detectable limit and 1,100 Bq/L.[20]. The reprocessing facilities in Japan discharged a maximum of 1,300 TBq a year (fiscal year 2007), while changes in the concentration in the surrounding sea area range between below the detectable limit and 1.3 Bq/L[21].

The tritium contained in vapor evaporates naturally from the spent fuel pools and others are discharged to the atmosphere through ventilation.

Previously, advanced thermal reactor (ATR) Fugen, which used heavy water as the moderator, discharged a maximum of about 4.1 TBq[22] (fiscal year 1987) into the atmosphere and about 6.7 TBq (fiscal year 1989) into the sea, and changes in the concentration in the surrounding sea area between fiscal years 1986 and 1990 were between below the detectable limit and 2.9 Bq/L, while water concentration in the air remained between below the detectable limit and 22.9 Bq/L-water.

Nuclear power facilities in other countries conduct discharge into the sea, similar to those in Japan. At one such site, reprocessing facilities release 10,000 TBq or more a year, while another site with a heavy-water reactor discharges hundreds of trillions of Becquerel a year. Near the Bruce Nuclear Generating Station, Canada, which is

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[17] *Fiscal Year 2013 Annual Report on Nuclear Power Facility Operation Control* (Japan Nuclear Energy Safety Organization)

[18] Method that produces electricity by utilizing steam from steam generator with high temperature and pressure water which is generated in the reactor.

[19] Method that produces electricity by using steam generated in a nuclear reactor.

[20] Source: *Environment Radiation Database.* The measured value of 1,100 Bq/L was obtained only once when the water near the discharge canal of Fugen was sampled and measured in April 2009; other measured values, including those at the same sampling point at other times, were between below the detectable limit and 21 Bq/L.

[21] Source: *Fiscal Year 2018 Nuclear Power Facility Disaster Countermeasures Commissioned Expenses* (Ocean Environment Radioactivity Comprehensive Assessment Project) Research Report (Marine Ecology Research Institute)

[22] *Advanced Thermal Reactor, ATR Fugen Development Records and Technological Achievements* (2003)

one such site with a heavy-water reactor, the surrounding lake water concentration is between 3 Bq/L and 88.9 Bq/L (2016)[23], while the water concentration in the atmosphere is below the detectable limit (3 Bq/m^3).

As discharge to the atmosphere, vapor is released via ventilation in nuclear power facilities. At the Three Mile Island Nuclear Power Plant in the United States, where a nuclear accident occurred, vapor release in which a boiler forcibly evaporated the water was implemented to dispose liquid radioactive waste. The amount of the tritium released from the Three Mile Island Nuclear Power Plant in the form of vapor was about 24 TBq, while the amount of water released was about 8,700 m^3, and the release took longer than two years.[24]

Regarding the discharge record of tritium in fiscal year 2010, about 2.2 TBq/year[17] of discharge into the sea and about 1.5 TBq/year[25] of vapor release were conducted at Fukushima Daiichi NPS, while the TEPCO's Fukushima Daini Nuclear Power Station ("Fukushima Daini NPS") had about 1.6 TBq/year[17] of discharge into the sea and about 1.9 TBq/year[25] of vapor release.

The operational target value for discharge into the sea (for tritium, operational standard value for discharge) from the Fukushima Daiichi NPS is 22 TBq/year for tritium, while that from Fukushima Daini NPS is 14 TBq/year. These operational standard values for discharge were not determined from the viewpoint of radiation sickness prevention but determined as nonbinding targets for each power-generating light-water reactor structure, considering the design, operation and experience for them.

The process for setting these value is as follows: in 1975, the Atomic Energy Commission set out "the Regulatory Guide for the Annual Dose Target for the Public in the Vicinity of Light Water Nuclear Power Reactor Facilities" (hereinafter referred to as "Regulatory Guide"),[26] which set out the radiation dose target value as 0.05mSv/year to keep the public radiation dose, which was affected by radioactive material emission at the time of operation, at a low level. The Regulatory Guide is in accordance with the ALARA (As Low As Reasonably Achievement) principle[27] by the International Commission on Radiological Protection (ICRP), that every exposure dose should be kept as reasonably low as possible, considering social and economic factors. To the extent that the discharge will satisfy the above-mentioned radiation

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[23] Canadian Nuclear Safety Commission (CNSC) website. "Independent Environmental Monitoring Program: Bruce A and B Nuclear Generating Stations."

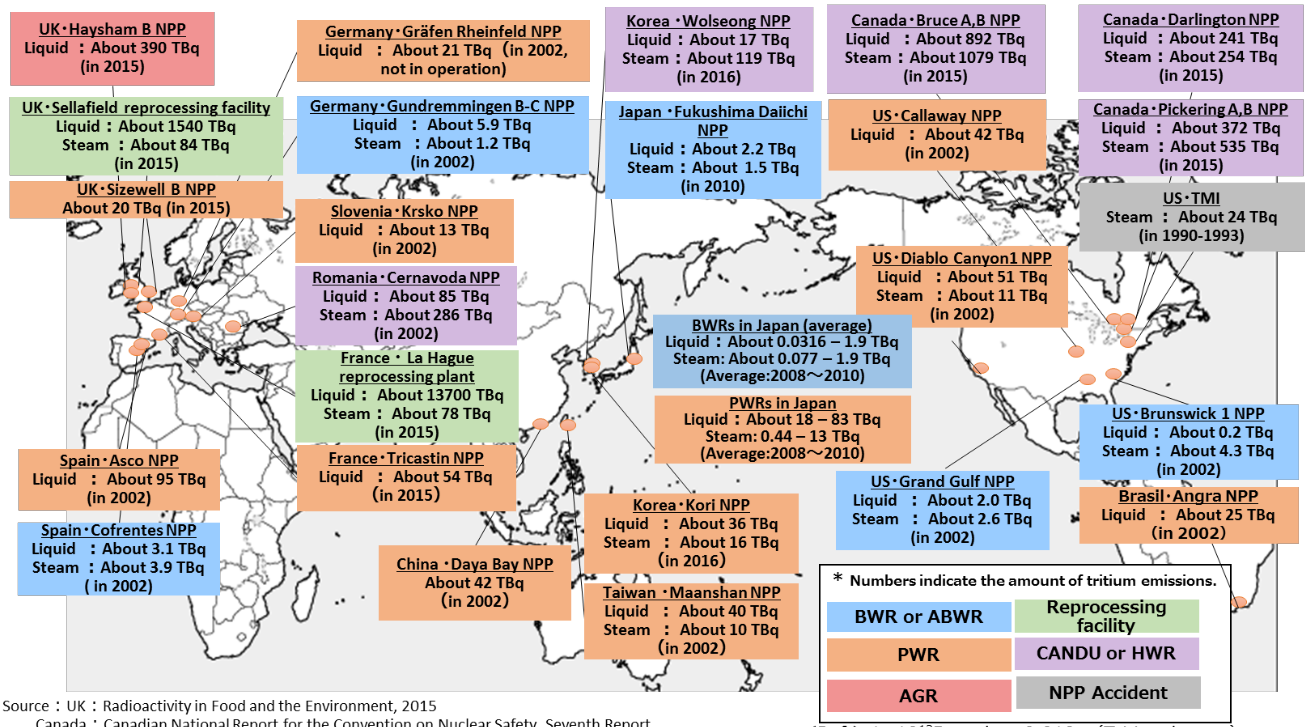
[24] 6th Tritiated Water Task Force, Document 3

[25] *FY2010 Results of Radioactive Measurement around Nuclear Power Station* (Fukushima Prefecture)

[26] The Regulatory Guide was revised by Nuclear Safety Commission in 1989 and in 2001.

[27] Expressions in recommendation by International Commission on Radiological Protection (ICRP) regarding the concept of limitation of exposure doses has varied with the times. The phrase in the recommendation at the time of establishment is "...that all doses be kept as low as is readily achievable, economic and social considerations being taken into account." and the basic principle has not been changed.

dose target value, the discharge control guide is determined for each radionuclides, based on the feasibility to achieve the discharge control guide, taking the design, operation and track record of the particular light water nuclear reactor facility into account. For liquid tritium discharge from Fukushima Daiichi NPS, the operational standard value of 22 TBq/year for tritium was set in 1979, when Unit 6 started its operation as the 6th unit in the NPS. However, even if these values are not satisfied, it would not pose a safety issue. If, for example, 22 TBq of tritium is discharged into the sea from the Fukushima Daiichi NPS, the conservatively estimated radiation impact will be 0.00001 mSv/year,[28] which is far lower than the radiation dose target value of 0.05 mSv/year. No operational standard value has been determined for tritium vapor release. Furthermore, the Fukushima Daiichi NPS was designated as a specific nuclear facility in November, 2012 after the accident. Since then, any operational standard value for discharge has not been set for Unit 1 to 4 of the Fukushima Daiichi NPS.



Source：UK：Radioactivity in Food and the Environment, 2015
Canada：Canadian National Report for the Convention on Nuclear Safety, Seventh Report
France：Tritium White paper 2016
Korea： FY2016 Survey on environmental radioactivity around the nuclear power plant and evaluation report, KHNP
Other countries ：UNSCEAR「2008 Annual report」 Japan： Fukushima Pref. and TEPCO report 2010 (data period from April 1, 2010 to March 11, 2011)

<Ref.> 1×10[12]Bq≒ about0.019g (Tritiated water)

Figure 6. Annual release of tritium from nuclear facilities in and outside Japan

After the accident at Fukushima Daiichi NPS, groundwater pumped up by groundwater bypass wells and sub-drain wells, both of which are meant to pump up groundwater before its ingress into reactor buildings and other buildings to reduce the

[28] Estimation by TEPCO

generation of contaminated water, and groundwater pumped up by groundwater drain wells to prevent groundwater inundation in the bank area after closure of the sea-side impermeable wall, have been discharged into the sea after being purified if necessary. Such ground water contains tritium at a level sufficiently below the regulatory standards for discharge.

In detail, groundwater pumped up by groundwater bypass wells and groundwater pumped up by sub-drain wells and groundwater drain wells and purified are discharged after the concentration of radionuclides are measured and confirmed to be below the operational target value. The operational target concentration for this release is 1,500 Bq/L for tritium, which is one-fortieth the regulatory standards for discharge. The operational target concentration is set so that the additional exposure dose of 1mSv/year or less at the site boundary in the Fukushima Daiichi NPS will be satisfied, hence the sum of the ratios of each radionuclides concentration to the regulatory standards should be 0.22 or less, that is assigned to the liquid radioactive waste including the influence of cesium and strontium. Confirmation that the concentration of radionuclides are below the operational target concentration is ensured via measurement by a third party, and the release is implemented with personnel from the local decommissioning and contaminated water countermeasure office in attendance, ensuring twofold control.

3. Examination on the disposal path

(1) Basic policy for the disposal of the ALPS treated water

Under the principle of coexistence of reconstruction and decommissioning, the decommissioning of Fukushima Daiichi NPS should be advanced safely and steadfastly. The disposal of the ALPS treated water falls under the "disposal of materials contaminated by nuclear fuel materials", which is a part of the decommissioning work specified in the Reactor Regulation Act, and the disposal must be completed duly before the completion of the decommissioning. Conversely, in order to proceed with decommissioning work, rushing the disposal of the ALPS treated water must not amplify reputational damage, as disposal of the ALPS treated water may induce impact on reputation. The disposal path of ALPS treated water must be discussed in consideration of the impact on reputation.

Accordingly, the disposal of the ALPS treated water should be so discussed as to neutralize such influence due to the disposal, without excluding its storage if necessary.

(2) The ALPS treated water disposal duration, amount to be disposed of, timing of disposal commencement, etc.

In consideration of the progress of future decommissioning work and the risks associated with the storage of large quantities of liquid waste, disposal should be completed as soon as possible not to leave such risks to future generations. However, if disposal starts at the later stage of the decommissioning, the amount of radioactive material to be disposed of can be reduced as radioactivity attenuation progresses with time. In consideration of the implementation period to neutralize the impact on reputation, it is important to determine disposal details to be optimal in light of disposal timing, duration, economic situation of local businesses, and psychosocial situations.

To complete disposal before the completion of decommissioning, the yearly amount of disposal and the disposal duration are in a trade-off relationship. Concerning the impact on reputation, a shorter-time disposal will cut the duration of reputational damage, but the yearly disposed amount will increase, and such reputational damage may be significant in a single fiscal year. If the start of disposal is delayed, the duration between its commencement and the completion of decommissioning will be shorter, and it will be necessary to increase the volume disposed of per year. It is highly possible that this will result in the disposal of amounts exceeding those released in the previous cases (discharge records and release control standard values at Fukushima Daiichi NPS, as well as discharge records at other nuclear power plants).

Table 4. Period of the disposal of the ALPS treated water* (year for completion) according to the starting time and annual volume of disposal[29]

Disposal amount / Start year of disposal	22 TBq/year*1	50 TBq/year	100 TBq/year	Maximum storage volume*2
2020*3	33 years (2052)	19 years (2038)	10 years (2029)	About 1.30 million m^3
2025	29 years (2053)	17 years (2041)	9 years (2033)	About 1.47 million m^3
2030	25 years (2054)	14 years (2043)	8 years (2037)	About 1.65 million m^3
2035	21 years (2055)	12years (2046)	7 years (2041)	About 1.83 million m^3

*1 Duration when yearly disposed volume is the same as the release control standard value for Fukushima Daiichi NPS before the accident.

*2 Current tank construction plan considers building additional tanks up to 1.37 million m^3 of capacity by the end of 2020.

*3 Since there is no possibility to commence the disposal in 2020, the row is presented as a reference case to show the relationship between annual disposal volume and duration.

<Major assumptions for calculation>

* Please be aware that these values are estimations calculated under various assumptions. Since, almost of all tritium in reactor buildings at Fukushima Daiichi NPS was generated in Unit 1-3 before the accident, it is assumed that the total amount of tritium which existed before the accident can be included in the contaminated water, while using trial calculations as much as possible, and that the duration of disposal may vary depending on the amount of tritium remaining in the fuel debris and other materials in the buildings.
* Contaminated water which will be additionally generated and daily radioactivity attenuation should be considered.
* It should be noted that even after disposal of the ALPS treated water stored in the tanks is completed, treated water continues to be generated until the end of decommissioning.

The impact on reputation may vary depending on whether the amount to be disposed of and concentration exceeds those of previous cases of existing nuclear power plants or cases of Fukushima Daiichi NPS after the accident. Therefore, disposals with lesser amounts and concentrations than those conducted in previous cases are expected to neutralize such impact on reputation to a certain level.

(3) The timing for initiating the disposal and the impact on reputation

The longer the delay in starting the disposal, the less interested the general public becomes and the less the amount of media coverage is generated, thus reducing

[29] 16th ALPS subcommittee, Document 3

impact on reputation. In addition, it is expected that understanding among the general public including the media will be enhanced. However, the commencement of disposal has the strong impact in media coverage as a new event. Thus, it is necessary to consider when the disposal will commence.

In comparing the decline in sales at the time of the disposal between starting the disposal while economic damage resulting from the accident remains and sales, etc. are low, or starting it after the Fukushima revitalization progresses and sales, etc. have recovered, the latter case will be more significant. However, in the latter case, business owners may have already rebounded and will be able to overcome reputational damage.

Currently, the ALPS treated water* has been stored in welded tanks with less leakage risk. In addition, double dikes have been built to prevent water from flowing out to the external environment in case of leakage from the tanks, while the water level in the tanks and tank leakage is perpetually monitored by means of monitoring and on-site touring. However, the risk of leakage due to a natural disaster, corrosion or operational errors during storage cannot be omitted, and if such leakage occurs, media coverage and others may lead to additional negative reputational impacts.

The influence on reputation is largely dependent on consumer psychology, so the discussion at the ALPS subcommittee should not be the only basis to determine the proper timing for the disposal start or duration.

Therefore, the Government of Japan should take the responsibility of determining the appropriate timing for initiating the disposal and the duration of the disposal taking into consideration the various factors related to the timing, the influence on reputation as well as the opinions of the parties concerned. At the same time, citizens' understanding should be encouraged and specific measures against reputational damage should be presented.

(4) Disposal path and other measures for the ALPS treated water

1) Social concern in case of disposal

As for the impact on social concern resulting from the disposal, the industries and areas influenced by the disposal will differ depending on the disposal path.

Table 5. Characteristics of social concern for each disposal path

	Geosphere injection, Underground burial (via leakage to groundwater)	Discharge into the sea (via ocean water)	Vapor/Hydrogen release (via atmosphere)
Areas which may be directly affected by social concern	- Though there may be social concern over leakages underground, the influence of social concern may stay focused on the land and sea area near Fukushima Daiichi NPS, as underground leakages may be perceived to be confined to a narrow area	- Social concern may have influence beyond the prefecture as the ocean covers a large area - Social concern over land may be limited - Social concern may have influence overseas if certain countries have concerns and invoke import restrictions	- Social concern may have influence beyond the prefecture as the atmosphere covers a large area - Social concern may have an impact on wide areas including land area and sea - Social concern may have influence overseas if certain countries have concerns and invoke import restrictions
Industries which may be directly affected by social influence	- As reputational damage would be induced by a leak from underground facilities, agricultural, forestry and fishery products may be the subject of social concern - With concerns over local foodstuffs, there may be avoidance of sightseeing and as a result, the lodging industry, the restaurant industry, public transportation and other industries may experience downturns in consumption	- The Fishery industry may be affected since the discharge path is the ocean. - As its emission path is the ocean, part of the tourism industry such as organizations catering to beachgoers may be influenced by social concern - With concerns over local foodstuffs, there may be avoidance of sightseeing and as a result, the lodging industry, the restaurant industry public transportation and other industries may experience downturns in consumption	- All commodities produced may experience social concern through air and rain, as the emission path is the atmosphere - In addition to the concern over direct external exposure and concern over the contamination of local foodstuffs and products, there may be avoidance of sightseeing. As a result, the lodging industry, the restaurant industry, public transportation and other industries may experience downturns in consumption
Timeframe for completing the disposal	Monitoring might be required after the end of disposal	From the start to the end of disposal	From the start to the end of disposal

*For discharge into the sea and vapor/hydrogen release, the influence on reputation from overseas must be considered

Social concern is greatly dependent on consumer psychology and other factors. Though the magnitude of the concern can be estimated on a certain assumption, the magnitude is difficult to compare comprehensively.

However, taking into consideration the opinions at the public explanatory meeting and public hearing as well as reactions from overseas, the magnitude of the social concern on discharge into the sea is expected to be particularly large if it is implemented without any countermeasures. Social concern on vapor release is also considered to be a significant magnitude. Although it is difficult to evaluate quantitatively, it has been pointed out that reputational damage occurred in the trading of marine products when discharging groundwater from the groundwater bypass and sub-drain started at Fukushima Daiichi NPS.

Regardless of which disposal path is selected, countermeasures for possible reputational damage which might arise after the start of disposal work must be prepared.

2) Examination of disposal path from a technical point of view

The Task Force examined five disposal paths as technologically feasible options including ones with technical challenges which may require time to be implemented, based on the basic precondition of scientific safety. For application to the treated water disposal at the Fukushima Daiichi NPS, the options are limited in practice. For example, geosphere injection would need to seek for the appropriate type of ground, while monitoring methods have not been established. When hydrogen release is used for the ALPS treated water, further technological development would be required for pretreatment, scale expansion and other processes and the possibility of a hydrogen explosion remains unresolved. For underground burial, solidification involves heating and thus involves water evaporation (tritium-included vapor release), and the establishment of new regulations may be necessary, while finding a disposal yard will remain an unresolved issue. It is difficult to estimate the period of time required to resolve these issues, although time restrictions should be considered. Namely, the three unprecedented options (geosphere injection, hydrogen release and underground burial) come with many unresolved issues for practical use in consideration of the regulations, technology, and time. For all of these reasons, the remaining practical options are discharge into the sea and vapor release, both of which have preceding practices.

3) Advantages and disadvantages for discharge into the sea and vapor release

Based on both social and technical points of view, the advantages and disadvantages for vapor release and discharge into the sea are as follows. The Government of Japan is expected to make a decision taking into account the following points and opinions of the parties concerned such as the local populations.

Vapor release was performed from a reactor that suffered from an accident. Although there is no standard for a controlled discharge, it is also performed from normal functioning reactors in a controlled manner at the time of ventilation. It should be noted that vapor release has the advantage that some radionuclides in the ALPS treated water would not be released but would remain as dried residue. As a result, the number of radionuclides to be released into the environment will be reduced. However, at the same time, the dried residue will remain as radioactive waste. Furthermore, attention should be paid to the difference in the scale and characteristics between the water of the precedent case and the ALPS treated water (For Three Mile Island nuclear power station accident: amount of tritium is about 24 TBq; and the volume of the water is about 8,700m^3). In Japan, there is no precedent in which liquid water is evaporated and released into the atmosphere in order to dispose of liquid radioactive waste.

Regarding vapor release, part of the vapor is re-evaporated into the air after falling onto the land. Thus, it is difficult to forecast the diffusion behavior of vapor release, which poses difficulties in considering measures such as a monitoring system. Furthermore, it is expected that the variation in monitoring results, which depends on climate conditions such as rainfall and wind direction, is wider than that of discharge into the sea. Therefore, in light of the impact on negative reputation, careful consideration will be required for release conditions, such as diluting sufficiently to make the vapor's concentration lower than the regulatory standard.

From the social viewpoint, it should be noted that vapor release will influence a wider range of industries than discharge into the sea. Countermeasures against reputational damage may arise in industries in Fukushima Prefecture as well as those in the surrounding region.

Regarding discharge into the sea, at nuclear facilities in Japan and abroad, radioactive liquid waste containing tritium is being released into the ocean etc. after dilution with coolant seawater etc. At Fukushima Daiichi NPS, the operational standard value for discharge was set as 22 TBq/year for tritium. Annual tritium emission from nuclear facilities in Japan is about 0.0316 to 83 TBq (three-year average before the accident, per site). Seeing these discharge records, the discharge into the sea can be done within the range of preceding practices in Japan.

One of the advantages for discharge into the sea is that this option can be implemented more reliably, considering the existence of the past track records for normal functioning reactors and ease of discharge facilities operation and proper monitoring methods.

That is, facility configuration for discharge into the sea is simple comparing to that for vapor release. In addition, as TEPCO has knowledge on the design of discharge system and its operation, it is possible to ensure steady disposal into the ocean in the construction and operation side. However, it should be noted that the concentration of tritium in the discharged water will not be the same as that of before the accident of Fukushima Daiichi NPS.

Regarding discharge into the sea, though particular situation where the levels of dilution and diffusion are lower than those forecasted depending on weather conditions etc. cannot be excluded, it is easier to forecast the dilution and diffusion behaviors after release when compared to vapor release. That is because the impact of the ocean current variation on the calculation is relatively small, compared to the impact of rain precipitation and wind direction on the calculation of vapor release. Therefore, it is easy to predict the area to be affected, and thus, easy to build an oversight system by setting proper monitoring equipment. In addition, when considering influence on reputation, it would be an advantage that the discharge into the sea has less incidence of unexpected diffusion behavior after the discharge. To neutralize the probability to cause the particular situation above, careful consideration will be required for discharge conditions, such as diluting sufficiently to make the water's concentration lower than the regulatory standard.

From the social perspective, discharge into the sea may cause reputational damage to the fishery industry and sightseeing industries in Fukushima Prefecture and the surrounding regions. Fish catches from tryout operations in Fukushima Prefecture have not even recovered to the level of 20% of those made prior to the Great East Japan Earthquake and measures based on those facts will be needed.

By means of the UNSCEAR-specified method, the exposure impact has been studied for vapor release and discharge into the sea, which shows that if the total amount of the ALPS treated water stored in the tanks is disposed of every year, the impact will be no more than one-thousandth of the exposure impact of natural radiation (2.1 mSv/year)[30]. Such scientific information should be thoroughly disseminated to neutralize the negative influence on reputation.

[30] 17th ALPS subcommittee, Document 3-2, 16th subcommittee, Document 2

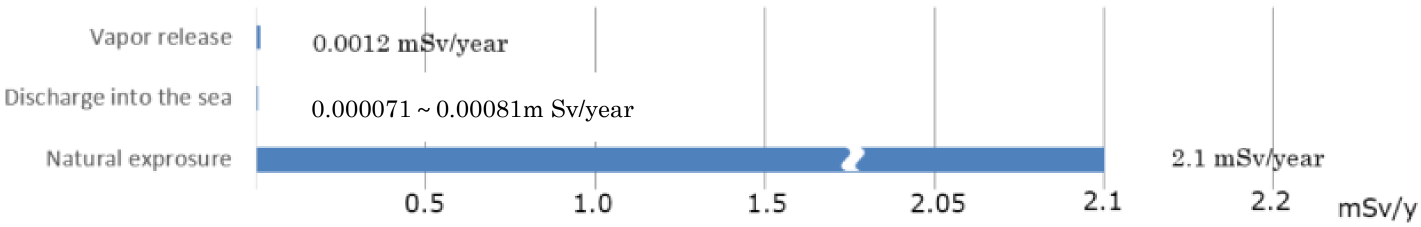


Figure 7. Comparison of radiation impacts between the releases of all amount of the ALPS treated water disposed of every year and natural radiation

- For discharge into the sea, concentration of radionuclides which are below their lower detection limit are assumed to be their detection limit value, and zero.
- In the case of vapor release, the effects of organically bound tritium (OBT) which is converted from tritiated water (HTO) are also considered.

In the case that both discharge into the sea and vapor release are performed, the merits of both methods can be utilized. However, it must be noted that there would be an increase in the number of facilities to be managed and added possibility of troubles. These should be added to the disadvantages of both methods.

(5) Thorough checks (monitoring, etc.) of radioactive material in the surrounding environment, etc.[31]

To neutralize the influence on reputation, it is essential to ensure safety and pursue assurance when disposal is implemented, and radioactive material checks (monitoring, etc.) of the surrounding environment should be performed thoroughly.

As an example, safety associated with disposal should be checked when disposal is implemented, such as whether the regulatory standard has been satisfied; and safety in the surrounding environment should also be checked to ensure that the concentration is sufficiently low in the surrounding environment.

Specifically, tritium monitoring should be strengthened before and after the start of disposal (more measurement locations and higher frequency).

- Measurement of the ALPS treated water concentration before dilution and disposal (ensuring safety during disposal)
- Measurement of exhaust vapor and/or discharged water concentration immediately after disposal (checking safety during disposal)

[31] 11th ALPS subcommittee, Document 4-2, 12th ALPS subcommittee, Document 2

- Measurement of concentration in the surrounding environment, agricultural and fishery products (checking safety in the surrounding environment)

Because the influence of tritium on the human body differs depending on its chemical form, it is important to learn the forms in which tritium exists in the environment. To measure tritium, normally a liquid scintillation counter and rare-gas mass spectrometer are used. However, the concentration in the environment is very low, and multiple pretreatments are required before measurement, including the removal of impurities by distillation and electrolytic enrichment where necessary, which require time and skills.

For measuring organically bound tritium in organic samples, more pretreatments are required than for liquid samples, including freeze-drying and combusting the organic matter samples before measurement. The combustion water will be used for measurement, both requiring time and skills.

A necessary analysis system should be built considering these conditions, and measurement target values must be set properly based on the international tritium drinking water standard values (e.g., EU, 100 Bq/L[*1]; and WHO, 10 kBq/L[*2]) to perform measurement.

*1: Screening value based on which judgement is made with regards to whether or not additional investigation is required.

*2: Guidance level required to determine whether dose reduction measures should be taken.

Further, to neutralize the influence on reputation, measurement by a third party and disclosure of measurement results and other measures are important to enhance the validity and transparency of the measurement results. To eliminate anxiety about disposal and pursue safety, easy-to-understand, considerate information communications should be implemented using measurement results. In addition, consideration is needed to disseminate information not only domestically but also internationally, and to involve international organizations.

4. Direction of countermeasures against reputational damage

The ALPS subcommittee has examined reputational damage based on cases in the past and the precedent measures for the accident of Fukushima Daiichi NPS.

(1) Basic knowledge of reputational damage

1) Mechanism and precedent cases[32] of reputational damage

Reputational damage is caused by media that reports safety-related social issues (accidents, environmental pollution, disaster and recession) which bring economic damage caused by people who shun the products of a certain region or refrain from traveling there due to concerns about the dangers of foods, products, soil, and companies that are actually "safe". Reputational damage is distinctly considered different from direct "virtual damage" due to the impact of radiation.

Precedents of reputational damage cases related to nuclear are as follows: Daigo Fukuryumaru exposure incident in 1954, radiation leakage of nuclear ship Mutsu in 1974, and critical accident at JCO nuclear fuel fabrication facility 1999. Daigo Fukuryumaru exposure incident was widely covered by media and as a result, almost all fishery products including tuna got thrown off the market. Economic damage on fishery products was officially recognized as "indirect damage", for the first time. Following that incident, radioactive fallout was detected in many regions of Japan, which caused concern over agricultural products and drinking water. Regarding the radiation leakage from the nuclear-powered ship "Mutsu", it was reported that there was no release of radioactive material harmful for the human body. However, economic damage to the scallop related industry was considered to be about 10 billion yen. At the time of the critical accident of JCO nuclear fuel fabrication facility, even after safety was confirmed, economic damage due to the suspension of trading and price decline across a wide number of businesses. These include agricultural products such as sweet potato, fish and shellfish such as whitebait, processed food such as dried sweet potato and fermented soybeans, as well as business within the sightseeing industry such as hotels and inns.

There could be several causes for reputational damage: the society in information overload where the judging with scientific accuracy is difficult and alternative products are easily obtained, and social trends where people psychologically seek a high level of assurance and safety. For example, consumers think that they should protect by themselves. Around 90% of people are conscious of the safety of fresh products. It should be noted that being safe is not the equivalent to being reassured. In addition, the decision of whether to buy or not is an important action for consumers.

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[32] 2nd ALPS subcommittee, Document 2, 5th ALPS subcommittee Document3,and 8th ALPS subcommittee, Document 3

The examination has been conducted assuming that the ALPS treated water will be disposed of. To prevent reputational damage, risk communication measures for accurate information dissemination and economic measures for reputational damage prevention, restraint and compensation are conceivable. Proper measures need to be considered on individual layers of consumption, and the distribution and production stages, including the impact on overseas.

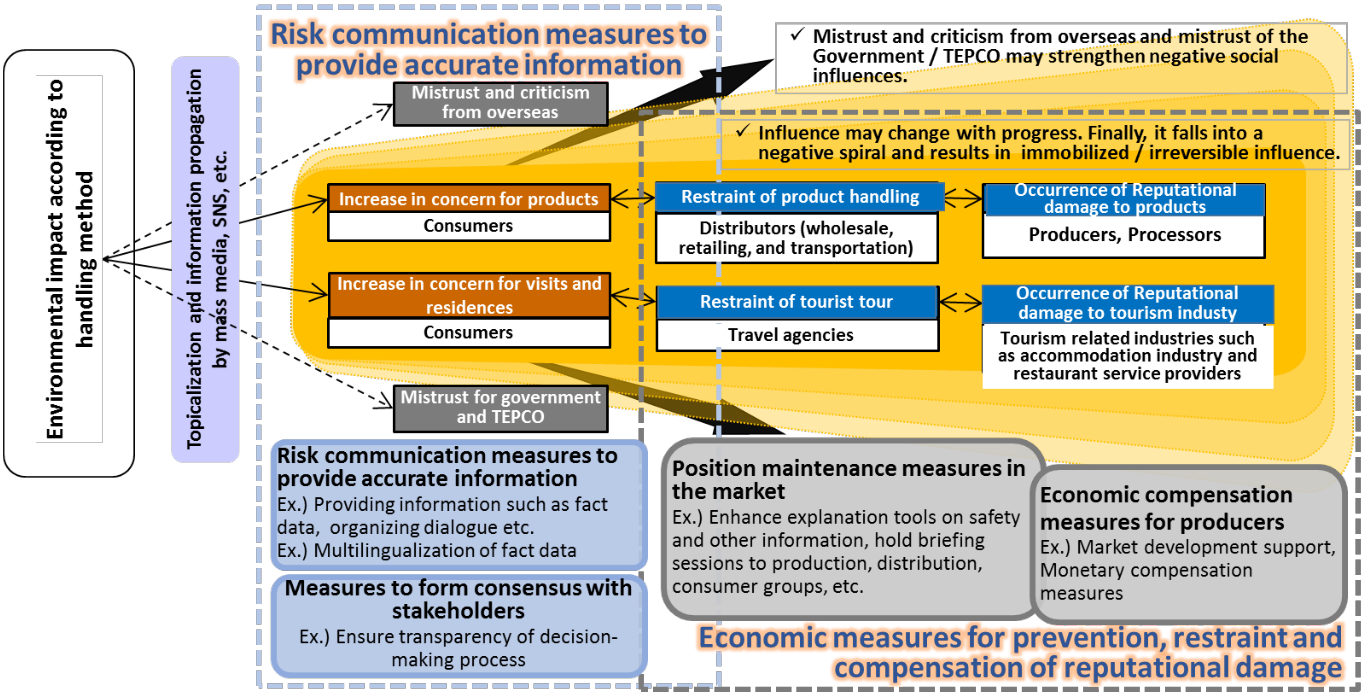

Figure 8. Major social impact which may arise with the disposal of the ALPS treated water and countermeasures

2) Reputational damage resulting from Fukushima Daiichi nuclear accident[33]

Fukushima Daiichi nuclear accident is considered to have had an influence on the occurrence of avoidance of purchasing agricultural, forestry and fishery products and of sightseeing as well as defamation which has arisen from information related to radioactive materials.

To ensure the safety of agricultural, forestry and fishery products, decontamination of farmland has been implemented in order not to distribute any food containing radioactive materials above their standard values. In addition, the inspection system has been strengthened to allow the distribution of only the food products whose safety are confirmed. For the fishery industry, tryout fishing has been conducted for the fish

[33] 2nd ALPS subcommittee, Document 2 and 3, 3rd ALPS subcommittee Document 2,3 and 4, 4th ALPS subcommittee, Document 2 and 3, 5th ALPS subcommittee, Document 2, 12th ALPS subcommittee, Document 3-2 and 3-3

species whose safety are confirmed through monitoring analysis which exceeds 60,000 samples.

However, the price of rice produced in Fukushima was almost the same as its national price before the Earthquake, but it has been continuously lower than its national price since the Earthquake. The price of Fukushima beef was also about the same as its national price before the Earthquake. After 2011, the price of Fukushima beef experienced a sharp decline followed by a gradual recovery. The price is still lower than the national beef price. It is noted that the proportion of rice production in Fukushima sold for professional use has increased after the Earthquake.

Various countermeasures have been implemented to mitigate reputational damage. In particular, for rice, Fukushima Prefecture has been voluntarily conducting radiation checkups for all rice products in bags to secure consumers' confidence. Regarding the fishery industry, Fukushima Prefectural Fishery Cooperation has been conducting radiation checkups with the voluntary standard which is stricter than the national standard value, and prevented fish and seafood with higher values than the voluntary standard from being distributed.

By conducting these measures and disseminating information on them, the number of people who avoid the Fukushima's products and economic impact of reputational damage has been declining. On the other hand, it should be stated that the influence of reputational damage still remains. This is due to the fact that the distribution of products has not been continued, to shipping restrictions and voluntary restraint of farming and operations following the accident, and Fukushima products' market have not recovered, as the continuous avoidance of Fukushima products has changed distribution structures in favor of alternative products from other prefectures. As reputational damage has continued since the accident, it has become entrenched and a continuous distribution structure problem. If the market share of Fukushima's product is high, Fukushima's product is bought. However, when the share of the other prefectures' products are substantial, Fukushima's product is not bought at the distribution phase. For those reasons, economic damage on Fukushima's industries has persisted. For example, fish catches from tryout operations in Fukushima Prefecture have not recovered beyond 20% of their pre-Earthquake sales, even though the number of people who avoid the purchase of Fukushima's marine products has been decreasing. An investigation showed that the number of people who avoid Fukushima products declined from over 40% of the total just after the accident, to over 10% of the total in 2018.

3) Impact on reputational damage in case of the disposal of the ALPS treated water[34]

In the case of disposal of the ALPS treated water, though its magnitude and timing might vary, a wide variety of negative social impacts may arise if all people's concern are not dispelled. Information on the disposal is distributed through the media, social media and the other means and as a result, consumers' concerns will be spread to distribution businesses, producers, and other related businesses.

Moreover, various anxieties which are associated with the disposal of the ALPS treated water, may induce different reputational damage at the consumption, distribution and production stages.

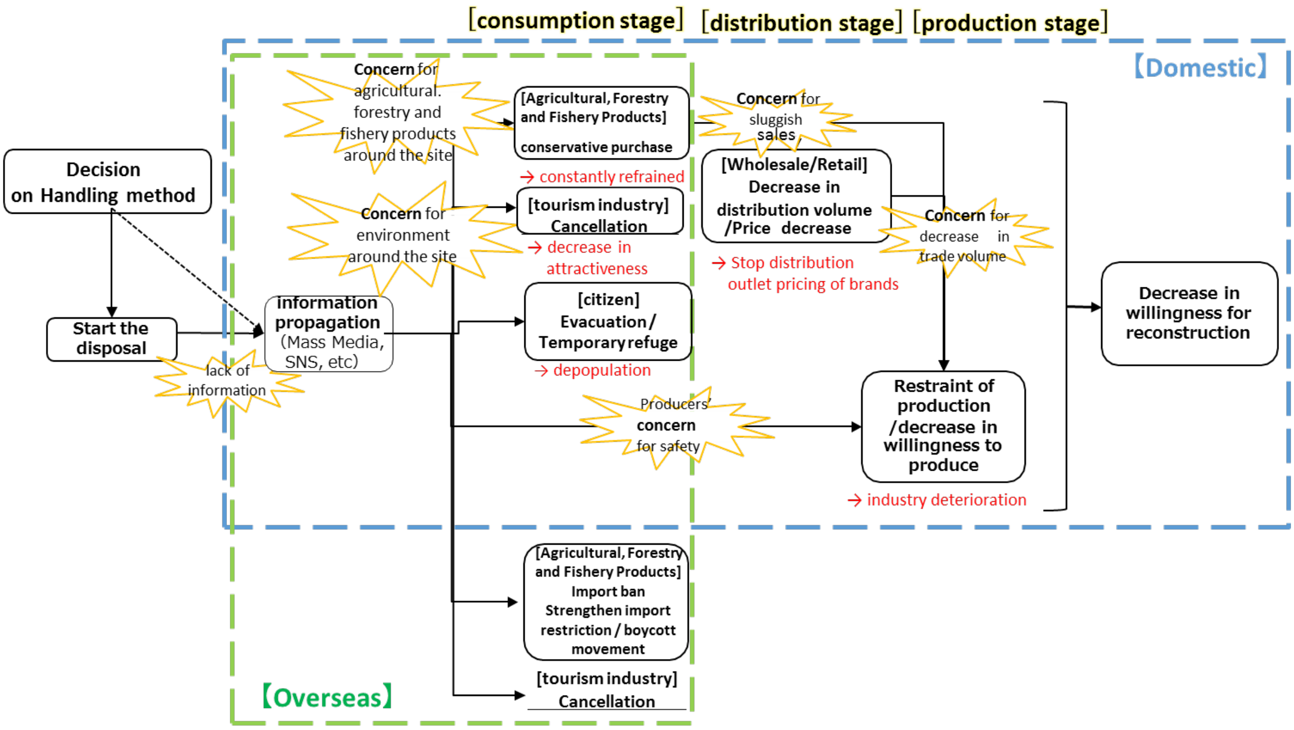

Figure 9. Mechanism of reputational damage occurrence

In addition to these general discussions, seeing that the current situation in which the economic damage has continued as the reputational damage grows from a short-term issue to a structural problem, the impact of the disposal of the ALPS treated water on reputation should be examined taking the current situation into consideration. The newly arising impact seems to be the same as the one which arose after the Fukushima Daiichi NPS accident and continues to spread in addition to the existing negative reputation. Therefore, comprehensive countermeasures against

[34] 12nd ALPS subcommittee, Document 3-1

reputational damage should be implemented, considering the existing countermeasures from the accident to date, and giving due consideration to the fact that the possibility of additional arising economic impact to the existing reputational damage is extremely high. The ALPS subcommittee reviewed the existing measures and examined the necessary measures in the future.

(2) Measures taken to date against the reputational damage by Fukushima Daiichi accident[35]

The Government of Japan, Fukushima Prefecture and TEPCO are taking various measures to reduce reputational damage. The measures taken by each organization are summarized and categorized below as risk communication measures for accurate information dissemination and economic measures for preventing, neutralizing and compensating reputational damage.

1) Measures taken by the Government of Japan

The Government of Japan is taking measures both domestically and internationally such as accurate and effective information dissemination and the expansion of markets for products from the disaster-affected area based on “the strategy for reputational damage elimination and risk communication reinforcement.”

Domestically, the Government of Japan disseminates information by mixed media such as TV, radio, website, and social media to promote accurate public understanding of the knowledge of radiation and to dispel misunderstandings, as well as implements the publication / distribution / utilization of radiation-explanatory side books for school use and brochures. Internationally, Government of Japan disseminates information in such forms as brochures in multiple-languages.

The ALPS treated water issue has been drawing strong interest from neighboring countries with environmental concerns about its disposal. The information regarding the decommissioning and contaminated water management has been provided internationally by various ways such as short films on the current situation, brochures, and articles in the journal “Japan Spot Light” in English. Besides that, the Government of Japan has held briefing sessions and site visit tours to Fukushima Daiichi NPS for all diplomatic missions in Tokyo and for the foreign press to explain the current states of the decommissioning and the contaminated water management as well as the examination status of the ALPS subcommittee.

[35] 3rd ALPS subcommittee Document 3-1 to 3-4, 7th subcommittee Document 2-1 to 3-2

The status of the Fukushima Daiichi NPS decommissioning and contaminated water management has been explained at various international events, such as the IAEA General Conference, G7 meetings, and other international conferences including bilateral committees with various countries.

Regarding economic measures for preventing, neutralizing and compensating reputational damage, the Government of Japan is comprehensively supporting all stages from production to distribution to sales in order to enhance "Fukushima"'s brand power of agricultural, forestry and fishery products and to expand and open sales channels, thus restoring Fukushima Prefecture's agricultural, forestry and fisheries industries. More specifically, producers are encouraged to acquire third-party certificates such as Good Agricultural Practice (GAP) and Marine Eco-label (MEL). New distribution channels using online stores, etc. are being opened. Opportunities for sales meetings are supported for their enhancement. Finally, the establishment of retail space for Fukushima products in major mass merchandising stores is promoted. According to an investigation on the distribution status of Fukushima's agricultural products based on "the Act on Special Measures for the Reconstruction and Revitalization of Fukushima", production amounts and price levels have not yet recovered to the pre-Earthquake levels, and suppliers including wholesalers, evaluate Fukushima Prefectural products more negatively than their customers such as retailers and restaurants. For Fukushima Prefecture agricultural products to be evaluated and handled properly, guidance, etc. has been given to inform that customers such as retailers are not at all negative concerning the handling of Fukushima Prefectural products.

For countries and regions that impose import restrictions on Japanese agricultural and fishery products and food, the Government of Japan has made efforts to abolish or relax such restrictions. As a result, 33 out of 54 countries and regions have abolished their import restrictions and 20 have relaxed them (as of January, 2020). Concerning the Republic of Korea's import regulations, in April 2019, the World Trade Organization (hereafter referred to as "WTO") Appellate Body reversed the Panel's substantive findings of these measures' WTO inconsistency. Against such background, the "Direction of Actions Considering the Results of WTO Appellate Body Report" was released in May 2019, aiming to further relief or eliminate import restriction measures maintained by some countries and regions.

In addition to the measures above, to attract more tourists from in and outside Japan to disaster-hit areas, information is disseminated through cooperation with influencers and through sales campaigns in collaboration with travel companies to increase visitors to the Tohoku region from overseas. As the dialog-based "Hope Tourism" promotion, the government is committed to restore educational tours to Fukushima Prefecture.

2) Measures taken by Fukushima Prefecture

Fukushima Prefecture has established "the strategy for strengthening reputation and weathering measures (currently the 3rd edition)", and is taking measures to restore and develop sales channels for local products, promote tourist attraction, disseminate accurate information both domestically and internationally, and expand "the circle of sympathy and support" and "collaboration".

Specifically, Fukushima Prefecture organizes promotion events at commercial facilities and others in the Tokyo metropolitan area by "all Fukushima" in which relevant people and organizations in Fukushima cooperate, information is disseminated using national newspapers, social media, and cutting-edge video contents. Information dissemination in and outside Japan is reinforced by appearing in major international conferences and conducting field visits to Fukushima by officials from diplomatic missions in Tokyo.

Moreover, Fukushima Prefecture is expanding distribution and consumption, and attracts inbound tourism by the following means,

- setting up and expanding merchandise showcase of Fukushima products at retails stores with the aim to regularize the distribution,
- holding "the Fukushima Pride Fair" dealing with rice, beef, GAP products and seasonal agricultural products in Tokyo metropolitan area and other areas,
- promoting the attractiveness and safety of local agricultural products by using TV commercials and other media,
- strengthening product development and branding with "Fukushima Mantendo" which is a common brand name for the 6th industrialized products,
- expanding the acquisition of third-party certificates such as GAP, and Marine Eco-label (MEL) certification and retaining sales channels by settling merchandise showcase for those products, or by holding fairs,
- promoting tourism by showcasing Fukushima food, sake, history, the beautiful local scenery, local activities such as mountain climbing and so on, and
- promoting Fukushima's attractiveness by combining of local food and tourism.

In addition, Fukushima Prefecture enforces information dissemination cooperates with local governments such as by publishing articles in public relations magazines and promotes support activities from companies by meeting with those companies or holding seminars for them. Also, Fukushima Prefecture reinforces the collaboration with companies, organizations and municipalities nationwide by conducting field tours, holding meetings or visiting events held by companies and universities interested in Fukushima. Besides that, by promoting immigration from other areas and inviting companies newly located in Fukushima, the Prefecture tries to appeal to people's sense of empathy and resonance in order to foster collaboration.

Furthermore, as an approach for radiation risk communication (dissemination of accurate information and knowledge), measurements of air radiation dose and strengthening management system in production stage of agricultural products (promotion of GAP acquisition, etc.), and food monitoring inspections with the strictest standard in the world are conducted and this information is disseminated proactively through cooperation with the government and municipalities. By these measures, they try to eliminate radiation anxiety (in other words, eliminating reputational damage).

3) Measures taken by TEPCO

TEPCO has established the "Action plan against reputational damage,[36]" and while listening to opinions from the parties concerned and through cooperation with Fukushima Support Company Network (Fukushima-OKnet) member companies, it is committed to the elimination of reputational damage as the central player of the accident, and conducts three key actions: "purchase increase and distribution promotion," "information dissemination," and "joint businesses."

Specifically, as a risk communication measure to disseminate accurate information, TEPCO disseminates information on Fukushima Daiichi NPS, promotes public understanding on radiation, and provides information on the safety and attractiveness of Fukushima products, in order to effectively present accurate information on safety.

As far as economic measures for preventing, neutralizing and compensating for reputational damage, TEPCO conducts initiatives such as;

i) Activities to increase the chance to touch and experience "Fukushima"

- Expanding purchases of Fukushima products as entire TEPCO Holdings,
- Supporting the usage of Fukushima products among member companies of "Fukushima OKnet",
- Promoting Fukushima products in the restaurant industry, retail and mass sales industry;

ii) Activity to engage in the production, distribution and consumption businesses of "Fukushima", taking into account the opinions of the parties concerned

- Examining ways to collaborate with people aiming to develop Fukushima's agriculture and fisheries industry, and

[36] 7th ALPS subcommittee Document 3-1 and 3-2

- Examining ways to engage in order to add higher value to Fukushima products (branding)

In addition, TEPCO compensates for losses from reputational damage according to the intermediate guidelines set by Dispute Reconciliation Committee for Nuclear Damage Compensation.

In addition to the measures mentioned above, the subcommittee examined the necessary countermeasures at the time of the disposal of the ALPS treated water.

(3) Countermeasures in the case of the disposal of the ALPS treated water

When the disposal is conducted, the disposal method should be well-crafted to neutralize the impact on negative reputation, keeping in mind that the reputational damage should not arise. However, in the case which people's concerns are not dispelled, it would be assumed that for any case of disposal, reputational damage may arise though the magnitude and the timing of the damage may differ. Therefore, the countermeasures should be examined in light of the preparation for the reputational damage arising after the disposal and necessary countermeasures are required to be implemented.

1) Examination of the disposal method considering the reputational impact

First, it is necessary to examine the disposal method which could avoid reputational damage as much as possible.

As an important precondition, radionuclides other than tritium should be surely reduced to satisfy the regulatory standards, not by dilution, but by secondary purification using the ALPS and other equipment. The appropriateness of the secondary purification should be confirmed by the measurement of their concentration before starting discharge.

In addition, it is important to dispel the anxieties related to disposal and to seek reassurance, in order to neutralize the negative reputational impact. Information on the situation in which the secondary purification is implemented and the concentration of the ALPS treated water to be disposed of should be disseminated in a considerate and easy-to-understand manner. At the same time, it is important to improve the transparency and to ensure the validity by the implementation of the measurement by a third-party organization and the disclosure of those measurement results.

Moreover, the appropriate methods, such as the timing for the start of the disposal, disposal volume, period for disposal, concentration at the time of disposal, should be determined taking into account the possible countermeasures for reputational damage and the opinions of the parties concerned.

In particular, the concentration at the time of disposal should be examined not only for satisfying the regulatory standards but also for being accepted by the parties concerned and consumers, while showing the past records and comparisons.

At the time of disposal, the operation should be stopped if a radiation monitor detected an irregular value and if the disposal facility had any malfunction.

As stated above, it is essential for the consumers including the parties concerned to neutralize the impact to the negative reputation to a certain degree. Considerate information disclosure of the measurement results is an important action. For example, the monitoring of the surrounding environment should start previous to the disposal and the information should be disclosed in an easy-to-understand manner such as by making comparisons between the pre-disposal and post-disposal environmental monitoring results. Safety of the surrounding environment should be explained, by implementing a diffusion simulation beforehand to show that the disposal will not pose a problem.

2) Risk communication measures for accurate information communication

Unlike immediately after the accident, there is a period for risk communication measures between the determination and implementation of the disposal of the ALPS treated water. Therefore, by utilizing this period, information should be disseminated thoroughly before starting the disposal, to deliver the message that there is no issue regarding the disposal method and its safety. Considering the fact that the disclosure of the evidence for safety has had a positive effect in encouraging people to buy products, courteous and comprehensible information dissemination is important. As measures taken after the accident, the facts such as the inspection system and measuring results have been disclosed, not relying on an image strategy. When disseminating information and keeping people informed, disposal methods and radiation effects of the disposal which would be sufficiently small, should be disclosed to the parties concerned and consumers using comparisons with existing cases and advanced simulation.

It is also necessary to promote public understanding of tritium. At the explanatory and public hearing meetings, it became clear that many people have been concerned or anxious about tritium. To address those concerns and anxiety, it is important to disseminate the information on scientific characteristics of tritium reported to the ALPS subcommittee in a clear and understandable manner. In particular, because the influence of tritium is small and its energy is too weak to measure. Conveying scientific knowledge through the experience of the measurement is one of the options. Needless to say that education on radiation is important.

The influence of reputational damage may not remain in the local area but instead may spread across the country as well as outside the country. Thus, the role of mass media is critical for information dissemination, and its effect is extremely significant. Therefore, the Government of Japan and TEPCO should make efforts to provide information to mass media not only promptly but also comprehensively and clearly including the background and scientific point of view.

The role of social media is also important. Easy-to-understand public communications and information dissemination should be thoroughly exercised by means of more varied media than in the past. As an example, by building a network consisting of influencers who proactively disseminate information about Fukushima, informed knowledge will be spread comprehensively. Not only the government's efforts, but also the support for the private sectors' information dissemination efforts using social media and other tools also needs to be reviewed.

In response to the Fukushima Daiichi NPS accident, seminars and workshops for discussing radiation and related issues with local people have been held so far, and study sessions on radiation measurement as well as an experiment program related to forest and food safety of Fukushima have been organized. By utilizing those existing occasions and, if necessary, newly built dialog, initiatives such as on-site lectures would enforce various layers so that experts and the general public such as consumers can directly communicate. In addition, it is important to implement the initiatives from a wide perspective, such as for example, hands-on learning, experience activities and outreach activities in which the administration visit local residents and hear their opinions directly.

In addition, by transmitting measures to eliminate the impact on reputational damage in those areas nationwide, the public understanding seems to be deepened. So, the information transmission of local initiatives to other areas should be proactively considered. In doing that, it is necessary to keep in mind that knowledge of radiation and an understanding of the geography of Fukushima differ between people who live in Fukushima and outside of Fukushima.

Concerns on the handling of the ALPS treated water arise mainly in neighboring countries, and accurate information on the progress of decommissioning of Fukushima Daiichi NPS and the situation of Fukushima is yet to be widely circulated in these countries. First of all, it is important to convey such basic information to them. In particular, information on the air radiation dose in Japan and food inspection system in Japan have not been sufficiently disseminated to the international society, and media reports based on inaccurate information have spread overseas and carried back to Japan. As a result, these inaccurate reports have become news in Japan which bring about a bigger influence on reputational damage. In consideration of such conditions, it is important to further disseminate information that Japanese food is very carefully inspected based on the establishment of the world's strictest levels of radioactive material standards and that its safety is ensured as well as the reconstruction which is underway in the disaster-affected areas.

For the handling of the ALPS treated water, it is necessary to proactively disseminate messages which show accurate facts and correct misunderstandings. Specifically, related information should be disseminated to the international society including neighboring countries, through all possible opportunities such as international meetings and briefing sessions organized for all diplomatic missions in Tokyo and foreign press.

3) Economic measures for the prevention, restraint and compensation for reputational damage

Regarding economic measures, reputational damage due to the influence of the accident shifted from a short-term issue into a structural issue. Some industries are on the way to revitalization. In consideration of these conditions, keeping in mind that the disposal of the ALPS treated water will cause additional economic damage in addition to existing reputational damage, fundamental measures should be taken. Thorough measures should be taken for relevant industries to recover and revitalize. For the production stage, not only compensation but also support for the independence of local economy is required. In the distribution stage, supportive measures are needed for solving structural problems in both Fukushima Prefecture and in other prefectures.

Regarding the countermeasures for reputational damage, the government and private sector have been making effort while utilizing nine years' of experience and adding measures to dispel the influence on the reputation. However, the reputational damage still present. Under the circumstances, making effective use of the experience regarding countermeasures against reputational damage after the accident, more effective measures in terms of both quality and quantity should be performed.

As an example, the effort of inspecting the total volume of Fukushima Prefecture-produced rice by checking every bag is a good example to help rebuild the trust of customers concerning the enhanced inspection system and safety of agricultural products.

Also, the acquisition of GAP and Marine Eco-Label (MEL) certificates endorses product safety and seems to be effective to regain trust in the origins of the products. By aiming at the establishment of sustainable agricultural, forestry and fishery industry including food safety as well as conserving the environment, not only does it lead to business improvement and effectiveness but also securing the trust from consumers.

It has also been effective to promote the establishment of permanent retail space for the restoration of sales channels for agricultural and fishery products and the allocation of special sales staff on in stores. Fukushima products are sold successfully at the events and other occasions. Having that experience, it is important to develop new market channels in the ordinal distribution structure and re-create a situation in which the Fukushima products can be purchased at retailers at any time, in order to clear the influence on reputational damage. In addition to the continuous effort to develop market channels, it has been reported that the allocation of special sales staff has had a positive effect for stores and it should be one of the measures to be continuously implemented.

Establishing on-line stores has also been effective, in addition to the above-mentioned efforts for recovering ordinary market channels and gaining new markets. Strengthening these new efforts is also one of the important measures under the situation where distribution structural problems arise by the continuous influence on reputational damage. These measures should be implemented while considering the situations of the existing distribution.

By expanding and enhancing measures against reputational damage, while referring to better practices, efforts would be accelerated for reducing reputational rumor.

4) Countermeasures for possible impact on the reputational damage in the future

In order to overcome the difficulty of disposal of the ALPS treated water and to realize Fukushima reconstruction and revitalization, efforts should be accelerated for reducing reputational damage by expanding and enhancing measures.

Regarding the negative influence on reputation in the future, relevant government agencies should be aware of what is happening and the influence on reputation, as there is possible influence which cannot be assumed at this time. It is also necessary for government agencies to work together to be able to respond in a flexible manner to reputational damage that may arise in the future.

5. Summary

The ALPS subcommittee conducted a comprehensive examination of the handling of the ALPS treated water taking into account the social aspects such as reputational damage, and summarized the recommendations to the Government of Japan. The summary of the recommendations are as follows:

(1) Basic approach on handling of the ALPS treated water

Regarding the situation of the decommissioning and the contaminated water management of Fukushima Daiichi NPS, there has been gradual progress in the returning of residents and reconstruction efforts in the surrounding area. To this end, systematic risk reduction will be realized under the concept of "coexistence of reconstruction and decommissioning," with consideration for the site conditions, rationality, promptness and certainty while placing top priority on the safety of locals, the surrounding environment and the workers.

"Coexistence of reconstruction and decommissioning" is a basic principle. It is necessary to complete the disposal of the ALPS treated water by the time that the decommissioning work is completed, since the disposal of the ALPS treated water is part of the decommissioning work.

Conversely, in order to proceed with the decommissioning work, rushing the disposal of the ALPS treated water must not amplify reputational damage which could stagnate the reconstruction process. Therefore, it is important to dispose of the ALPS treated water as part of the decommissioning work in order to fully complete the decommissioning with necessary storage and taking into consideration the reputational damage.

(2) Scientific information on the ALPS treated water and implementation of the secondary treatment

ALPS has the ability to purify 62 types of radionuclides, except for tritium, to less than regulatory standards. This examination was made based on the premise that the secondary treatment is performed to meet the regulatory standards for discharge if needed before dilution, in the case of discharging the ALPS treated water stored in tanks to the environment

Tritium, which is difficult to remove through ALPS, is naturally produced in nature, and is also present in natural water such as vapor in the atmosphere, rainwater, seawater, as well as in the human body. Tritium is a radioactive material which has a lower influence on human health compared to other radioactive materials. Additionally, tritium is generated at nuclear facilities through the operation of nuclear power plants both in Japan as well as outside of Japan. When tritium is discharged to the sea, rivers, lakes and the atmosphere in compliance with the respective country's regulations, there have been no examples of a negative impact attributable to tritium at the areas located around the nuclear power facilities.

(3) Disposal method of the ALPS treated water which satisfies the regulatory standards for discharge with dilution

Among the five options examined in the Task Force, the options of geosphere injection, hydrogen release, and underground burial come with too many unresolved issues to practically consider their use with regard to regulations, technology and time. For these reasons, discharge into the sea and vapor release are the practical options, both of which have precedent in current practice.

As social influence, which could be caused by these consumers, is greatly dependent on their psychology as well as other factors, it is difficult to compare the superiority or inferiority of disposal methods from the viewpoint of the social influence. In addition, taking into consideration the opinions expressed at the public explanatory and hearing meeting and other reactions from abroad, the social influence is expected to be particularly large if discharge into the sea is implemented without any countermeasures. On the other hand, vapor release may also invite significant concerns and have social impact.

Although there is a difference in the disposal volume, there is already a precedent for the vapor release method which was implemented at a reactor that suffered from an accident. Although there are no standards for the amount of discharge from normal functioning reactors, vapor that contains radioactive materials is also released in a manner that controls its concentration at the time of ventilation. It should be noted that, in Japan, there is no precedent of vapor release in which the liquid water is evaporated and released into the atmosphere for the purpose of disposing liquid radioactive waste. In addition, it also should be noted that although the vapor release method has the advantage of reducing the radionuclides in the ALPS treated water that is released into the atmosphere, instead the radionuclides that are not released with vapor remain as dried residue, as a result, this dried residue will remain as radioactive waste.

Regarding the discharge into the sea, radioactive liquid waste containing tritium is already being released into the ocean, rivers etc. from nuclear facilities in Japan and abroad, after dilution by the coolant seawater and other water. Discharge into the sea can be implemented more reliably, considering the existence of the past track records of normal reactors and the ease of operating discharge facilities as well as proper monitoring methods. However, it should be noted that the concentration of tritium of the ALPS treated water differs from that of tritium which was discharged from the Fukushima Daiichi NPS in operation before the accident.

The radiation impact of both the discharge into the sea and vapor release is notably small, compared to natural radiation exposure. Taking into account the impact on reputational damage, careful consideration will be required for release conditions, such as the sufficient dilution in order to make the concentration levels lower than the regulatory standards.

(4) Policy orientation of countermeasures for reputational damage

Both the discharge into the sea and vapor release can be safely implemented while satisfying their regulatory standards. However, under the circumstances where all the people's concerns are not dispelled, it should be assumed that any disposal of the ALPS treated water could impact the already existing reputational damage.

Therefore, when the disposal is conducted, thorough countermeasures for reputational damage should also be conducted, with a will that additional reputational damage should not be caused, so that the industries in Fukushima and its neighboring prefectures can continue their businesses without anxiety.

Firstly, in order to neutralize the influence on reputation, it is important to consider disposal methods that allow people to feel at ease. To do so, radionuclides other than tritium should be treated by secondary purification. In addition, the starting time of disposal, disposal volume, period for disposal, and levels of concentration at the time of disposal should be determined appropriately, taking into account the opinions of the parties concerned. To dispel the concern of these parties and consumers, efforts to strengthen monitoring of the surrounding environment and to disclose the monitoring results in an easy-to-understand manner are important.

On the other hand, under the circumstance where everyone's concerns are not dispelled, it should be assumed that the disposal of the ALPS treated water may induce reputational damage. Therefore, taking best practice of countermeasures for reputational damage implemented so far into account since the Fukushima Daiichi NPS accident, risk communication measures to convey information accurately as well as countermeasures to prevent, neutralize, and compensate the reputational damage should be enlarged and strengthened.

Regarding the risk communication measures, there is a time gap between the determination of the disposal and the actual implementation. By utilizing this period of time, the following countermeasures should be implemented:

- Comprehensive information dissemination focusing on the disposal method and scientific findings on tritium,
- Implementation of on-site lectures to a wide-range of people in addition to providing the information via mass media and social media.
- Strengthening the dissemination of information abroad focusing on,

- Basic information on the progress of the decommissioning and reconstruction
- Messages that provide accurate facts and solve misunderstandings for the handling of the ALPS treated water,

There might be an influence on reputation in the future by factors that are not expected at this point in time. To deal with future reputation impacts, it is necessary to take countermeasures by continuously seeking to concretely understand what is happening, and to try to predict the influence on reputation as it arises.

Regarding the economic measures to prevent, neutralize and compensate the reputational damage, the following measures should be enlarged and strengthened, considering best practice of countermeasures against reputational damage:

  - To re-establish the trust of customers on the safety of agricultural, forestry and fishery products, constructing the measurement framework which consists of the environmental monitoring and sampling measurement of food and disclosing the comprehensive measurement results
  - To utilize the third-party certification systems such as GAP and MEL to secure the trust of consumers
  - To promote the establishment of permanent retail space for Fukushima products by new market channel development through measures such as:

- Promotional events for Fukushima products,
- Allocation of special sales staff in stores
- E-commerce through the opening of an online store etc.

With regard to the negative influence on reputation in the future, relevant government agencies should be aware of what is happening and the influence on reputation, as there is possible influence which cannot be assumed at this point. It is also necessary for these government agencies to work together to be able to respond in a flexible manner to reputational damage that may arise in the future.

(5) Recommendation Summary

The ALPS subcommittee expects that the Government of Japan will decide upon the policy with responsibility and sincerity while taking into account the opinions from a wide-range of the parties concerned including local municipalities, farmers, foresters and fishermen, as well as the recommendations provided in this report. Through the decision making process the Government of Japan should make a decision with transparency.

The disposal method, as well as the countermeasures which should be taken against reputational damage should be incorporated into the governmental policy decision, in the form of expansion and reinforcement, based on previous countermeasures against the reputational damage from the Fukushima Daiichi NPS accident.

After the decision is made, the dissemination of information in a transparent manner including two-way communication should be implemented long-term, with an aim toward fostering public understanding.

As of January 30, 2020

The Subcommittee on Handling of the ALPS-treated Water
Member list

[Chairperson]

Ichiro Yamamoto: Vice Principal, Nagoya University of Arts and Sciences (Honorary Professor, Nagoya University)

[Members]

Yuzo Onishi: Honorary Professor, Kyoto University, Guest Professor, Kansai University

Hiroshi Kainuma: Ritsumeikan University Associate Professor Kinugasa Research Organization

Hideki Kakiuchi: Researcher, Institute for Environmental Sciences Environmental Impact Research Division

Ryota Koyama: Professor, Economics and Business Sciences, Fukushima University

Yuko Sakita: Journalist and Environment counsellor, Director, NPO Corporation Genki Net for creating sustainable society

Naoya Sekiya: Associate Professor, University of Tokyo, Graduate School of Interdisciplinary Information Studies, The Centre for Integrated Disaster Information Research

Hiroshi Tauchi: Professor, Faculty of Science, Ibaraki University

Yoshihisa Takakura: Director, Tohoku Radiation Science Centre

Kikuko Tatsumi: Executive Advisor, Nippon Association of Consumer Specialists

Takumi Morita: Group Leader, National Research Institute of Fisheries Science, Fisheries Research and Education Agency, Research Center for Fisheries Oceanography & Marine Ecosystem, Radioecology Group

Toshihiko Yamanishi: National Institutes for Quantum and Radiological Science and Technology

Tokuhiro Yamamoto: Director, Japan Atomic Energy Agency

[Operator]

Junichi Matsumoto: Director, D&D Promotion Office, Fukushima Daiichi D&D Engineering Company, TEPCO (From the 8th meeting)

Jun Matsumoto: Vice president, Fukushima Daiichi D&D Engineering Company, TEPCO (Up to the 7th meeting)

[Observer]

Ministry of Foreign Affairs, Ministry of Agriculture

Fisheries Agency

Nuclear Regulatory Agency

Nuclear Damage Compensation and Decommissioning Facilitation Corporation

Fukushima Prefecture

The Subcommittee on Handling of the ALPS-treated Water
Meeting Records

November 11, 2016 (1st meeting)
- Bylaws of the Subcommittee (draft)
- Fukushima Daiichi NPS decommissioning and contaminated water management
- Tritiated Water Task Force Report
- “Task Force on the Nuclear Hazard's Influence Including the Negative Reputation Impact”
- How to proceed with the discussion in the future

December 16, 2016 (2nd meeting)
- Review of the 1st meeting minutes (draft)
- Hearing from committee members
  (1)Member Sekiya
  (2)Member Kainuma
  (3)Member Yamanishi
- Targets for operation of the groundwater bypass wells

February 24, 2017 (3rd meeting)
- Review of the 2nd meeting minutes (draft)
- Hearing from a member and the parties concerned
  (1)Member Koyama
  (2)Fukushima Prefecture
  (3)Fisheries Agency
- Status of operation of the groundwater bypass wells and sub-drain wells

April 21, 2017 (4th meeting)
- Review of the 3rd meeting minutes (draft)
- Hearing from experts
  (1)Prof. Hamada, Hokkai-Gakuen University
  (2)Director Inomata, Zen-Noh Fukushima
  (National Federation of Agricultural Cooperative Associations Fukushima Branch)

June 2, 2017 (5th meeting)
- Review of the 4th meeting minutes (draft)
- Hearing from committee members and the parties concerned
  (1)York Benimaru Co., Ltd.
  (2)Member Tatsumi
  (3)Member Sakita

July 15 and August 5, 2017 (Visit to the site of TEPCO’s Fukushima Daiichi NPS)

October 23, 2017 (6th meeting)
- Review of the 5th meeting minutes (draft)
- Hearing from the parties concerned: Mariko Nishizawa, Director, Litera Japan Corporation
- Summary of visits to Fukushima Daiichi NPS
- Report of the revision of the Mid-and-Long-Term Roadmap

February 2, 2018 (7th meeting)

- Review of the 6th meeting minutes (draft)
- Strategy for reinforcing rumor elimination risk communication
- Action plan against reputational damage
- Countermeasures against reputational damage
- Characteristics, etc. of tritium

May 18, 2018 (8th meeting)

- Review of the 7th meeting minutes (draft)
- Characteristics, etc. of tritium
- Approach to social influence
- How to proceed with the discussion in the future

July 13, 2018 (9th meeting)

- Review of the 8th meeting minutes (draft)
- Task Force on the Nuclear Hazard's Influence Including the Negative Reputation Impact (July 5, 2018)
- Review of the 8th Subcommittee meeting
- Explanatory and public hearing meetings (draft of handout materials, etc.)

August 30 and 31, 2018 (Explanatory and public hearing meetings about water treated by multi-nuclide removal equipment, etc.)

October 1, 2018 (10th meeting)

- Review of the 9th meeting minutes (draft)
- Explanatory and public hearing meetings
- Characteristics of the ALPS treated water

November 30, 2018 (11th meeting)

- Review of the 10th meeting minutes (draft)
- Update of data concerning the ALPS treated water
- Biological impact of tritium and associated regulatory standards
- Approach to control (monitoring, etc.) radioactive material discharged to the environment

December 28, 2018 (12th meeting)

- Review of the 11th meeting minutes (draft)
- Approach to control (monitoring, etc.) radioactive material discharged to the environment
- Social impact neutralization measures

July 20 and August 3, 2019 (Visit to the site of TEPCO's Fukushima Daiichi NPS)

August 9, 2019 (13th meeting)

- Review of the 12th meeting minutes (draft)
- WTO Appellate Body's decision, and international communications concerning decommissioning and contaminated water management
- Role of the Subcommittee on Handling of the ALPS treated water
- Continued storage and disposition path

September 27, 2019 (14th meeting)

- Review of the 13th meeting minutes (draft)
- Review of facts concerning continued storage
- Continued storage and disposition path, and response to rumor-caused damage

November 18, 2019 (15th meeting)

- Review of the 14th meeting minutes (draft)
- Treatment of soil due to the nuclear power station accident resulting from the Tohoku Pacific Ocean Earthquake and Tsunami
- Impact of radiation resulting from discharge of the ALPS treated water
- Review of discussion at earlier meetings and arguments left unresolved

December 23, 2019 (16th meeting)

- Review of the 15th meeting minutes (draft)
- Suggestions presented at the 15th meeting
- Arguments remaining unresolved and discussion for preparation of the report

January 31, 2020 (17th meeting)

- Review of the 16th meeting minutes (draft)
- Update of ALPS processing status
- The ALPS subcommittee report (draft)