

Lessons Learned from The Great East Japan Earthquake and Tsunami
～ Restoration and Reconstruction of Power Facilities ～

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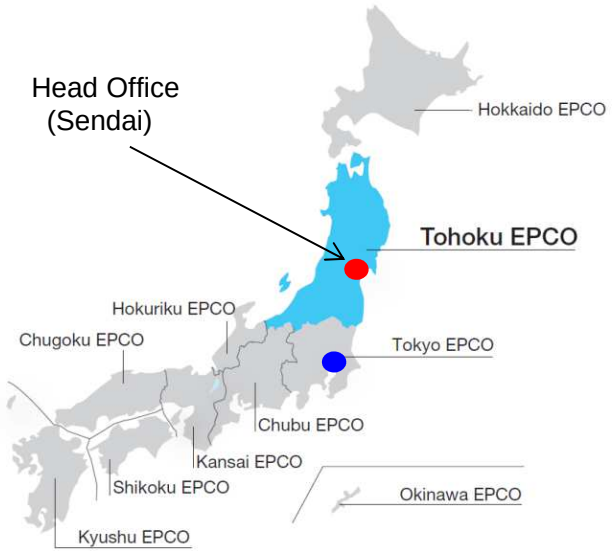
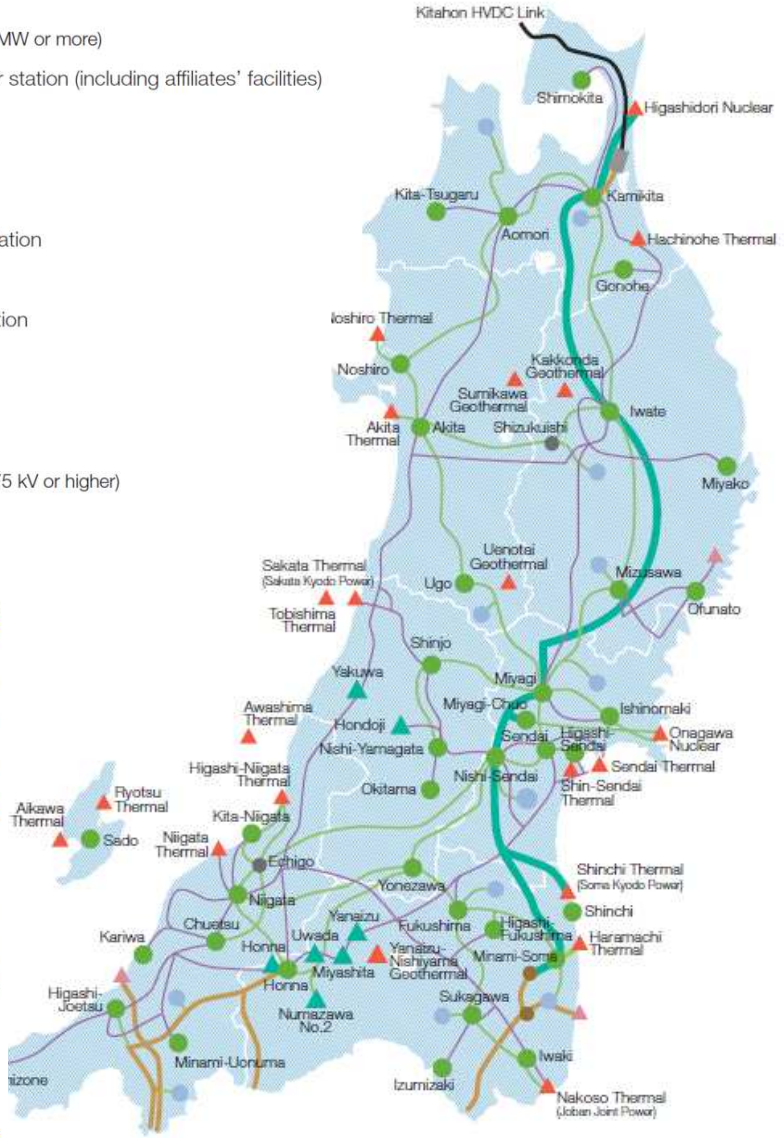
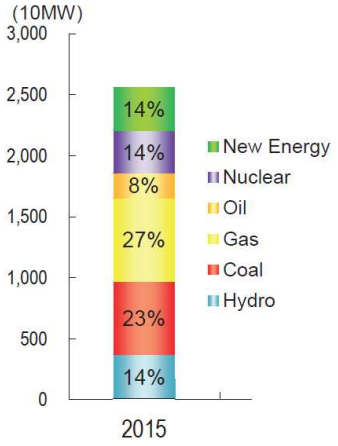
Generation and Network Facilities of TOHOKU EPCO.



- Major hydroelectric power station (60 MW or more)
- Thermal, geothermal or nuclear power station (including affiliates' facilities)
- Other company's power station
- Major substation
- Other company's major substation
- Other company's AC/DC converter station
- Major switching station
- Other company's major switching station
- Transmission line (500 kV)
- Transmission line (275 kV)
- Major transmission line (154 kV)
- Other company's transmission line (275 kV or higher)



Generating Capacity by Energy Source
(including purchased power)

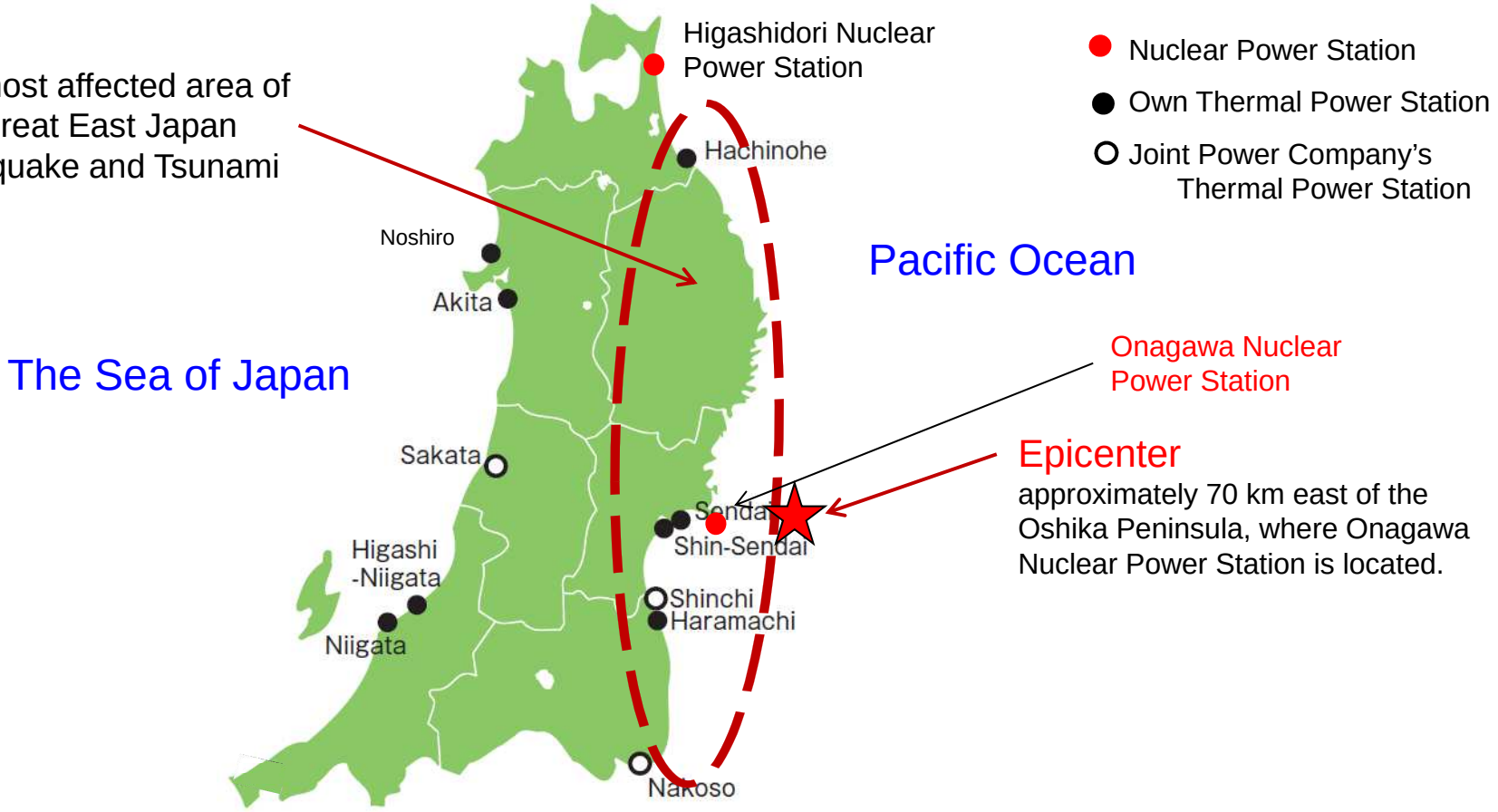


Major Facilities

(Consolidated basis) (as of March 31, 2016)

Power Stations (Total)	259	18,812 MW
Hydro	226	2,538 MW
Thermal (including internal combustion)	13	12,725 MW
Renewable	18	276 MW
Nuclear	2	3,274 MW
Transmission Facilities		
Line Length		15,212 km
Circuit Length		24,794 km
Supports		58,229
Substations	627	75,211 MVA
Distribution Facilities		
Line Length		146,550 km
Circuit Length		583,091 km
Supports		3,088,541

The Great East Japan Earthquake and Tsunami



The 9.0-magnitude Great East Japan Earthquake hit the wide area of northeast coast of the main island of Japan on March 11, 2011. It was the most powerful earthquake ever recorded to have hit Japan, and the fourth most powerful earthquake in the world since modern record-keeping began in 1900.

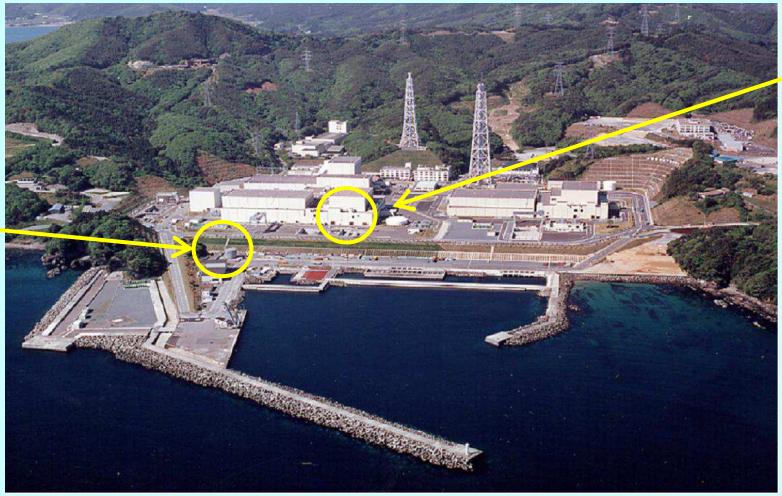
The subsequent gigantic tsunami caused devastating damages across the coast in the Tohoku region, where Tohoku Electric Power Co., Inc. supplies electricity.

Damages of Facilities ~ Nuclear Power Station ~

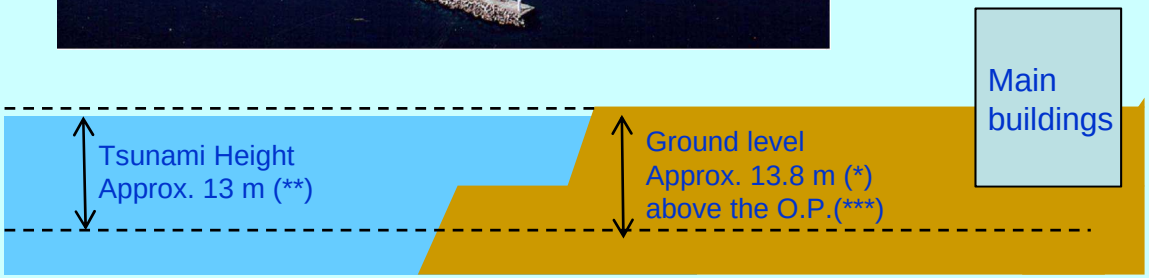
●	Higashidori	In regular maintenance: 1 unit (in stoppage)
●	Onagawa	In operation: 2 units In regular maintenance: 1 unit (in starting process) * All three units safely cold shutdown.

Onagawa Nuclear Power Station

A heavy oil tank for unit 1.
(Collapsed)



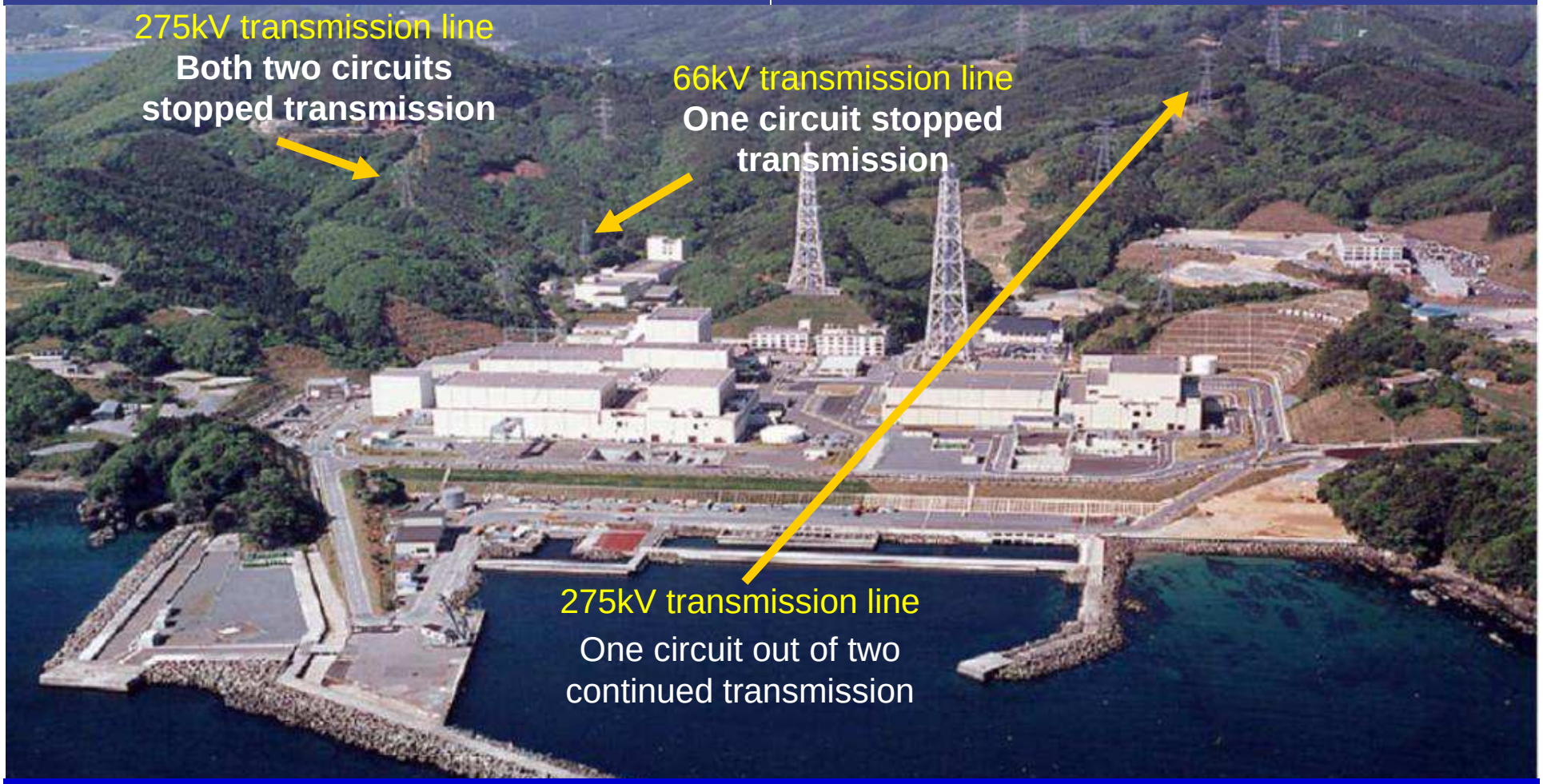
Accessory of reactor building for unit 2. (Sea water flooding.)



The height of the ground was determined to be 14.8m taking into consideration the records of tsunami in the past.
The tsunami did NOT exceed the height of the ground.

(* Considering subsidence of 1m due to the earthquake, ** Trace of tsunami: Maximum 13.8m
*** Onagawa NPS datum plane for construction, -0.74m below standard mean sea level of Tokyo Bay)

Damages of Facilities ~ Onagawa Nuclear Power Station ~



One out of 5 transmission line circuits continued power transmission.
Six out of 8 emergency diesel generators were integral.

Damages of Facilities ～ Onagawa Nuclear Power Station ～

IAEA Expert Team investigated the Onagawa NPS in summer 2012, and published a report.

"It was concluded that the facilities of the Onagawa NPS remain "remarkably undamaged" given the magnitude, distance and duration of ground shaking."

(IAEA Mission to ONAGAWA nuclear Power Station to examine the Performance of Systems, Structures and Components Following the Great East Japan Earthquake and Tsunami, 30 July - 11 August 2012, IAEA MISSION REPORT)

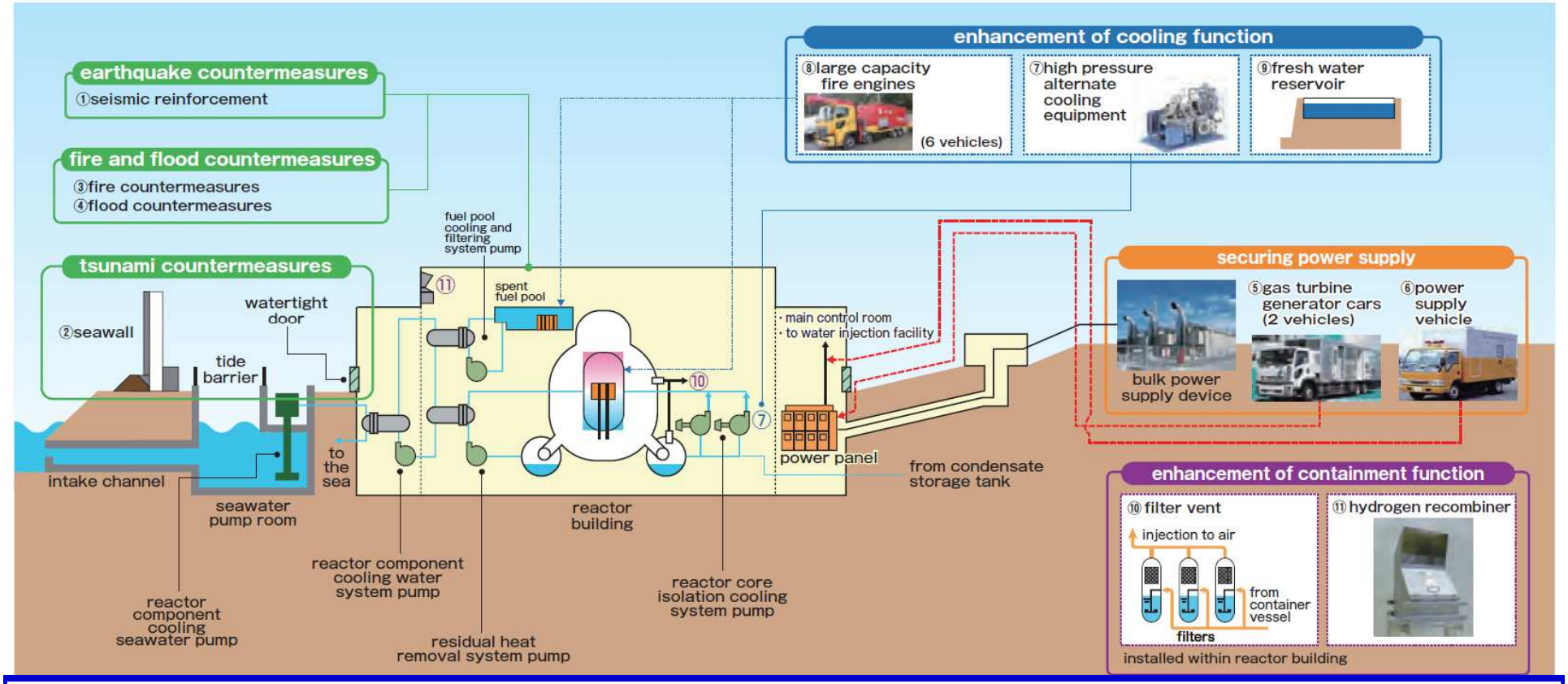
Max. 364 residents who suffered from the tsunami took shelter in a facility of Onagawa Nuclear Power Station for max. about three months.

We served food and blankets for them, and transported expecting mothers and those who needed medical treatment to hospitals in Sendai city using our helicopter.

The activity was highly evaluated and the station was awarded by WANO.

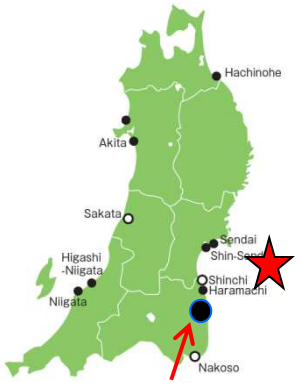
Countermeasures ~ Onagawa Nuclear Power Station ~

Safety Measures Taken at Nuclear Power Stations (Onagawa Unit 2)



For enhancing safety, various countermeasures are being taken
including seismic reinforcement, building about 15m-height seawall, securing emergency power supply, and enhancement of cooling and containment functions.

Damaged facilities ～Thermal power stations～



Haramachi Thermal Power Station

Haramachi Thermal Power Station with a capacity of 2,000 MW was devastatingly damaged by the about 18m-height tsunami.

Thanks to the strenuous reconstruction effort on 24-hour basis, it resumed full operation in April 2013, which greatly improved the stability of power supply in the Tohoku region.
As the damage was quite severe, it took as long as two years to resume the full operation.

The damages of thermal power stations decreased our generation capability greatly.
In order to meet the power demand particularly in summer and winter

- **Full operation of the undamaged power stations along the coast of The Sea of Japan.**
- **Purchase of power from other utilities in case of need.**
- **Asking customers to save energy.**

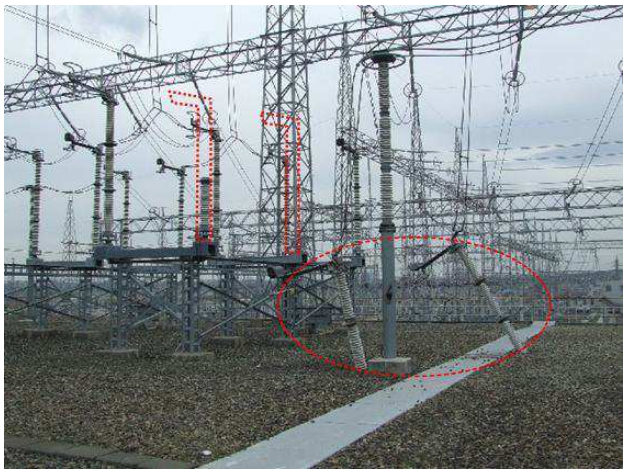
➡ **We have achieved stable power supply without power interruption.**

Damaged facilities ～substations～

Totally 75 substations were damaged.

A great amount of debris destroyed substation structures and apparatuses.

Some substations were submerged and some were nearly swept away by the tsunami.



A number of substation apparatuses such as transformers, disconnectors, and lightning arresters were broken by vibration.

Damaged facilities ～Transmission lines～

Totally 46 towers were damaged.

Transmission towers were collapsed or tilted by massive debris, such as wave-dissipating concrete blocks and broken rails of railway, attacking them.

Jumper support long-rod insulators were broken by massive vibration.

Cable accessories, such as terminations and oil-filled tanks, were destroyed by the debris of the tsunami.

Damaged facilities ~Distribution lines~

Totally about 36,000 poles were damaged.

Some areas were nearly swept away and no poles and wires could be seen.

A great number of poles, wires, and accessories such as pole transformers were collapsed or broken.

Toward early restoration ~Being all united, filled with a sense of mission.~

We set up temporary facilities for early restoration of power supply.

We restored power supply using vehicle-mounted transformers and cubicles.

Temporary apparatuses were used for restoration.

Satellite communication systems were set up where telecommunication systems were destroyed.

We built temporary substations near the damaged substations within three weeks after starting construction.

Toward early restoration ~Being all united, filled with a sense of mission.~

We reconstructed destroyed facilities for early restoration of power supply.

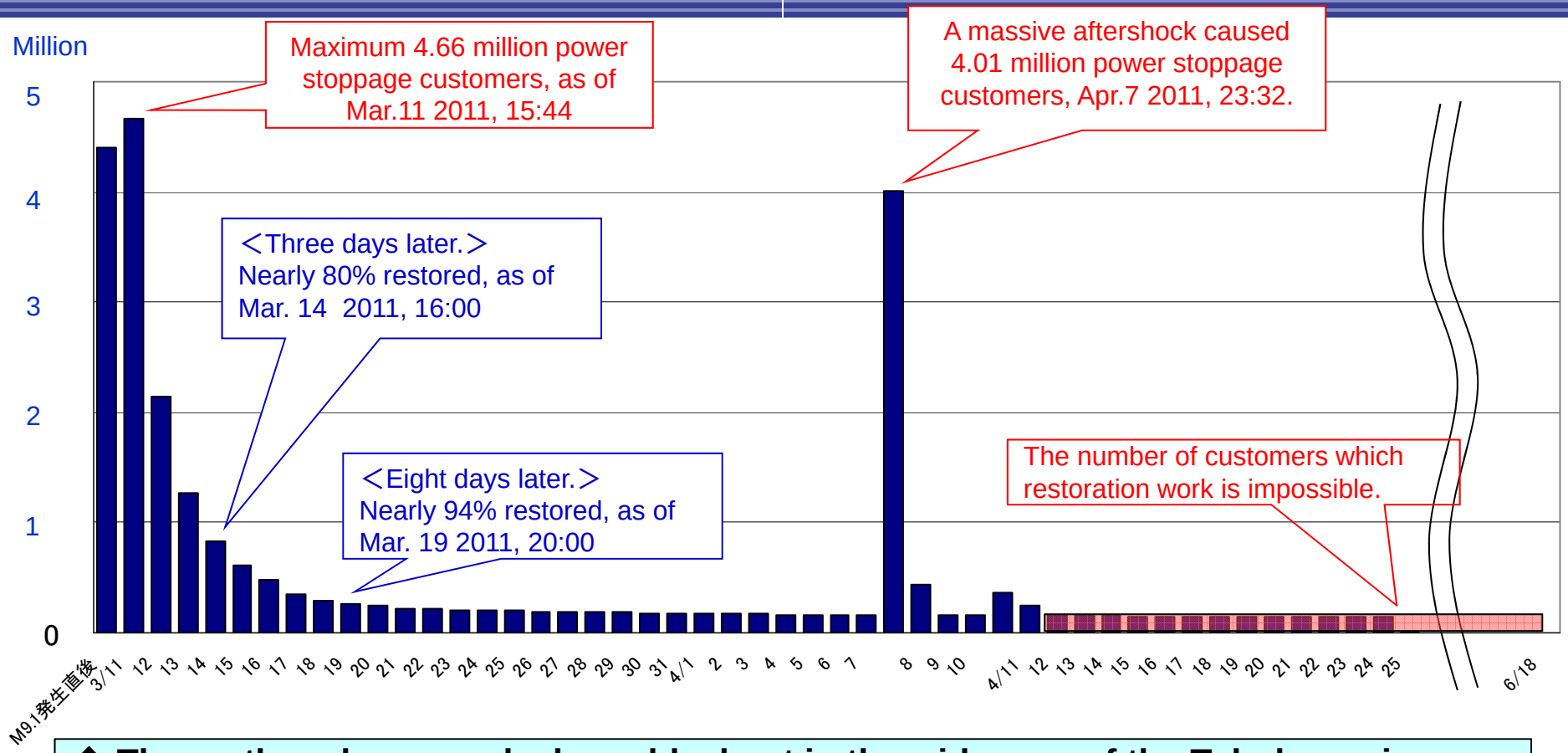
Workers were constructing a temporary tower, while they were still having a fears of aftershocks.

Restoration work was carried out with the help of other utilities and many subcontractors willing to provide help.

We rebuilt distribution lines before debris had been cleared. The debris made restoration works very hard.

Once debris was cleared, the restoration work became highly efficient.

Toward early restoration ~The number of power stoppage customers~

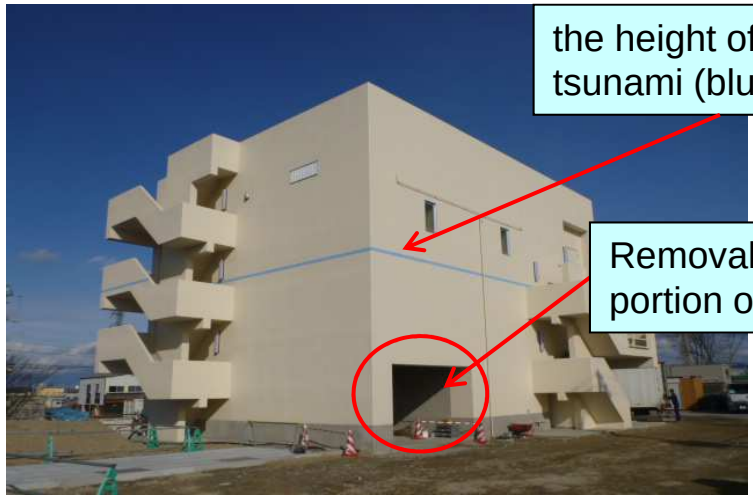


- **The earthquake caused a huge blackout in the wide area of the Tohoku region. The number of affected customers were maximum 4.66 million.**
- **Nearly 80% of the customers were restored within 3 days after the earthquake.**
- **The early restoration not only provided local residents with a sense of security, but also contributed to prompting the restoration works of other infrastructures.**

Countermeasures

Against Tsunami

- Move substation to higher place
  where even larger tsunami CANNOT reach
- Elevate the ground and floor levels
  on which power apparatuses are placed
- Reinforce the strength of building
- Remove a portion of wall so that tsunami can passes through the building without damaging it.



For early restoration

We developed and installed air-transportable vehicle-mounted LV generator “ToMoS (Tohoku Mobile Speedy)”, which can be transported in a helicopter owned by the Japan Self-Defense Forces. The vehicle makes it possible to supply power to islands and to areas where access roads are cut off.

Vehicle	Engine: gasoline, 660 cc Seating capacity: 2
Generator	100V/200V, 13kVA/15kVA (50Hz/60Hz)
Weight	492 kg (including diesel fuel (40 l.)
Continuous operation time	10 hours with 75 % load

Countermeasures

Against strong vibration

Applying flexible materials to substation apparatuses and transmission lines

Polymer bushings of 154/66kV transformer

154kV Polymer lightning arresters

154kVPolymer cable terminations

275kV Polymer jumper support insulator

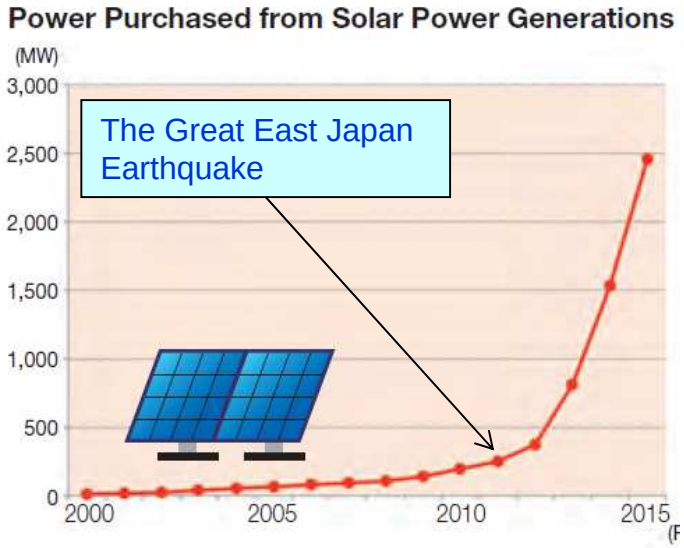
Efforts for Achieving Sustainability

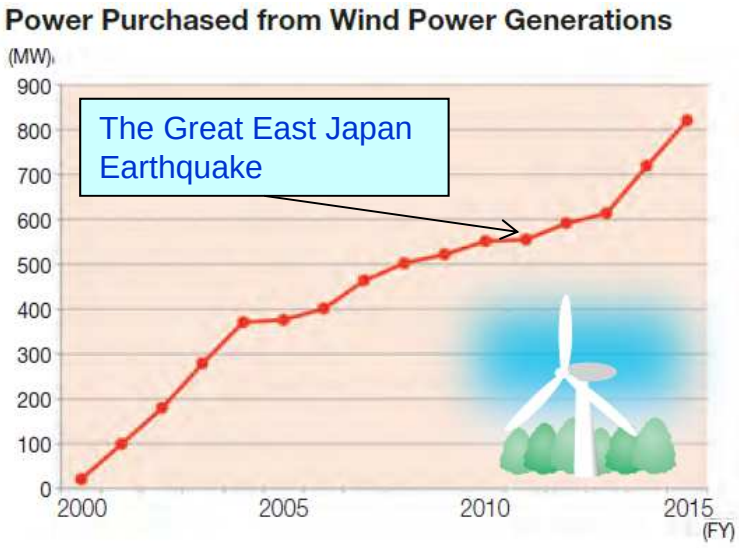
We has been expanding introduction of renewables being connected to our power grid.

Renewables connected to our power system

Solar	**2.45 GW**
Wind	0.8 GW

as of March, 2016





Sendai Mega Solar (2,000kW)

Noshiro Wind Park (14.4MW)

Minami-Sohma Li-ion Battery (40,000kWh)

Efforts for Achieving Sustainability

Field Test of Hydrogen manufacturing and the use of hydrogen for stabilization of power grid

Hydrogen-manufacturing facility including PV, Fuel and Li-ion Batteries, and Hydrogen storage tank at R&D Center (under construction)

Hydrogen Manufacturing Rate	about 5Nm^3/h
Hydrogen Tank Capacity	about 200 Nm^3 (corresponding to about 300kWh when discharged)
PV	Output: about 50kW
Fuel and Li-ion Batteries	Fuel: less than 10kW Li-ion: about 60kWh

Participation in Smart Community Project

"Smart Community" being field-tested by Ishinomaki City, and Toshiba (in collaboration)

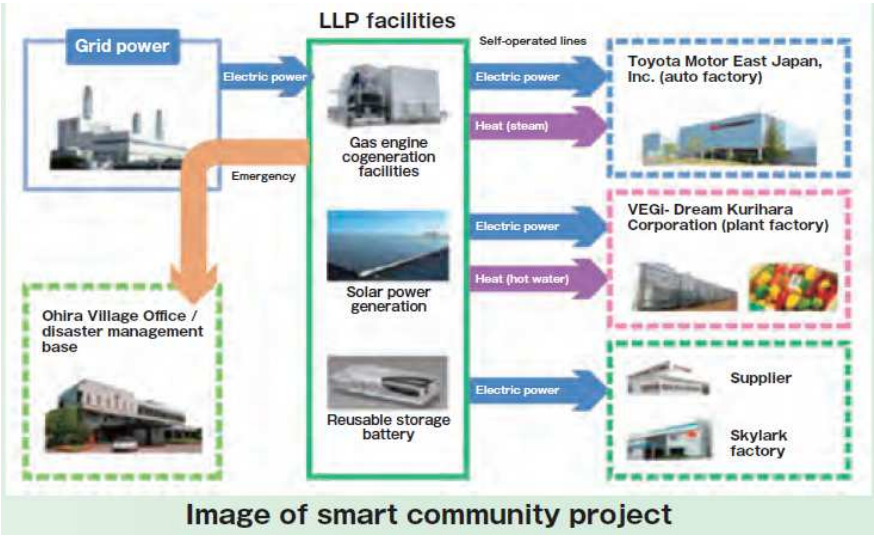


Image of smart community project

"Smart Community" being field-tested by Ohira Village, Toyota Motor, and Toyota Motor East (in collaboration)

Ending

“Rebuilding of TOHOKU advances with Electricity”

Thank you