

The Impact on Oil Distribution by the Great East Japan Earthquake, and Future Issues and Countermeasures

APERC

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by the Great East Japan Earthquake,
and Future Issues and Countermeasures**

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Foreword

During the 11th APEC Energy Ministers' Meeting (EMM11) held in Beijing, China on 2nd 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

A handwritten signature in black ink, consisting of a stylized 'T' followed by a series of loops and a long horizontal stroke.

Acknowledgments

I would like to thank all those who contributed to the completion of this report in various forms. Completing of this report may have not been possible without their invaluable contributions.

I wish to express my deepest appreciation to the following members for reviewing this report and providing me with their constructive advices and comments, namely, Mr. Takato Ojimi, President and Dr. Kazutomo Irie, Director General of Research Department of APERC, Mr. Masahiro Nagai, President, Mr. Ikuo Hamabayashi, Secretary General, Mr. Kimito Mimura, Senior Coordinator, the Oil Information Centre, of IEEJ. As well, I would like to thank Mr. Hideki Tanaka, General Manager and Mr. Morihiko Ono, Manager, Business Environment Department, of Petroleum Association of Japan (PAJ).

I acknowledge with appreciation the contribution to this report of the following organizations through authorizing the use of their graphs, pictures and tables, namely, PAJ [*Figure 6: Operation Room in Emergency Headquarters of PAJ*], [*Figure 7: Joint Use of Oil Depots in Shiogama*], [*Figure 8: Temporary SS Operated in Area Having No SS Nearby*], [*Table 8: Comparison of Gasoline and Gas Oil demand with the Previous Year*], Zensekiren [*Table 6: Damage to Service Stations by the Earthquake*], [*Figure 3: Damaged Service Station in Kesenuma City*], [*Figure 4: Damaged Service Station in Shichirigahama, Sendai City*].

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(Executive Summary)

The Great East Japan Earthquake caused tremendous damage: about 20,000 people were dead or missing, and approximately 280,000 houses were completely or half destroyed; and the damage to the nuclear power plant added to the direct damage, which was estimated as 16 to 25 trillion yen.

The impact on infrastructures was also enormous: full restoration of electricity and city gas took about 100 days and 50 days respectively; all traffic lanes became available on February 3, 2012, nearly 11 months after the earthquake; and as for railways, only 91% has been restored even as of the end of June, 2014.

In the meantime, the oil industry was also heavily damaged, but the major confusion abated in April, and the convenience of petroleum at the time of disaster was reconfirmed. In the Basic Energy Plan, the government regarded petroleum as an important energy source to be utilized in the future.

Following the earthquake, the government asked oil companies to maintain a sufficient supply capacity to perform a stable supply to disaster areas (on March 12) and ease the private sector stockpiling requirements (reduced the amount of 3 days on March 14, and 22 days on March 21, from the total).

On the other hand, the private sectors established an emergency headquarters within the Petroleum Association of Japan (PAJ) to deal with the emergency situation (on March 11), and implemented an around-the-clock emergency supply to socially important infrastructures (hospitals, etc.), municipalities and the Self-Defense Forces engaged in life-saving activities, in the manner of complying with the requests by the Prime Minister's Office.

In addition, the private sectors newly structured oil supply logistics to provide long distance transport by tankers, tank trucks, and tank cars beyond the usual commercial sphere, which were required to cover damaged infrastructures such as oil refineries and oil depots, roads, and railways. At the same time, they established a cooperative system among oil companies mainly in disaster areas, and promoted joint use of the oil storage facilities capable of shipping oils, and tank cars. Such cross-company efforts enabled the prompt supply.

As for the supply of petroleum, the volume of crude oil processed decreased by 30% just after the earthquake, but it returned to about 90% level by the end of March, and the shortfall was compensated by increasing the operation rates of existing oil refineries, cancelling export, performing emergency import, and transferring oil products to disaster areas.

Furthermore, tank trucks were brought in from other areas to ease the logistical bottleneck of long-distance transportation caused by tank trucks washed away by the tsunami, and deteriorated road conditions.

Post-quake retail prices of oil products from March to May were 1 to 3 yen per liter higher than the usual prices (at the national level), but the prices came back to the normal in June, so major turmoil or violent fluctuations didn't occur. It seems to be due to the attitudes of oil companies and the oil distribution industry, in which they did not raise the price by taking advantage of the panic, and they emphasized the relationships with the customers from a

long-term perspective.

The volume of oil shipments from March to August also largely decreased over the previous year, but it returned to almost normal in September. In the meantime, the volume of gas oil shipments in April and subsequent months was higher than the previous year, partially because of reconstruction demand.

Measures taken by the private sectors, based on the lessons learnt from the earthquake, were to improve quake resistance of oil refineries and petrochemical complexes, toughen up them against liquefaction, and participate in a maintenance program of core service stations against disasters. Measures by the government based on the lessons were to revise the Petroleum Reserve Law (effective on November 1, 2012), in which the national reserve oil and LP gas could be released not only when oil import was insufficient, but also when the amount to certain areas was not enough due to disaster. Moreover, the government mandated oil wholesalers to prepare a cooperative supply plan against disaster for every 10 areas in Japan beforehand.

As future issues, while disposal of oil refinery capacity being advanced (approx. 10% of the status), excess facilities are expected to be reduced. Therefore, it would be difficult to increase the operation rates using the surplus capacity, as seen in the Great East Japan Earthquake. The current stockpiled oil is mainly crude oil, but in order to make flexible responses, an increase in the proportion of oil products in stockpiling would be desirable.

Furthermore, if a great earthquake occurs, restoration of infrastructure networks including roads, and sea and air routes, would take a long time, and long-distance transportation of oil become difficult. Therefore, power consumers regarded as important infrastructures such as hospitals and fire stations, are required to improve the reserved amount of fuel for in-house power generators (at present, approx. 50% reserved fuel for more than 3 days) so as to deal with temporary oil supply disruptions after earthquakes.

(The key points for having resolved the situation of oil distribution in the Great East Japan Earthquake in a relatively short period of time)

1. Prompt responses by the government
 - 1) Requested oil companies for a stable supply to disaster areas (March 12)
 - 2) Eased the private sector stockpiling requirements (reduced by the amount of 3 days on March 14, and by 22 days on March 21)
2. PAJ, as an organization of the industry, put together oil companies, and which functioned effectively.
 - 1) Set up an emergency headquarters within PAJ (March 11) and handled the emergency supply to socially important infrastructures (hospitals, etc.), municipalities, and the Self-Defense Forces engaged in life-saving activities, in the manner of complying with the requests by the Prime Minister's Office. Eliminated needless confusion by integrating the industry's authorities.
 - 2) Established a cooperative system among oil companies mainly in disaster areas, and promoted joint use of oil depots capable of shipping oil, and tank trucks. Such cross-company efforts enabled the prompt supply.

3. Orderly responses in the distribution phase

It was not seen that oil products were held back, or the prices were raised more than the actual cost by taking advantage of the panic, so the turmoil in the distribution aspect subsided early. It might be partially because of the severe competition in the industry, but mainly it would be due to their business practice of emphasizing relationships with the customers from a long-term perspective.

(Introduction)

The Great East Japan Earthquake on March 11, 2011 damaged oil refineries and other oil depots, and temporarily disrupted supplies of the oil products. Delivery bottlenecks caused by significantly damaged road conditions and tank trucks washed away by tsunami added to the turmoil.

However, major confusion over the supplies of oil products subsided in early April, a month after the earthquake. This would be because the government and private sectors fulfilled their own roles. In this research, we clarify, confirm, and examine how the government and private sectors responded after the earthquake and the results, and then how much the impact on retail prices of oil products and the demand was. We believe the research would be valuable when applying the lessons from the earthquake to the future.

In addition, the earthquake revealed issues as well, and we need to promptly establish and improve the system for a stable supply.

1. Outline of the Great East Japan Earthquake and the Damage

1-1 Outline of the earthquake and the damage

The earthquake off the Pacific coast of Tohoku occurred at 14:46:18 (Japan time) on March 11, 2011 with the hypocenter on the Pacific Ocean floor, approximately 130 km off the coast of east-southeastern Oshika Peninsula of Miyagi Prefecture and 70 km off the coast of eastern Sendai City.

The magnitude was 9.0 (Mw), the most powerful ever recorded to have hit Japan, far exceeding the Great Hanshin and Awaji Earthquake in 1995.

The epicenter was extensive with approximately 100,000 km² in total, the north-south distance of 500 km and the east-west extension of 200 km from the coast of Iwate to the coast of Ibaraki. The maximum seismic intensity was 7 on the Japanese scale, registered in Kurihara City, Miyagi. Other thirty-six municipalities of four prefectures—Miyagi, Fukushima, Ibaraki and Tochigi—and one ward of Sendai City recorded an upper 6 on the same scale.

The earthquake triggered the powerful tsunami with the waves higher than 10 m and the highest run-up of 40.1 m on some areas, inflicting a catastrophic damage on the Pacific coast of Tohoku and Kanto areas. Besides the gigantic tsunami, the ground motion, soil liquefaction, land subsidence, and dam collapse caused damage to the broad range from the coast of southern Hokkaido, through Tohoku to the southern Kanto including Tokyo Bay, resulting in disruptions of various infrastructures (so-called lifelines vital for people's lives).

As of October 10, 2014, the government officially confirmed 18,487 deaths and missing persons as well as 401,306 buildings totally or half collapsed in the earthquake. According to the report, more than 400,000 people were displaced, over 8 million households were left without electricity, and at least 1.8 million households without water at its peak after the earthquake. The Reconstruction Agency revealed that 243,040 people were still displaced as of September 11, 2014; the prolonged refuge life is characteristic of the earthquake.

The Japanese government estimated the amount of loss directly caused by the earthquake as 16 to 25 trillion yen. This figure is equivalent to the total production of three prefectures—Iwate, Miyagi and Fukushima—that suffered most from the calamity (the total loss in the Great Hanshin and Awaji Earthquake was around half of the total production of Hyogo Prefecture). The World Bank estimated that it was the biggest economic loss caused by natural disasters in world history.

The Fukushima Daiichi Nuclear Power Plant complex owned by the Tokyo Electric Power Company (TEPCO) lost all power sources after being hit by the tsunami with the run-up height of 14 to 15 m, which arrived an hour after the earthquake. Cooling function for nuclear reactors failed, resulting in meltdowns in Units 1, 2, and 3, which led to a serious nuclear power accident involving a leakage of large amounts of radioactive substances.

This accident was measured as level 7 on the International Nuclear Event Scale, which was the worst level, and placed in the equivalent position of Chernobyl nuclear power plant accident. While the evacuation of people living in Hama-dori area of Fukushima and its surroundings have been prolonged, “difficult-to-return zone” and “restricted residence area” have been designated since 2012. In addition, thermal power plants also suffered damage, so

Kanto area served by TEPCO faced a serious power shortage. To deal with it, the government performed scheduled outage in the area for a certain period just after the earthquake, which was the first time in 65 years in Japan. Such outage was also conducted in some areas served by the Tohoku Electric Power Company (TEP) immediately after the earthquake.

Table 1. Outline of the Great East Japan Earthquake

Date and time	14:46 on March 11, 2011
Epicenter	Sanriku Coast
Depth of hypocenter	24 km
Magnitude	9.0
Maximum seismic intensity	7 on Japanese scale (Kurihara City, Miyagi)
Tsunami	Enormous with the wave height of more than 10 m and the maximum run-up height of 40.1 m on some areas
Type of earthquake	Ocean-trench earthquake, reverse fault type
Casualties	18,487 deaths and missing persons (as of October 10, 2014)
Building damage	401,306 buildings totally or half collapsed
Damage to nuclear power plant	The accident involving a leakage of large amounts of radioactive substances occurred in TEPCO Fukushima Daiichi Nuclear Power Plant complex, due to failure of cooling function for reactors.
Amount of direct damage	16 to 25 trillion yen

Figure 1. Seismic Intensity Map (at the time of the Great East Japan Earthquake)

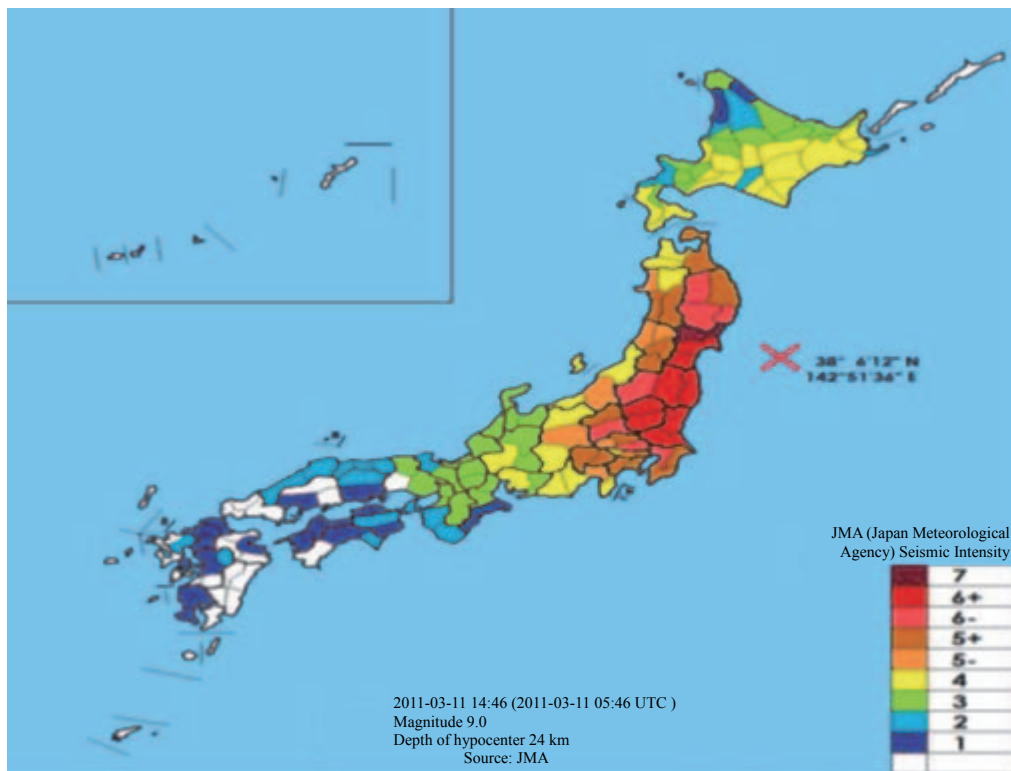
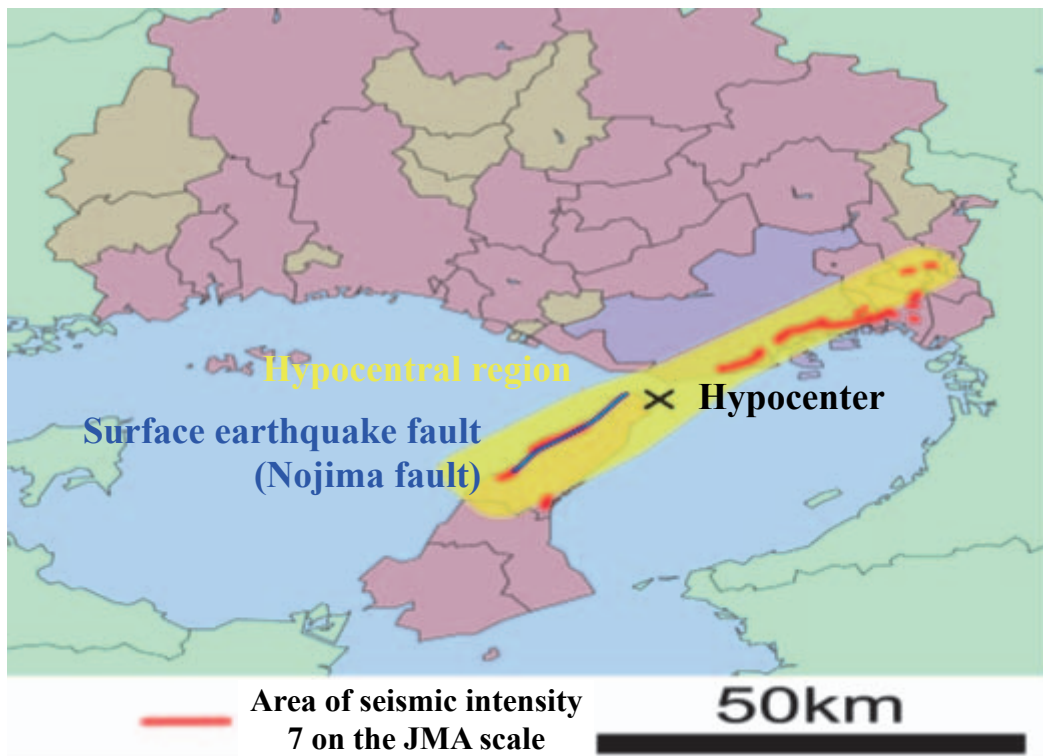


Table 2. Outline of the Great Hanshin and Awaji Earthquake

Date and time	05:46 on March 17, 1995
Epicenter	Northern Awaji island
Depth of hypocenter	16 km
Magnitude	7.3
Maximum seismic intensity	7 on Japanese scale (in the area between Osaka and Kobe, and in Awaji island)
Tsunami	-
Type of earthquake	Directly above its epicenter
Casualties	6,437 deaths and missing persons
Building damage	249,180 buildings totally or half collapsed
Amount of direct damage	Approx. 10 trillion yen

Figure 2. The Areas of Seismic Intensity of 7 (at the time of the Great Hanshin and Awaji Earthquake)



1-2 Outline of damage to infrastructures

Various infrastructures were disrupted by the earthquake. Among them, the following shows how electricity, gas, roads, and railways were damaged and when they were fully restored:

(Electricity) Approximately 4.66 million households in the area served by TEP and 4.05 million household in the area by TEPCO lost electricity. The power was fully restored on June 18, 2011, approx. 100 days later.

(Gas) City gas was cut off at around 420,000 households and LP gas supply was stopped to around 1.66 million, and they were fully recovered on May 3, 2011, approx. 50 days later, and on April 21, 2011, approx. 40 days later, respectively.

(Roads) Fifteen expressways were blocked due to the damage by the earthquake, but were opened on April 1, 2011. As for national roads, 69 sections were closed, and they were fully available on February 3, 2012.

(Railways) The length of routes damaged was 2,330 km in total. As of the end of June 2014, approx. 91% or 2,114 km have returned to normal.

Table 3. Infrastructure Damage Overview

	Status of Damage	When Fully Restored*
Electricity	Lost by approx. 2.58 million households in three prefectures in Tohoku (March 11). Cut off to about 4.66 million households in the area served by TEP and 4.05 million in the area by TEPCO (March 12).	June 18, 2011
City Gas	Cut off to around 420,000 households in three prefectures in Tohoku	May 3, 2011
LP Gas	Supply stopped to 1.66 million households in three prefectures in Tohoku	April 21, 2011
*except the areas where houses were washed away by the tsunami (about 80,000 households) and restricted areas in Fukushima (about 30,000 households)		
Roads	Expressway: 15 were damaged and shut down National roads: 69 sections were damaged and closed	Opened on April 1, 2011. Opened on February 3, 2012.
Railways	Total 2,330 km length of routes were damaged	Operation was resumed in routes of total 2,114 km (91% restored) as of the end of June, 2014

Source: Cabinet Office, Reconstruction Agency, etc.

2. Impact on and Recovery of Oil Facilities

2-1 Oil refineries

Operations were stopped at six refineries and the volume of crude oil processed fell to around 70% of the pre-quake level immediately following the earthquake, but, by March 21, three refineries went back to work one by one and the volume recovered to about 90%.

JX Sendai shut down the whole operations after the system was exposed to seawater by the tsunami. JX Kashima avoided any impact on the system, but it stopped the operations because a petrochemical ship broke the berth, disabling the delivery of products. Cosmo Chiba was forced to close the facilities after the system was broken by a fire caused by a collapse of the LPG tank that was being filled with water.

After that, JX Kashima resumed the operations in June 2011, but JX Sendai, which was heavily damaged by the tsunami, restarted on March 9, 2012, and Cosmo Chiba operated part of the system on January 12, 2012.

Table 4. Oil Refineries Damage Overview

Wholesalers	Group refinery	Refining Capacity 10,000 B/D	Operation and Product Shipment Status
JX Nippon Oil & Energy	Negishi	27.0	Resumed operations on March 21
	Kashima	25.3	Stopped the whole operations/shipments. Resumed in early June
	Sendai	14.5	Ditto. Resumed production on March 9, 2012
	Muroran	18.0	Not affected
	Osaka	11.5	Completed regular maintenance
	Mizushima	23.7	Not affected
	Marifu	12.7	Not affected
Showa Shell Sekiyu	Oita	13.6	Not affected
	Toa Oil /Keihin	18.5	Resumed shipments on land and sea on March 13
	Showa Yokkaichi Sekiyu /Yokkaichi	21.0	Normal operations
TonenGeneral Sekiyu	Seibu Oil /Yamaguchi	12.0	Normal operations
	TonenGeneral /Kawasaki	33.5	Resumed operations on March 18
Fuji Oil	Sodegaura	14.0	Normal operations. Resumed shipments on sea on March 13
Cosmo Oil	Chiba	22.0	Stopped the whole operations /shipments. Resumed operations of part of the system on January 12, 2012
Kyokuto Petroleum	Chiba	17.5	Resumed operations on March 16. Full production on 21
Idemitsu Kosan	Chiba	22.0	Normal operations
	Hokkaido	14.0	Normal operations
	Aichi	16.0	Normal operations
	Tokuyama	12.0	Normal operations

2-2 Oil Depots

Although operations were stopped due to the power failure just after the earthquake, most of facilities went back to work one by one on the next and following days.

However, some depots were severely damaged by the tsunami, so they took approximately 6 to 8 months to return to normal.

Table 5. Oil Storage Damage Overview

Status: ○-> keep shipping, Δ-> temporary stopped, ×-> function totally stopped

Prefecture	Oil depots	Status	Resumption of operations /remarks
Aomori	TOT Aomori	○	
	JONET Aomori	○	
	TOT Hachinohe	Δ	March 20
	JX Hachinohe	Δ	March 25
	Idemitsu Hachinohe	Δ	March 20
	JONET Hachinohe	Δ	March 22
Iwate	JOT Morioka	Δ	March 15
	IOT Kamaishi	Δ	March 19
Miyagi	Kamei Miyako (Kesenuma)	×	Tank washed away by tsunami. Resumed shipments on September 2, 2011
	TOT Shiogama	Δ	April 1
	Zen-noh Sendai	×	Piping and shipment facilities damaged. Resumed shipments on November 23, 2011
	Idemitsu Shiogama	Δ	March 17
	Shell Shiogama	Δ	April 10
	EM Shiogama	Δ	March 20
	Kamei Shiogama	Δ	March 18
	Marubeni Energy Shiogama	Δ	May 9
Fukushima	TOT Onahama	Δ	March 31
	JX Onahama	Δ	March 29
	Onahama Petroleum	Δ	March 19
	JOT Koriyama	Δ	March 25
Akita	JX Akita	Δ	March 15
	Shoyu Akita	○	
	Idemitsu Akita	○	
	TOT Akita	○	
Yamagata	TOT Sakata	Δ	March 14
Ibaraki	TOT Hitachi	Δ	March 17
	Idemitsu Hitachi	Δ	March 29

TOT: Tozai Oil Terminal, JOT: Japan Oil Terminal, IOT: Iwate Oil Terminal, JONET: Japan Oil Network

2-3 Service Stations

Table 6 below shows damage to service stations by the earthquake. Damage by the tsunami was substantial in Iwate and Miyagi, where 19% and 28% of service stations were shut down, respectively, as of March 28.

In a total of seven prefectures, approx. 13% of service stations were closed down.

However, damage was limited to ground facilities. No damage was found in underground tanks, and no fire occurred in any stations. This fact proved again that the quake and fire resistance, and durability of the underground oil tanks were sufficient.

Service stations closed down were reduced to approx. 5% as of July 11 (which means that around 63% of service stations shut down by the earthquake resumed operations)

Table 6. Service Station Damage Overview

As of March 28, 2011

	Aomori	Iwate	Miyagi	Fukushima	Ibaraki	Tochigi	Chiba	Total
Total No. of SS (service station)	492	487	538	728	1,079	623	1,022	4,969
Totally collapsed	0	73	37~42	7	1	0	1	183~188
Flooded	2	10	48~51	10	15	0	9	94~97
Partially collapsed	0	9	55~67	40~50	188	36	23	351~373
Shut down by nuclear accident		0		64				64
Total SS shut down	2	92	140~160	55~67	204	36	33	628~658
Rate of shut down	0.4%	18.9%	26~30%	8~9%	18.9%	5.8%	3.2%	12.6~13.2%



As of July 11, 2011

	Aomori	Iwate	Miyagi	Fukushima	Ibaraki	Tochigi	Chiba	Total
Total No. of SS	492	487	538	728	1,079	623	1,022	4,969
Totally collapsed	0	68	56	11	2	0	1	138
Flooded	0	2	7	0	0	0	4	13
Partially collapsed	0	0	0	15	36	2	0	53
Shut down by nuclear accident		0		34				34
Total SS shut down	0	70	63	60	38	2	5	238
Rate of shut down	0.0%	14.4%	11.7%	8.2%	3.5%	0.3%	0.5%	4.8%

Source: Zensekiren

Figure 3 (Damaged service station in Kesenuma City)



Figure 4 (Damaged service station in Shichirigahama, Sendai City)



3. Response by the Government

3-1 Response immediately after the earthquake

- 1) Called for PAJ to set up an emergency headquarters in order to address emergency requests for petroleum, and, on behalf of the Prime Minister's Office, asked PAJ to have the oil companies supply more fuel.
- 2) Decided to relax the private sector stockpiling requirements in order to increase the supply for the demand (by the amount of 3 days' domestic demand) (March 14)

3-2 Several days after the earthquake

- 1) The Minister of Economy, Trade and Industry requested the oil industry to take measures regarding the supply to disaster areas in order to remove fundamental drawbacks. (March 17)
(Contents of the request)
 - Transport the stock of oil products and secure a stable supply of the products to disaster areas.
 - Resume operations of refineries stopped after the earthquake early on the premise of ensuring safety, and prepare to increase production in refineries in operation.
- 2) Decided to ease the private sector stockpiling requirements by the amount of 22 days' domestic demand (March 21)

3-3 Around Two Weeks After the Earthquake

Asked the oil industry to provide isolated areas with petroleum using drums and other means temporarily, because service stations were damaged devastatingly by the tsunami. The industry followed it.

- Complying with the request that was made soon after the earthquake, the industry shipped approximately 7,400 oil drums to the Self Defense Forces and municipalities.

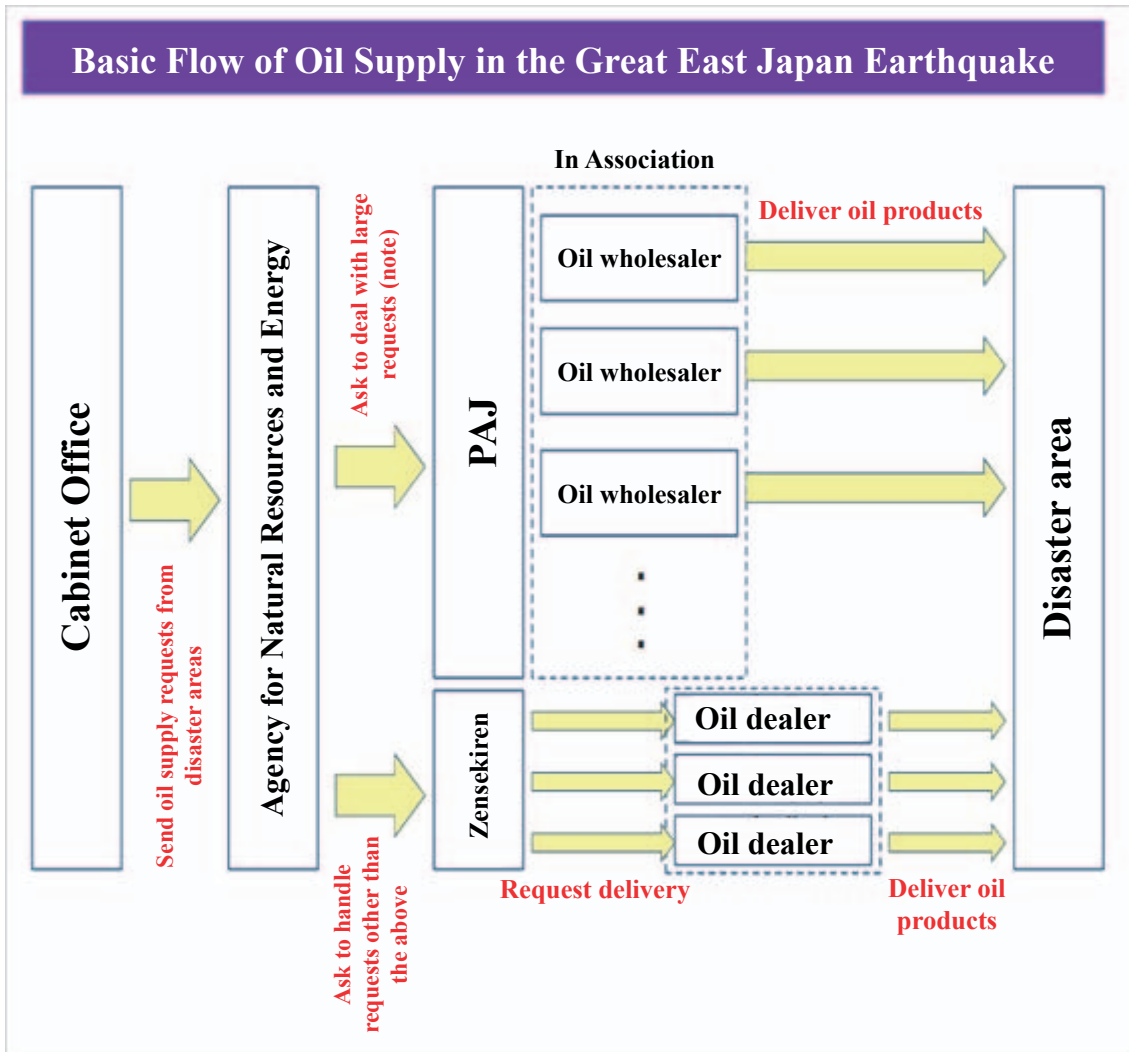
3-4 After Early April

Disruption in oil supply gradually settled (except some areas)

3-5 Basic Flow of Oil Supply to Disaster Areas in the Earthquake (refer to Figure 5)

- 1) The Cabinet Office sends oil supply requests from disaster areas to the Agency for Natural Resources and Energy.
- 2) The Agency asks PAJ to deal with large requests, and the Zensekiren to handle other requests.
- 3) PAJ calls for associated oil wholesalers to address the requests.
- 4) The Zensekiren asks each oil dealer to respond to assigned requests.

Figure 5. Basic Flow of Oil Supply at the Disaster Stricken Area



(Source) The Agency for Natural Resources and Energy

4. Response by the Oil Industry

4-1 Emergency measures

- 1) Established an emergency headquarter within PAJ (March 11) (Figure 6)
 - Handled fuel supply requested by the Prime Minister's Office (around 1,400 cases) (Fukushima Airport, fuel for cooling systems in the nuclear power plant and for vehicles, hospitals, municipalities, etc.)
 - Responded to the emergency procurement by the Ministry of Defense (for life-saving activities)
- 2) Provided petroleum preferentially to emergency vehicles such as of medical teams (only priority service stations in emergencies)
- 3) Set up temporary service stations in municipalities that had no service station within the radius of 10 km (10 areas) (Figure 8)

4-2 Supply Side (compensation for reduced supply capability due to shut down of some oil refineries)

- 1) Increased operation rates of existing refineries
- 2) Canceled the export of products and performed the emergency import
- 3) Requested the government to reduce the private sector stockpiling requirements (the amount of 3 days [approx. 1.26 million kl] were approved on March 14, and 22 days [approx. 9.24 million kl] on March 21)

<Changes in the volume of crude oil processed>

- Approx. 4 million BD before the earthquake
- Approx. 2.7 million BD after the earthquake -> about 30% decrease of total
- March 30: approx. 3.5 million BD per day -> returned to about 90% level before the earthquake

4-3 Logistics Side

- 1) Transferred petroleum from refineries in western Japan and Chubu areas, which increased operation rates, to Tohoku and Kanto areas
- 2) Established a cooperative system among oil companies mainly in disaster areas
 - Joint use of oil storage facilities and tank trucks, etc. (Figure 7)
- 3) Brought in approx. 300 tank trucks from western to eastern Japan in order to eliminate the bottlenecks in the logistics (about 150 tank trucks were washed away by the tsunami, and delivery distance was extended due to damage on oil depots)

Partially because of the measures described above, the turmoil that occurred immediately following the earthquake subsided in early April.

Figure 6. Operation Room in Emergency Headquarters of PAJ



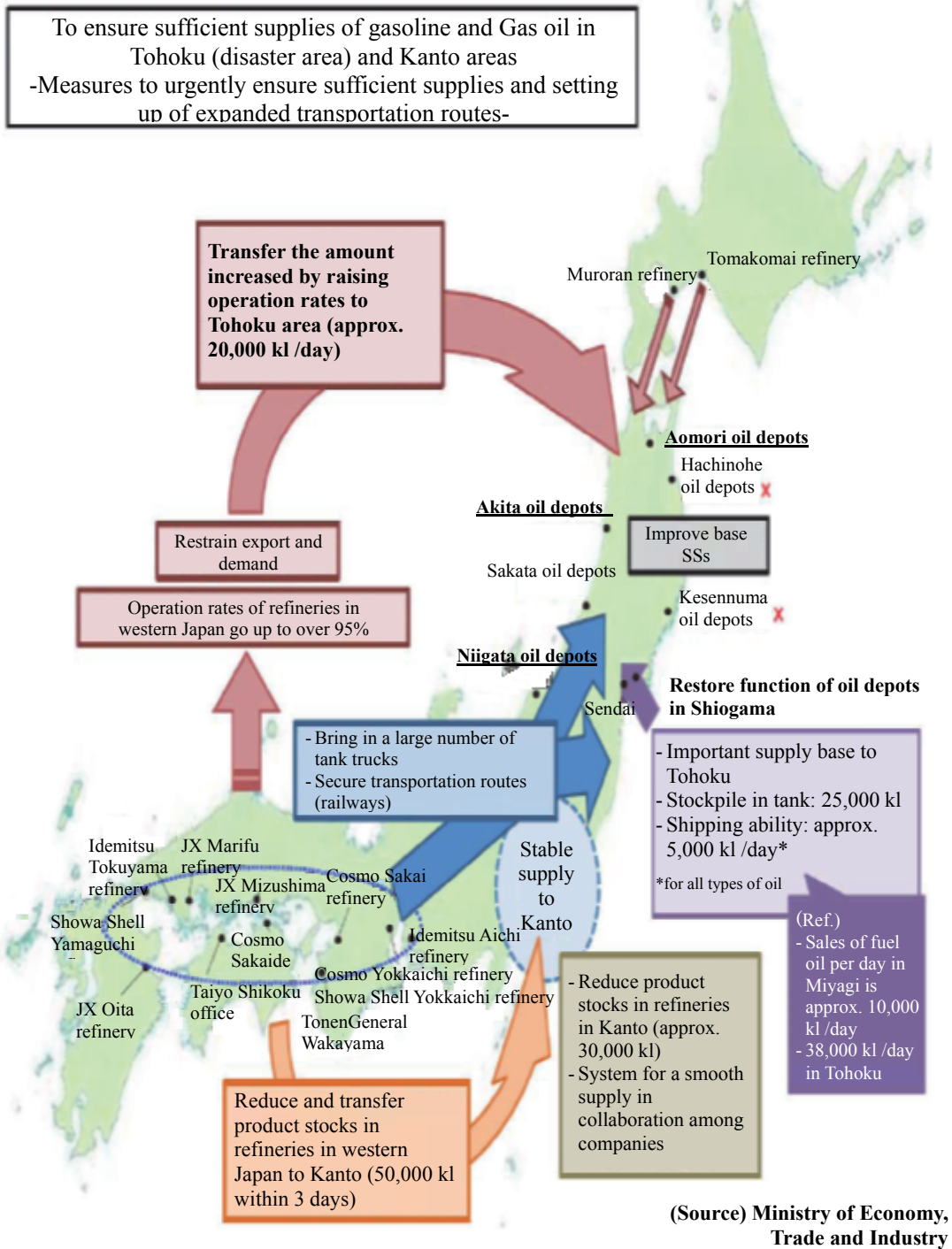
Figure 7. Joint Use of Oil Depots in Shioyama



Figure 8. Temporary SS Operated in Area Having No SS Nearby



Figure 9. Emergency Supply Flow in the Earthquake



5. Prices of Oil Products after the Earthquake

5-1 Impacts on prices in Tohoku by the earthquake

- 1) The price level in Tohoku before the earthquake was lower than the national average: -0.5 yen per liter in gasoline, -2.6 yen per liter in kerosene, and -0.9 yen per liter in gas oil.
- 2) The price level in March, just after the earthquake, changed against the national average: +1.1 yen per liter in gasoline, -1.3 yen per liter in kerosene, and +0.3 yen per liter in gas oil, which meant +1.6 yen per liter, +1.3 yen per liter, and +1.2 yen per liter higher than the usual levels, respectively. It may come from the damages of supply routes.
- 3) This tendency increased in April: +3.0 yen per liter in gasoline, +2.9 yen per liter in kerosene, and +2.8 yen per liter in gas oil, from the usual levels.
- 4) In general, however, there was no service station where prices were set to an extremely high level in the confusion.
- 5) In May, gasoline price was +1.1 yen per liter, kerosene +1.6 yen per liter, and gas oil +1.1 yen per liter, which suggested the prices were somewhat close to normal, compared to those in April.
- 6) In June, the prices further stabilized: +0.1 yen per liter in gasoline, +0.9 yen per liter in kerosene, and +0.1 yen per liter in gas oil from the usual levels, which meant the price level was almost the same as that before the earthquake.

Table 7. Price Comparisons of Oil Products between Tohoku District and the Rest of Japan before and after the Great East Japan Earthquake

	Average in Tohoku compared to the nationwide (yen per liter)		
	Gasoline	Kerosene	Gas oil
Pre-quake ... 1)	- 0.5	- 2.6	- 0.9
Post-quake to the end of March ... 2)	1.1	- 1.3	0.3
2) – 1)	1.6	1.3	1.2
April ... 3)	2.5	0.3	1.9
3) – 1)	3.0	2.9	2.8
May ... 4)	0.6	- 1.0	0.2
4) – 1)	1.1	1.6	1.1
June ... 5)	- 0.4	- 1.7	- 0.8
5) – 1)	0.1	0.9	0.1
July ... 6)	- 0.5	- 1.8	- 0.5
6) – 1)	0.0	0.8	0.4

(Source: the Oil Information Center)

5-2 Consideration

- 1) From just after the earthquake until the end of May, prices hovered at a higher level than the usual probably because the supplied amount was insufficient due to shut down of six refineries in Tohoku and Kanto, as well as logistical bottlenecks, such as partial closures of the road network and tank trucks washed away.
- 2) From June, the prices began returning to the usual level maybe because refineries were reopened one by one, oil products were transferred from western Japan, and tank trucks were supplemented.

Figure 10. Changes in Gasoline Price

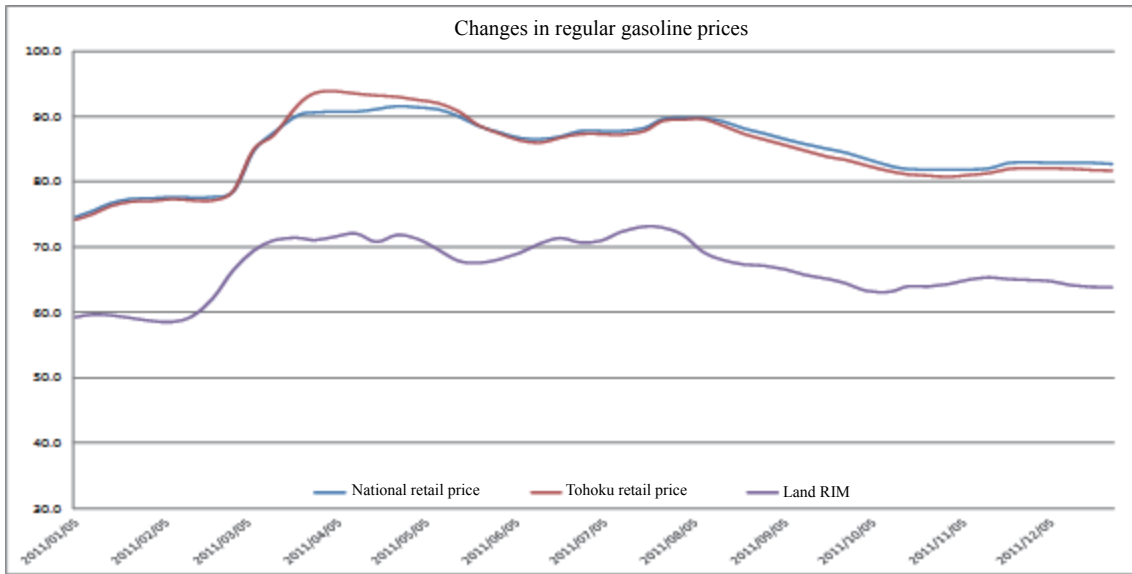
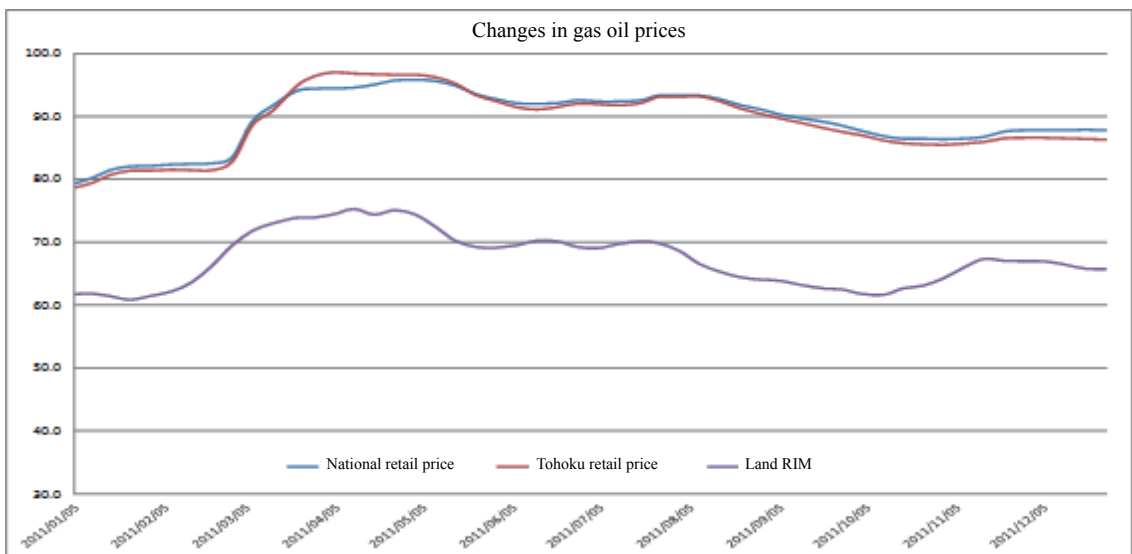


Figure 11. Changes in Gas Oil Price



6. Demand for Oil Products after the Earthquake

6-1 Impact on demand of oil products in Tohoku from the earthquake

- 1) In March when the earthquake occurred, the demand was largely affected in Tohoku: gasoline fell to 77.4% over the previous year and gas oil to 92.5%. In the whole nation as well, gasoline dropped to 92.5% compared to the previous year and gas oil to 94.0%.
- 2) While the gasoline demand returned to the level of the previous year in December, nine months after the earthquake, gas oil exceeded the prior year's level in June, three months later.

Table 8. Comparison of Gasoline and Oil Demand with the Previous Year

	Gasoline			Gas oil		
	Tohoku	Nation	Tohoku - Nation	Tohoku	Nation	Tohoku - Nation
Oct. 2010	96.6%	99.9%	-3.2%	97.6%	95.5%	2.1%
Nov.	106.8%	104.1%	2.7%	105.3%	102.1%	3.2%
Dec.	101.6%	100.5%	1.0%	103.2%	102.5%	0.7%
Jan. 2011	101.0%	100.2%	0.8%	105.2%	99.4%	5.8%
Feb.	105.7%	101.7%	3.9%	110.2%	105.1%	5.1%
Mar.	77.4%	92.5%	-15.1%	72.2%	94.0%	-21.8%
Apr.	84.9%	90.4%	-5.5%	95.8%	93.8%	2.0%
May	90.4%	98.3%	-7.9%	97.5%	98.2%	-0.8%
Jun.	93.8%	99.4%	-5.6%	103.9%	102.6%	1.3%
Jul.	95.5%	97.2%	-1.7%	106.5%	101.8%	4.7%
Aug.	91.7%	98.1%	-6.4%	107.9%	102.8%	5.2%
Sep.	95.6%	96.9%	-1.3%	107.7%	99.9%	7.7%
Oct.	99.6%	101.3%	-1.6%	104.3%	105.2%	-0.9%
Nov.	99.4%	98.8%	0.6%	104.5%	101.3%	3.2%
Dec.	100.9%	100.6%	0.3%	107.5%	101.7%	5.8%
Jan. 2012	101.5%	100.9%	0.5%	103.4%	101.2%	2.2%
Feb.	104.8%	103.0%	1.8%	111.6%	105.1%	6.5%
Mar.	124.3%	102.2%	22.1%	147.8%	106.2%	41.7%
Apr.	105.5%	100.7%	4.8%	104.2%	97.2%	7.0%
May	106.6%	101.9%	4.7%	124.6%	109.3%	15.4%

(Source: PJO)

6-2 Consideration

- 1) The significant decrease in demand in Tohoku was probably due to loss of houses and vehicles in the earthquake, and a tight supply caused by logistical bottlenecks, etc. The nationwide drop would be because of a tight supply and people's self-restraint in recreation.
- 2) Gas oil demand recovered more quickly maybe because of demand led by reconstruction.
- 3) A large increase in March 2012 was a reaction to the decrease in the previous year.

Figure 12. Comparison of Gasoline Demand with the Previous Year

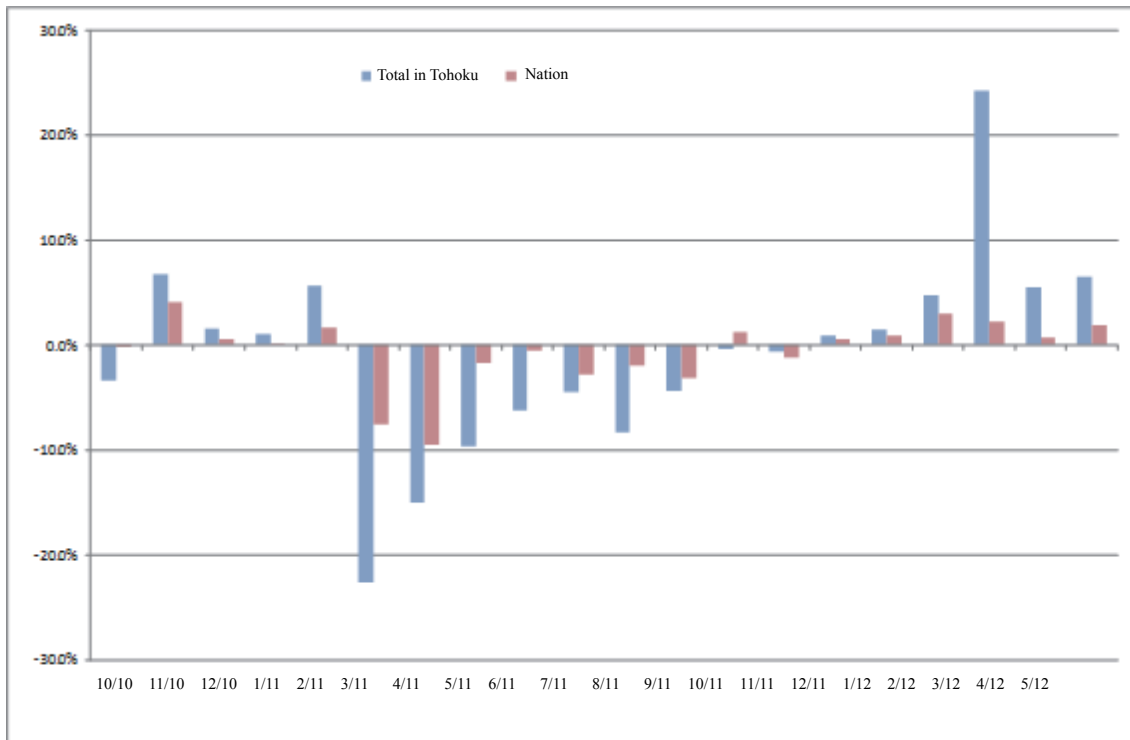
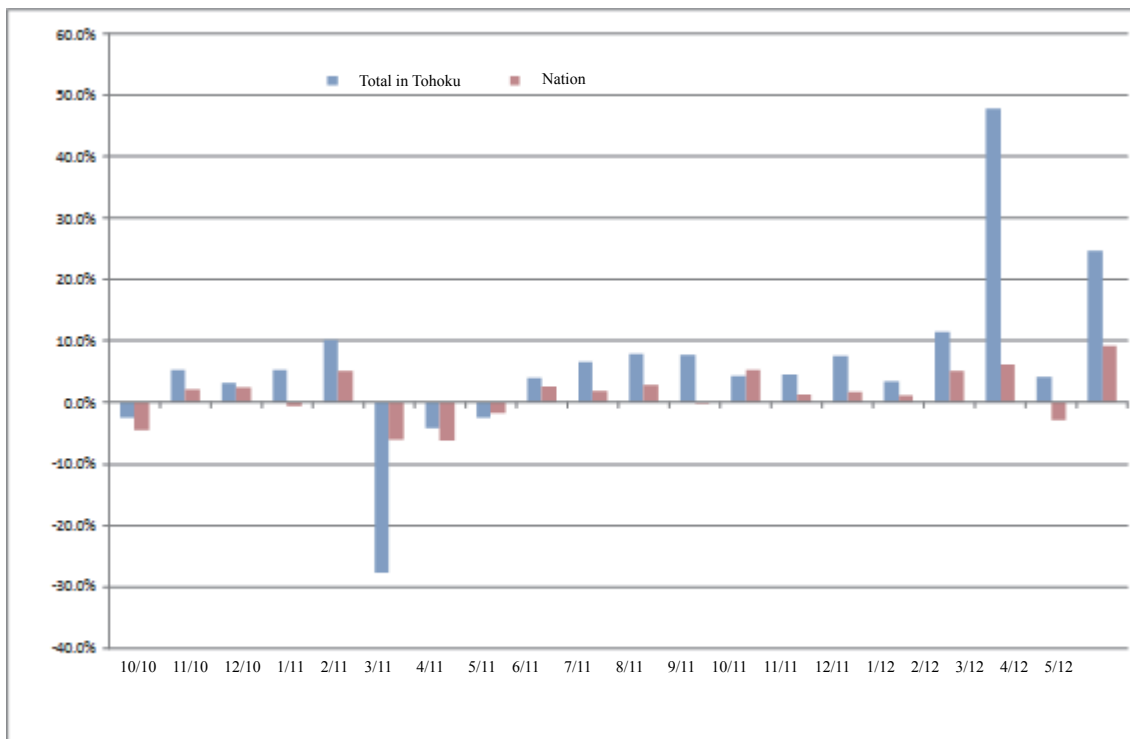


Figure 13. Comparison of Gas Oil Demand with the Previous Year



7. Subsequent Response

7-1 Subsequent response by the government

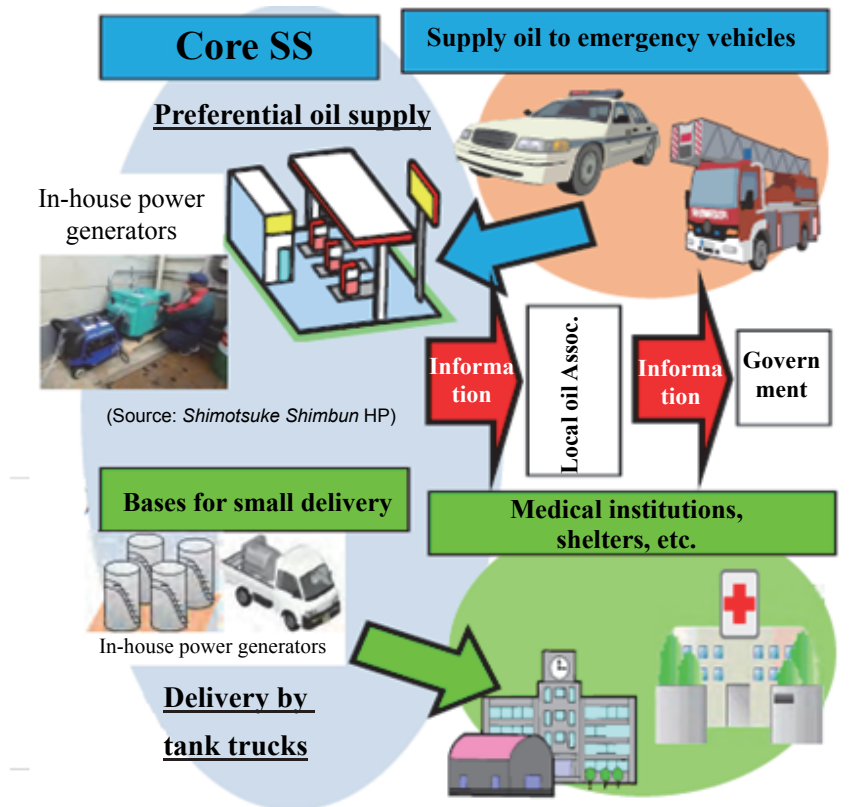
1) Preparation of core service stations to deal with emergencies (core SS)

In order to improve the ability of oil supply chains to address emergencies, the government supported the increase and improvement of in-house power generators, telecommunication equipment, and underground tanks, and promoted the policy to prepare core SSs as supply bases. (At present, the government has designated 1,700 SSs around the nation)

In addition, for the purpose of improving delivery bases of fuel in small amounts, the government enhanced the assistance to installation of in-house power generators and telecommunication equipment, the increase and improvement of underground tanks, and the introduction of tank trucks for delivery.

This is the support provided through collaboration among the industry, municipalities, and related government offices, to the both sides of hardware and software of service stations that are aware of importance of, and motivated to prepare for, a smooth logistics and a stable supply from refineries to service stations in emergencies. This is promoted as a government's program with a subsidy for necessary cost

Figure 14. Strategy of Oil Supply by Core Service Stations during Emergency



7-2 Subsequent response by the oil industry

(1) Strengthening of refineries and petrochemical complexes

After the Great East Japan Earthquake caused a significant damage to infrastructures, such as roads and port facilities as well as to oil companies, the oil industry made concerted efforts to supply sufficient oil products, including increased production in refineries in western Japan, bringing in tank trucks to eastern Japan from other areas, and joint use of oil depots in disaster areas.

In the meantime, since it experienced various problems in the earthquake, the industry is now advancing efforts to enable a stable supply of both hardware and software in case of an earthquake occurring below the Tokyo metropolitan region or major earthquakes along the Nankai Trough, which are predicted for the future in Japan.

Table 9. Oil Industry's Future Measures against Earthquakes

<u>Events in the Grate East Japan Earthquake</u>	<u>Measures against an earthquake occurring below the Tokyo metropolitan region or Great Earthquakes along the Nankai Trough</u>
1. Power sources to drive receiving and shipping pumps (public electricity and in-house power generators) were lost	Measures on the hardware side 1) Enhance the capacity to ship oil products 2) Take measures against the earthquake and liquefaction for refineries
2. Telecommunication means in refineries and oil depots were damaged	
3. Many requests for fuel supplies by drums came in, which were usually rare in peace time.	Measures on the software side 3) Develop a plan to collaborate for oil supplies in disasters 4) Prepare a BCP* for the corporate group 5) Designate oil companies as public institutions, based on the Disaster Control Measures Act*
4. Shioyama oil depots (near Sendai), which were recovered early, were jointly used beyond the company's borders	
5. Supply of products to consumers was disrupted by damage to tank trucks and SSs.	
6. Registration of tank trucks as emergency vehicles took a long time. *Procedures in police stations were required by March 15	
7. Access to refineries and oil depots became difficult (deposition of sediments and driftage to sea routes, collapse of roads, etc.)	

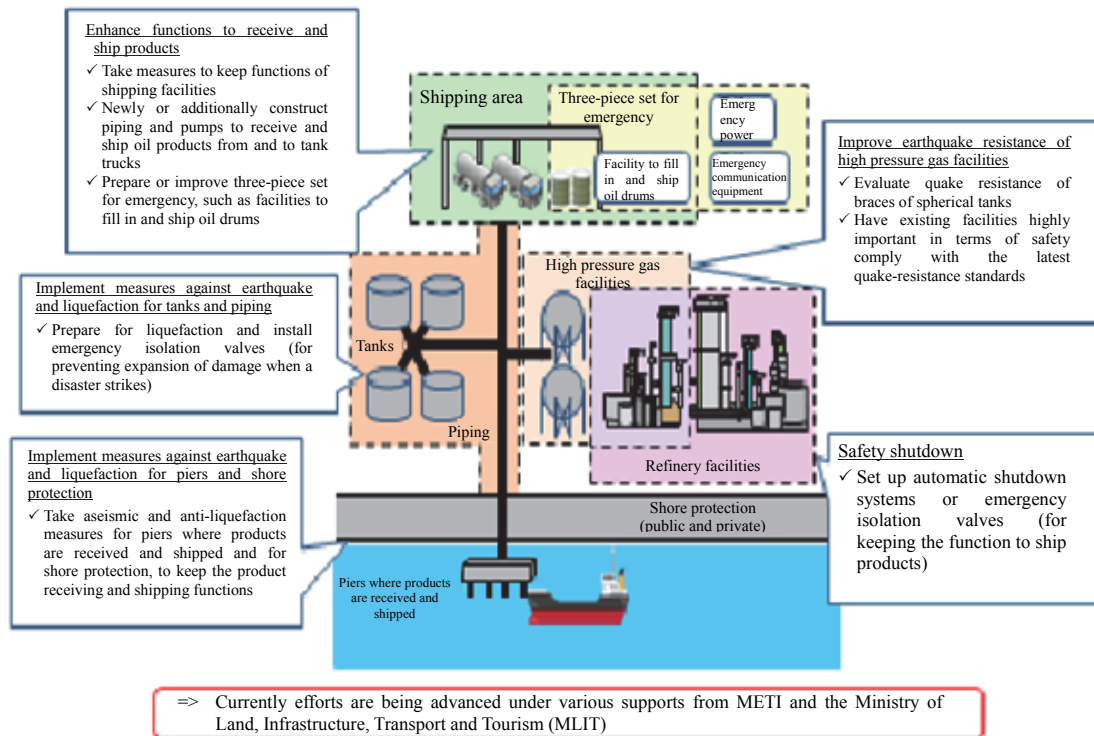
※BCP: Business Continuity Plan

(2) Measures on the hardware side of refineries

Enhancement of shipping capability has been decided because, even if production facilities are shut down in refineries, the oil supplies are to be continued by using product stocks and stockpiling in refineries and oil depots and by receiving backups from other refineries.

Measures are also being implemented for refineries against earthquakes and liquefaction.

Figure 15. Oil Refineries' Future Measures against Earthquakes



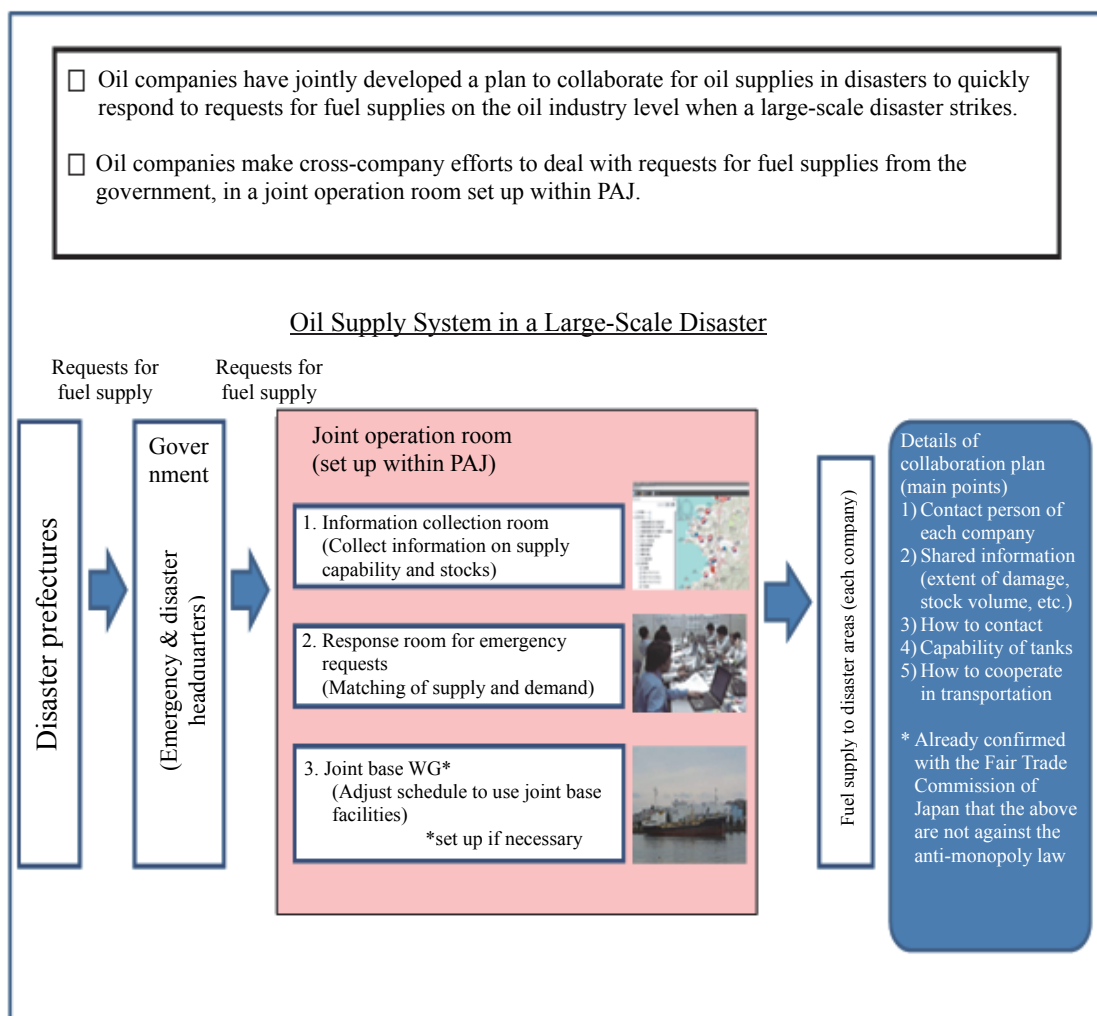
(3) Measures on the software side

1) Oil supply in emergencies, based on a plan to collaborate for oil supplies in disasters

Oil companies have jointly developed a plan to collaborate for oil supplies in disasters to quickly respond to requests for fuel supplies on the oil industry level when a large-scale disaster strikes.

Oil companies make cross-company efforts to deal with requests for fuel supplies from the government in a joint operation room set up within PAJ.

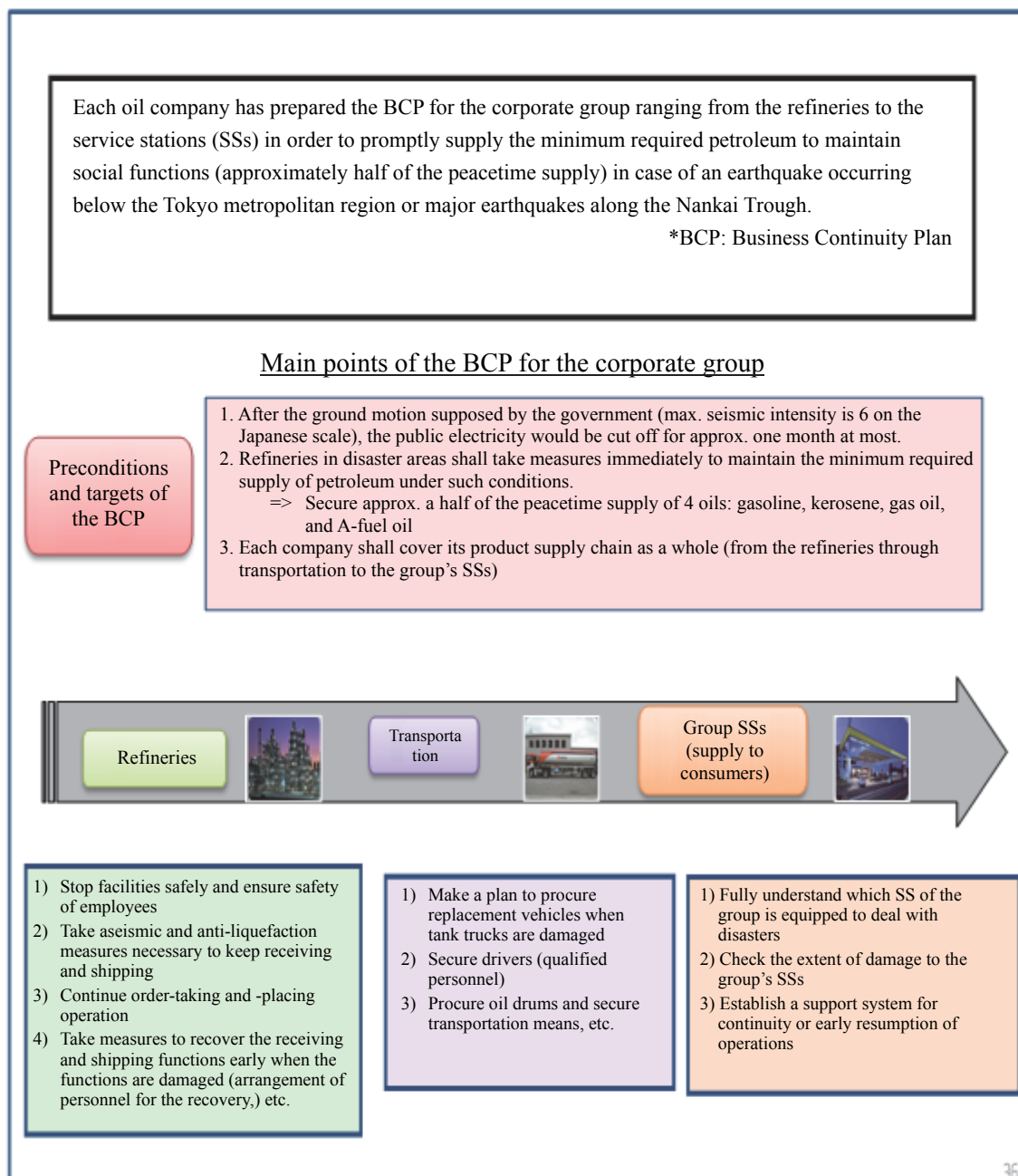
Figure 16. Cooperation between Government and Oil Companies at the time of Disaster



2) Development of BCP for the corporate group

Each oil company has prepared the BCP for the corporate group ranging from the refineries to the service stations (SSs) in order to promptly supply the minimum required petroleum to maintain social functions (approximately half of the peacetime supply) in case of an earthquake occurring below the Tokyo metropolitan region or major earthquakes along the Nankai Trough.

Figure 17. Basic Flow of Oil Supply from Oil Refineries to Service Stations



8. Future Issues

8-1 Measures already taken

Revision of the Petroleum Reserve law (effective on November 1, 2012)

1) Review of stockpile release requirements

Now it is possible to release the government oil reserve and LP gas at the time of a domestic oil supply shortage in a certain area due to a disaster, in addition to a shortage of oil supply from overseas.

2) Obligation of preparation of joint supply plans

Oil wholesalers are obliged to cooperatively prepare in advance a joint supply plan for every 10 areas in Japan regarding how to supply oil products at the time of a disaster.

8-2 Issues

1) Shift of part of stockpiles from crude oil to oil products

At present, the stockpiles owned by the government are composed of crude oil, and as for stockpiles of the private sectors, the amount beyond the running stocks is reserved in the form of crude oil because the obligation assumes a crude oil shortage. In the meantime, at the time of the Great East Japan Earthquake, oil products were temporarily in short supply due to shutdowns of refineries, which caused turmoil. Currently, further shutdowns of refineries are considered under the Law Concerning Sophisticated Methods of Energy Supply Structures, so more balanced allocation between crude oil and oil products would be necessary.

2) Promotion of self-defensive reserve on the consumer side

It is supposed that long-distance transportation of petroleum would be difficult in case of a great earthquake because recovery of damaged infrastructure networks such as roads and sea routes would take a long time. Therefore, bodies (consumers) that operate so-called socially important infrastructures, such as municipalities (including fire stations, police stations, water supply and sewerage, etc.), hospitals, broadcasting and communications, and financial business, should advance their self-defensive reserve of fuel to ensure keeping their operations. According to the survey by the Agency of Natural Resources and Energy, among facilities related to broadcasting, communications and finance, and disaster base hospitals, only 47% reserve “3-days or more” fuel for in-house generators.

(Reference) Summary of Petroleum Reserve System in Japan

Petroleum accounts for 47.4% of the primary energy supply in Japan (in FY 2012), but the most of it depends on imports from overseas. Especially, around 85% rely on the Middle East, which is higher than 81% in 1972 just before the first oil crisis.

For Japan, a country with few natural resources, energy security is a critical issue affecting the fundamentals of people's lives and economic activities, so it constitutes the basis of our energy policy. Following the first oil crisis, IEA was established, and obligated the member countries to reserve petroleum for 90 days. To comply with the requirement, Japan enacted the Petroleum Reserve Law in 1975, and private sector stockpiling officially began. In 1978, government stockpiling also started under the Japan National Oil Corporation (current JOGMEC).

Currently, as the government stockpiles, approx. 50 million KL of crude oil and 130 thousand KL of products (kerosene) are reserved, and the private sectors are obliged to reserve the amount of 70 days. At present, the private sector stockpiles exceed the 70-days requirement by 10 days because oil demand has significantly fallen and the domestic demand decreased, so the total stockpiles are 185 days (85.9 million S as of the end of march, 2013).

During the Gulf crisis in 1990, the Japanese reserve was at a high level of 142 days (as of the end of December 1990), which enabled Japan to respond to the crisis calmly, and contributed to stabilizing the oil supply and prices. Through this event, the importance of the oil reserve was reconfirmed.

In the Great East Japan Earthquake in March 2011, METI reduced the requirement of the private sectors by 3 days and subsequently by 22 days, which totaled 25 days (equivalent to 10.5 million KL), in order to ensure a smooth supply of gasoline and gas oil to disaster areas.

In 2012, based on the experiences from the Great East Japan Earthquake, the government revised the Petroleum Reserve Law by allowing the government stockpiles to be released at the time of an oil supply shortage in a certain area due to a disaster, in addition to an oil supply disruption from overseas.

Furthermore, the following provisions were incorporated into the law in order to deal with large disasters in Japan: (1) oil companies are obliged to cooperatively prepare in advance a joint supply plan in disaster for every 10 regions across Japan, (2) when a disaster occurs, the METI ministry will urge oil companies to take measures based on the joint supply plan, and (3) oil dealers are obliged to inform the government of the facility conditions of their service stations so that the stations that satisfy requirements such as the size of the fueling system can be used as supply bases (core SS) in the event of a disaster.

Figure 18. Changes in Stockpiling Requirement Days

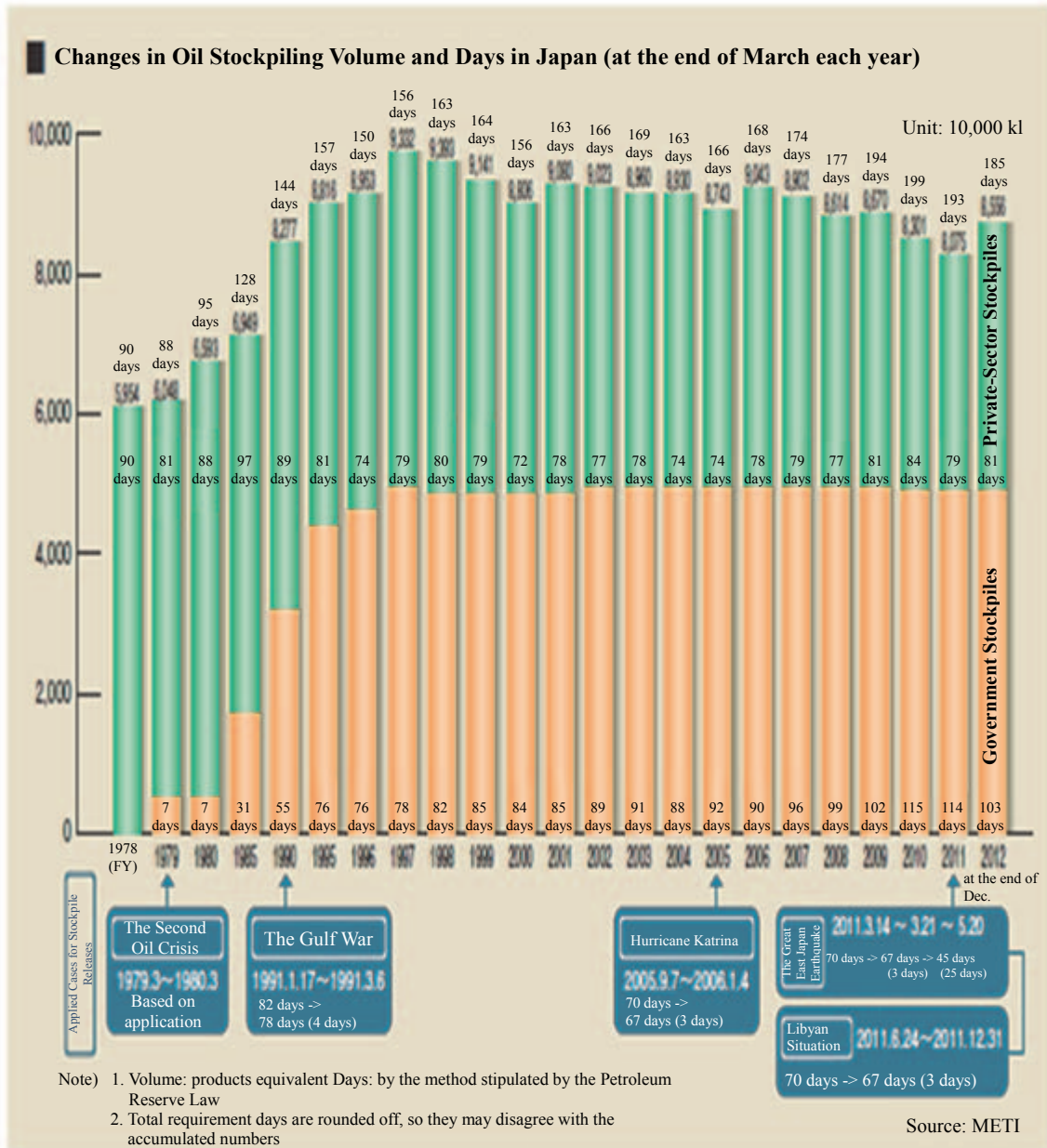


Table 10. Outline of Stockpiling System

	Government stockpiles	Private-sector stockpiles
Days	103 days	81 days
Volume (products equivalent)	47.83 million kl	37.73 million kl
Target	50 million kl (basically crude oil, attained in February, 1998)	70 days of domestic demand
Method	In sealed designated storage tanks	Through production and distribution processes
Location	1) Bases for government stockpiles 2) Tanks borrowed from private sectors	Private-sector tanks in refineries, bases, and oil storage facilities
Composition	Crude oil: 99.5% Products: 0.5%	Crude oil: 50% Products: 50%
Administrative body	1) Government-run reserve companies (approx. 2/3 of government stockpiles) (8 companies and 10 bases across Japan) 2) Private oil companies (approx. 1/3 of government stockpiles) (Borrowed tanks from private sectors and commissioned the administrative work to private companies)	Oil refiners and importers. Joint reserve companies are allowed to handle the work.
Characteristics when released	1) Release of the reserved crude oil by the government will ensure an increase in supply to the market, and a large announcement effect can be expected, which will contribute to achievement of government's objectives 2) Less mobility than private sectors, but the oil reserved in private-sector tanks and in some bases of the government stockpiles can be released promptly.	1) Oil is reserved in forms of crude oil and products mainly in refineries and oil storage facilities through the processes of production and distribution, so the prompt supply to the distribution channel is possible. 2) It is possible to release flexibly according to the procurement trends of crude oil and demand changes of oil products. 3) The announcement effect is weaker than the government
Actual cases of release	None (only replacement in release training)	1) The Second Oil Crisis (Mar. 1979 - Aug. 1980) 2) Gulf Crisis (responding to CERM) (Jan. - Mar., 1991) 3) Hurricane Katrina damage (Sep. - Dec., 2005) 4) The Great East Japan Earthquake (Mar. - May, 2011) 5) Libyan Situation (Jun. - Dec., 2011)