

Plans for Fuel Supplies during Disasters in Expectation of Nankai Megathrust Earthquakes

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**Asia-Pacific
Economic Cooperation**

**Plans for Fuel Supplies during
Disasters in Expectation of Nankai
Megathrust Earthquakes**

**APEC Oil and Gas Security Studies
Series 7**

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Foreword

During the 11th APEC Energy Ministers' Meeting (EMM11) held in Beijing, China on 2 September 2014, the Ministers issued instructions to the Energy Working Group (EWG). This includes an instruction to Asia Pacific Energy Research Centre (APERC) to continue its cooperation on emergency response so as to improve the capacity building in oil and gas emergency response in APEC region.

Following this instruction, APERC has started implementing the Oil and Gas Security Initiative (OGSI) in November 2014. One of the three overarching pillars of the OGSI is the publication of the Oil and Gas Security Studies (OGSS).

The OGSS serves as a useful publication to APEC economies by having access to developments and issues on oil and gas security, and information on individual economy's policies related to oil and gas security including responses to emergency situation. The research studies included in OGSS will help encourage the APEC economies to review and revisit their respective policies, plans, programmes and measures on oil and gas security, and may probably help them adopt appropriate approaches to handling possible supply shortage or supply emergencies in the future.

I would like to thank the contributors to the OGSS for the time they have spent doing research works. May I however highlight that the independent research project contents herein reflect only the respective authors' view and not necessarily APERC's and might change in the future depending on unexpected external events or changes in the oil and gas and policy agendas of particular economies or countries.

I do hope that the OGSS will serve its purpose especially to the policy makers in APEC in addressing the oil and gas security issues in the region.

Takato OJIMI

President

Asia Pacific Energy Research Centre



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Executive Summary

The Nankai Trough is the 4,000-meter-depth groove (trough) at the bottom of the ocean extending from Suruga Bay in Shizuoka to the eastern ocean off the coast of Kyushu. It is located at the border where the Philippine Sea Plate sinks beneath the Eurasian Plate. The total length is about 770 kilometers. The term “trough” refers to a geographical feature of the ocean floor with a depression that looks like the bottom of a ship. It is distinguished from trenches that are ocean grooves reaching deeper than 6,000 meters.

The Nankai Trough is a massive and active fault. Magnitude (M) 8-class earthquakes have repeatedly occurred around it at intervals of 100 to 200 years.

According to the Cabinet Office, the following damage is expected to be caused by maximum levels of earthquakes and tsunamis: up to 323,000 deaths, 1,015 km² of flooding, 9.5 million evacuees, 2.38 million houses completely destroyed, up to about 32.10 million people without tap water immediately after an earthquake, 27.10 million buildings without power, and 1.80 million buildings without a gas supply.

Economic damage is expected to amount to 220.3 trillion yen, which is 42% of the gross domestic product (GDP) of Japan, or more than ten times the damage caused by the Great East Japan Earthquake.

In terms of damage to oil refineries in the Great East Japan Earthquake, about 70% of them were operating immediately after the earthquake around Japan. The operation rate recovered to about the 90% level in ten days. Oil refineries in the Sendai area where tsunami flooding occurred resumed operations in about one year.

Meanwhile, extensive tsunami damage is also expected in Nankai megathrust earthquakes, and about 36% of all oil refineries in Japan (or 60% in areas west of Chukyo area) will be exposed to tsunamis, which may reach five meters or higher. Operation shutdowns in these oil refineries may extend for a long time.

Learning from the experiences of the Great East Japan Earthquake, the government planned and implemented the following measures.

[1] Revision of the Oil Stockpiling Act in August 2012 so that oil could be released in case of disasters:

->The conventional measure that was applicable only when sharing was disrupted became applicable to disaster situations.

[2] Mandating the submission of the notification of preparation for cross-group cooperation among oil companies:

->This measure was stipulated in the emergency oil supply plan in the Oil Stockpiling

Act so that the oil industry would build a cross-group supply system based on the BCPs* of individual groups.

[3] Budget allocation to reinforce the emergency response capacities of core SS's (service stations) in rural areas:

->Twenty to forty core SS's equipped with power generators and large tanks which serve as regional oil product bases in case of disasters are going to be established in each prefecture, and about 1,700 SS's have already been designated around Japan.

*Business Continuity Plan

[4] Establishment of plans for fuel supply:

->Minister of Economy, Trade and Industry orders the implementation of emergency oil supply cooperation plans after establishing an emergency headquarters to respond to disasters. Based on this order, the oil industry starts supplying fuels beyond the boundary of groups.

The private sector plans and implements the following measures in addition to the government measures above.

[1] Reinforcement of emergency response capacities of oil refineries and oil terminals:

->Implementation of measures to continue oil supply while oil refining functions are stopped because of the effect of massive earthquakes by shipping gasoline, light oil, and kerosene stocked in oil refineries and receiving the support of oil refineries

->The following investments are promoted to minimize damage to oil product receiving and shipping facilities at oil refineries and quickly recover from damage.

- Reinforcement of shipping facilities, emergency power supplies, emergency shutdown valves of pipes, automatic tanker release systems

- Promotion of the installation of three-piece emergency set at oil refineries (emergency power generators, emergency information communication systems, and facilities to fill oils in drums and ship them)

[2] Establishment group BCPs covering the entire group supply chains from oil refineries to SS's

->Each oil refiner-distributor establishes a group BCP and submits it to Ministry of Economy, Trade and Industry.

[3] Sharing of the information of important facilities between local governments and Petroleum Association of Japan

->Acquisition of the information of facilities, which require prioritized oil, supplies, such as hospitals and communication facilities before emergencies

Introduction

In the Great East Japan Earthquake that occurred on March 11, 2011, the supply of oil products temporarily became disorderly due to the damage to oil product bases, including oil refineries, and the bottleneck effects on the distribution chains caused by severe damage to road conditions and the loss of tank trucks in tsunamis. Yet, quick action by the government and the private sector eliminated the major problems with the oil supplies in early April, about one month after the onset of the earthquake.

Meanwhile, the economic damage caused by Nankai megathrust earthquakes in the near future is expected to amount to about ten times the damage caused by the Great East Japan Earthquake (about 20 trillion yen).

The government and the private sector are trying to control the damage and prepare for Nankai megathrust earthquakes by learning from the experience of the Great East Japan Earthquake (including the revision of the Oil Stockpiling Act, mandating the submission of the notification of preparations for the cross-boundary cooperation among oil companies to the government, and reinforcement of emergency response capacities at oil refineries and oil terminals). The author finds it is meaningful to check and examine the specific measures taken in these actions. The main contents of this paper are based on damage forecasts. The paper also summarizes measures announced by the Cabinet Office and the Ministry of Economy, Trade and Industry.

The author also visited multiple oil bases damaged in the Great East Japan Earthquake and ones located within expected high-risk zones of Nankai megathrust earthquakes and explored lessons learned from the past and damage control measures implemented for the future. The author hopes that the information in this paper will be useful.

1. Overview of expected damage from Nankai megathrust earthquakes

1-1 The definition of Nankai megathrust earthquakes

Nankai megathrust earthquakes are magnitude (M) 9-class massive earthquakes, which are expected to occur in series in a wide hypocentral region along the Nankai Trough in the Pacific off the coast of the Japanese Archipelago.

The Nankai Trough is the 4,000-meter-depth groove (trough) at the bottom of the ocean extending from Suruga Bay in Shizuoka to the eastern ocean off the coast of Kyushu. It is located at the border where the Philippine Sea Plate sinks beneath the Eurasian Plate. The total length is about 770 kilometers. The term “trough” refers to a geographical feature of the ocean floor with a depression that looks like the bottom of a ship. It is distinguished from trenches that are grooves reaching deeper than 6,000 meters.

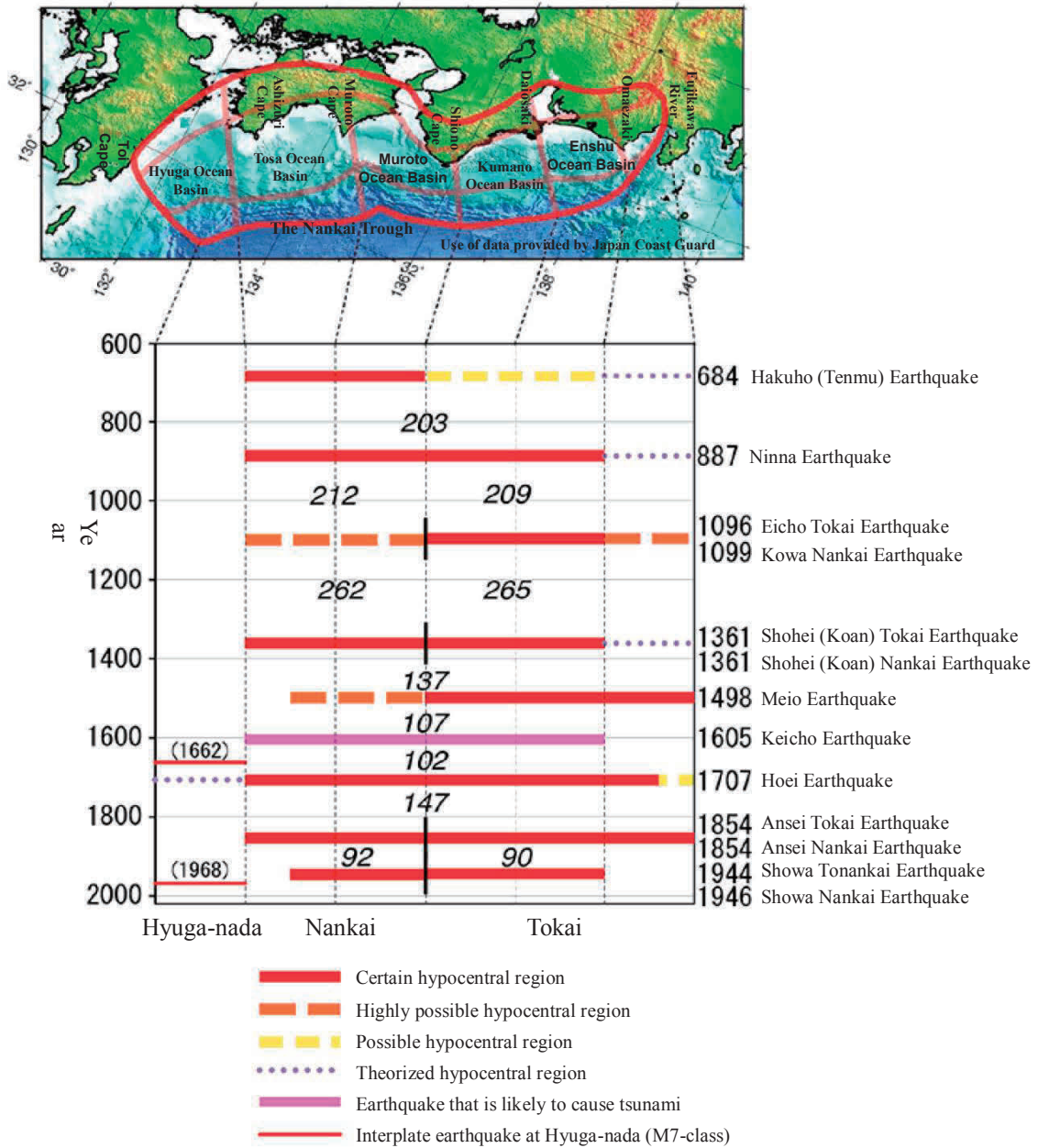
The Nankai Trough is a massive and active fault. Magnitude 8-class earthquakes have repeatedly occurred around it at intervals of 100 to 200 years. Various measures to prepare for Nankai earthquakes, Tonankai earthquakes, and Tokai earthquakes have been implemented so far in regions where massive earthquakes related to plate tectonics occur. Yet, after the Great East Japan Earthquake, the national government added the Hyuga-nada region to the hypocentral region and started revising the expected damage caused by massive earthquakes, which occur in combination with multiple large earthquakes.

A council, the Nankai Megathrust Earthquakes Response Working Group (chief examiner: Dr. Yoshiaki Kawata, professor of Kansai University) was installed under the Committee for Policy Planning on Disaster Management of the Central Disaster Management Council, Cabinet Office, in April 2012. The Working Group released the primary report of expected damage from the Nankai megathrust earthquakes in August 2012. The report included estimated damage to buildings and people caused by maximum possible earthquakes. They released the secondary report containing estimated damage to facilities and economic damage in March 2013.

1-2 Past earthquakes

A variety of massive earthquakes have occurred along the Nankai Trough in the past in terms of the spread of hypocentral regions. Earthquakes in the Nankai region and ones in the Tokai region occur at the same time in some cases or with some time gap (within a few to several years) in other cases. Earthquakes in the Tokai region also have different hypocentral regions, such as the Showa Tonankai Earthquake (1944) in which the fault slip stopped west of Omaezaki and the Ansei Tokai Earthquake (1854) in which the fault slip extended to the deep part of Suruga Bay. Meanwhile, studies of tsunami deposits indicated the possibility that the hypocentral region of the Hiei Earthquake (1707) had extended to the west of the hypocentral regions of the Showa Nankai Earthquake (1946) and the Ansei Nankai Earthquake (1854). The Keicho Earthquake (1605) was a peculiar earthquake, which recorded small vibrations but large tsunamis. It was likely a tsunami-causing earthquake like the Meiji Sanriku Earthquake (1896). Studies have found branch faults at the Nankai Trough, indicating the onset of past earthquakes caused by slipping of the faults in addition to earthquakes at the plate boundaries. (See Figure 1.)

Figure 1. Times and areas of the onset of Nankai megathrust earthquakes recorded in historical documents

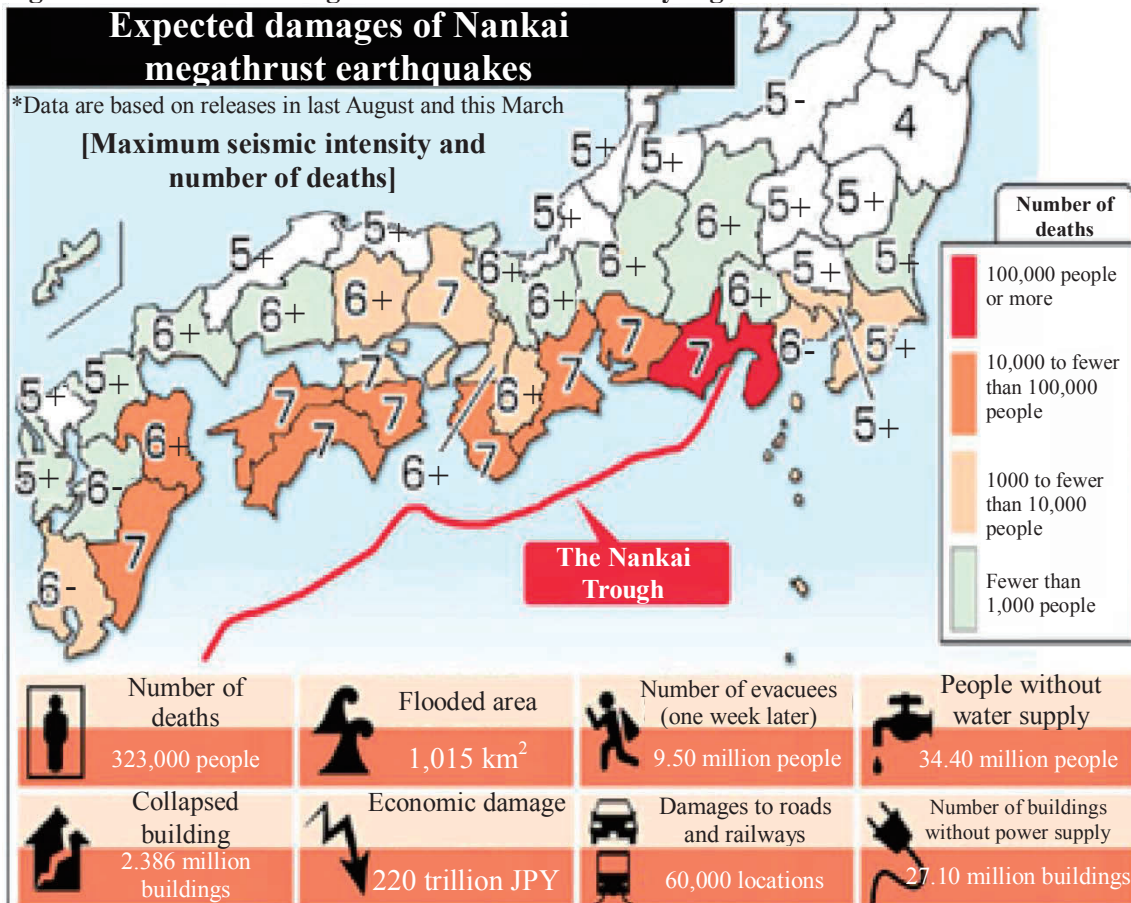


Source: Cabinet Office

1-3 Overview of expected damage

The Central Disaster Management Council of the Cabinet Office estimates the damage caused by the maximum possible earthquake and tsunami to be up to 323,000 deaths and 220.3 trillion yen in economic damage. This accounts for 42% of the gross domestic product (GDP) of Japan and more than ten times greater than the damage caused by the Great East Japan Earthquake. Yet, according to their reports, they released the estimates to recognize and share approximate conditions and scales of damage to look for effective preparations. They emphasize that the damage can surely be reduced regardless of the scale of the earthquakes if proper disaster management and damage reduction measures, such as earthquake resistance reinforcement, are implemented. The secondary report provides estimated damage, including the number of deaths. With these estimates, the national government is establishing an outline of the basic policies for disaster management. (See Figures 2, 3, and 4)

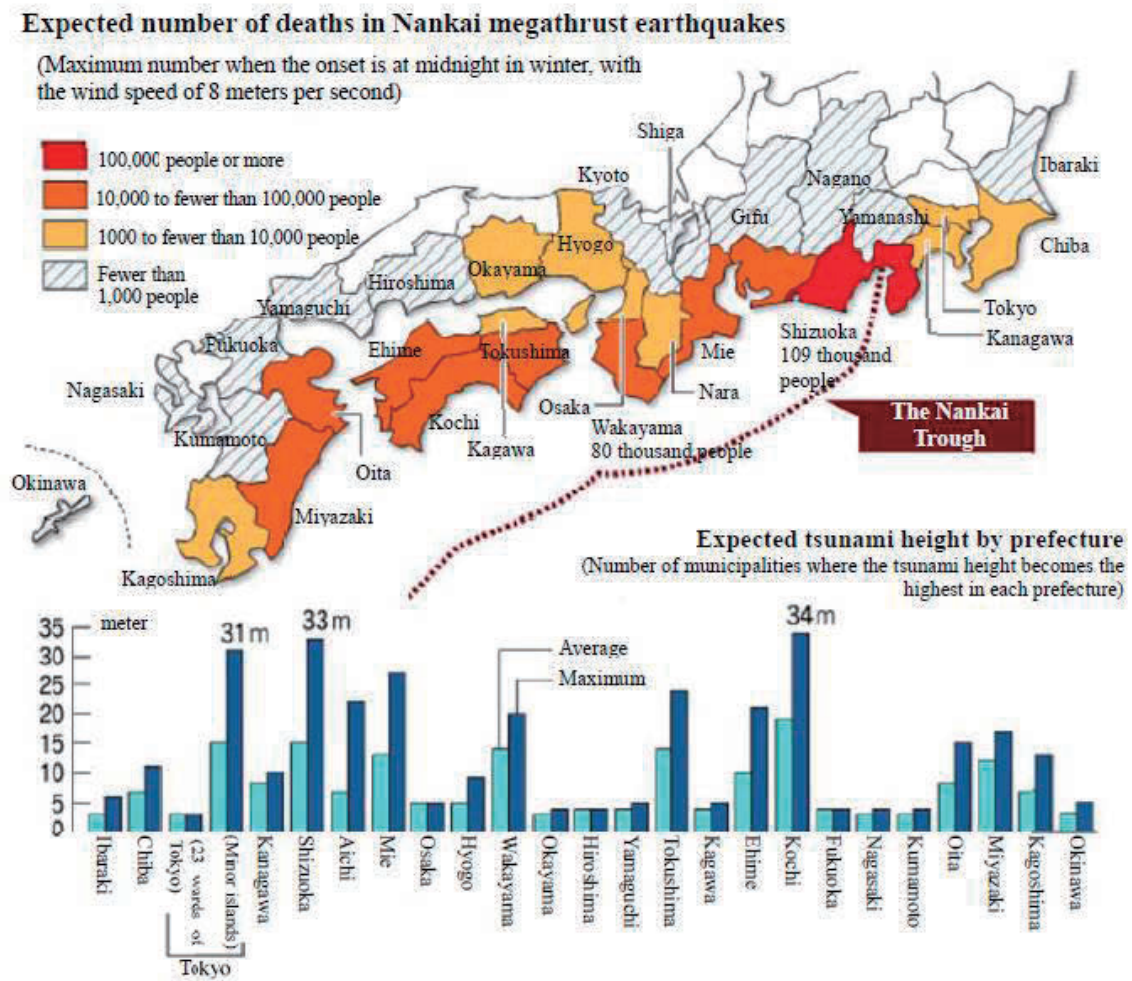
Figure 2. Estimated damage and seismic intensities by regions



Source: Cabinet Office

- Strong earthquakes recording 7 on the Japanese seismic intensity scale are expected at the Pacific side of the Tokai, Kinki, Shikoku, and Kyushu regions.
- The estimated damage is about 320,000 deaths and 9.50 million evacuees mostly on the Pacific side because of tsunami damage.

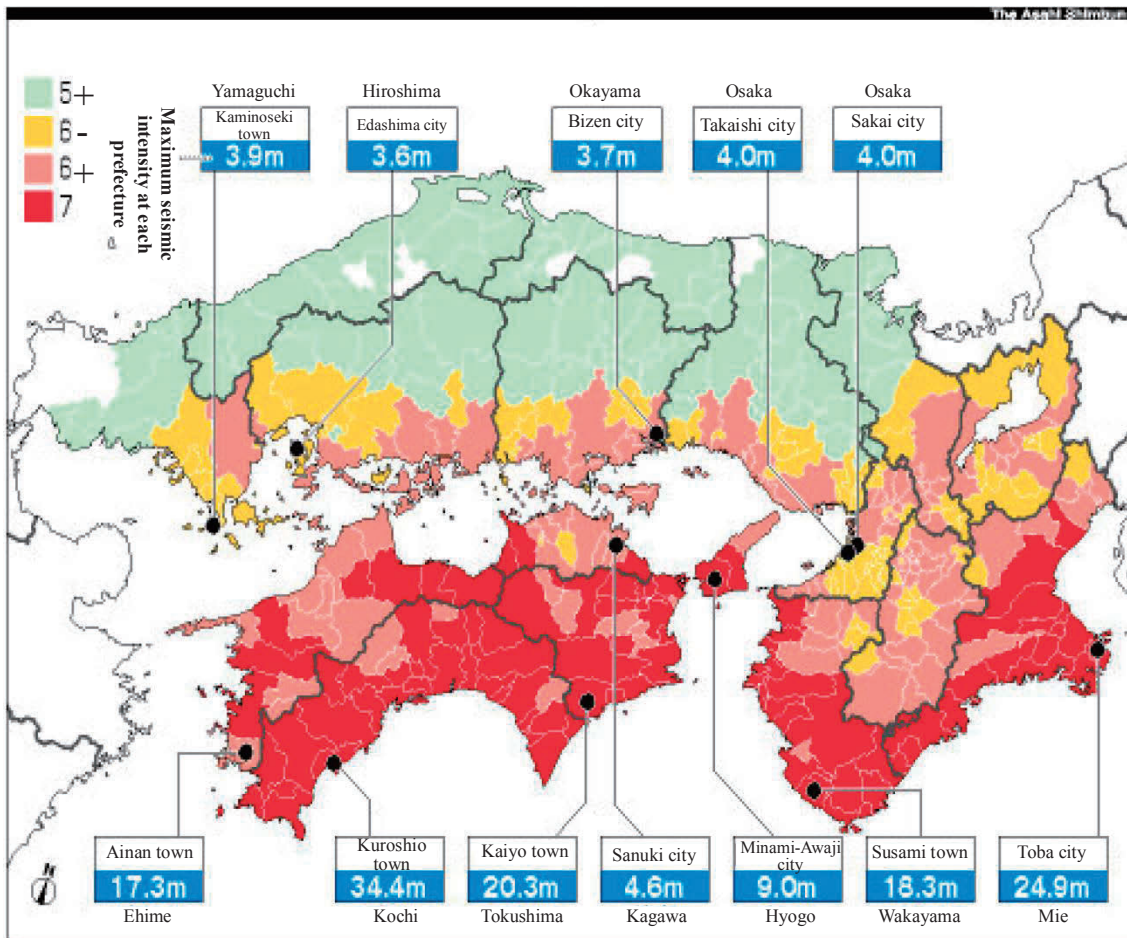
Figure 3. Expected tsunami heights and number of deaths by prefectures



Source: Cabinet Office

- Most of the Pacific-facing prefectures are expected to have more than 10,000 deaths, especially more than 100,000 deaths in Shizuoka.
- The highest tsunami expected is 34 meters in Kochi, followed by 33 meters in Shizuoka.

Figure 4. Maximum seismic intensities and expected tsunami heights by municipalities in Kinki, Chugoku, and Shikoku



Source: Cabinet Office

- The expected tsunami height is 34.4 meters at Kuroshio town in Kochi.
- Expected tsunami height in the Seto Inland Sea including the Osaka Bay is around four meters.

1-4 Damage to infrastructures

(1) Lifeline infrastructures

- Tap water supply
 - Up to about 34.40 million people lose access to tap water supply immediately after earthquakes. Water supply is expected to stop at about 60% to 80% of the three Tokai prefectures, 40% to 60% of the three Kinki prefectures, 20% to 50% of the three Sanyo prefectures, 70% to 90% of Shikoku, and 90% of the two Kyushu prefectures.

- Sewer
 - Up to about 32.10 million people face difficulty using sewer systems immediately after earthquakes. About 90% of sewer services are expected to face difficulty continuing in the three Tokai prefectures, 90% in the three Kinki prefectures, 30% to 70% in the three Sanyo prefectures, 90% in Shikoku, and 90% in the two Kyushu prefectures.

- Electricity
 - Power supply stops at up to about 27.10 million buildings immediately after earthquakes. About 90% of buildings are expected to be without power in the three Tokai prefectures, 90% in the three Kinki prefectures, 30% to 70% in the three Sanyo prefectures, 90% in Shikoku, and 90% in the two Kyushu prefectures.

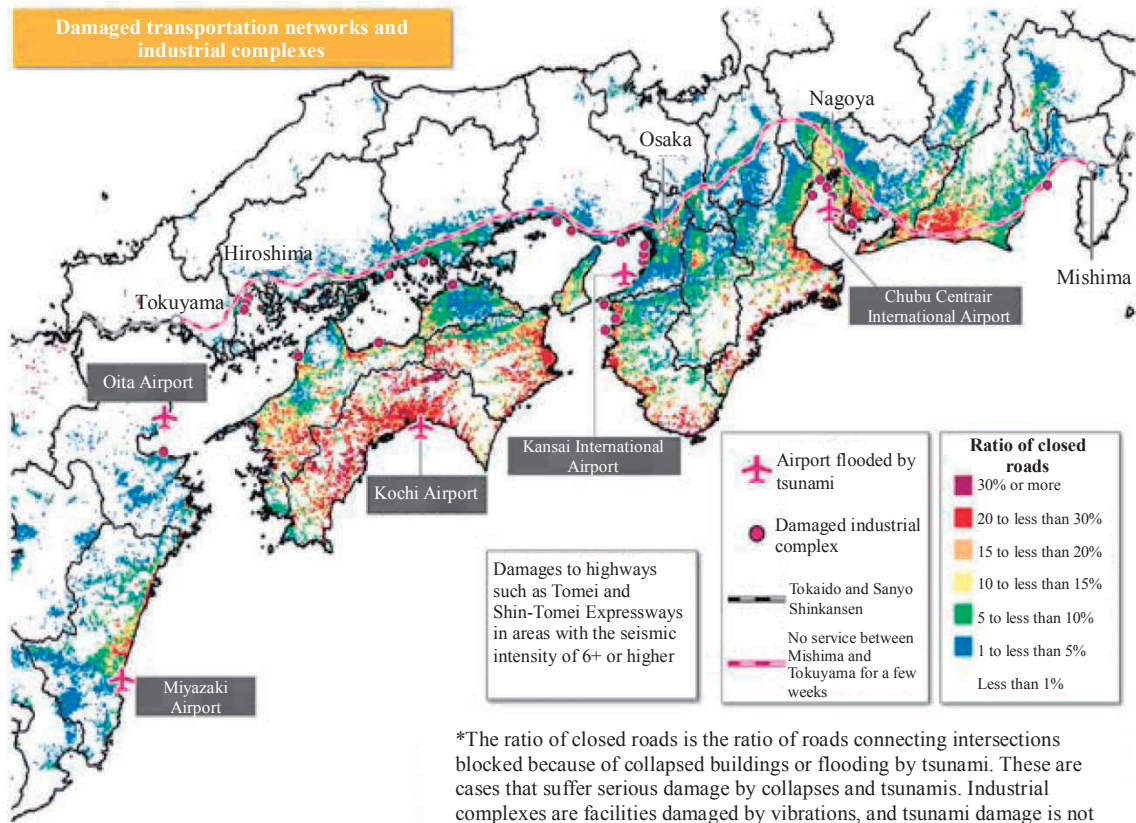
- Communication
 - Up to about 9.30 million landline telephones go out of service immediately after earthquakes. About 90% of landline telephones are expected face communication difficulties in the three Tokai prefectures, 90% in the three Kinki prefectures, 30% to 60% in the three Sanyo prefectures, 90% in Shikoku, and 90% in the two Kyushu prefectures.
 - In terms of mobile phones, the ratio of base stations with interrupted transmission reaches the maximum one day after the onset of an earthquake when the power supply from emergency power supply systems installed at individual bases stop. Most mobile phone communications become difficult to connect immediately after an earthquake because of congestion.
 - In terms of Internet connections, areas without Internet connections occur because of damage to telephone landlines and interrupted transmissions at base stations.

- City gas
 - Gas supply stops to up to 1.80 million buildings immediately after earthquakes. About 20 to 60% of gas supply is expected to stop at three Tokai prefectures, up to about 10% in the three Kinki prefectures, up to about 10% in the three Sanyo prefectures, 20 to 90% in Shikoku, and 30 to 40% in the two Kyushu prefectures.

(2) Damage to traffic facilities

- Roads
 - Damage to roads (e.g. damage to road surfaces, ground subsidence, collapses of slopes, and damage to bridges) are expected to occur at about 30,000 to 41,000 locations.
- Railroads
 - Damage to railroad facilities (e.g. deformation of rails, collapse of roadbeds) are expected to occur at about 13,000 to 19,000 locations.
- Ports and harbors
 - Among mooring facilities at about 17,000 locations of target ports and harbors, damage is expected about 3,000 to 5,000 locations.
 - Damage is expected at about 126 to 135 kilometers of target seawalls among about 417 kilometers in total length.
- Airports
 - Tsunami flooding is expected to occur at Chubu Centrair International Airport, Kansai International Airport, Kochi Airport, Oita Airport, and Miyazaki Airport. Among them, more than half of Kochi Airport and Miyazaki Airport are expected to be flooded. (See Figure 5.)
 - Like the airports, industrial complexes, railroads, roads, and other infrastructures are expected to be flooded and damaged.

Figure 5. Damage to transportation networks

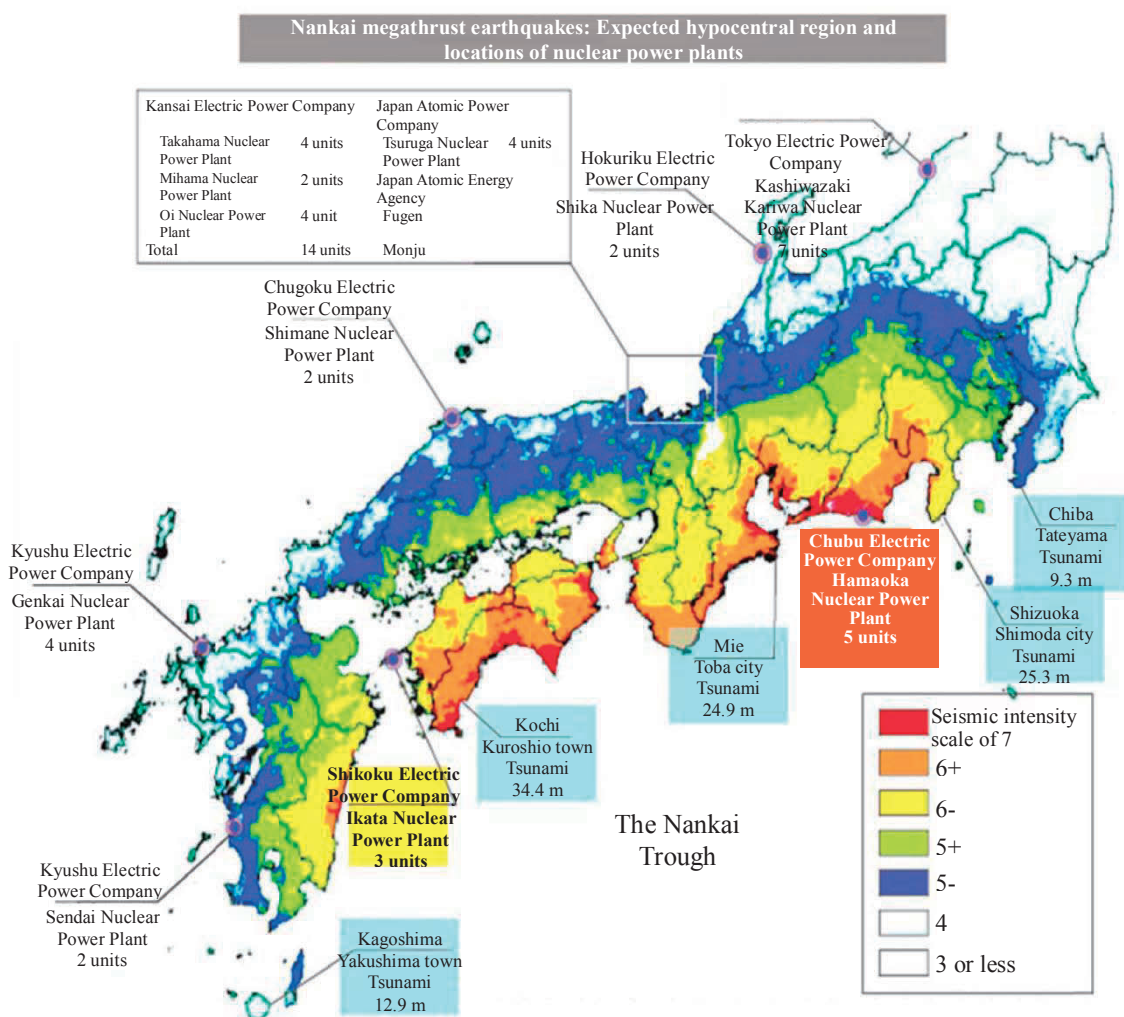


*The ratio of closed roads is the ratio of roads connecting intersections blocked because of collapsed buildings or flooding by tsunamis. These are cases that suffer serious damage by collapses and tsunamis. Industrial complexes are facilities damaged by vibrations, and tsunami damage is not considered here.

Source: Cabinet Office

- Nuclear power plants
 - Figure 6 shows locations of expected earthquake zones and nuclear power plants.
 - Hamaoka Nuclear Power Station of Chubu Electric Power Company is located in the area where earthquakes with the seismic intensity scale of 7 or greater are expected (not in commercial operation today).
 - Sendai Nuclear Power Station of Kyushu Electric Power Company is the only commercially operating nuclear power plant at this point.

Figure 6. Locations of expected earthquake zones and nuclear power plants



Prepared based on the forecast of Tokai-Tonankai earthquake by Central Disaster Management Council of Cabinet Office (2012)

Source: Cabinet Office

2. Effects on oil refineries

2-1 Expected damage to oil refineries

- [1] As shown in Table 1, 89.4% of the nationwide capacity of oil refineries is expected to be affected by earthquake vibrations or tsunamis.
- [2] The ratio of oil refineries which are expected to be affected by tsunami flooding (tsunami height of four meters or higher) for a long-term (six months to one year) accounts for 51.7% of the nationwide unit capacity.
- [3] Especially serious damage is expected at Tonen Wakayama and JX Oita, where expected tsunami heights are ten and nine meters, respectively.

(Reference) - At JX Sendai Oil Refinery that was damaged by the tsunami in the Great East Japan Earthquake, the tsunami height was six to seven meters, and the premise of the facility was submerged under 2.5 to 3.5 meters of the water.

- It took about one year for the facility to resume the operation.
- The shipment of oil drums resumed in seven days, and shipment using temporary tank truck facilities started about two months later.

2-2 Effects of damage to oil refineries

[1] At the time of the Great East Japan Earthquake

- Six out of nine oil refineries in Kanto and Tohoku stopped operations immediately after the earthquake, and the amount of crude oil processed in Japan became about 70% of before the earthquake. Three of the oil refineries then gradually resumed operations by March 21, and the processing rate recovered to about 90% of before the earthquake.
- JX Kashima, where a petrochemical tanker had damaged a berth and shipment and operations had stopped, resumed their operations in June in the same year.
- At Cosmo Chiba, LPG tanks filled with water collapsed and caused fire which damaged facilities and stopped operations. The plant resumed operations in January 2012.
- JX Sendai fully stopped the operations because equipment and facilities had been covered with seawater in the tsunami. The plant resumed operations in March 2012.
- The confused demand and supply situation disappeared in one month thanks to added operations at oil refineries and related facilities in West Japan, import of products, and bringing tank trucks and other vehicles in shortage from West Japan and other regions.

[2] Expectations for Nankai megathrust earthquakes

- 2-1 Long-term (six months to one year) operation shutdown might occur at 51.7% of oil refineries which are affected by expected tsunamis.
- Responses to the above situation include increasing the operation rate of oil refineries in East Japan and importing products.

Yet, oil refineries have been reducing their refining capacities because of the so-called Advanced Energy Structure Law, and their operations are already more than 90%. Thus, the current oil refineries cannot increase their operations to compensate for insufficiencies. This implies that chaotic demand and supply balance may extend for a long term.

Table 1. Expected seismic intensities and tsunami heights at oil refineries

Region	Company	REF	TP capacity thousand B/D	Seismic intensity*	Tsunami*
				5-	m
Kanto	JX	Negishi	270	5+	3
	JX	Kashima	189	5-	6
	Idemitsu	Anegasaki, Chiba	220	5-	3
	Cosmo	Goi, Chiba	240	5-	3
	Toa	Keihin	70	5-	3
	Tonen	Chiba KPI	152	5-	3
	Tonen	Kawasaki	258	5+	3
	Fuji	Sodegaura, Chiba	143	5-	2
			Subtotal	1,542	
		TP ratio in the country	39.1%		
Chubu	Idemitsu	Aichi	175	7	5
	Cosmo	Yokkaichi	132	6+	5
	Shell	Yokkaichi	255	6+	5
			Subtotal	562	
		TP ratio in the country	14.2%		
Kinki	Cosmo	Sakai	100	6-	5
	JX	Sakai	115	6-	5
	Tonen	Sakai	156	6-	5
	Tonen	Wakayama	132	7	10
			Subtotal	503	
		TP ratio in the country	12.7%		
Chugoku & Shikoku	JX	Marifu	127	6-	3
	JX	Mizushima	345	6+	4
	Shell	Seibu	120	6+	4
	Taiyo	Kikuma	118	6+	4
			Subtotal	710	
		TP ratio in the country	18.0%		
Kyushu	JX	Oita	136	6+	9
			TP ratio in the country	3.4%	
Okinawa	Nansei	Nishihara	100	-	3
			2.5%		
Total			3,553		
TP ratio in the country			90.0%		
Tsunami height 4 m or more			1,973		
TP ratio in the country			50.0%		
Tsunami height 5 m or more			1,390		
TP ratio in the country			35.2%		

*Expected tsunami height in the bay

(Source) Prepared by Oil Information Center based on documents of the Cabinet Office (Orange->

Tsunami height of 5 m or more, Red-> Tsunami height of 9 m or more)

2-3 Example of JX Sendai Oil Refinery at the time of the Great East Japan Earthquake

(1) Onset of the earthquakes and the arrival of the tsunamis

- [1] Onset of earthquakes at around 14:46, March 11, 2011
 - Power outage at the entire plant and shutdown of all facilities
- [2] Reception of the updated massive tsunami warning at around 15:15 on the same day
 - Tsunami height of ten meters or higher at Sendai Harbor, the expected arrival time around 15:40
- [3] Arrival of the tsunami at around 15:50 on the same day
 - Tsunami height was six to seven meters, and the depth of flooding at the premise of the plant was 2.5 to 3.5 meters above the ground.
- [4] Onset of fire at the western zone of the plant at around 21:25 on the same day
 - The fire was extinguished at around 14:30 on March 15.

(2) Flow of restoration

Year	Month	Condition
2011	3	3/11 Onset of the Great East Japan Earthquake
		3/18- Start of emergency shipping using oil drums
	4	Resumption of receiving industrial water
	5	Start of tank truck shipping with temporary facility Start of receiving fuels on the sea Start of receiving low-voltage power
	10	Start of receiving high-voltage power
	11	Partial resumption of tank truck shipping with permanent facility
2012	1	Start of trial runs of refining facilities
	2	Start of receiving crude oil Resumption of shipping on the sea
	3	Declaration to resume production (March 9)
	9	Resumption of shipping with tank cars
	10	Full recovery of tank truck shipping

(3) Measures to reduce damage

- [1] Relocation of tank truck shipping facilities to higher elevations at the eastern zone of the plant
- [2] Raising floors of electric facilities and control systems
- [3] Construction of seawalls (by the prefecture)
- [4] Installation of emergency oil drum shipping facilities and power generators as permanent equipment
- [5] Installation of solar power, fuel cell, batteries, and communication systems at the main building

3. Plans for fuel supplies

3-1 Review of the Great East Japan Earthquake

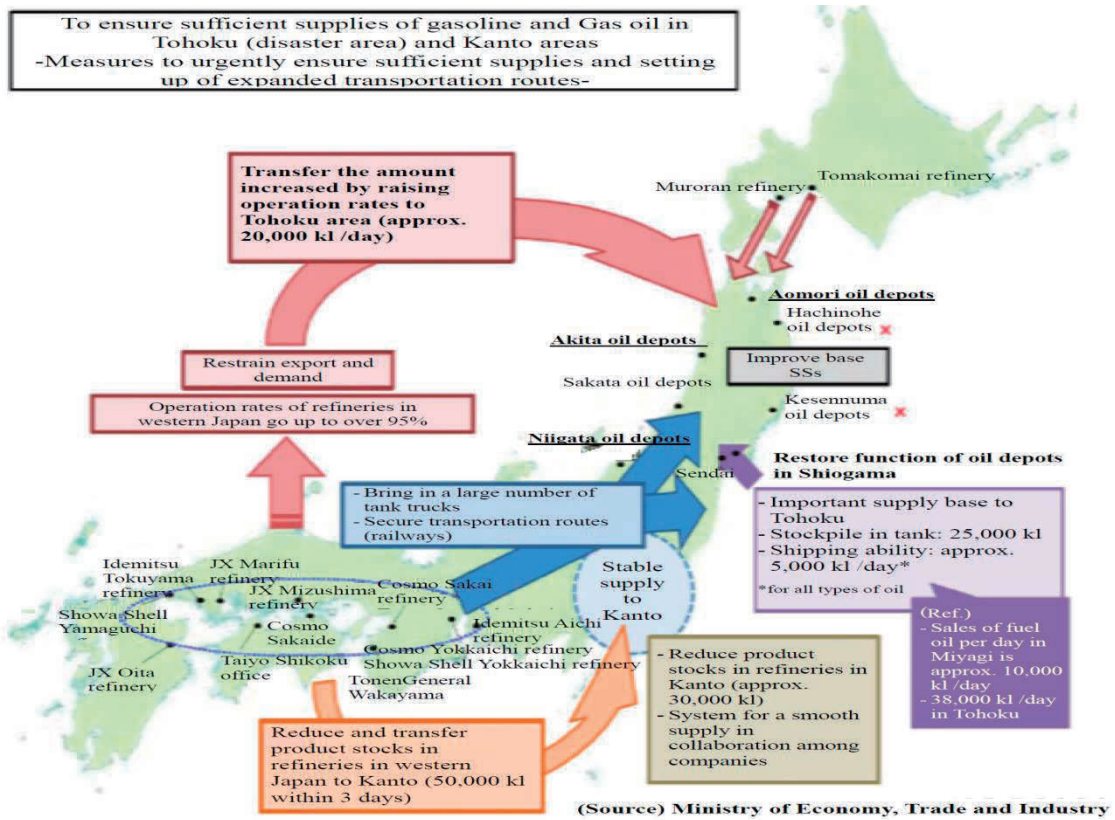
(1) Reactions of the national government

- [1] The national government requested the installation of emergency headquarters within the Petroleum Association of Japan. The government also requested oil suppliers via the Petroleum Association of Japan to supply fuels as requested by the Official Residence of Prime Minister.
- [2] The national government determined to lower the mandatory private-sector storage to alleviate the chaotic supply and demand balance of oil.

(2) Reactions of the private sector

- [1] Immediately after the earthquake, six oil refineries stopped their operations, and the amount of crude oil processing decreased to about 70% of before the earthquake. Three oil refineries then gradually resumed their operations by March 21, and the operation rate returned to about 90% of before the earthquake.
- [2] The private sector responded to requests for fuel supply released from the Official Residence of Prime Minister (about 1,400 requests) (to Fukushima Airport, nuclear power station cooling system and emergency vehicles, hospitals, and local governments, etc.) and emergency oil procurement of Ministry of Defense (to engage in rescue activities).
- [3] They installed temporary oil stations at ten locations in areas without fuel supply stations (local governments without fuel supply stations within ten kilometers).
- [4] They increased the operation of oil refineries, cancelled exports of products, and started emergency imports.
- [5] They transferred oil and tank trucks from the West Japan area to the East Japan area

Figure 7. Damage to oil-related facilities in the earthquake and responses



3-2. Overview of plans for specific emergency responses in the Nankai megathrust earthquakes

(1) Rescue, first aid, and firefighting, etc.

[1] Up to about 140,000 officers will be dispatched from Japan Self-Defense Forces, police departments, fire departments, and other relevant organizations.

[2] 620 aircrafts and 470 vessels will be sent to the affected areas.

[3] Medical

- Request for the dispatch of DMAT* (1,323 teams registered)

[4] Supplies

Necessary supplies will be gathered in four to seven days after the onset of the earthquake and sent to bases in affected prefectures.

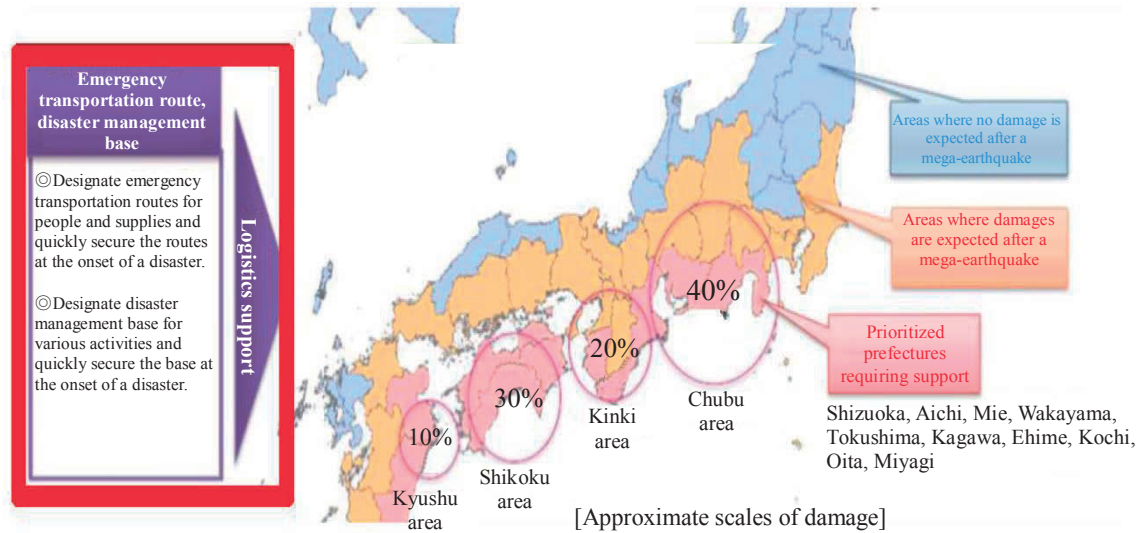
- Water: Emergency water supply 460,000 m³

- Food: 72 million meals

- Blanket: Six million blankets

*Disaster Medical Assistance Team

Figure 8. Overview of plans for emergency response activities

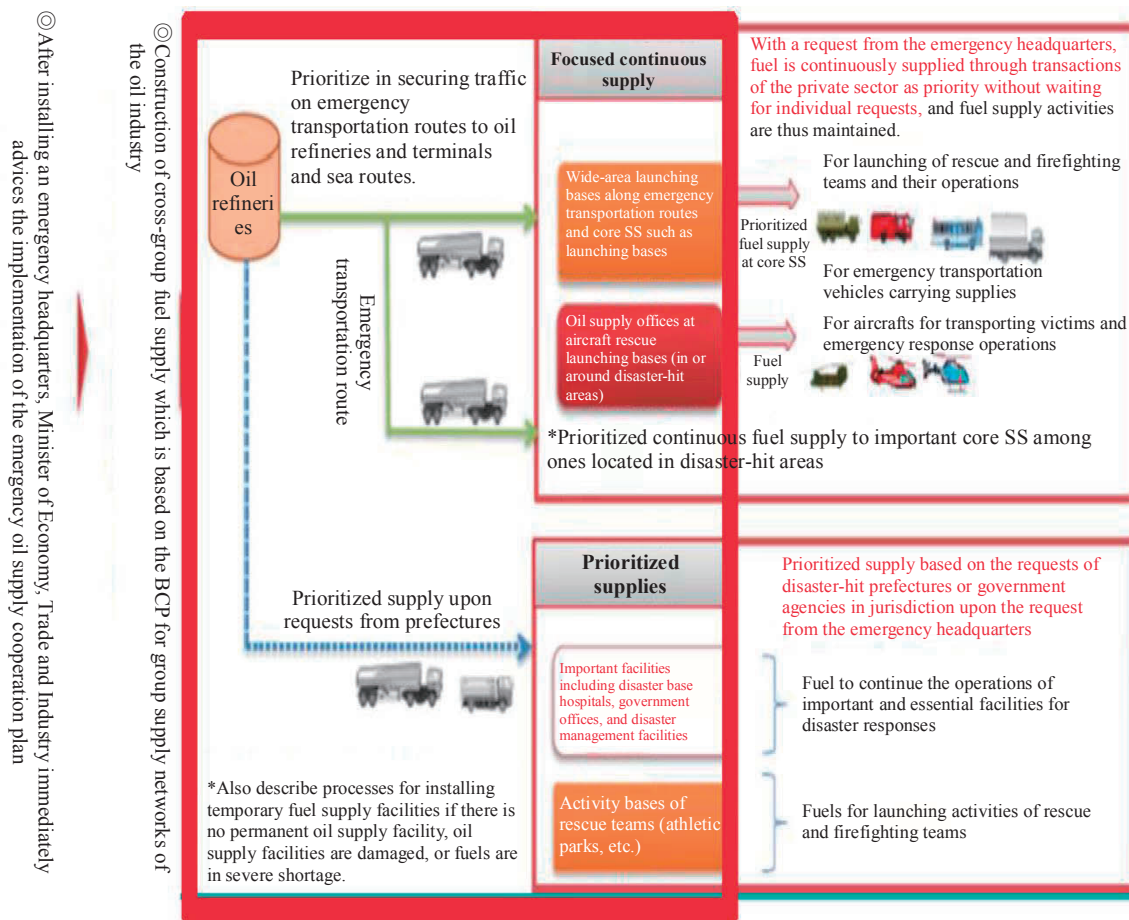


Source: METI

3-3 Overview of plans for fuel supplies in the Nankai megathrust earthquakes

- (1) Necessary fuels for disaster responses need to be secured and quickly and efficiently supplied even when Nankai megathrust earthquakes damage many oil refineries and oil terminals in the coastal areas facing the Pacific.
- (2) Thus, a cross-group fuel supply system is established based on BCPs (business continuation plans) of oil industry groups.
 - (->Stipulated in the Emergency Oil Supply Plan of the Oil Stockpiling Act)
- (3) Fuel transportation networks are quickly established by prioritizing in securing roads and sailing routes to oil refineries and oil terminals, which are planned as emergency transportation routes. Smooth and prioritized supply of fuel to important facilities and rescue bases will be secured thanks to continuous supply of fuel to focused areas, such as rescue launching bases and rescue bases for aircraft and arrangement by rescue headquarters.

Figure 9. Overview of plans for fuel supply



Source: METI

3-4 Establishment of fuel supply cooperation system of oil refiners and establishment and ranking of “group BCP” of each company

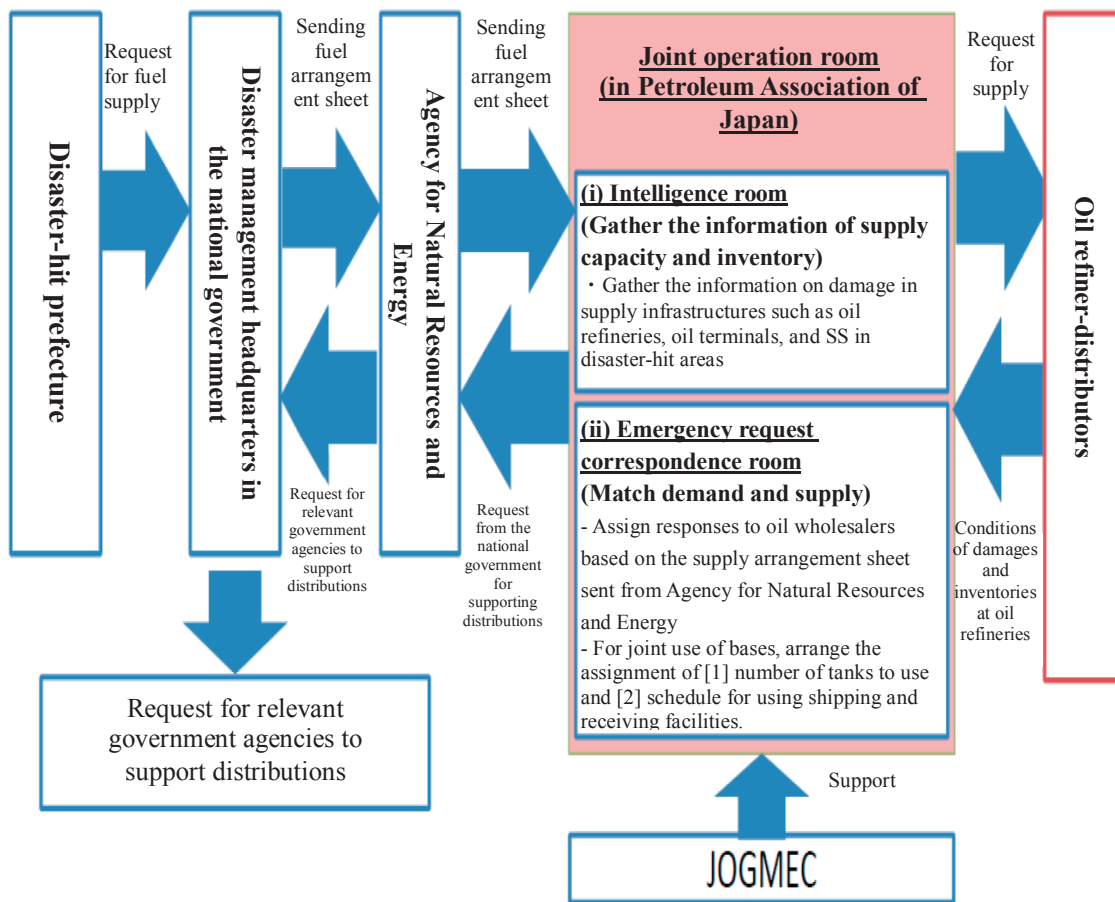
- (1) Learning from the experiences of the Great East Japan Earthquakes, the system for submitting “emergency oil supply plan” is already in place so that oil refiners can jointly supply oil in case of a mega disaster (revision of the Oil Stockpiling Act in 2012). Oil refiners gather in the Petroleum Association of Japan and work on joint operations based on methods pre-arranged with the Japan Fair Trade Commission. JOGMEC* also provides labor and technical support.
- (2) Also, Agency for Natural Resources and Energy requested oil companies to prepare BCPs of their entire group supply chains covering from oil refineries to SS’s (service stations) and started ranking the group BCPs. The ranking will be used as the ground for providing

subsidies in the future to continuously improve the risk management system of the entire industry.

*Japan Oil, Gas, and Metals National Corporation

Figure 10. Supply cooperation system of oil refiners

The work flow of "Emergency oil supply cooperation plan" based on the Oil Stockpiling Act



Source: METI

(3) Petroleum Association of Japan shares the information of important emergency facilities with local governments.

[1] The national government is also going to implement a new system to ensure smooth supply of gasoline and kerosene to hospitals, police departments, and shelters in cooperation with oil refiner-distributors in case of mega disasters, such as the Nankai megathrust earthquakes.

[2] The purpose is to establish a robust system to face emergencies by learning from the lessons in the Great East Japan Earthquake during which confused information prevented fuel supply to necessary locations.

[3] A new system is established so that prefectures enter information, such as necessary quantity, length of fuel supply hoses, and types of fuel supply outlets to the new system on the Internet when they receive requests for fuel supply from police departments and hospitals.

The system is designed so that the emergency headquarters of the national government can organize requests for fuel supplies from different regions and then sends requests to oil suppliers, which deliver fuels in tank trucks and oil drums to facilities that need them.

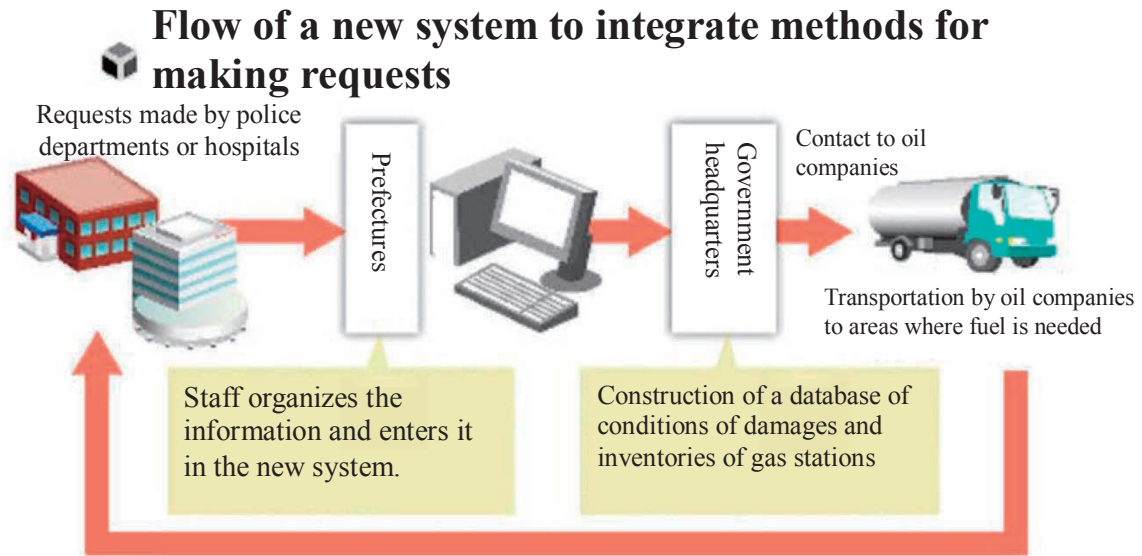
[4] Petroleum Association of Japan establishes operation rooms for oil suppliers to gather to respond to these requests.

Figure 11. Examples of sharing the information about important facilities among local governments and Petroleum Association of Japan

#	Municipality	Timing for signing protocol	#	Municipality	Timing for signing protocol	#	Municipality	Timing for signing protocol
*	Tokyo	Nov. 2008	10	Kagoshima	Mar. 2013	20	Akita	Mar. 2014
1	Saitama	Mar. 2012	11	Kyoto	Mar. 2013	21	Tottori	Mar. 2014
2	Yamagata	Oct. 2012	12	Osaka	Mar. 2013	22	Niigata	Apr. 2014
3	Gunma	Nov. 2012	13	Iwate	Jun. 2013	23	Toyama	Apr. 2014
4	Aomori	Jan. 2013	14	Hokkaido	Jul. 2013	24	Ibaraki	Apr. 2014
5	Saga	Feb. 2013	15	Tochigi	Aug. 2013	Government organization		
6	Wakayama	Feb. 2013	16	Tokushima	Oct. 2013	1	Shikoku Regional Development Bureau	Mar. 2013
7	Miyagi	Feb. 2013	17	Hiroshima	Nov. 2013	2	Kyushu Regional Development Bureau	Sep. 2013
8	Kanagawa	Mar. 2013	18	Chiba	Nov. 2014	3	Hokuriku Regional Development Bureau	Feb. 2014
9	Shizuoka	Mar. 2013	19	Okayama	Feb. 2014			

Source: METI

Figure 12. Flow of the new system



Source: METI

3-5 Preparation of supply support systems in cooperation with relevant government agencies and local governments

- (1) Support of relevant government agencies is essential for inter-regional transfers of backup fuels and user-end distributions performed by oil refiner-distributors during disasters (such as quick establishment of sailing routes and roads, emergency vehicle registration, issuing road traffic permits, and support for transportations).
- (2) Disaster response programs and joint training are being planned with government agencies related to disaster prevention at industrial complexes and oil supplies (Cabinet Office, Ministry of Defense, Ministry of Land, Infrastructure, Transport and Tourism, Fire and Disaster Management Agency, and National Police Agency).

*In relation to Ministry of Land, Infrastructure, Transport and Tourism

- Establishment of sailing routes and roads connecting oil refineries located outside of disaster-hit areas with oil refineries and oil terminals in disaster-hit areas
- Issuing permissions for tank trucks to drive through long tunnels
- Expansion of emergency transportation of tank cars on railways

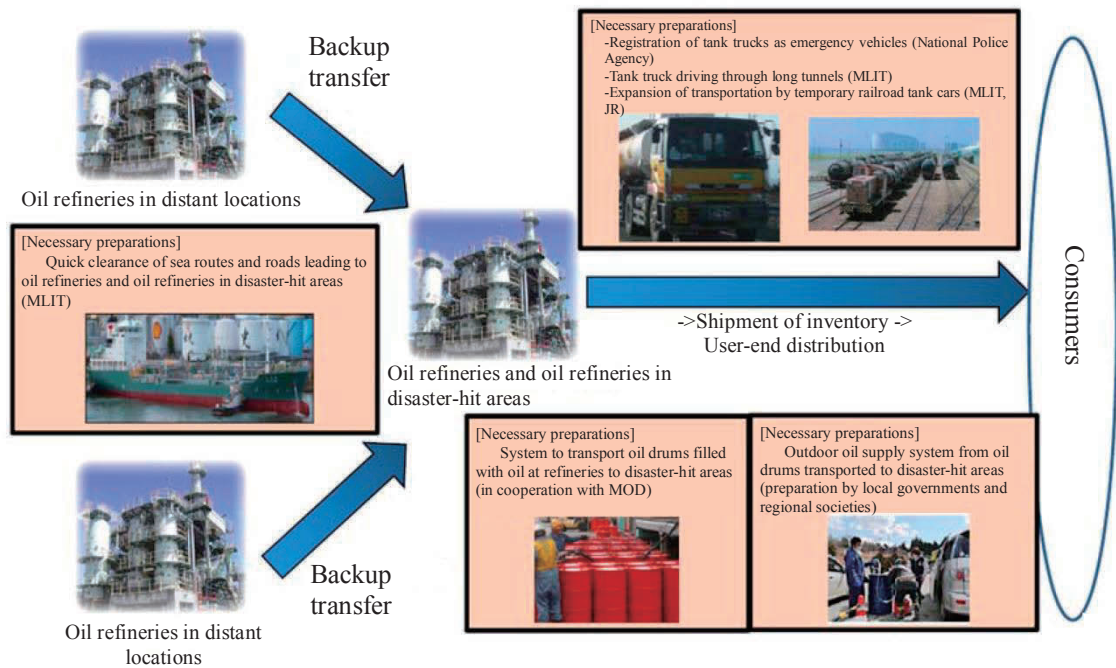
*National Police Agency

- Emergency vehicle registration of tank trucks

*Ministry of Defense

- Cooperative transportation of oil drums filled at oil refineries to disaster-hit areas

Figure 13. Cooperation with relevant government agencies



Source: METI

3-6 Maintenance and reinforcement of regional oil product supply chains (e.g. disaster response core service stations)

- (1) The Oil Stockpiling Act was revised based on experiences of the Great East Japan Earthquake. The government recognized the importance of reinforcing disaster response ability of regional oil product supply chains in order to control and reduce nationwide damage. With this recognition, 20 to 40 “disaster response core service stations” equipped with power generators and large tanks that will become regional oil product bases are going to be established in each prefecture, and 1,700 service stations have already been designated around the country. (Figures 14 and 15)
- (2) Prefectures of Gunma and Shimane established subsidy systems to assist 1/10 of business expenses separately from the national subsidy.
- (3) Prefectures around Japan started training and drills targeting core SSs starting in FY 2013. (Figure 15)

Figure 14. Status of the establishment of regional supply chains (1)

Project overview

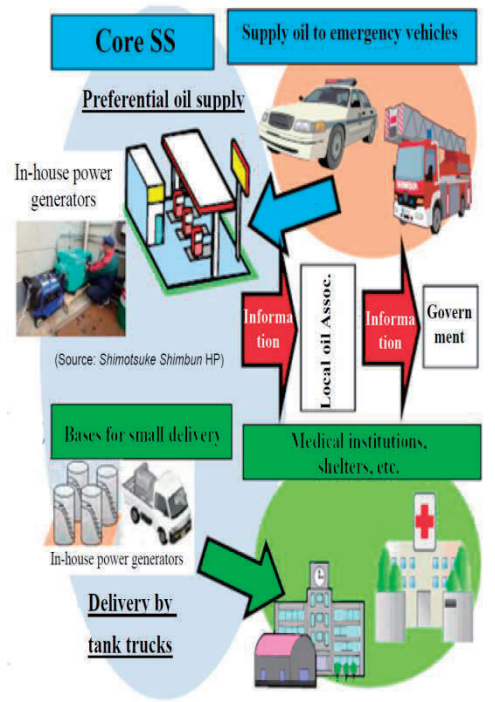
- ◆ **Development of core SS** (subsidy rate: 2/3)
 - Subsidy for installing power generators for private uses and information communication system and other equipment, reinforcement of underground tanks
- ◆ **Development of small-lot fuel distribution base** (subsidy rate: 2/3)
 - Subsidy for installing power generators for private uses and information communication system and other equipment, reinforcement of underground tanks, purchase of tank trucks for delivery
- ◆ **Development of bases to support quick reopening of nearby SS** (subsidy rate: fixed rate)
 - Permanent installation of multiple portable cans, power generators, portable pumps, etc.

Development status –Preparations are gradually being implemented starting with prefectures expected to suffer larger damages of earthquakes

◆ **FY 2011 revised budget: 4.00 billion yen** –Five prefectures (disaster-hit prefectures: Aomori, Iwate, Miyagi, Fukushima, and Ibaraki)

◆ **FY 2012 initial budget: 5.67 billion yen** –Ten prefectures (Backup regions of the Great East Japan Earthquake, and areas that are expected to suffer damages in Tokai Earthquake: Akita, Yamagata, Niigata, Tochigi, Gunma, Yamanashi, Shizuoka, Aichi, Gifu, and Mie)

◆ **FY 2012 revised budget: 13.20 billion yen** –32 prefectures (Areas that are expected suffer damage in Tonankai-Nankai Earthquake and earthquakes that directly hit the Tokyo area)
->To be completed within 2014



Source: The Agency for Natural Resources and Energy

Source: METI

Figure 15. Status of the establishment of disaster response core service stations

Status of construction of core SS in Japan

April 11, 2014

Prefecture	Number of core SS		
Hokkaido	73	Mie	26
Aomori	35	Shiga	27
Iwate	58	Kyoto	14
Miyagi	44	Osaka	54
Akita	23	Hyogo	39
Yamagata	23	Nara	15
Fukushima	55	Wakayama	26
Ibaraki	55	Tottori	16
Tochigi	49	Shimane	16
Gunma	53	Okayama	42
Saitama	48	Hiroshima	43
Chiba	43	Yamaguchi	28
Tokyo	130	Tokushima	17
Kanagawa	38	Kagawa	21
Niigata	35	Ehime	21
Toyama	19	Kochi	6
Ishikawa	18	Fukuoka	31
Fukui	22	Saga	14
Yamanashi	19	Nagasaki	14
Nagano	54	Kumamoto	33
Gifu	53	Oita	33
Shizuoka	57	Miyazaki	33
Aichi	47	Kagoshima	37
		Okinawa	17
		Total	1674

Figure 16. Status of the establishment of regional supply chains (2)

○ Training targeting core SS started in all prefectures starting in FY 2013.

(Detail of the training)

- Explanation of roles and duties of core SS and disaster response guidelines
- Measures to avoid confusions at SS in during disasters (role-playing)
- Method of operating and maintaining power generators
- Training to report conditions of damages based on disaster response guidelines



[Examples of cooperation among local governments and oil co-operatives]

Example 1: Oil co-operatives cooperated with the general disaster management training organized by the government of Tokyo. Fuel supply training was conducted at core SS to supply fuel to police vehicles (Nov. 2013).



Example 2: The prefecture and oil co-operatives organized training in Gunma. (*As a voluntary activity without using the subsidy) Fuel supply training was conducted at core SS to supply fuel to police vehicles (Mar. 2014).



Source: METI

4. Ongoing measures and challenges

4-1 Risks that oil refineries and oil terminals are facing

Risks that oil refineries are facing in expectation of Nankai megathrust earthquakes are organized as follows.

- [1] Oil refining facilities automatically shut down after earthquakes in case of the Japanese seismic intensity scale of six or greater. It takes about a week to resume operations even when facilities are not damaged or longer if facilities are damaged. It took six months to one year for three oil refineries to resume operations after the Great East Japan Earthquake.
- [2] There is a possibility that power outage occurs in power supply systems, which takes a long time to recover.
- [3] There is a possibility that receiving and shipping functions on the sea and land are damaged because of ground liquefaction and other situations.
- [4] In case of an especially extensive ground liquefaction, an entire industrial complex may be pushed out to the sea. This makes it difficult for tankers to dock in oil refineries. Also, damage and ruptures of pipes in oil refineries and uneven sinking of tanks may disable oil receiving and shipping functions.

Figure 17. Breakdown of emergency response requests sent from disaster-hit areas in the Great East Japan Earthquake

Breakdown of responses to requests made from disaster-hit areas in the Great East Japan Earthquake

Among the 5046 requests made from the disaster-hit areas to supply fuel, **about 29%** was the request to supply oil.

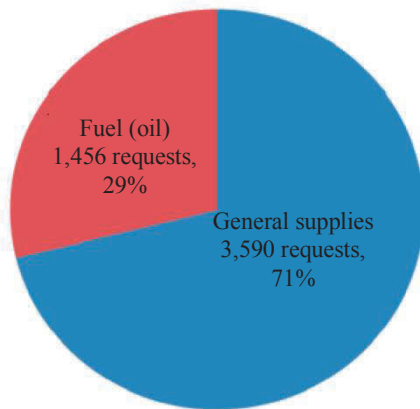
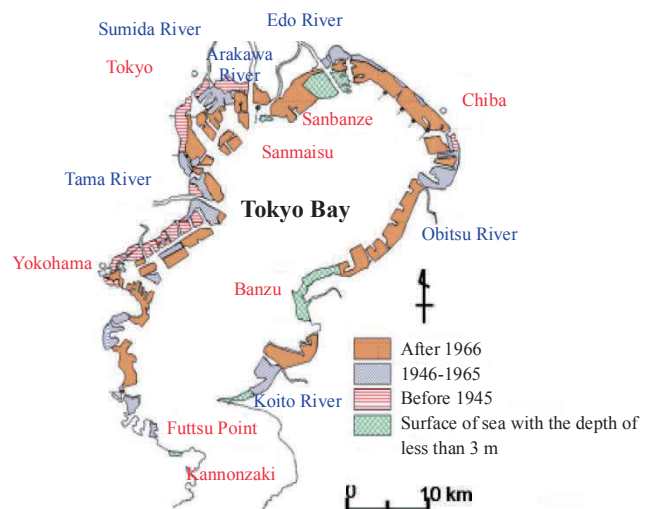


Figure 18. Risks which coastal industrial complexes have

History of landfill areas at the coast of Tokyo



Source: Sohei Kaizuka, "Terrains, geological conditions, and water of the Tokyo Bay"

Source: METI

4-2 Reinforcement of disaster response capacities at oil refineries and SS bases

(1) Reinforcement of oil supply infrastructures and shipping functions

[1] It is important that oil supply is continued by shipping out stocks and reserves of fuels, such as gasoline, light oil, and kerosene in oil refineries and receiving the support of oil refineries while oil refining functions are stopped after a massive earthquake.

[2] Therefore, the national government is promoting investments to minimize damage to oil product shipping and receiving facilities and to ensure quick recovery of oil refineries as follows (subsidy to businesses). (See Figure 19.)

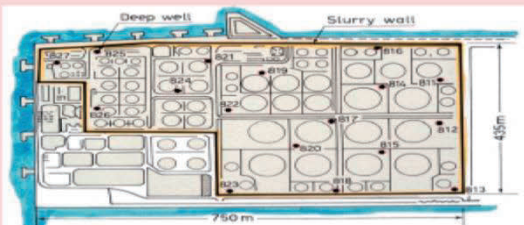
Figure 19. Measures taken at oil refineries and oil

Oil supply infrastructure reinforcement project (revised budget in FY 2013) 12.5 billion yen (the first year of the seven-year project)


[1] Safe emergency shutdown of facilities
Reinforcement and other necessary measures for emergency shutdown valves of pipes and automatic tanker release systems to contribute to safe emergency shutdowns and prevent damages from spreading in case of emergencies

[2] Earthquake resistance reinforcement, prevention of ground liquefaction, and tsunami damage control
Earthquake resistance reinforcement of receiving and shipping facilities (tanker piers, seawalls, pipes in premises, tank truck shipping lanes, etc.), measures to prevent ground liquefaction, etc.

[3] Reinforcement of the capacity of acceptance and shipping facilities, preparation for quick recovery
Reinforcement of the capacity of acceptance and shipping pumps, tank truck shipping lanes, pipes in premises, and preparation for materials and equipment for early recovery in case of emergency



Prevention of ground liquefaction
(method to lower the groundwater level)





Reinforcement of the capacity of tanker piers

Oil product shipping function reinforcement project (budget for FY 2014) 5.1 billion yen (fourth year of the five-year plan)

Support for the purchase of "three-piece emergency set" at oil refineries

[1] Emergency power generators
[2] Emergency information communication system (satellite communications, etc.)
[3] Oil drum filling and shipping facility

Shipping facilities are operated using emergency generators in oil refineries.

↓

Oil drums are filled with oil and shipped.

↓

Oil drums are transported to disaster-hit areas to supply oil there (provisional permissions for the storage and handling of explosives)

Source: METI

(2) Earthquake resistance reinforcement of high-pressure gas facilities

- [1] Serious damage may occur if an accident occurs at a high-pressure facility in an oil refinery during a massive earthquake. (The accident at the oil refinery in Chiba during the Great East Japan Earthquake is an example.)
- [2] The national government promotes the earthquake resistance reinforcement of already installed facilities to prepare for massive earthquakes, such as earthquakes that directly hit Tokyo and the Nankai megathrust earthquakes, which may become larger than expected. (See Figure 20.)

Figure 20. Earthquake resistance reinforcement for high-pressure gas facilities


Earthquake resistance reinforcement project for high-pressure gas facilities (revised budget in 2013, about 2.8 billion yen)

[1] **Earthquake resistance reinforcement of spherical tanks**
(Responses to explosions during the Great East Japan Earthquake)

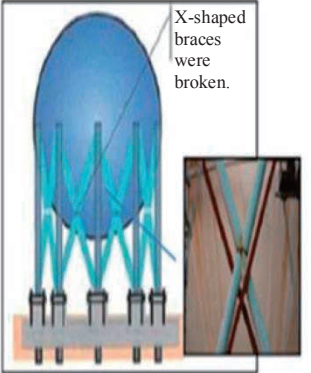
- Earthquake resistance standards were raised for spherical tanks that were damaged in the Great East Japan Earthquake. Specifically, a new standard was set for x-shaped braces.
- For already installed spherical tanks in the same shape as ones damaged in the earthquake, business owners of the applicable tanks were asked to evaluate their earthquake resistance. The national government provides support if earthquake resistance is reinforced based on proper plans.

[2] **Stronger earthquake resistance reinforcement for already installed facilities**
(in preparation for earthquakes which directly hit Tokyo and Nankai megathrust earthquakes)

- In preparation for earthquakes that are greater than current expectations such as earthquakes that directly hit Tokyo and Nankai megathrust earthquakes, the national government provides support if earthquake resistance is reinforced based on proper plans for already installed key facilities (towers and tanks) that especially require reinforcement. This includes when business owners reinforce these facilities to comply with the latest earthquake resistance standards.



[Explosions occurred in the Great East Japan Earthquake]



[The section of a spherical tank that caused problems in the explosion]

Source: METI

5. On-site investigation

5-1 Oil terminal in Sendai (hearing of measures implemented in the Sendai area after the earthquake)

(1) Responses at the onset of the Great East Japan Earthquake

At 14:46, March 11, 2011, a M9.0 earthquake occurred off the coast of Sanriku.

[1] Conditions at the plant at the onset of the earthquake:

- 1) Workers: Seven people including the director were working (locations: four in the office and three at the dock)
- 2) People in recess: Five (Three of them were security guards.)
- 3) Shipping operation: There was no loading vehicle (Remaining reservation for the day: One vehicle)
- 4) Receiving operation: After receiving 1,000 kiloliters of heavy oil A, the loading arm was detached, and 240 meters (at that time) of oil fence was extended.
- 5) Tank: Five tanks were waiting to be shipped (one for each type).

Oil was being filled into one tank (heavy oil A only).

[2] Responses after the onset of the earthquake (Office)

- 1) Activation of the automatic emergency shutdown of tank truck shipment
- 2) Power outage
- 3) Workers temporarily evacuated from the office to the outside
- 4) They closed all master valves of tanks when the ground stopped shaking.
*Since the power supply had stopped, the UPS (uninterrupted power supply) was supposed to supply power for motors, and automated master valves of tanks were supposed to be closed. Yet, this system was not functioning for some reasons. (Reasons were found later during the on-site inspection.)
- 5) Workers at the dock: Workers received the information of the onset of a massive tsunami from drivers of arriving tank trucks and broadcasting of nearby companies.
- 6) Director of the base instructed dockworkers to start emergency undocking of the ship.
- 7) After undocking the ship, the director joined the dockworkers and started evacuation in a car to a nearest city hall that was a designated evacuation shelter. Yet, some roads were blocked by collapsed utility poles and other objects. Other roads were heavily congested as well. Thus, they gave up on evacuating to the city hall and instead headed to a large suburb-type supermarket.

*They could not notify the fire department of where they would evacuate. This

was because that the fire department had notified them after the massive tsunami warning issued the year before after an earthquake in South America that all workers must start evacuation to prioritize in saving their lives and that emptying the base would be an unavoidable action to take.

- 8) Report of conditions to the head office and request to check the safety of family members
- 9) The tsunami arrived near the harbor at around 15:50.
- 10) They remained in the supermarket until the evening of March 12. The supermarket workers guided evacuees to move to the city hall that was a designated evacuation shelter, and the evacuees started heading to the city hall.
- 11) They remained in the city hall until the noon of March 13.
Some of them then headed to their homes, and some decided to stay in a place that the head office arranged for them.
- 12) While they were in the city hall, they learned that two kilometers area around a nearby oil refinery had been closed because of the fire from the oil refinery, and they would not be able to return to the base.
- 13) Director of the base and staff from the head office visited the fire department in the jurisdiction to check conditions and gather information on March 14.
*They learned that no fire had occurred at their base.
 - The access to areas around the base was restricted, and they could not return to the base.
 - The fire from a nearby area is going to be extinguished within the day. The restricted access will be lifted once the safety of the area is confirmed. The fire department will notify them when that happens.
- 14) The restricted access to the base was lifted at 17:00, March 15.
- 15) They entered the base with officials of the fire department on March 16.
They checked the ejection of oil from the vent of the regular gasoline release pile around 13:50.
- 16) They reported conditions to relevant people on March 16. They also requested the dispatch of Japan Self Defense Forces and fire departments to deal with the leak of gasoline.
- 17) Fire engines started injecting foam into the oil fence at 10:28, March 17 (starting at the inner oil fence of TK-2).
*This was the measure to reduce the generation of combustible steam from oil that had leaked into the oil fence and to close the master valves of the tanks.
The master valves of the TK-2 tanks were closed, and the ejection of regular

gasoline stopped at 12:20.

Wooden plugs were placed on damaged sections of vent pipes later.

Foam was injected into other areas, and master valves were closed.

(2) The flow up to the recovery

[1] March 22-25: Start of the recovery of oil leaked inside the oil fence

[2] April 11 – June 13: Recovery of oil products inside tanks

[3] May 10: Start of full-scale recovery works

[4] November 4 - : Accepting the shipment of oil products and trial runs of facilities

[5] November 23 - : Start of regular shipment

(3) Measures implemented after the earthquake

An automatic master valve shutdown system activated by an earthquake was installed to prevent oil leak from the vent pipes of regular gasoline.

(Line indicating the tsunami height at about five meters)



(Preparation of emergency backpacks for individual workers)



5-2 Oil terminal in the Nagoya area number 9

(1) Lessons learned from the Isewan Typhoon

The Isewan Typhoon in September 1959 caused serious damage in the prefecture of Aichi (total number of deaths: 5,098 of which 1,909 were in Nagoya city).

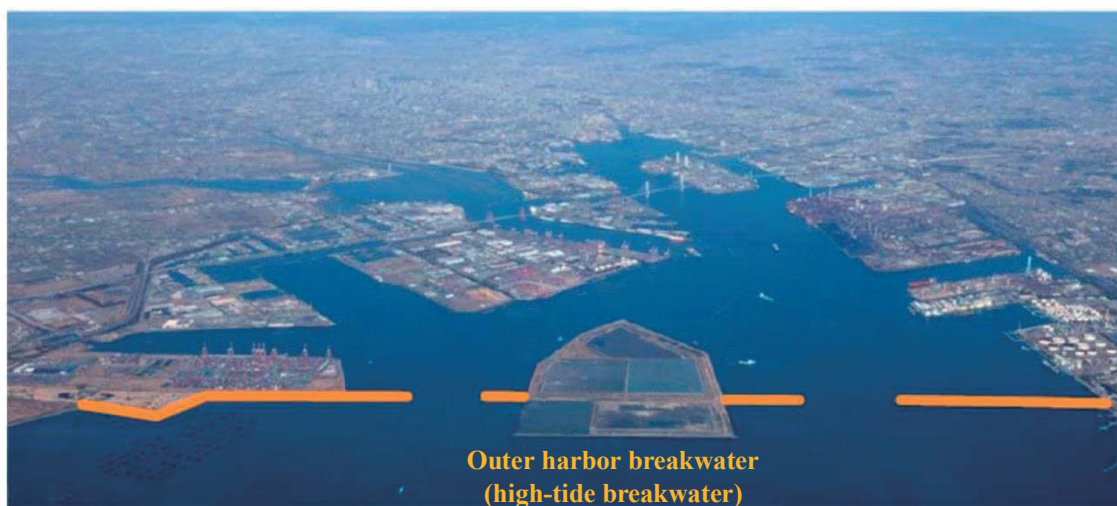
Most damage in Nagoya was caused as the high tide that reached 389 centimeters flushed lumbers from lumberyards, and lumbers damaged houses and people.



Driftwood filling Daidocho Station on the Meitetsu Tokoname Line in Minami-ku, Nagoya:
This photo was taken on September 28, 1959.

Learning from this lesson, the seawall for storm surges was completed in 1964. The total length of the seawall is 7.6 kilometers, and the average height is 6.5 meters.

The seawall for storm surges has been functioning as a protection against powerful typhoons of the same level as the Isewan Typhoon. It has been protecting areas inside the Port of Nagoya and areas inland from the seawall. This means that this area had higher risk awareness than other areas toward mega disasters in general rather than a specific awareness for the Nankai Megathrust earthquakes.



Yet, fifty years have passed since the construction of the seawall, and the Nagoya area is facing challenges due to the aging of the seawall and changes in the environment.

(2) Damage to breakwaters and seawalls in the Great East Japan Earthquake

- In the Great East Japan Earthquake, unexpectedly greater earthquakes and tsunamis caused serious damages in the inner portions of harbors and harbor facilities.
- With damaged breakwaters, the calmness in harbors could not be maintained, which caused difficulties in reconstructing industrial and distribution functions.



Source: Ministry of Land, Infrastructure, Transport and Tourism

(3) Problems seen in seawalls in the outer part of the Port of Nagoya

Current problems seen in breakwaters (high-tide breakwaters) in the outer parts of Nagoya Harbor

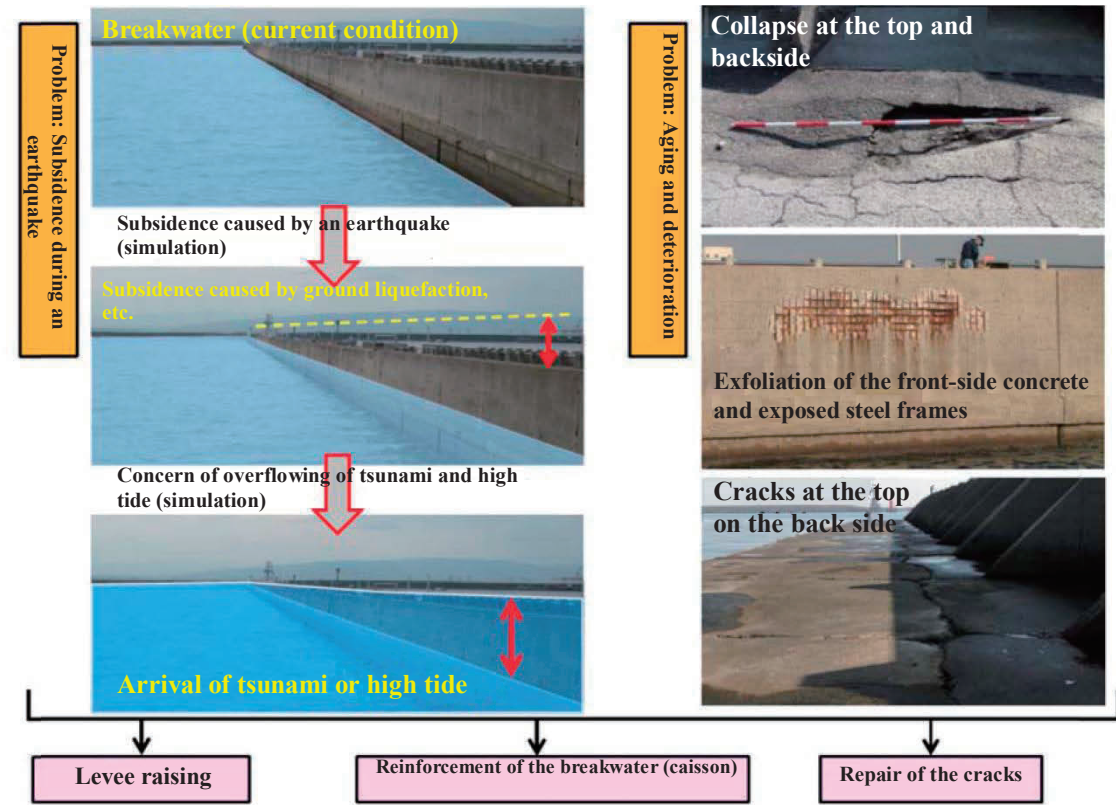
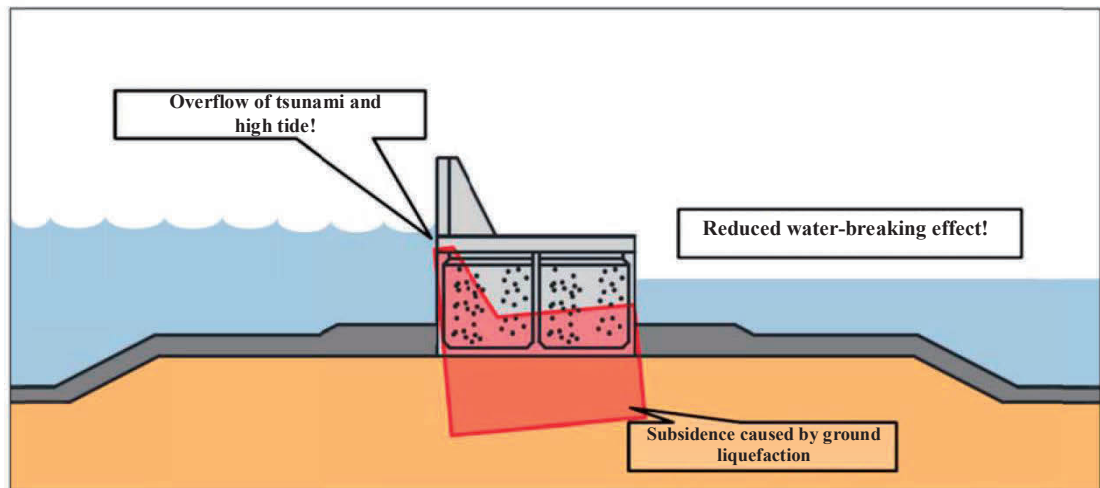


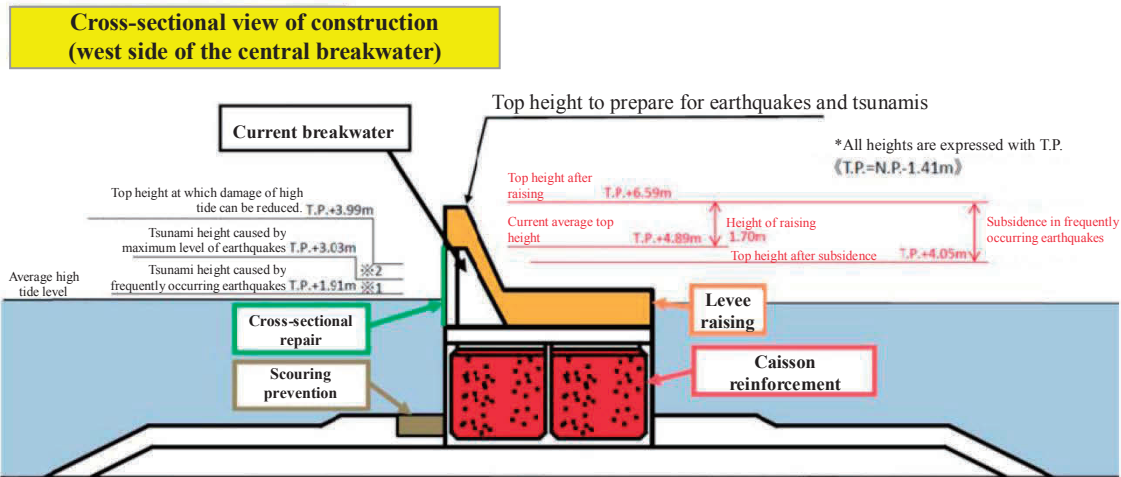
Image of damages to breakwater caused by earthquakes



Source: Ministry of Land, Infrastructure, Transport and Tourism

(4) Project to improve seawalls in the outer part of the Port of Nagoya

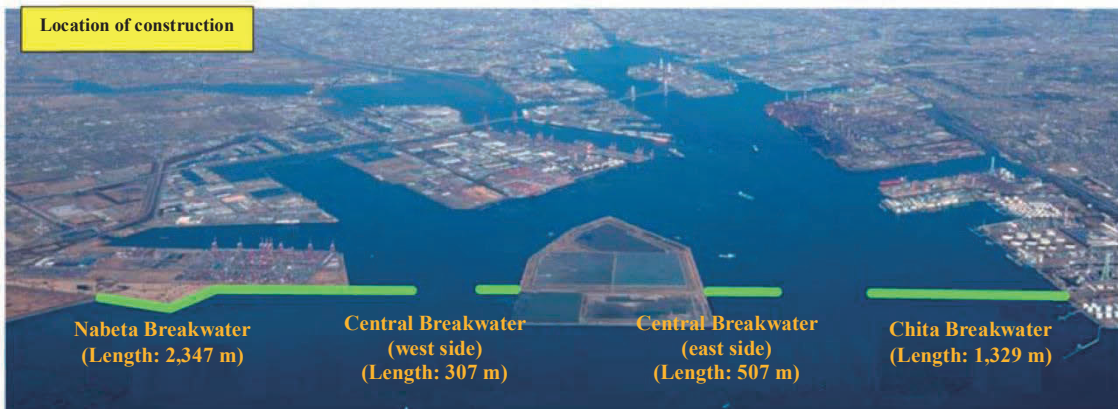
Construction is underway to repair deterioration, prevent subsidence, and improve wave resistance of the seawall.



Overview of process (plan)

Location of construction	FY 2013	FY 2014	FY 2015
Caisson	[Construction bar]		
Raising		[Construction bar] ※1	
Scouring prevention		[Construction bar]	
Cross-sectional repair		[Construction bar]	

The construction of a part of the Nabeta Breakwater (land on the backside) is going to be completed in FY 2015.



Source: Ministry of Land, Infrastructure, Transport and Tourism

(5) Preparation for disasters at the oil terminal of company K

- Location: Land reclamation zone number 9 in the city of Nagoya

- This is a land reclamation zone designated as zones from which people must evacuate in case of a disaster. There is an agreement that workers voluntarily walk to the highway interchange (Meiko-Shiomi IC) in case of a massive tsunami, since there is no high-rise building that can be used as tsunami shelters nearby.



Overview of disaster control measures at zone number 9
A three-meter seawall is surrounding the zone number 9.



In addition, the oil fence (about two-meter high) in the tank area in the premise is preventing damage to tanks in case of the entrance of seawater.

5-3 Oil refinery in the target areas of the Nankai Trough earthquake

Measures implemented to reduce damage from earthquakes at oil refineries in the target areas of the Nankai Trough earthquake

[1] Background of the damage reduction measures

Loading of crude oil was underway at an oil refinery of the same group company when the earthquake occurred on March 11, 2011. Upon receiving the earthquake warning, the tanker left the dock by detaching the receiving pipe (loading arm) and avoided damage.

Meanwhile, other oil refineries caused extensive fire, because pipes broke due to ground liquefaction, and valves of shipping line extending from tanks could not be closed.

[2] Responses to earthquakes

The entire oil refinery will be shut down because of the location of the refinery in case of the Nankai megathrust earthquake. Yet, complete shutdown will not be performed in case of an earthquake directly hitting Tokyo, because expected damage is small.

[3] Specific measures

- Reinforcement of the foundation to prevent damage to pipes caused by ground liquefaction (not yet implemented)
- Plan to replace the loading arm to make it easier for vessels to leave docks in case of a tsunami during unloading (not yet implemented)

Emergency removal system (ERS unit)



- QRH (quick release hook): All ropes securing tankers are released at once in case of emergency.



- Complete sealing of doors to protect instrument rooms from tsunami, fixing window frames



- Preparation of a set of backups of shipping facilities and equipment
(To continue shipping by replacing facilities and equipment in case they become flooded with water)



5-4 Oil storage base in the target area of the Nankai Trough earthquake

(1) Overview of bases

- [1] Lot size 196 ha
- [2] Crude oil tanks 43 tanks
- [3] Sea berth 1.4 kilometers offshore
Docking ten vessels per year

(2) Expected damage caused by Nankai megathrust earthquakes

- [1] Magnitude 7.2
- [2] Japanese seismic intensity scale 5+
- [3] Expected damage caused by flooding:
Flooding to the depth of two meters, no floating of tanks
- [4] Risk of losing the functions of private power generators and distribution stations due to flooding
- [5] Damage to docks caused by tsunamis while crude oil tankers are docked

(3) Measures to implement

- [1] Plans are now being established.
- [2] Possible measures include the relocation of private power generators and distribution stations to higher elevations and sealing them for waterproofing
- [4] Addition of ropes to prevent damage to crude oil vessels at docks
The automatic shutdown of shipment is activated by a 80-gal earthquake with the current system.



5-5 Oita Prefecture Oil Business Union

The union is implementing disaster drills led by local governments in preparation for the Nankai megathrust earthquakes.

The scenario expects a magnitude 9.0 earthquake and 6+ in Japanese seismic intensity scale in the Chubu region.

They are conducting drills to continue fuel supply based on the agreement to support victims during disasters. They also assigned disaster response core service stations around the prefecture to secure fuel supplies.

