The Update of Fukushima Daiichi NPS

Agency for Natural Resources and Energy, METI
4th, March 2021
Current situation of Fukushima Daiichi NPS

(1) March 2011  Fukushima Daiichi nuclear accident
   i) Due to the earthquake and tsunami, electricity to the plant was lost.
   ii) Core melt (unit 1, 2 and 3) / hydrogen explosion (unit 1, 3 and 4)

(2) NOW  Fukushima Daiichi keeps stable state
   i) Decommissioning (risk reduction by removing spent fuel, fuel debris. etc)

At the time the accident occurred:
The accident cut off the water supply to the reactors. As a result, the fuel generated heat, and hydrogen explosions occurred.

Today:
Reactors are being kept stable.
Fukushima Daiichi Decommissioning is a continuous risk reduction activity to protect the people and the environment from the risks associated with radioactive substances by:

- Removing spent fuel and fuel debris from the Reactor Building
- Reducing the risks associated with contaminated water and radioactive waste

Safe and steady decommissioning is a prerequisite for reconstruction of Fukushima.
Diagram of areas under evacuation orders
(as of March 10th, 2020)

< Blue framed area >

Futaba [Lifted on March 4th, 2020]
- Preparation Area for lift of Evacuation order
- Futaba Sta. and streets around the Sta. : ARD

Okuma [Lifted on March 5th, 2020]
- Ono Sta. and streets around the Sta. : ARD

Tomioka [Lifted on March 10th, 2020]
- Yonomori Sta. and streets around the Sta. : ARD
- JR Joban Line between Namie Sta. and Tomioka Sta. : ARD

Ref. Lift of evacuation orders

Areas where Returning is Difficult (ARD)
Preparation Area for lift of Evacuation order
Area in which evacuation orders were lifted
JR Joban Line (The entire line is reopened in 14 March, 2020)
The recovery of the regional economic hub is also making steady progress, with the restoration of infrastructure, the maintenance of shopping malls, and the reopening and improvement of industrial facilities.
Completed fuel removal from the spent fuel pool of Unit 3 and transfer to the common pool, by remote control. [Apr. 2019-Feb. 2021]
### Major milestones of Mid-and-Long-Term Roadmap (Dec. 2019)

<table>
<thead>
<tr>
<th>Major milestones</th>
<th>Revised Roadmap</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contaminated water management</strong></td>
<td><strong>Within 2020</strong>&lt;br&gt;<strong>Within 2025</strong>&lt;br&gt;&lt;br&gt;<strong>NEW</strong></td>
</tr>
<tr>
<td>Reduce to about 150 m³/day&lt;br&gt;&lt;br&gt;<strong>Reduce to about 100 m³/day or less</strong></td>
<td>Further reduction of generation</td>
</tr>
<tr>
<td><strong>Stagnant water removal / treatment</strong></td>
<td><strong>Within 2020(*)</strong>&lt;br&gt;&lt;br&gt;<strong>achieved</strong></td>
</tr>
<tr>
<td>Complete stagnant water removal / treatment in buildings*</td>
<td><strong>FY2022 - 2024</strong>&lt;br&gt;&lt;br&gt;<strong>NEW</strong></td>
</tr>
<tr>
<td>Excluding the reactor buildings of Units 1-3, Process Main Buildings, and High Temperature Incineration building.&lt;br&gt;&lt;br&gt;*Expected to be delayed by approximately 1 year</td>
<td></td>
</tr>
<tr>
<td><strong>Reduce the amount of stagnant water in reactor buildings to about a half of that in the end of 2020</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Fuel removal</strong></td>
<td><strong>Within 2031</strong>&lt;br&gt;&lt;br&gt;<strong>NEW</strong></td>
</tr>
<tr>
<td>Complete of fuel removal from Unit 1-6</td>
<td><strong>Around FY2023</strong>&lt;br&gt;&lt;br&gt;<strong>NEW</strong></td>
</tr>
<tr>
<td>Start fuel removal from Unit 1&lt;br&gt;&lt;br&gt;Start fuel removal from Unit 2</td>
<td><strong>FY2027 – 2028</strong>&lt;br&gt;&lt;br&gt;<strong>REVISED</strong></td>
</tr>
<tr>
<td>Methods have changed to ensure safety and prevent dust scattering</td>
<td><strong>FY2024 - 2026</strong>&lt;br&gt;&lt;br&gt;<strong>REVISED</strong></td>
</tr>
<tr>
<td><strong>Fuel debris retrieval</strong></td>
<td><strong>Within 2021</strong>&lt;br&gt;&lt;br&gt;*Expected to be delayed by approximately 1 year</td>
</tr>
<tr>
<td>Start fuel debris retrieval from the first Unit&lt;br&gt;&lt;br&gt;(Start from Unit 2, expanding the scale gradually)</td>
<td></td>
</tr>
<tr>
<td><strong>Waste management</strong></td>
<td><strong>Around FY2021</strong>&lt;br&gt;&lt;br&gt;<strong>Within FY2028</strong>&lt;br&gt;&lt;br&gt;<strong>NEW</strong></td>
</tr>
<tr>
<td>Technical prospects concerning the processing/disposal policies and their safety</td>
<td></td>
</tr>
<tr>
<td><strong>Eliminating temporary storage areas outside for rubble and other waste</strong></td>
<td></td>
</tr>
</tbody>
</table>
What is “contaminated water” and “treated water”? 

i) “Contaminated water” contains a large amount of radioactive materials, and have been generated in buildings every day since the accident.

ii) “Treated water” is water in which most of radionuclides are removed by purification.

However, “tritium” cannot be removed by purification, and remains in the treated water at the level higher than its regulatory standards for discharge.

* C-14 also cannot be removed by ALPS, but its concentration is far lower than its regulatory standard for discharge.
The frequency of an additional tank installation has decreased to “once a week”, compared to “every two days” around 2014.

- The volume of treated water stored in tanks per day has been decreased through countermeasures such as installation of frozen-soil walls and sub-drains.
- Volume of the treated water at FDNPS is about 1.24 million m³ (as of December 17, 2020)
- Capacity of the tanks is about 1.37 million m³

(Ref.) Decrease in volume of treated water stored per day

(Ref.) rate of contaminated water generation** (per day)

** rate of contaminated water generation has a correlation to that of treated water stored in tanks per day.

around 540m³/day (in May 2014, before measures were taken) → around 140m³/day (in 2020)
Tanks as well as a variety of **facilities are needed to be built**.

✓ (e.g.) **temporary storage facilities for spent fuel and fuel debris**

✓ analytical facilities for various samples
Why are two options suggested by the expert committee feasible?

◇ “1) Vapor release” and “2) discharge into the sea” are suggested by the committee in February 2020.

✓ Both option 1) and 2) are recommended to be realistic, because of the precedents and track records for them.

✓ “2) Discharge into the sea” can be implemented more reliably, considering the ease of discharge facilities operation and proper monitoring methods.

◇ The International Atomic Energy Agency (IAEA) acknowledged that the options suggested by expert committee is “based on a sound scientific and technical basis of analysis”.

Comparison of “vapor release” and “discharge into the sea”

<table>
<thead>
<tr>
<th>1) Vapor release</th>
<th>2) Discharge into the sea</th>
</tr>
</thead>
</table>
| ● A precedent in case of accident at NPP overseas  
  * Vapor is also released from reactors in normal operations at the time of ventilation.  
  ● Difficult to predict how the released vapor is diffused into the air and to establish proper monitoring method | ● Precedents exist world-wide  
  ● Relatively easy to predict how discharged water is diffused in the ocean and easy to examine proper monitoring method |
1) Well planned disposition process
2) Expansion and enhancement of countermeasures building on best practices
3) Continuous and flexible response

<<1. Well planned disposition processes>>

- **Re-purify the water to remove** radionuclides other than tritium
- **Stop the discharge process in case of emergency**
  e.g. environmental situation, malfunction of facilities
- **Determine the details (starting time, volume, and period of discharge),**
  while listening to opinions of stakeholders
- **Disseminate information** in a considerate and an easy-to-understand manner
  - Concentration of pre-disposition ALPS treated water
  - Monitoring results of surrounding environment
- **Explain safety of surrounding environment by** utilizing diffusion simulation
The key points of the draft report of the ALPS Subcommittee:

- continued

**< Economic measures >**
- for reputational damage

- **Constructing analytical framework**
  for:
  ✓ environmental monitoring, and
  ✓ food sampling measurement

- **Utilizing third-party certification**
  to secure consumer trust, such as
  ✓ GAP (Good Agricultural Practice)
  ✓ MEL (Marine Eco-label)

- **Developing new market channels**
  by
  ✓ Promotion events for Fukushima products
  ✓ Allocation of special sales staff in stores
  ✓ Opening of on-line stores etc.

**< Risk communication >**
- to convey relevant information

- **Disseminating information** on the disposal method and scientific knowledge in advance

- **Providing information** via:
  ✓ SNS, mass media
  ✓ On-site lectures

- **Strengthening information dissemination abroad**
  ✓ Basic information on decommissioning
  ✓ Disposition methods in the world as well as precedents outside of Japan

**<2. Expansion and enhancement of countermeasures building on best practices >**
The IAEA considers the disposal options (discharge into the sea and vapor release) as technically feasible and in line with international practice. Once a decision is taken on the way forward, the IAEA would be ready to assist in its implementation, for example in radiation monitoring. It could help provide reassurance to the public – in Japan and elsewhere – that any releases of water would be within international standards.

The two options selected (discharge into the sea and vapor release) are technically feasible and would allow the timeline objective to be achieved. (Acknowledgement 4)

The IAEA Review Team also notes that the ALPS treated water will be further purified as necessary to meet the regulatory standards for discharge before dilution. (Acknowledgement 4)

The IAEA Review Team is not aware of a solution currently available for the separation of tritium commensurate with the concentration and the volume of ALPS treated water. (Acknowledgement 3)

The IAEA Review Team holds the view that a decision on the disposition path for the stored ALPS treated water must be taken urgently, considering safety aspects and engaging all stakeholders. (Advisory Point 1)

Fukushima Status Update at IAEA website [https://www.iaea.org/newscenter/focus/fukushima/status-update](https://www.iaea.org/newscenter/focus/fukushima/status-update)
Characteristics of ALPS treated water

- Regarding **about 30%** of the treated water stored in tanks, the concentration of radionuclides other than tritium meets the regulatory standards for discharge.

- Regarding **about 70%** of the water, concentration of radionuclides exceeds the regulatory standards. It will be **re-purified** to meet the regulatory standards with an exception of tritium.
  
  * In early years, the ALPS treatment has been carried out by prioritizing the volume of water treatment to quickly reduce the radiation impact to outside the site. There were also cross filter permeate troubles and other troubles.

- Re-purification test shows that the **ALPS has ability to remove the radionuclides sufficiently**.

- In the case of releasing it to the environment, the treated water will be **sufficiently diluted** also to meet the regulatory standard for tritium.

**Sum of the ratios of actual concentrations to regulatory standards for 62 nuclides** (as of November, 2020)

- Water treated in early years when crossflow filter permeate had trouble etc.: 19,600 m³

- **Water to be re-purified**: (73%)
  
  - 295,000 m³ (27%)
  - 374,100 m³ (34%)
  - 207,500 m³ (19%)
  - 161,700 m³ (15%)
  - 63,200 m³ (6%)

* "less than 1" means that the water concentration meets the regulatory standards for tritium.
How much is the radiation impact of treated water release?

The impact of the radiation to human health as a result of the discharge is considerably small.

- Even if the entire amount of the ALPS treated water containing tritium and other radioactive material were to be disposed of in one year*, the impact would be no more than 1/1000 of the exposure impact of natural radiation in Japan.

<table>
<thead>
<tr>
<th>Natural exposure</th>
<th>Discharge into the sea</th>
<th>Vapor release</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.15 mSv/y</td>
<td>0.15 mSv/y</td>
<td>0.1 mSv/y</td>
</tr>
</tbody>
</table>

* Based on a UNSCEAR-specified method.
* All volume of the ALPS treated water stored in tanks is discharged in one year, and similar amounts are discharged during following 100 years.
* The treated water contains 860 trillion Bq of tritium and the other radionuclides.
Vapor release

- There is no diffusion simulation model available for vapor.
  
  i. Simple evaluation is difficult: It requires consideration of morphological changes in vapor due to weather conditions, advection caused by groundwater or rivers, re-release, and transpiration from plants
  
  ii. Knowledge of continuous simulation is not available

Discharge into the sea

- The areas in which tritium concentration exceeds the background level (1 Bq/L) will be limited to within 2km offshore from the FDNPS.

- Even in the areas, the level of tritium concentration (1 to 10 Bq/L) is far lower than the WHO drinking water guideline value (10,000 Bq/L).
What are the steps toward the handling of treated water?

◇ Considering the opinions received, the GOJ will decide its basic policy including measures against possible reputational damage.

◇ Based on the governmental basic policy, TEPCO will determine the specific method and will obtain an approval from the Nuclear Regulatory Authority (NRA), and then will start the preparatory work.

Subcommittee on Handling of the ALPS treated water

Recommendations to the GoJ (2020/2/10 Subcommittee report)

Examination from professional standpoint

The Government of Japan

The Government of Japan, and TEPCO

TEPCO

NRA

Now

Decision of basic policy

Decision of specific method

Implementation of preparatory work

Start of discharge

About 2 years

Further strengthen two-way communication

Implementation of further countermeasures against reputational damage

Receiving opinions from parties Concerned (e.g. local community)
How has the GOJ been providing information to the international community?

- Briefing sessions for Diplomatic Missions in Tokyo have been held.

- Technical briefings on the occasions such as international conventions.
  - At WTO/SPS (sanitary and phytosanitary) committee in November 2020 (online), monitoring results of Japanese foods, treated water management were presented.
  - At IAEA General Conference in Sept. 2020, a side event by Japan was held to provide technical briefing on decontamination and treated water management.
  - At the briefing session and site tour for foreign press, current situation of FDNPS including treated water management are presented by METI and TEPCO.

- Reports on the decommissioning progress and the surrounding environment.

  [https://www.iaea.org/newscenter/focus/fukushima/status-update](https://www.iaea.org/newscenter/focus/fukushima/status-update)
What is tritium? 1) Characteristics

Tritium is a relative of hydrogen that emits weak radiation. Tritium exists naturally and is found in rain water, sea water, tap water and inside of human body as a form of tritiated water.

Tritium is taken into the human body via drinking water and excreted from the body, and then circulates in nature as the water does. It has not been confirmed to be accumulated in humans or specific organisms.

* Tritium concentration for tap water: 1 Becquerel/L
* Amount of Tritium in human body: tens of Becquerel

What is tritium? 2) Can tritium be removed?

It is very difficult to remove tritiated water from water, as it has the same properties.

Experts have concluded that there is no tritium separation technology that is immediately applicable to the treated water with low concentration and large volume.

IAEA (International Atomic Energy Agency) is “not aware of a solution currently available for the separation of tritium commensurate with the concentration and the volume of treated water”.
Tritium is discharged from nuclear facilities in and outside Japan, in compliance with the regulatory standards of each country.

- **Average amount of Tritium discharged from Boiling Water Reactor type nuclear power plants (NPPs) [annual] (less than 2.9 trillion Bq/year)**
- **Average amount of Tritium discharged from Pressured Water Reactor type NPPs [annual] (less than 85 trillion Bq/year)**
- **Amount of Tritium discharged from CANDU type NPP [annual] (about 140 trillion Bq/year)**
- **Amount of Tritium discharged from reprocessing plant [annual] (less than 13 quadrillion Bq/year)**
- **Amount of Tritium stored in Fukushima Daiichi NPS [total] (about 860 trillion Bq)**
- **Amount of Tritium in rainwater in Japan [annual] (about 220 trillion Bq/year)**
- **Amount of Tritium in human body [total] (tens of Bq)**
(Ref.) Examples of tritium emission -Annual discharge from NPPs-

* Numbers indicate the amount of tritium emissions.

**Source:**
- UK: Radioactivity in Food and the Environment, 2019
- Canada: Canadian National Report for the Convention on Nuclear Safety
- France: Tritium White paper
- Other countries: Prepared from reports published by electricity providers in various countries and regions.

**Examples of tritium emission:**

- **UK • Sizewell B NPP**
  - Liquid: About 28 TBq (in 2019)
  - Steam: About 0.4 TBq (in 2019)

- **UK • Sellafield reprocessing facility**
  - Liquid: About 423 TBq (in 2019)
  - Steam: About 56 TBq (in 2019)

- **Germany • Gundremmingen B-C NPP**
  - Liquid: About 1.4 TBq (in 2019)
  - Steam: About 0.1 TBq (in 2019)

- **Slovenia • Krsko NPP**
  - Liquid: About 14 TBq (in 2019)

- **Romania • Cernavoda Unit1 NPP**
  - Liquid: About 140 TBq (in 2018)
  - Steam: About 152 TBq (in 2018)

- **Spain • Cofrentes NPP**
  - Liquid: About 0.9 TBq (in 2018)
  - Steam: About 0.8 TBq (in 2018)

- **Spain • Ascó Unit1 NPP**
  - Liquid: About 27 TBq (in 2018)
  - Steam: About 0.5 TBq (in 2018)

- **France • La Hague reprocessing plant**
  - Liquid: About 11400 TBq (in 2018)
  - Steam: About 60 TBq (in 2018)

- **France • Tricastin NPP**
  - Liquid: About 35 TBq (in 2018)

- **China • Fuqing NPP**
  - Liquid: About 52 TBq (in 2020)
  - Steam: About 0.8 TBq (in 2020)

- **China • Sanmen NPP**
  - Liquid: About 20 TBq (in 2020)
  - Steam: About 0.4 TBq (in 2020)

- **Korea • Wolseong NPP**
  - Liquid: About 25 TBq (in 2018)
  - Steam: About 110 TBq (in 2018)

- **Korea • Kori NPP**
  - Liquid: About 50 TBq (in 2018)
  - Steam: About 16 TBq (in 2018)

- **US • Diablo Canyon Units1,2 NPP**
  - Liquid: About 82 TBq (in 2019)
  - Steam: About 2.7 TBq (in 2019)

- **US • Brunswick Units1,2 NPP**
  - Liquid: About 3.7 TBq (in 2019)
  - Steam: About 6.0 TBq (in 2019)

- **US • Grand Gulf NPP**
  - Liquid: About 0.8 TBq (in 2020)
  - Steam: About 0.8 TBq (in 2020)

- **US • Bruce A,B NPP**
  - Liquid: About 756 TBq (in 2018)
  - Steam: About 994 TBq (in 2018)

- **Canada • Bruce A,B NPP**
  - Liquid: About 220 TBq (in 2018)
  - Steam: About 210 TBq (in 2018)

- **Canada • Darlington NPP**
  - Liquid: About 140 TBq (in 2018)
  - Steam: About 300 TBq (in 2018)

- **Canada • Pickering Units1-4 NPP**
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“The Tritiated Water Task Force (2013-2016)"
Technical feasibility (including monitoring to ensure safety), regulatory feasibility period and cost of five handling methods were examined;
✓ All cases were examined on the premise that there is no scientific impact on the human habitant.
✓ Verification project showed that the separation technology for tritium cannot yet put into use.

“The Subcommission on Handling ALPS Treated Water (2016-)”
Five handling methods and long-term storage are examined in a comprehensive manner, including from the perspective of countermeasure for reputational damage and of ensuring scientific safety

All the measures, throughout their implementation, are subject to the approval of Nuclear Regulatory Authority in accordance with the Reactor Regulation Act.

Table Results of assessment of Tritiated water task force

<table>
<thead>
<tr>
<th>Method of disposal</th>
<th>(1) Example of geosphere injection</th>
<th>(2) Example of discharge to the sea</th>
<th>(3) Example of vapor release</th>
<th>(4) Example of hydrogen release</th>
<th>(5) Example of underground burial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
</tr>
<tr>
<td>Technical feasibility</td>
<td>If proper stratum is not found, commencement of handling will be delayed.</td>
<td>Examples) Existing Nuclear facilities’ liquid radioactive waste discharge to the sea</td>
<td>Example) TMI-2 - water volume: 8,700 m³ - Tritium volume: 24 tri. Bq - Tritium conc.: 2.8mil. Bq/L - Total period: 2.8 years</td>
<td>To handle the ALPS treated water, R&amp;D for pre-treatment and scale expansion might be needed.</td>
<td>examples) Concrete pit disposal site Shut-off disposal site</td>
</tr>
<tr>
<td>Regulatory feasibility</td>
<td>Feasible</td>
<td>Feasible</td>
<td>Feasible</td>
<td>Feasible</td>
<td>New standards might be needed.</td>
</tr>
</tbody>
</table>
Decommissioning and Contaminated Water Management at TEPCO's Fukushima Daiichi NPS

Film, Fukushima Today 2019
- Efforts to Decommission and Reconstruction
  https://www.youtube.com/watch?v=v_PeSp--Wuk

Film, Fukushima Today
- 8 years after the earthquake
  https://www.youtube.com/watch?v=pKjsSAz5Kws

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

Observation Data, Fukushima Daiichi NPS
https://www7.tepco.co.jp/responsibility/decommissioning/1f_newsroom/data/index-e.html
Fukushima Daiichi Status Updates
https://www.iaea.org/newscenter/focus/fukushima/status-update

IAEA Review mission reports (Press release)
*IAEA Follow-up Review of Progress Made on Management of ALPS Treated Water and the Report of the Subcommittee on Handling of ALPS treated water at TEPCO’s Fukushima Daiichi Nuclear Power Station
*IAEA Reviews Management of Water Stored at Fukushima Daiichi Nuclear Power Station (April 2, 2020)

Joint project, Workshop
*Preparatory Study on Analysis of Fuel Debris (PreADES)
*International Symposium on Decommissioning, Reconstruction, Rehabilitation, and Food Safety: Rebuilding Post-Accident Confidence (March 26, 2019)

UNSCEAR 2016 REPORT
-Sources, effects and risks of ionizing radiation