*“Fukushima: consequences and lessons learnt” jointly organised by the Belgian Nuclear Society & the Belgian Society for Radiation Protection*

# *The accident and situation of the TEPCO’s Fukushima-Daiichi site today*

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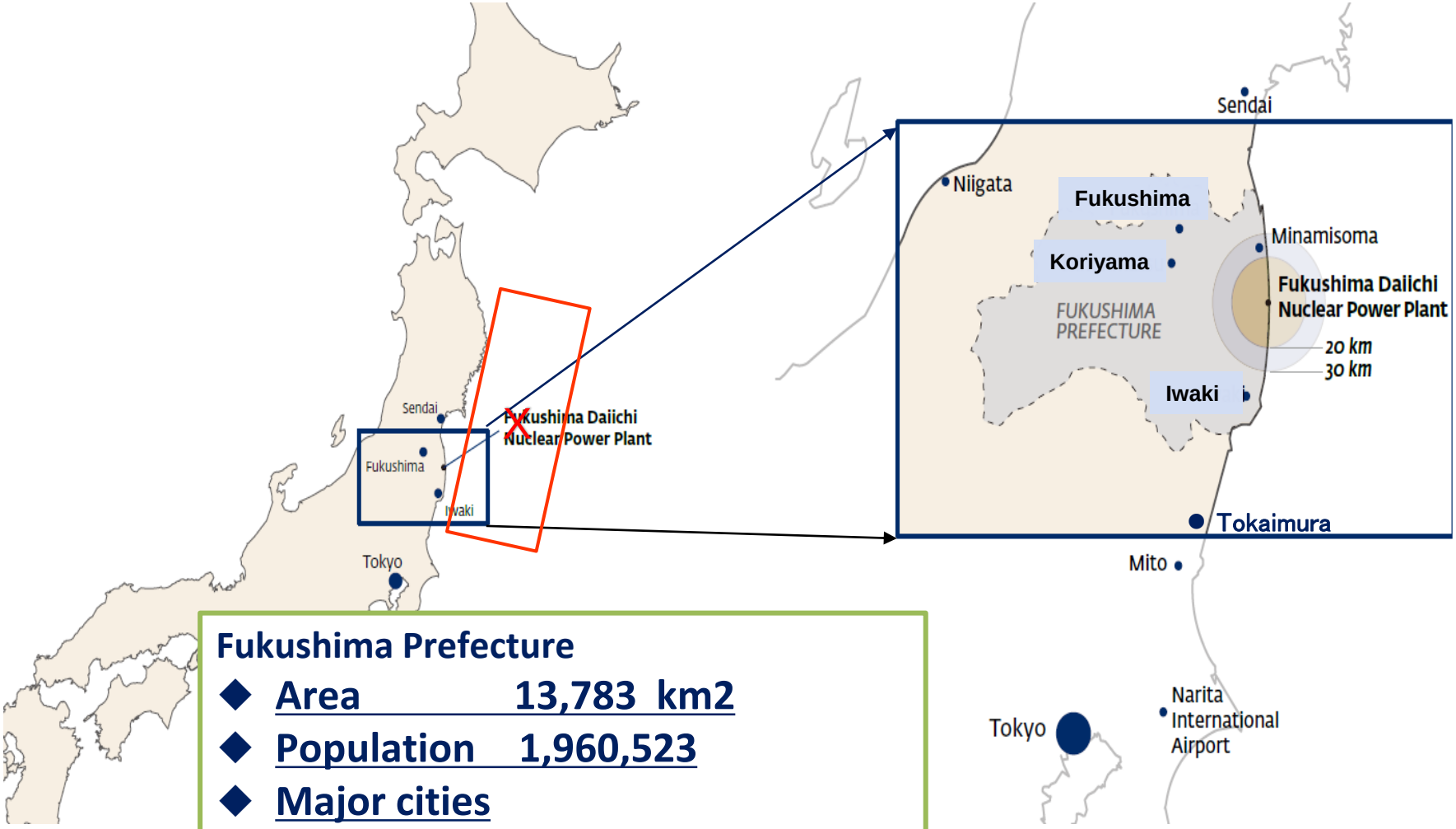
**Nuclear Regulation Authority, Japan**

**9th March 2021**
**Brussels, by videoconference**

# Where is Fukushima?




**Fukushima Prefecture**

- **Area 13,783 km2**
- **Population 1,960,523**
- **Major cities**
  1) Fukushima : 284,065
  2) Koriyama : 328,145
  3) Iwaki : 329,986

# What happened ?

**Earthquake and Tsunami**

↓

**SBO**

↓

**Cooling failure**

↓

**Core damage/Containment failure/Fuel meltdowns**

↓

**Hydrogen explosions**

↓

**Radioactive releases**

↓

**The worst “complex disaster”**

**(Natural hazards + Human induced failures)**

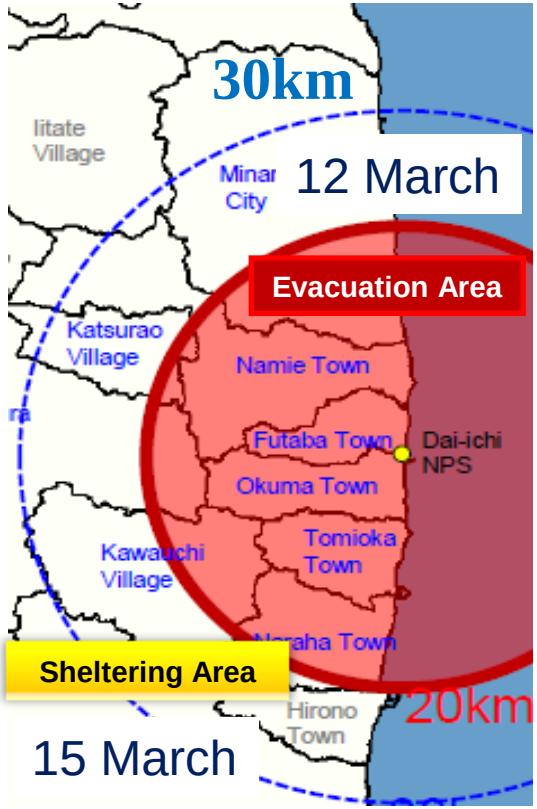
by Tokyo Electric Power Co

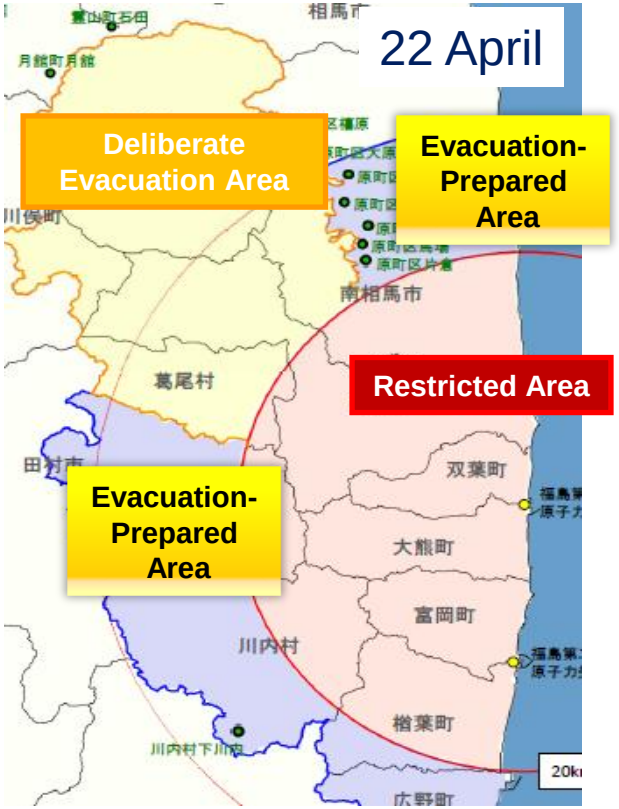
by Tokyo Electric Power Co

by AIR PHOTO SERVICE

# Urgent protective action areas

- Restrict Areas
  Areas within a 20 km radius of NPS
- Deliberate Evacuation Areas
  Areas in which radiation dose was expected to reach 20 mv in the first year
- Evacuation Prepared Areas in case of emergency
  Areas between 20-30 km radius of NPS



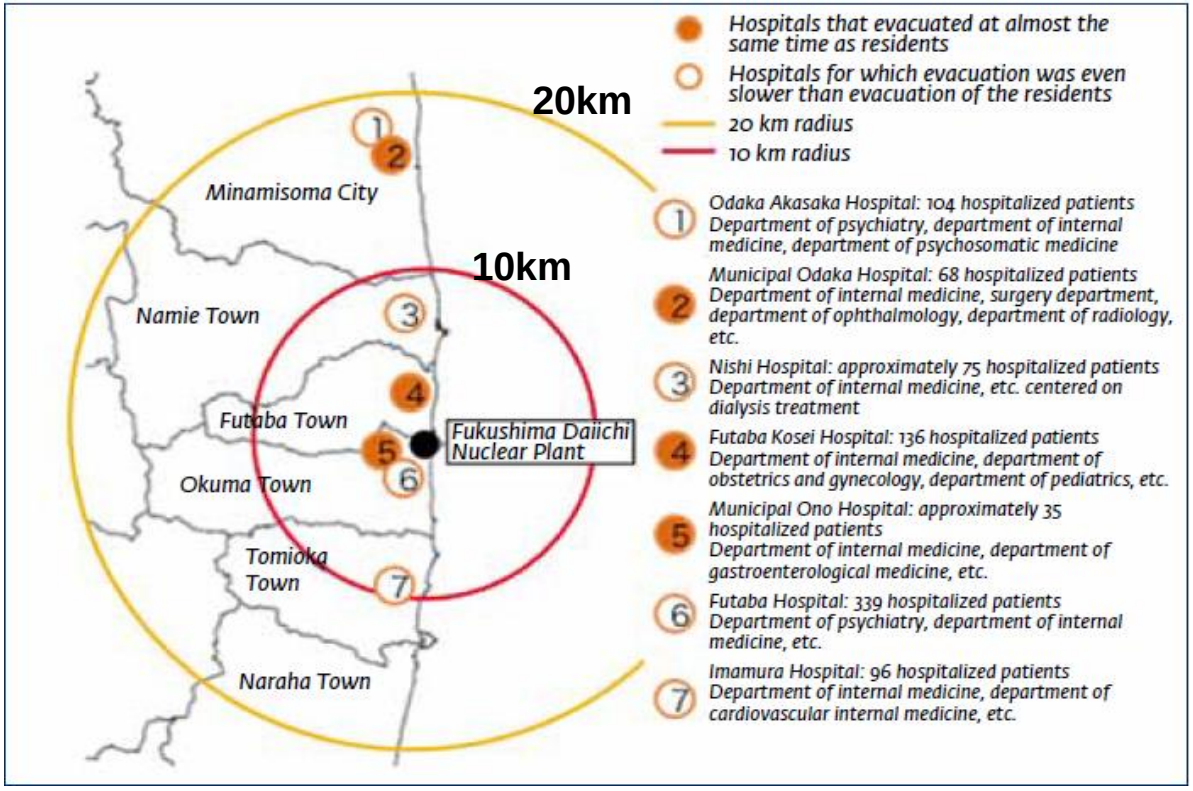



# Major consequences

- Radiologically important radionuclides I-131 and Cs-137 released : **approximately 1/10 of Chernobyl releases**
- Approximately 8,900 $km^2$ was contaminated with >37 $kBq/m^2$ (mainly Cs-137 and 134, as of Nov. 2011), extending over 8 prefectures
- Approximately 37,000 people in Fukushima Prefecture still evacuated (as of July 2020)
- **No early irradiation induced health effects**
- **No discernible increased incidence of radiation-related health effects** are expected (UNSCEAR)
- 51 **deaths of patients and elderly residents** during evacuation (as of April 2011)
- The most important health effect from the accident is on mental and social wellbeing (UNSCEAR)
- Huge economic consequences

# Evacuation of hospital patients

- Approximately 2200 patients and elderly people stayed in 7 hospitals and 17 nursing homes within 20 km evacuation zone.



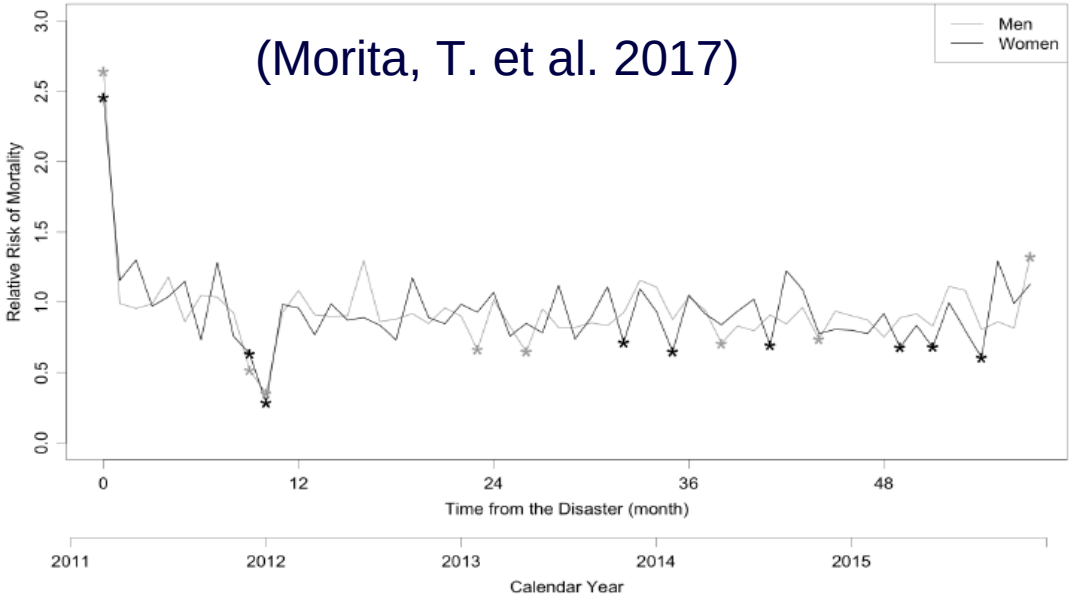

(The National Diet Report, Chapter 4)

# Disaster related death (DRD)

- DRDs in Fukushima accounted for 60% of all DRDs (2147 of 3591 DRDs in total: 463 in Iwate, 926 in Miyagi ) that occurred for the first 72 months after the earthquake (as of March 31, 2017).

* ***Disaster related deaths (DRD)*** *are defined as deaths which occurred due to aggravation of injury as a result of the Great East Japan Earthquake, and who qualified for condolence money pursuant to the Act on Payment of Condolence Money due to the natural disaster.*

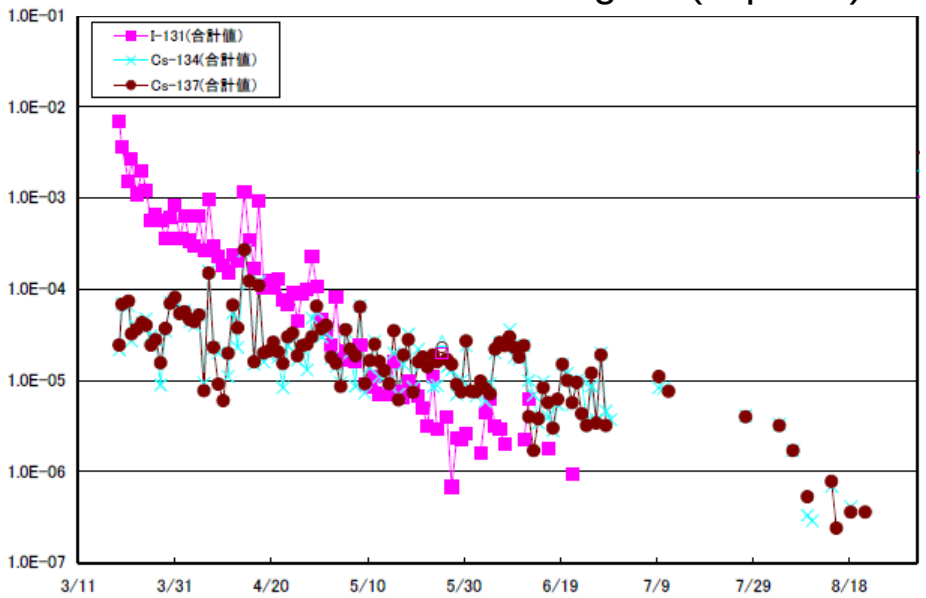
- The mortality risk was significantly higher in the first month of the triple disasters.
- This excess risk of death is attributed to the indirect health impacts.



# Action towards stabilization and restoration of the units

- TEPCO issued the Roadmap towards Restoration from the Accident at Fukushima Daiichi NPS (17 April 2011)
  - ✓ Step 1 : “Radiation dose is in steady decline” (19 July 2011) ;
  - ✓ Step 2 : “Release of radioactive materials is under control and the radiation dose is significantly being held down” (16 December 2011)

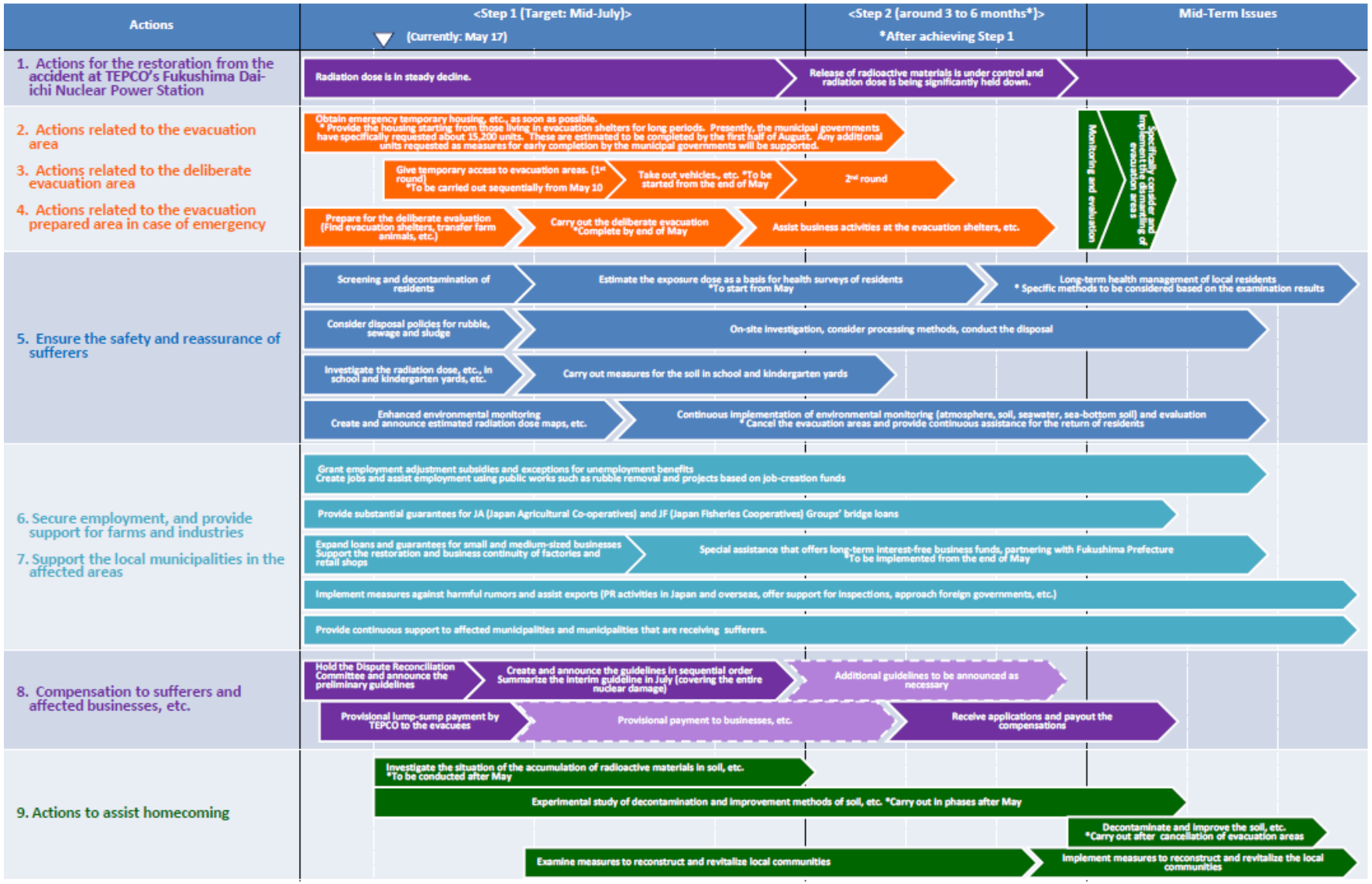
Dust collected at the west gate (Bq $cm^{-3}$)




Date, 2011

# Roadmap for Immediate action for the assistance of residents

(17 May, NERHQ)




(https://www.meti.go.jp/english/earthquake/nuclear/roadmap/immediate_actions.html)

# Activities during intermediate phase

◆ 17 May **2011**, **Roadmap** to return to normality by NERHQ

- June: Arrangements for long-term **health surveillance** (The Fukushima Health Management Survey);
- June-August: Detailed and comprehensive **monitoring plan** by the MEXT;
- August: L**ong-term management of radioactive waste**;
  - ***Act on Special Measures*** *concerning the Handling of Environmental Pollution by MOE (enacted on 26 August)*
  - *Basic Policy for Emergency Response on* ***Decontamination*** *Works by NERHQ*
- 30 September, **Lifting the recommendation to shelter** by NERHQ;

◆ 16 December, **Control of the situation** at NPP has been regained;

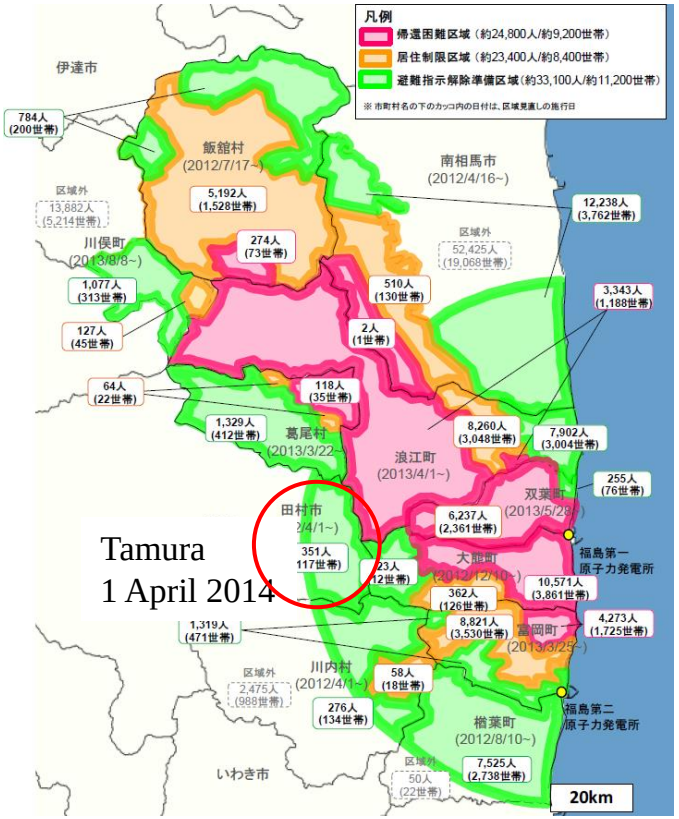
- 26 December, **Basic concept for rearranging** the evacuation areas
- January **2012**, Act on Special Measures was fully enforced
- 30 March, **Rearrangement of the evacuation areas** started by NERHQ
- April: New **food regulation** came into effect by MHLW

# Current status of restricted zones

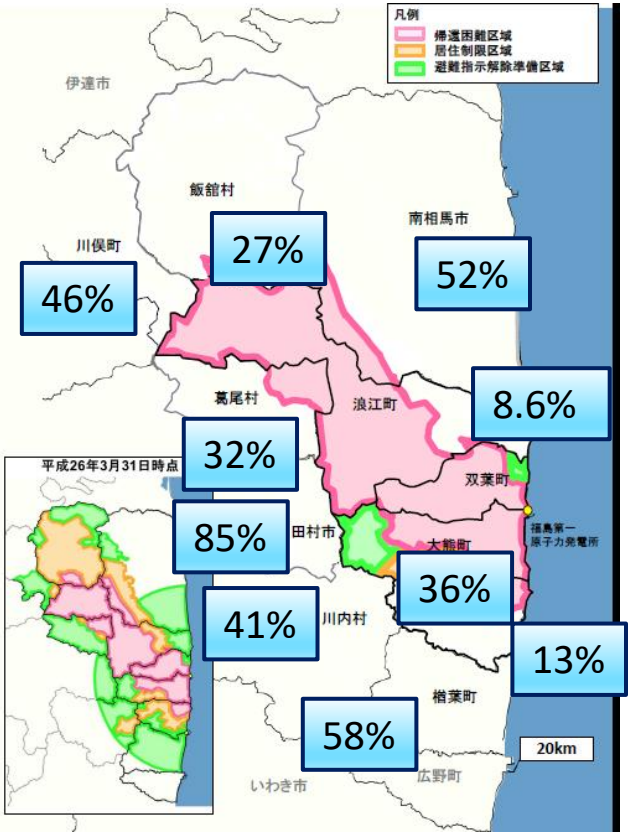
Evacuation : Fukushima : 146,000 people

- Exclusion zone : 81,300
  - Area 3 ( 50mSv< ) : 24,800
  - Area 2 (20 - 50mSv): 23,400
  - Area 1 ( 20mSv> ) : 33,100

- **Lifting conditions (December 2011)**
  - ✓ Dose level < 20 mSv/y
  - ✓ Infrastructures and live services
  - ✓ Consultation with local gov. and residents




April 2012 – August 2013




1 April 2017

# Food safety in Fukushima Prefecture

◆State of monitoring by Fukushima Prefecture of agricultural, forestry and fishery products (April 1, 2019 to Februaru 29, 2020)

| Classificationr | Total No. samples | No. of samples exceeding standard limit | Proportion of samples exceeding standard limit |
|---|---|---|---|
| Vegetables & Fruits | 2,147 | 0 | 0.00 |
| Livestock products | 3,782 | 0 | 0.00 |
| Cultivated edible plants & Mushrooms | 975 | 0 | 0.00 |
| Marine Fishery products | 5,054 | 0 | 0.00 |
| Inner water-cultivated fish | 60 | 0 | 0.00 |
| Wild edible plants & Mushrooms | 768 | 0 | 0.00 |
| Inland water Fishery products | 1,076 | 4 | 0.37 |

(https://www.reconstruction.go.jp/topics/main-cat1/sub-cat1-4/fuhyou/pamphlet/latest/huhyou-higai-husshoku_E-A3.pdf)

Inspection of Brown-Rice Bags

| | | Test samples (Thousands) | # Bags Exceeding Standard | Percentage Exceeding Standard |
|---|---|---|---|---|
| Rice-bag Inspection (Fukushima and Miyagi Prefectures) | 2015 | 10,470 | 0 | 0 |
| | 2014 | 11,010 | 2 | 0.00002 |
| | 2013 | 11,040 | 28 | 0.0003 |
| | 2012 | 10,370 | 84 | 0.0008 |

Note: Un-milled rice (brown rice) is shipped in 35 kg bags, each of which is measured

# Status of countries introduced import measures on food

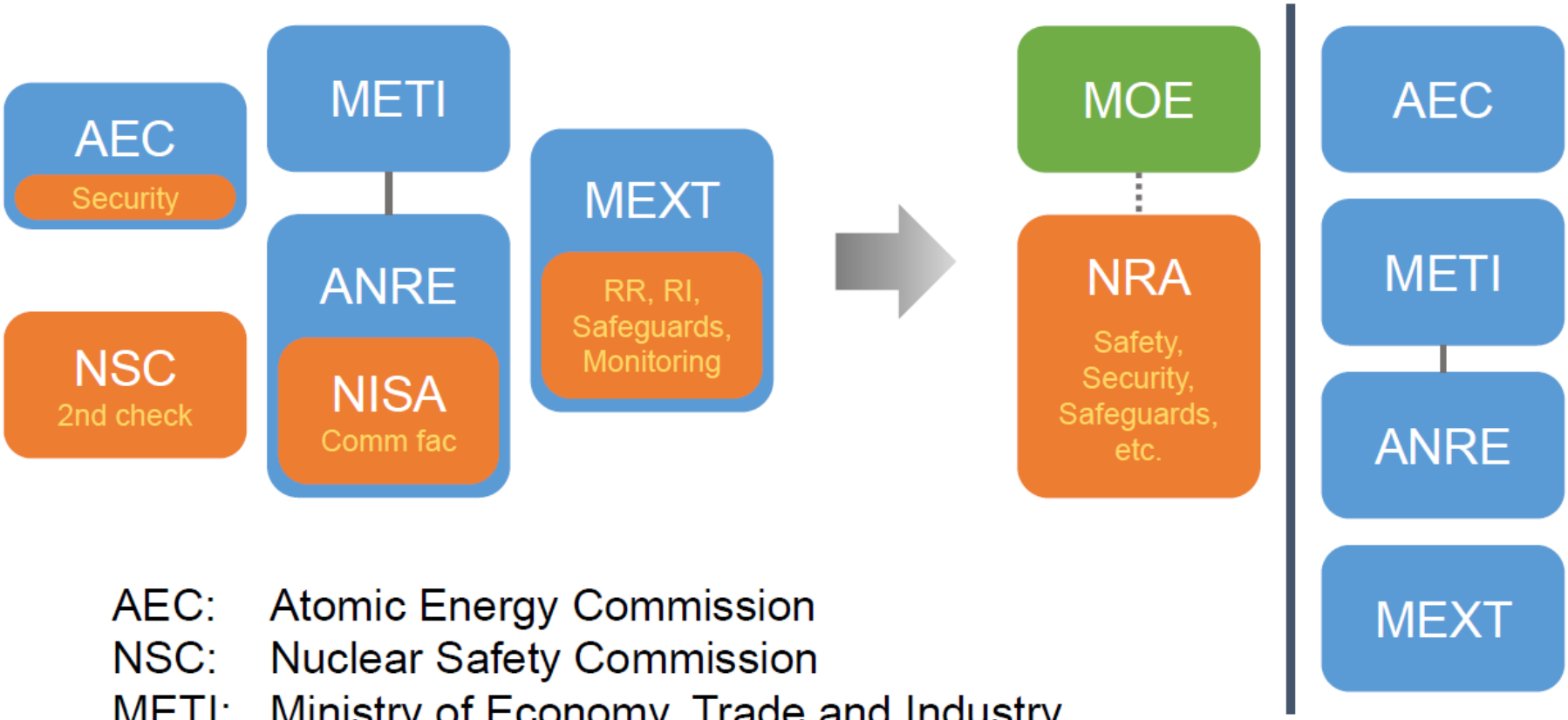
(As of 29 January 2021)

| Type of measures and number of countries or regions | | | | Name of countries or regions |
|---|---|---|---|---|
| Introduced additional measures after the accident<br>54 | **Lifted all the measures** | | **39** | Canada, Myanmar, Serbia, Chile, Mexico, Peru, Guinea, New Zealand, Colombia, Malaysia, Ecuador, Vietnam, Iraq, Australia, Thailand, Bolivia, India, Kuwait, Nepal, Iran, Mauritius, Qatar, Ukraine, Pakistan, Saudi Arabia, Argentina, Turkey, New Caledonia, Brazil, Oman, Bahrain, Congo DR, Brunei, Philippines, Morocco, Egypt, Lebanon, United Arab Emirates, Israel |
| | Remaining the measures<br>15 | Import ban | 6 | China, Korea, Taiwan, Hong Kong, Macau, USA* |
| | | Test certificate requirement | 9 | EU and UK**, Iceland, Liechtenstein, Norway and Switzerland (EFTA member states), French Polynesia, Russia, Singapore, Indonesia |

* USA imposes import ban on the products subject to Japanese shipment restriction, at prefectural level.

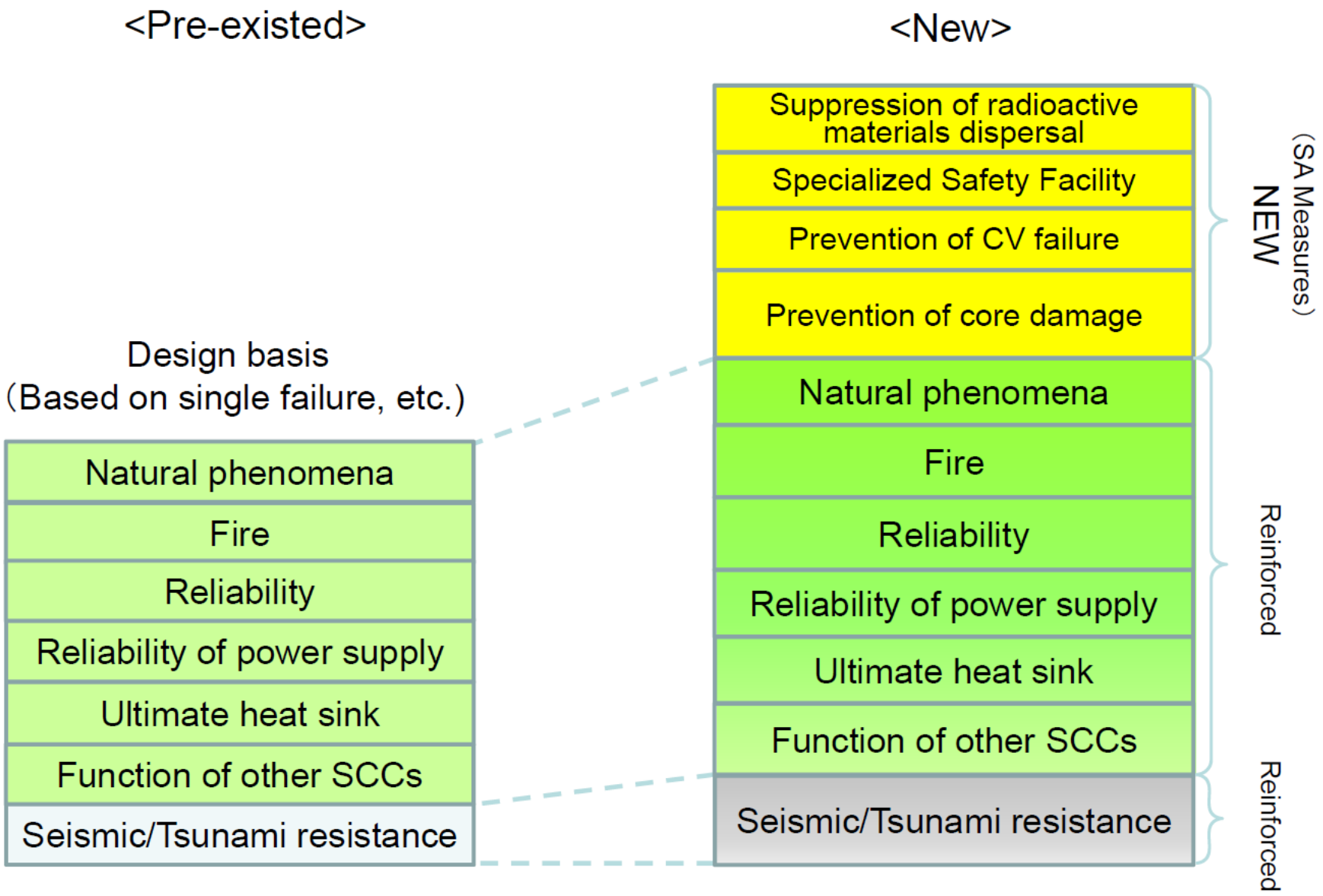
** Total 27 EU member states and UK are counted in as one region, because they have introduced measures on Japanese food following the nuclear power station accident as one entity.

# Integrated and Independent

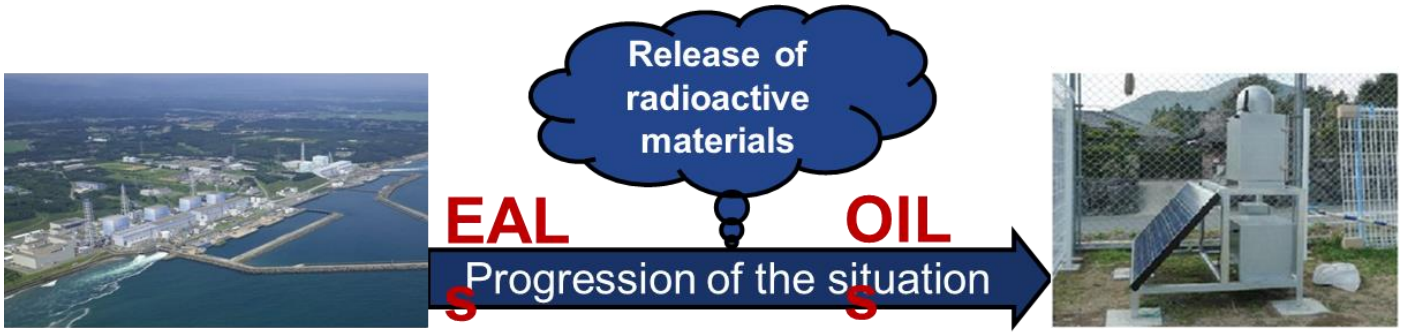



AEC: Atomic Energy Commission
NSC: Nuclear Safety Commission
METI: Ministry of Economy, Trade and Industry
ANRE: Agency for Natural Resources and Energy
MEXT: Ministry of Education, Culture, Sports, Science and Technology
MOE: Ministry of Environment

# Structure of new requirements



# Revised EPR-Guide protection strategy

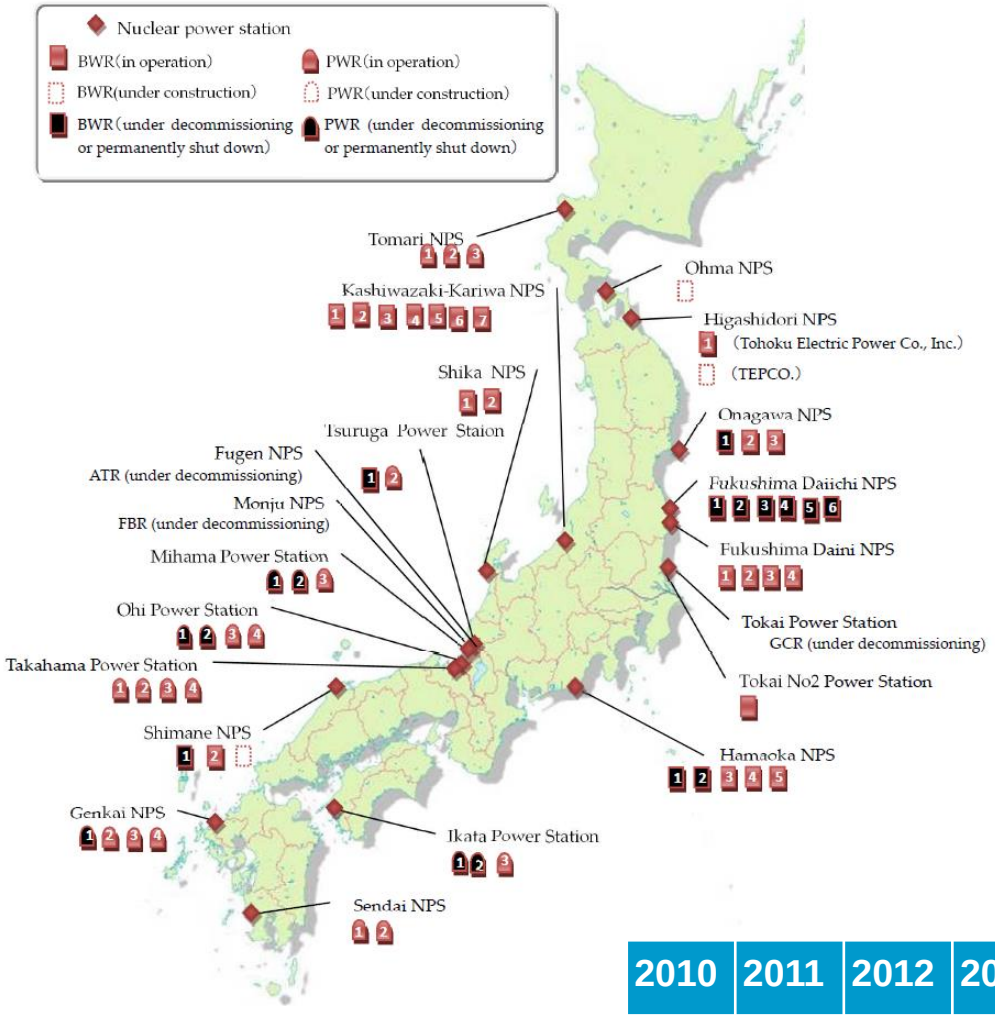



**Predefined protective actions (Care for the vulnerable people)**

| Emergency Class | PAZ / 5km | UPZ / 30km | beyond *2 |
|---|---|---|---|
| Alert | vulnerable people: Preparatory actions; others | | |
| Site Area | Evacuation; Sheltering-in-place: Preparatory actions | Preparatory actions | |
| General | Evacuation *1 | Sheltering-in-place | Preparatory actions *2 |
| | | | Sheltering-in-place *2 |

*1 Combined with stable iodine prophylaxis.
*2 Prior to a significant release NRA shall make decision on extending protective action zone, based on the facility conditions.

# Current status of commercial NPPs




| Status | BWR | PWR | Total |
|---|---|---|---|
| Restart | 0 | 9 | 9 |
| Approved | 4 | 3 | 7 |
| Application | 4 | 5 | 9 |
| Not apply yet | 8 | 0 | 8 |
| Construction | 3 | 0 | 3 |
| Closed down | 16 | 8 | 24 |

(as of March 4, 2021, JAIF)

## Capacity factor (%)

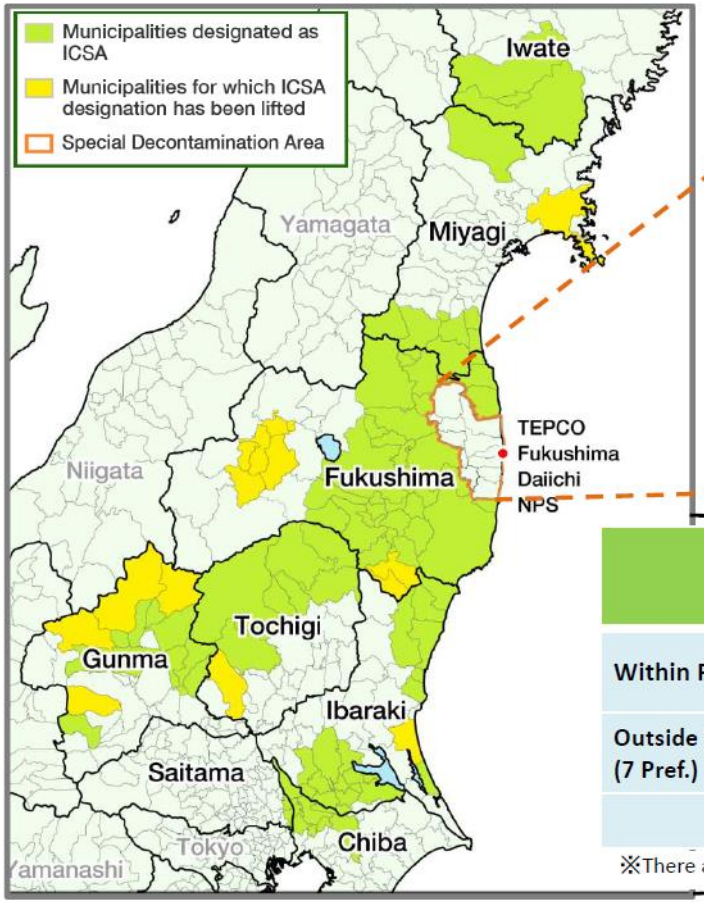
| 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| 68.3 | 38. | 4.4 | 3.6 | 0. | 1.2 | 5. | 8.4 | 15. | 21.4 | 15.5 |

(from Japan Atomic Industrial Forum Inc. HP)

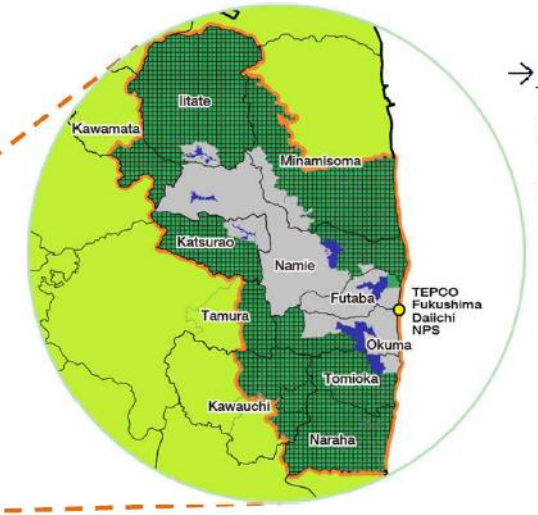
(NRA, Convention on Nuclear Safety
National Report of Japan
for the Eighth Review Meeting, 2019)

# Decontamination process

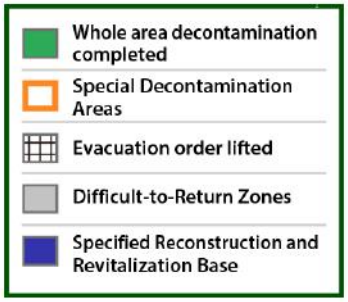
<Intensive Contamination Survey Areas (ICSA)>




<Special Decontamination Areas (SDA)>




→ **Whole area decontamination in the SDA was completed at the end of March 2017**



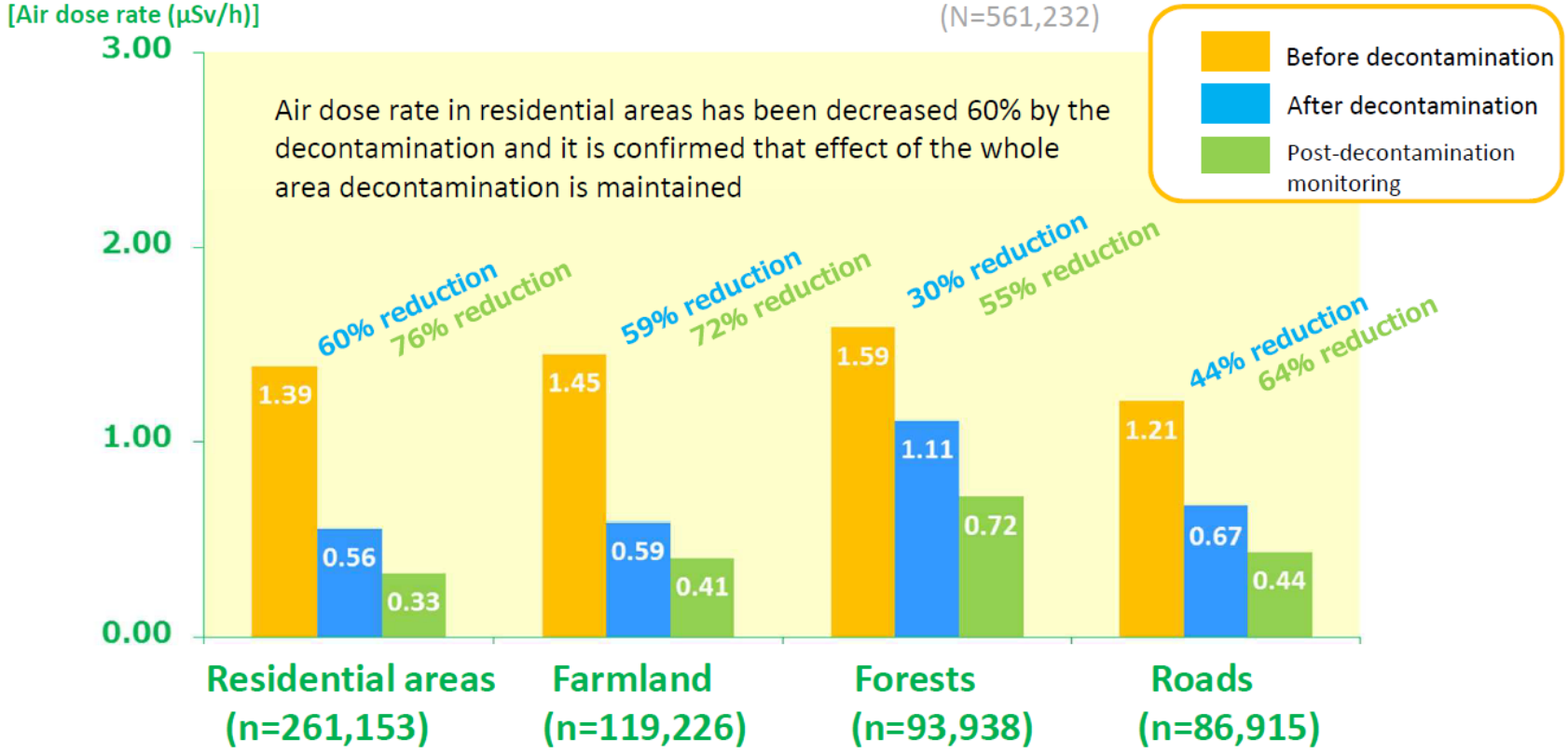

| | Municipalities where whole area decontamination was completed | | |
|---|---|---|---|
| | | SDA (11) | ICSA (93) |
| Within Fukushima Pref. | 43※ | 11 | 36 |
| Outside Fukushima Pref. (7 Pref.) | 57 | — | 57 |
| Total | 100 | Completed in March 2017 | Completed in March 2018 |

※There are both SDA and ICSA in Minamisoma, Tamura, Kawamata, and Kawauchi

(http://josen.env.go.jp/en/decontamination/)

# Effects of decontamination in SDA

<Air dose rate measured at the height of 1m from the ground / Transition according to land category>

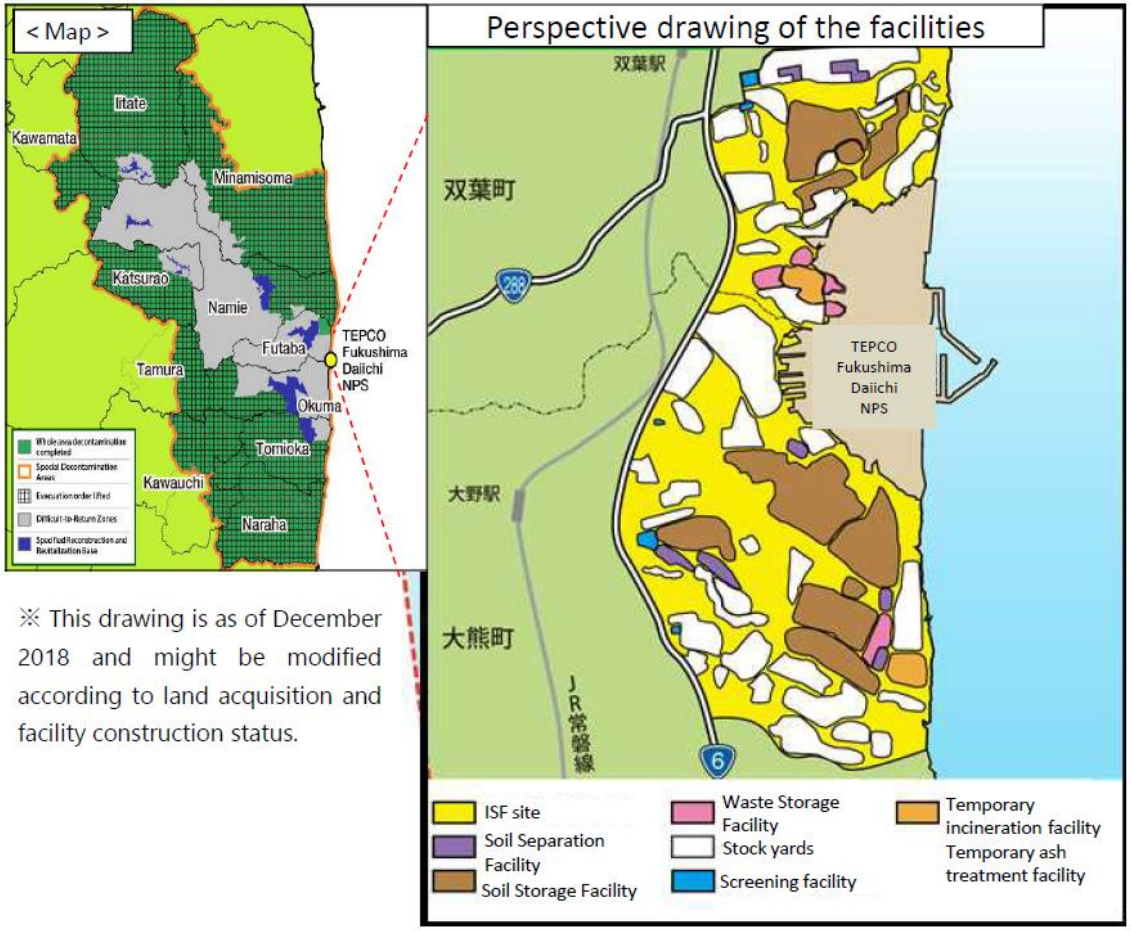



NOTE: The chart shows the air dose rate average in each category (aggregated data of measuring points).
Residential areas include schools, parks, cemeteries, and large-sized facilities, farmland includes orchard, and forests include slopes, grassland and lawn.
Post-decontamination monitoring was implemented after 6 months to a year after the decontamination work. The latest result of post decontamination monitoring in municipalities were summarized

| | | |
|---|---|---|
| [Implementation period] | ・Monitoring before decontamination | Nov.2011 - Nov. 2016 |
| | ・Monitoring after decontamination | Dec. 2011 - Dec. 2017 |
| | ・Post decontamination monitoring | Oct. 2014 - Aug. 2018 |

(http://josen.env.go.jp/en/decontamination/)

# Interim Storage Facility (ISF)




※ This drawing is as of December 2018 and might be modified according to land acquisition and facility construction status.

【Process of the ISF Project】

**Land acquisition**

**Construction of facilities**
For soil separation and soil storage facility

**Transportation of soil and waste from TSS to ISF**

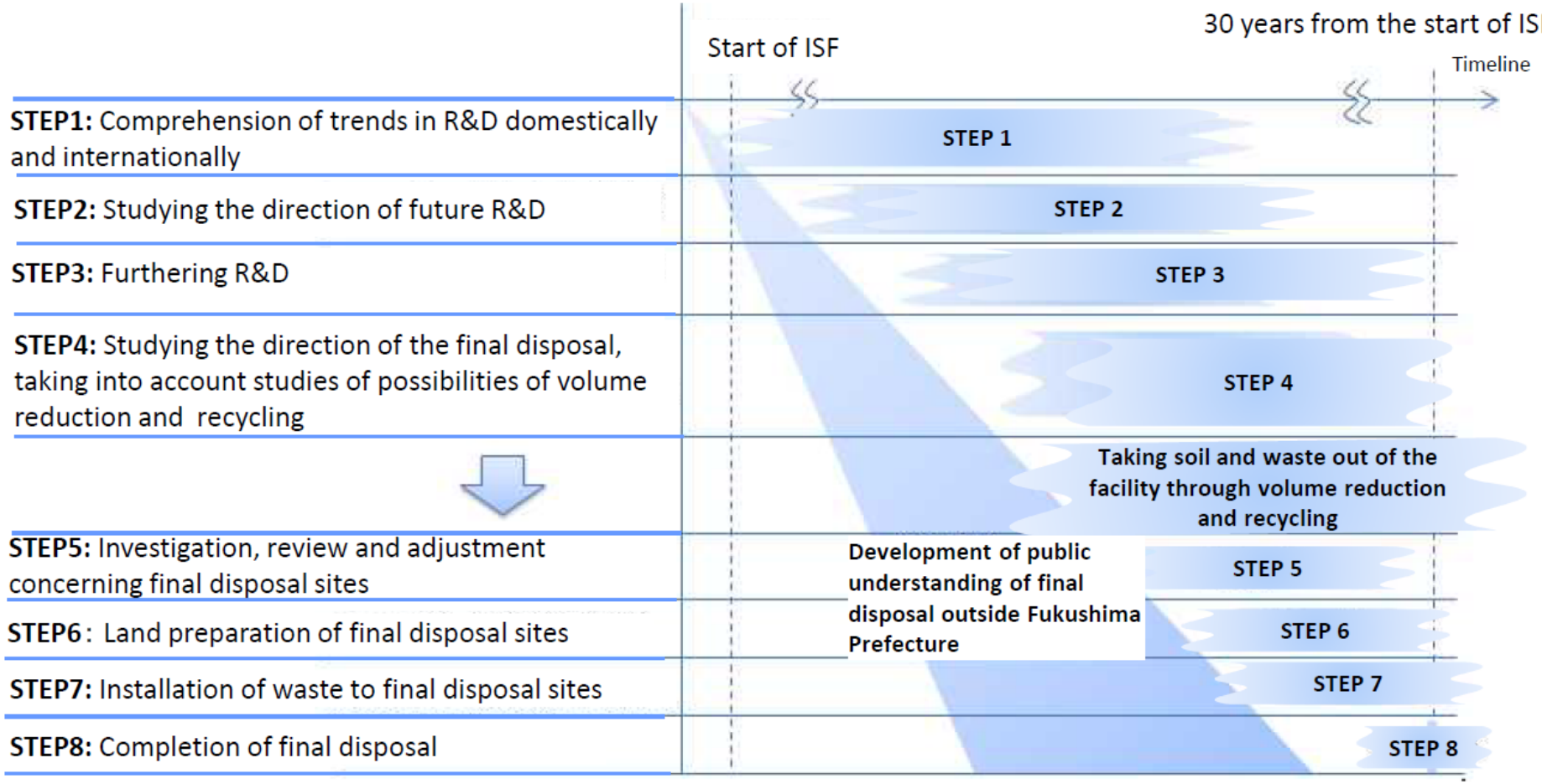
**Processing and storage of soil and waste**

(http://josen.env.go.jp/en/storage/)

# Photo of the ISF taken by drone

Source : http://www.jesconet.co.jp/interim_infocenter/index.html

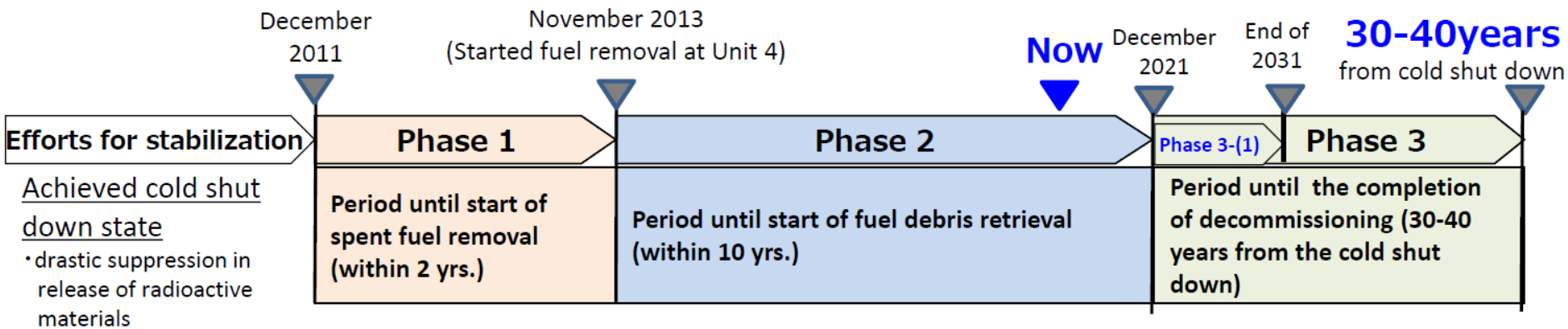
# Eight steps towards the final disposal

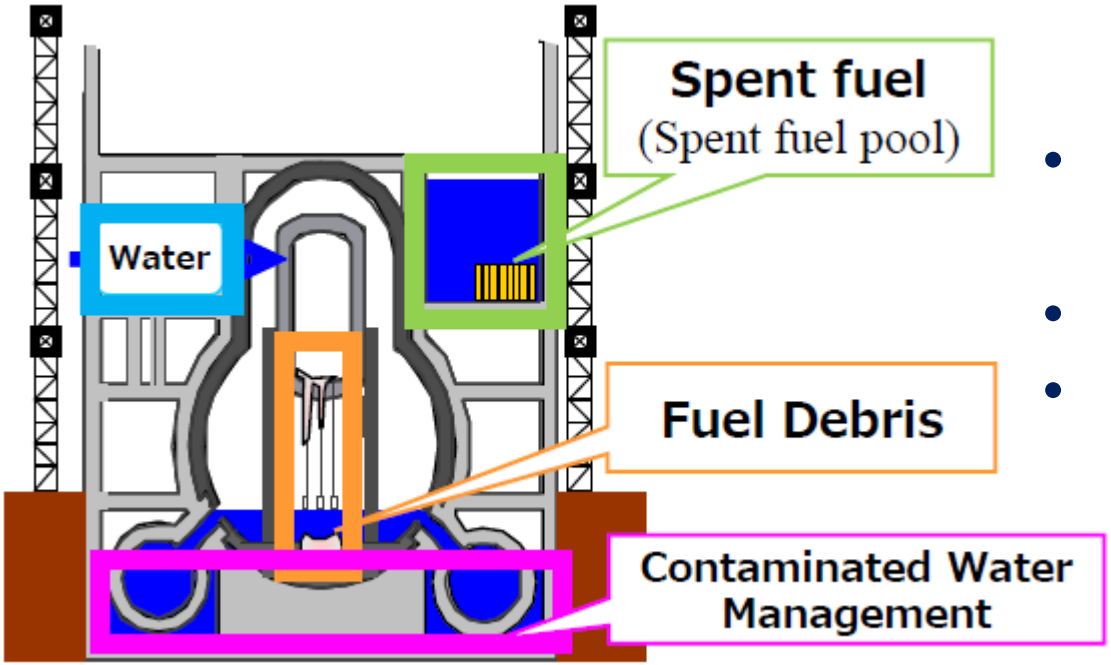



(http://josen.env.go.jp/en/storage/)

# The Mid-and-Long-Term Roadmap

## Time flame for Fukushima Daiichi Decommissioning



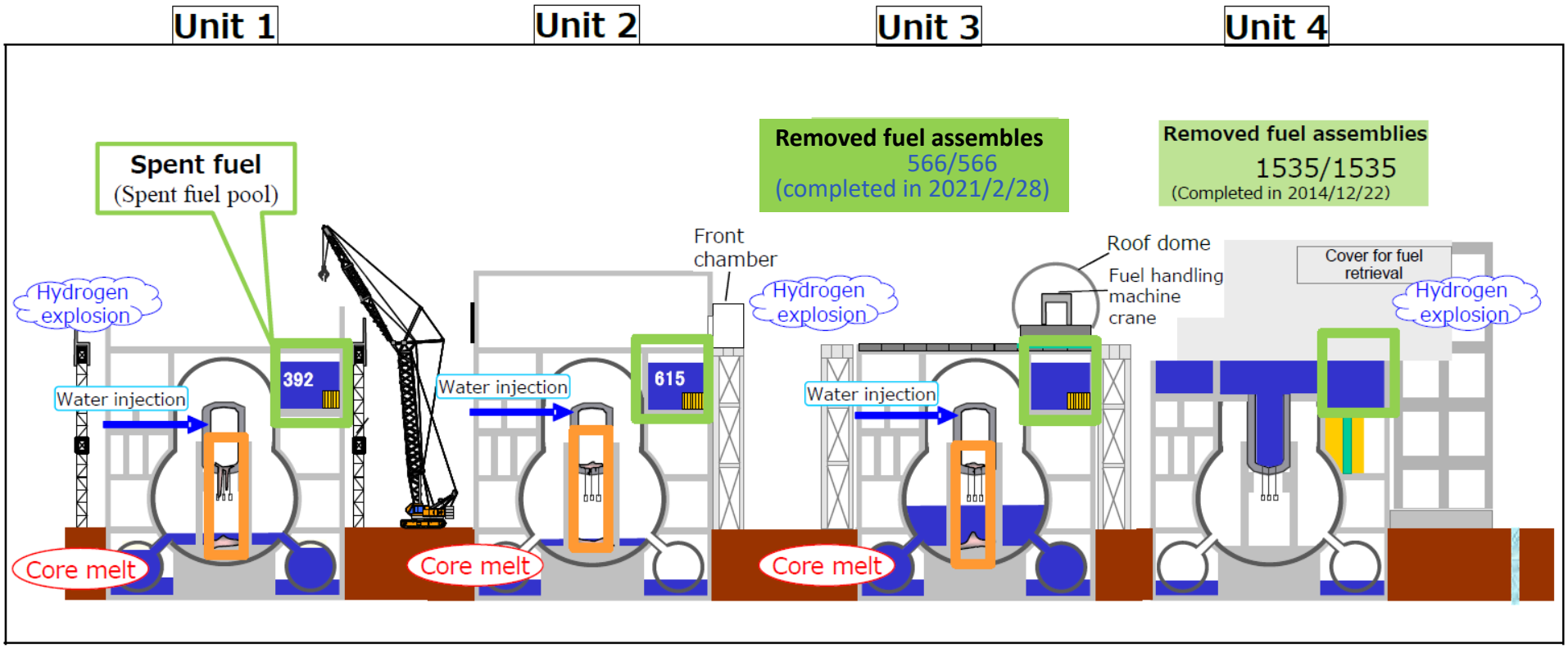




## Specific measures

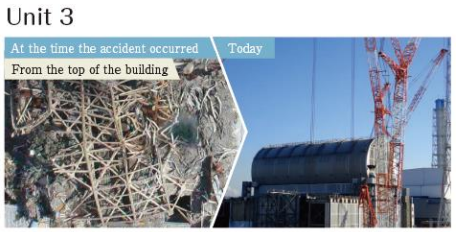
- Remove fuel from spent fuel pool
- Retrieve fuel debris
- Management of contaminated water

(https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html)

# Current status of Unit 1-4





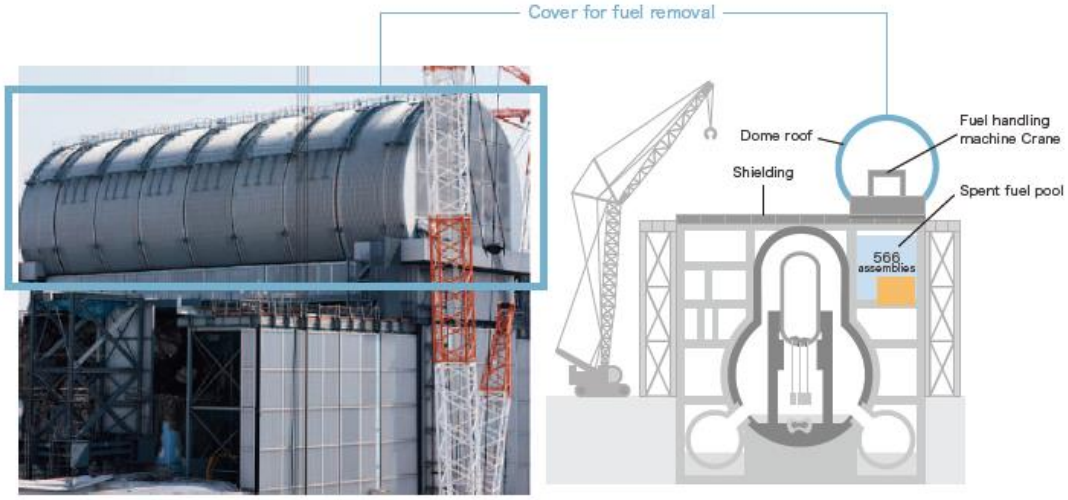





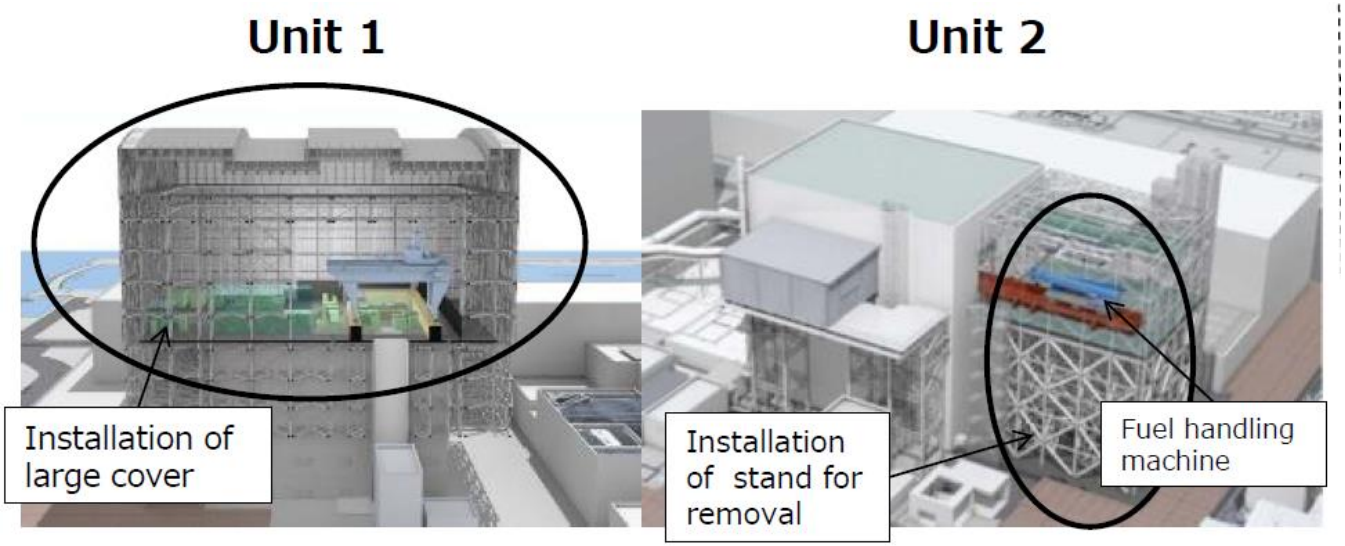
(https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html)

# Fuel removal from pools

## Unit 4




| Unit | Fuels | Plan |
|---|---|---|
| 1 | 392 | Start 2027-28 |
| 2 | 615 | Start 2024-26 |
| 3 | 566 | Completed 2021/Feb/28 |
| 4 | 1535 | Completed 2014/Dec/12 |

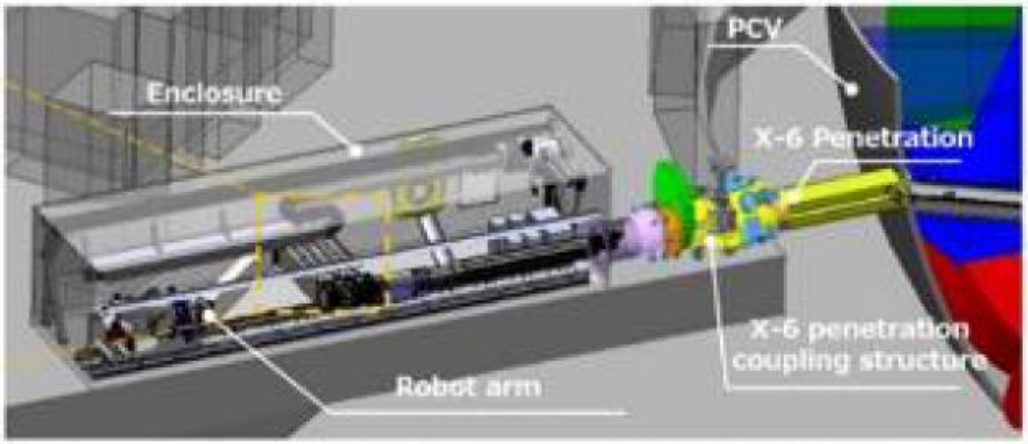



(https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html)

# Retrieve fuel debris

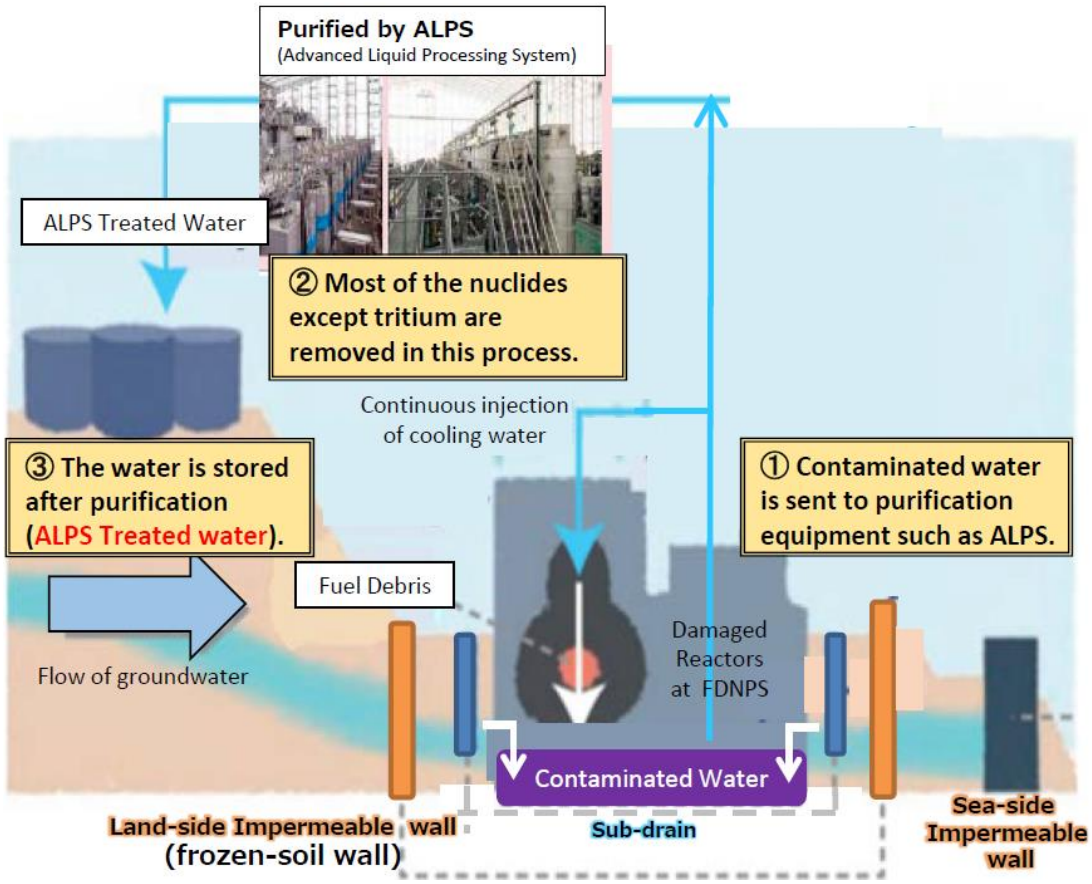
| | -FY2019 | FY2020 | FY2021 | FY2022 | FY2023- |
|---|---|---|---|---|---|
| Unit 1 | | Investigation at the bottom of PCV (including small amount sampling)  Metallic brush  Vacuum vessel | | | |
| Unit 2 | Contact investigation (Feb. 2019)  | | Trial retrieval/Internal investigation  | | Fuel debris retrieval (Gradual enlargement of the retrieval scale) |
| Unit 3 | | | | | Detailed investigation at the bottom of PCV |

Robot arm



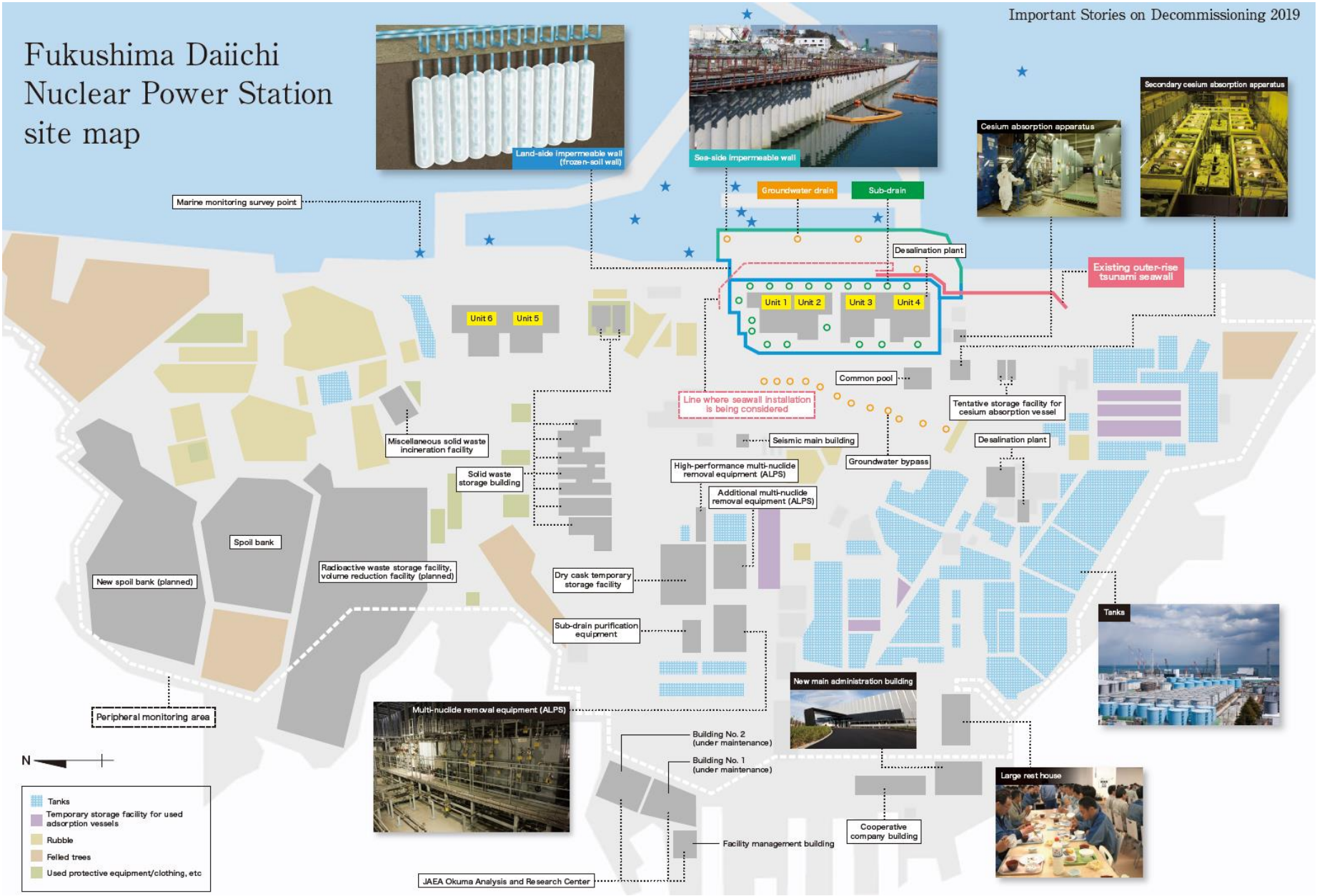

(https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html)

# Management of contaminated water




| Status of treated water in FDNPS (As of August 20, 2020) | |
|---|---|
| Tank storage volume | About 1.23 million m³ |
| Tank capacity (at the end of 2020) | About 1.37million m³ |
| Increase of treated water | About 50,000 to 60,000 m³/year |

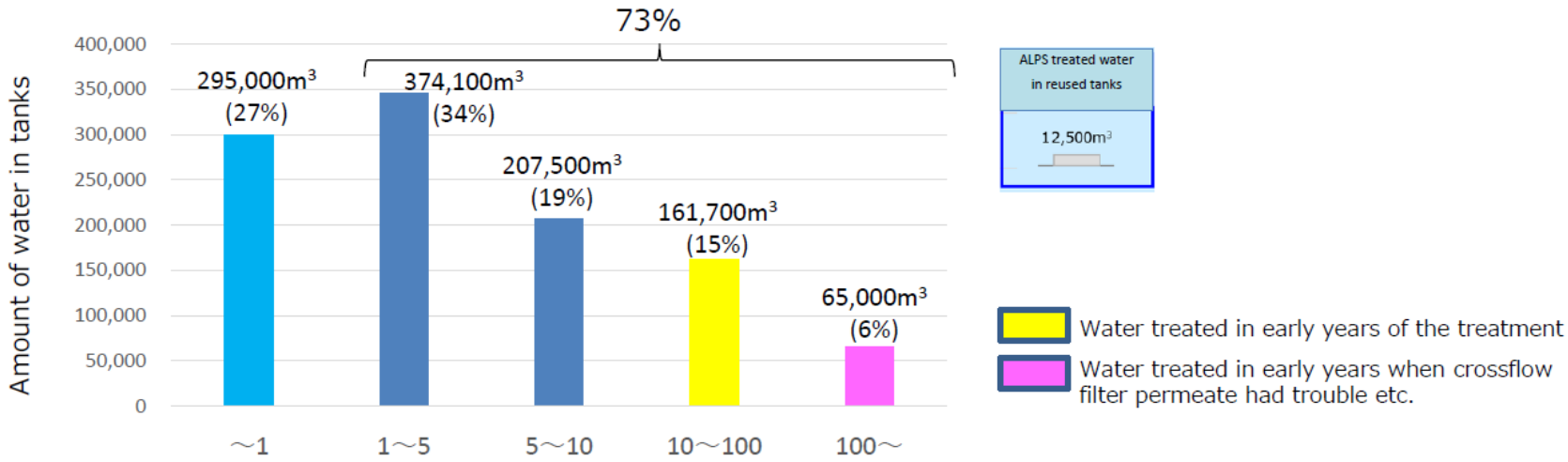
(https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html)



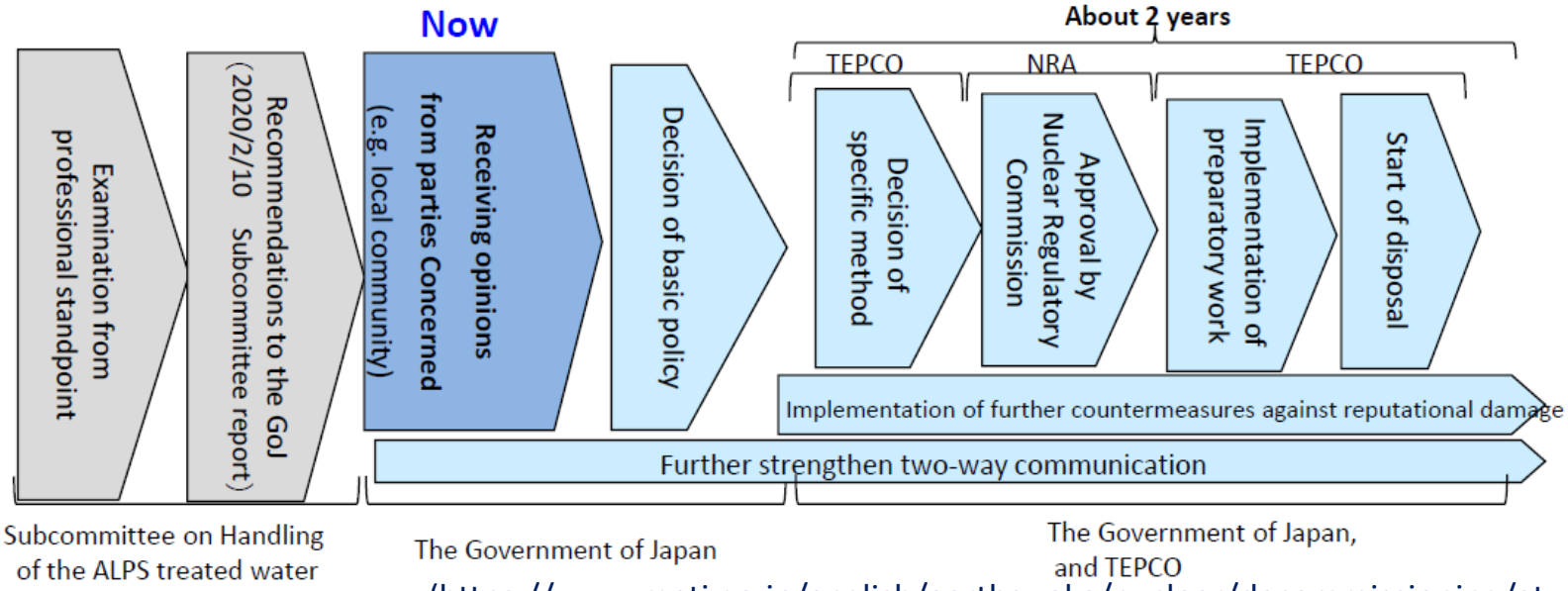

(https://www.meti.go.jp/earthquake/nuclear/hairo_osensui/images/reactorpamph2019en.pdf)

# Handling of the ALPS treated water

**Sum of the ratios of actual concentrations to regulatory standards for 62 nuclides* (as of August, 2020)** * other than tritium



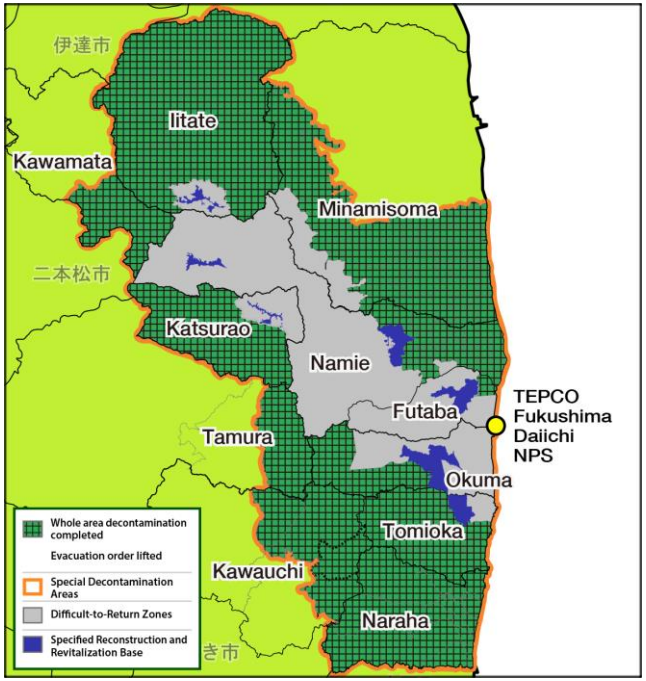

*73% of the total volume of ALPS treated water stored in tanks contains radionuclides other than tritium at the concentration that exceeds the regulatory standards for discharge. This will be further re-purified to meet the regulatory standards other than tritium.

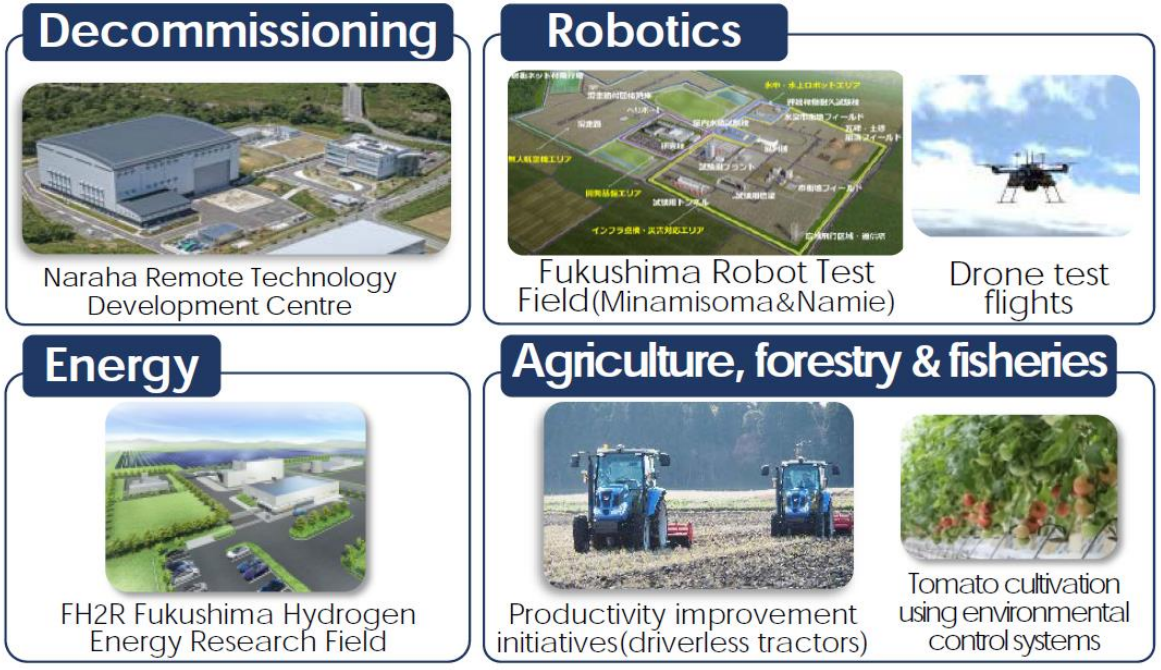



(https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/atw.html)

# Path to the reconstruction of Fukushima

- Area under evacuation order: 1,150 km$^2$ (Aug.2013) ➡ 340 km$^2$ (Apr.2019)
  Number of evacuee; 81,000 ⟶ 24,000
- The development of the **Specified Reconstruction and Revitalization Base** is to be carried out.
- Restoration of infrastructures, such as road and rail way are making steady progress.
- Priority areas of Fukushima Innovation Coast scheme are decommissioning, robot, energy and agriculture.




(https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html)