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Gas Resiliency Assessment of Japan

Findings from the workshop held in Tokyo on 11 July 2016, organised jointly by the International Energy Agency and the Ministry of Economy, Trade and Industry of Japan (METI).

INTERNATIONAL ENERGY AGENCY

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Executive summary

The "Gas Resiliency Assessment of Japan" workshop, organised jointly by the International Energy Agency (IEA) and the Ministry of Economy, Trade and Industry (METI) of Japan, was held in Tokyo on 11 July 2016. It was attended by an assessment team from the IEA and representatives of the Japanese power and gas industry. This unprecedented initiative undertook a general assessment of the current Japanese gas market and of Japan's gas emergency response policies, exploring the potential impact of, and expected response to, possible major gas disruption.

Japan has a large and mature energy system where gas plays an important role, particularly so after the 2011 Great East Japan Earthquake. In 2015, Japan's total primary energy supply (TPES) stood at an estimated 436 million tonnes of oil-equivalent (Mtoe), a 16% decline from its peak in 2005. The earthquake significantly affected Japanese energy supply, with the shutdown of all nuclear power stations that had provided 25% of power generation in 2010. As a consequence, natural gas has become significantly more important in the country's energy mix. Its use in power generation increased considerably after the earthquake from 28% in 2010 to 39% in 2015 in order to compensate for the significant loss of nuclear power generation, which collapsed to zero in 2014.

As Japan produces less than 3 billion cubic metres (bcm) of domestic natural gas a year and has no cross-border pipelines, Japanese gas consumption has been met predominantly by liquefied natural gas (LNG) imports, making Japan the world's largest LNG consumer. With an import dependency of almost 98% in 2014, the country's total natural gas imports amounted to 125 bcm (equivalent to 91.5 million tonnes [Mt]) with relatively well-diversified import sources. In 2014, the power generation sector was the largest consumer of natural gas in Japan, representing about 70% of the country's total gas consumption; the industrial sector and the residential sector represented 13% and 8% respectively, while energy sector own use and commercial/other accounted for the remaining 9%.

The Asia-Pacific LNG market tightened following the sudden increase in LNG imports by Japanese electric utilities in response to the decline in power generation capabilities caused by the 2011 Great East Japan Earthquake and Tsunami, as well as the Fukushima Nuclear Accident. This coincided with high crude oil prices above USD 100 per barrel, which raised Asian LNG price levels to around USD 18 per million British thermal units (MBtu) via traditional oil indexing systems. Regional price disparities between Europe, North America and Asia widened, prompting discussions over the need for more liquid, flexible and transparent gas markets and new pricing mechanisms to replace oil-indexation after 2012-13.

Since then, utilities in Asia have made additional efforts to develop new procurement contracts and more flexible pricing, with some success. In parallel, market fundamentals both in supply and demand changed, with new supplies from Papua New Guinea starting production earlier than planned, nuclear power plants coming back on line and coal-fired power plants recovering in Japan. LNG price levels are currently around USD 6-7/MBtu.

Against this backdrop, the main findings of the workshop are:

- **Global market context**
  - The currently well-supplied market is providing a major opportunity to achieve more flexible market arrangements and new pricing systems to reflect the regional supply and demand balance. Government and the private sector should use the current favourable market conditions to secure more flexible and efficient LNG trade through such measures

as the elimination of destination clauses. They should also continue to diversify their long-term supply contract portfolios, for example by ensuring suitable contract flexibility to increase imports in emergencies and by leveraging upward quantity tolerance (UQT).

- With the changes in supply/demand fundamentals and the private sector's efforts to increase flexibility in procurement, the use of spot and short-term contracts has increased in recent years. The private sector should explore the most appropriate balance ratio of spot/short-term contracts and long-term contracts to enhance their supply security resilience in the long term.
- Government and the private sector should continue to promote better understanding of LNG market developments, including investment requirements as well as the need for better information transparency (e.g. spare gas liquefaction capacity). The promotion of a better dialogue between LNG producers and consumers helps improve market transparency, and the annual LNG Producer-Consumer Conference held in Tokyo is a commendable initiative along these lines.

- **Gas market reform**
  - To take advantage of increasing liquidity in global LNG markets, domestic gas markets should be liberalised with a hands-off approach by the government. The government of Japan recently started the comprehensive reform of the gas and electricity sectors to move from the existing regional monopolies to a more competitive model. This is in line with the past recommendation by the IEA in the report *Developing a Natural Gas Trading Hub in Asia* (IEA, 2013). This reform, together with additional measures on the finance side, such as creating liquidity by promoting LNG futures trade, may improve the position of the country as regards its ambition to function as an LNG trading hub. Within this context, it is important to continue encouraging the well-functioning of the spot market for LNG in order for players to leverage portfolios relying on flexible LNG cargos.
  - The government of Japan, therefore, should continue its ongoing energy sector market reforms and ensure that the new gas market rules allow truly effective and transparent third-party access to LNG terminals and natural gas pipeline networks. It should explore efficient, transparent and accessible mechanisms to resell the excess capacity of the primary contractor via a competitive secondary market.
- **Gas infrastructure**
  - Japanese gas markets are local, without major gas pipeline network connections at the national level. Current law empowers the government to be more involved in the development of pipelines that can connect isolated regions and expand city gas supplies. Such additional pipeline networks could provide critical infrastructure to promote competition in the gas market and enhance supply security.
  - The Great East Japan Earthquake damaged LNG terminals and supply networks along the north-eastern Pacific Ocean coast of Japan. The gas pipeline between Niigata on the Sea of Japan coast and Sendai on the Pacific Ocean coast worked as a backup supply channel. This experience emphasised the importance of having stable gas transport routes that connect coasts, as well as the importance of developing pipelines that connect LNG terminals in different regions. Ensuring a reasonable amount of reloading capacity at LNG terminals and increasing underground storage capacity, as well as clarifying the rules for its utilisation to enhance third-party access, also constitute important infrastructure-related measures to be taken for the overall security of supply.
- **Emergency response capacity**
  - Taking into account its high import dependency, Japan has developed a robust security of supply policy, including emergency response. Emergency response measures are

co-ordinated at three levels: at individual company level, industry level and cross-industry level. Emergency response actions in the recent past, both to the Great East Japan Earthquake and Tsunami and to the recent earthquake in Kumamoto, have been effective, with quick co-ordination at all three levels.

- Such good co-ordination in emergency response may have been made more straightforward by the limited number of players acting in their capacity as regional monopolies. However, the ongoing market reforms that will bring about benefits from market flexibility and transparency might also complicate co-ordination in emergency response, with more participants in the whole supply chain. New participants in the market may be smaller in size than traditional regional utilities. The government should monitor the impact of liberalisation of the gas market on emergency preparedness and ensure that new market entrants have suitable response capabilities.
- One possible measure to maintain robust emergency response capacities under a liberalised market system would be to create a National Emergency Strategy Organisation (NESO) for natural gas supply disruptions. Such an institution could help enhance situation awareness and engender effective and efficient co-ordination among relevant parties to ensure supply stability in an emergency situation; a close co-operation with the existing NESO for oil supply disruptions may also be part of the new arrangement for natural gas supply disruptions.

- **Demand restraint and fuel switching**
  - In general, Japanese gas utilities as a whole have well-diversified LNG sources and are well prepared for a possible supply disruption. That would not, however, be an excuse for not preparing demand-side response. The government should, in co-ordination with the gas industry, consider how best to reduce gas demand during significant supply shortages and prepare with stakeholders suitable operational procedures for activating demand restraint measures, including identification of priority users in emergencies. In doing so, it would be desirable to include options for more market-oriented demand restraint mechanisms.
  - Some electric power utilities in Japan have a high dependence on certain LNG-producing countries and regions. As a major proportion of imported LNG is used for power generation, providing nearly 40% of Japanese electricity, LNG supply security directly links with electricity security in Japan.
  - The government of Japan and power industries should continue to restore a better balance in the Japanese power generation mix, making additional efforts to restart nuclear power plants that are certified safe by the new nuclear safety authority based on the new standards.
  - The earthquake in 2011 also highlighted the unique role provided by ageing oil-fired power generation plants as backup capacity. This oil-fired power generation capacity supported the Japanese power system and helped avoid major black-outs. Government and the private sector should seriously consider the role of such ageing power plants and relevant supply chains, taking into account the balance between the need for supply security in an emergency and the cost of maintaining additional backup capacity.
  - In the longer term, gas-fired power generation will need to play an increasingly important role in providing flexibility to the electricity systems with higher shares of variable renewables. The nature of gas demand after the transformation to renewables-based power systems could be more rigid compared with power systems where most of the electricity is generated by dispatchable generation sources. Government should explore the implications for gas supply security under such a decarbonised power system.

Introduction

This is a summary of the findings of the "Gas Resiliency Assessment of Japan" workshop, organised jointly by the International Energy Agency (IEA) and The Ministry of Economy, Trade and Industry (METI) of Japan, held in Tokyo on 11 July 2016. The aim of the workshop was to identify the gas supply security risks and challenges facing Japan and to examine whether its existing policies to address these challenges are and will remain relevant in the near future.

The challenges surrounding security of gas supply are evolving, with increasing gas market globalisation through the expansion of liquefied natural gas (LNG) trade, and growing reliance on gas to provide flexibility in the context of greater variability from intermittent renewable power sources. These circumstances are creating greater interdependencies between natural gas and the rest of the energy system, whereby shocks in one sector or region can reverberate in others.

Accordingly, the traditional approach of viewing gas as a stand-alone fuel in a specific region is becoming less relevant – a broader approach to gas market security is now required, addressing international LNG trade flows, transparency aspects of the LNG value chain, and the demand-side aspects of supply security.

According to the new *IEA World Energy Investment 2016* report (IEA, 2016a), major oil and gas companies cut upstream spending by around 25% in 2015 and an estimated 24% in 2016. The IEA *Medium-Term Gas Market Report 2016* (IEA, 2016b) noted that there were no final investment decisions (FIDs) for new liquefaction projects in the first half of 2016, and also that 15% of global LNG capacity, mostly in North Africa, has come off line. This could lead to the re-emergence of concerns about security of gas supply.

In this light, considering the new challenges and opportunities associated with the growing globalisation of gas markets, ministers asked the IEA Secretariat at the 2015 IEA Ministerial meeting to develop potential options to enhance global gas supply security. Subsequently, the G7 Kitakyushu Energy Ministerial Meeting held in May 2016 in Japan asked the IEA Secretariat to conduct gas resiliency assessments as part of its work to improve the functioning and resilience of gas markets and to share experiences and approaches for managing gas emergencies.

The workshop was attended by an assessment team from the IEA and by representatives of the Japanese power and gas industry. The workshop undertook a general assessment of the current Japanese gas market and of Japan's gas emergency response policies, and explored the potential impact of, and expected response of Japan to, possible major gas disruption from one of the main suppliers to Japan and Asia in general. The hypothetical scenario showcased by IEA and the simulated emergency responses allowed for detailed discussions on the strategies of both the power and the city gas sectors both heavily reliant on LNG imports. The scenario was also used to explore the role of government in an emergency situation.

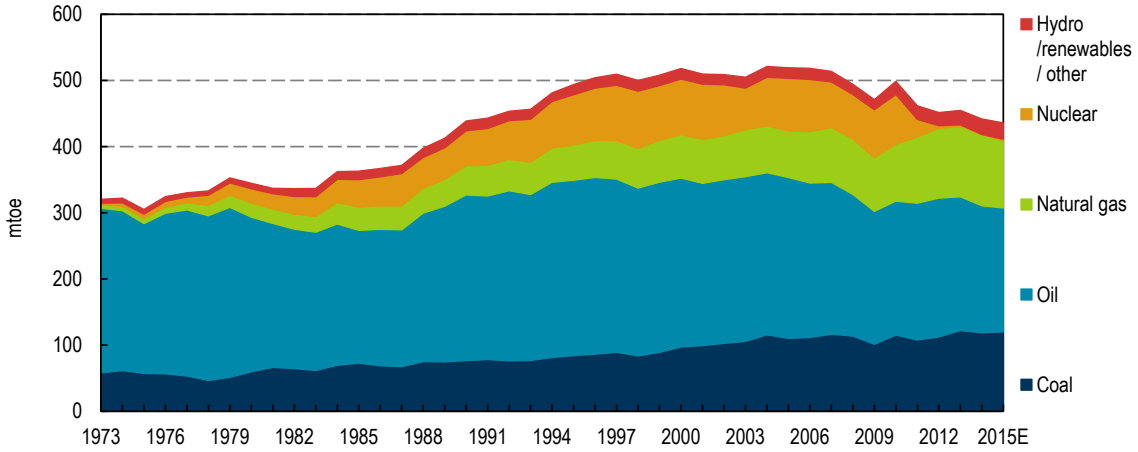
The remainder of this introductory section comprises a synopsis of Japan's energy sources and consumption, government energy policy, and natural gas supply and demand. It is followed by sections on each of the six themes covered during the course of the workshop:

- global market context
- gas market reform
- gas infrastructure
- emergency response capacity
- demand restraint and fuel switching.

Japan's energy supply and power mix outlook

Japan's total primary energy supply (TPES) stood at an estimated 436 million tonnes of oil-equivalent (Mtoe) in 2015, a 16% decline from 519 Mtoe in 2005 (Figure 1). Japan's domestic electricity production in 2015 totalled 1009 terawatt hours (TWh).

Figure 1 • TPES in Japan, 1973-2015

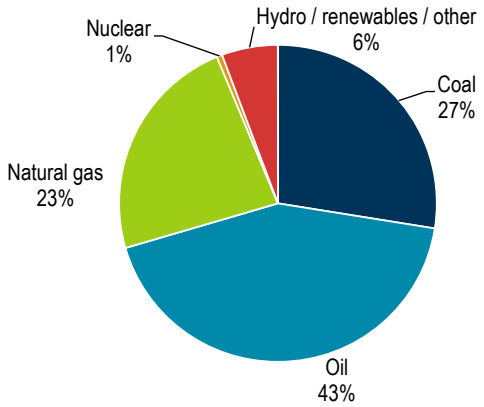


Note: E = estimate.

Source: IEA (2016c), *World Energy Statistics and Balances* (database), www.iea.org/statistics/.

After the 2011 Great East Japan Earthquake and the subsequent accident at the Fukushima Daiichi nuclear power station, all nuclear power was shut down. Some of the coal-fired power plants located along the Pacific coast in the affected region were also extensively damaged by the tsunami following the earthquake. Therefore, the significant loss of nuclear power generation, which saw its share drop from 25% in 2010 to zero in 2014, was mainly compensated by LNG power generation and oil power generation.

Figure 2 • TPES in Japan by source, 2015

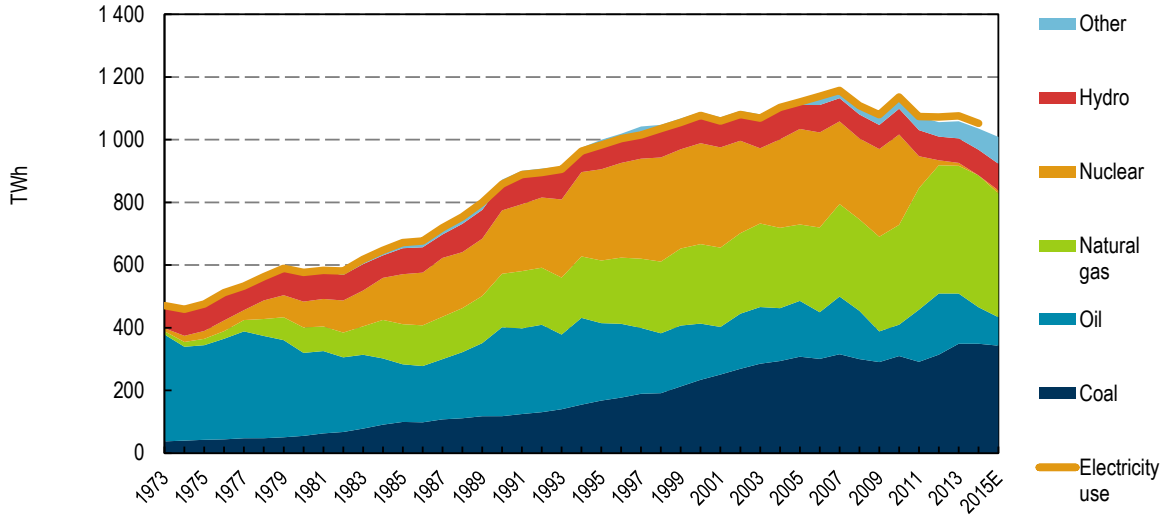


Note: These figures are not yet final. They are estimates and therefore subject to change.

Source: IEA (2016c), *World Energy Statistics and Balances* (database), www.iea.org/statistics/.

The share of natural gas in the country's TPES increased from 17% in 2010 to 23% in 2015 (Figure 2), and more significantly, natural gas use in power generation increased from 28% in 2010 to 39% in 2015.

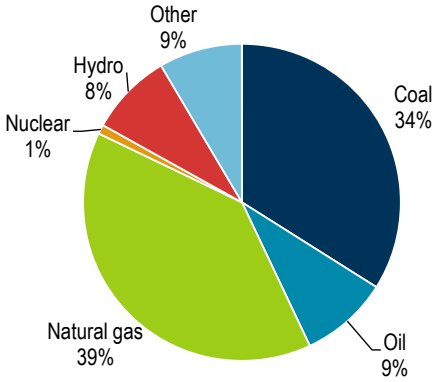
Figure 3 • Electricity generation in Japan, 1973-2015



Note: E = estimate.

Source: IEA (2016d), *Electricity Information*, (database), www.iea.org/statistics/.

Figure 4 • Electricity generation in Japan by source, 2015

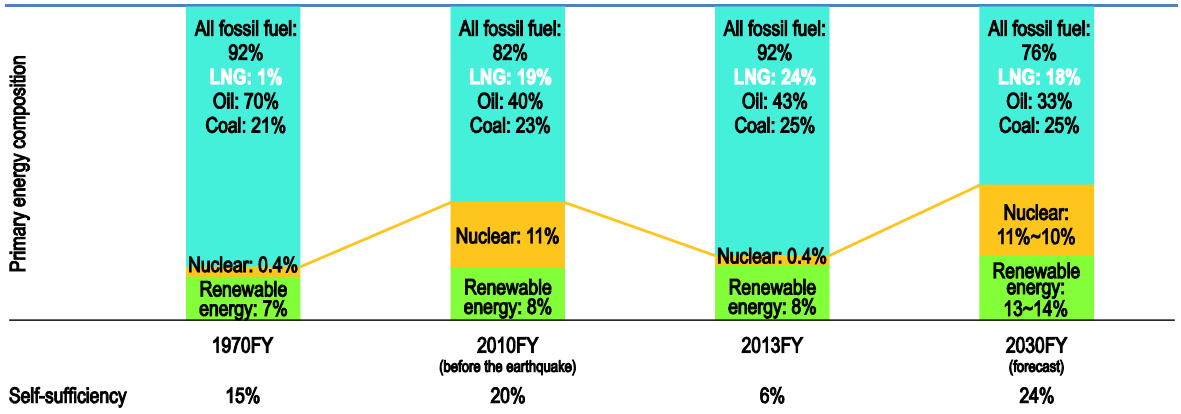


Note: These figures are not yet final. They are estimates and therefore subject to change.

Source: IEA (2016d), *Electricity Information*, (database), www.iea.org/statistics/.

According to the government's current *Strategic Energy Plan*, which was adopted in April 2014 (METI 2014), a shift to natural gas is expected in various sectors in Japan. In the plan, natural gas is positioned as a middle-load power source, as it involves relatively low geopolitical risk compared to oil and emits the least amount of greenhouse gases among fossil fuels, and its output can be adjusted flexibly according to demand. Natural gas is expected to consolidate its share in the energy mix of the country, for example by playing its part in laying the foundation for a "hydrogen society".

Figure 5 • Primary energy supply outlook for Japan, 1970-2030



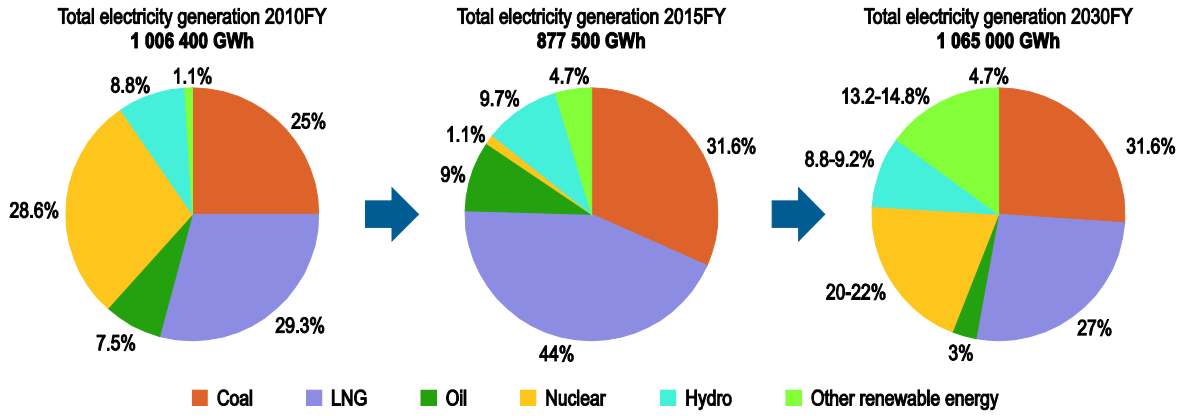
Note: FY = fiscal year (1 April to 31 March).

Source: Japanese Ministry of Economy, Trade and Industry (METI).

Based on the *Long-Term Energy Supply and Demand Outlook* prepared by the government in July 2015 (METI 2015), the share of natural gas in the primary energy supply in 2030 is projected to be approximately 18% (Figure 5). This would be similar to the level before the earthquake, but lower than the 24% seen in 2013. In the outlook of the country's primary energy supply structure, Japan's energy self-sufficiency rate is forecast to reach 24% in 2030, having dropped to 6% in 2013 compared to 19% prior to the earthquake. This increase will be met by additional renewable energy sources of 13-14% and nuclear energy being brought back online with 10-11% of the total share. As such, restarting nuclear power plants and increased deployment of renewable power generation are considered to be key factors for the overall energy security of Japan towards 2030 and will have a large impact on reducing dependency on LNG (Figure 6).

At the time of writing, three nuclear reactors have been put back into operation (two units at Sendai Nuclear Power Plant and one at Ikata Nuclear Power Plant, which resumed operation in August 2016) after a prolonged review process under the new safety regulations.

Figure 6 • Japan's power mix outlook towards 2030



Note: GWh = gigawatt hour.

Source: Japanese Ministry of Economy, Trade and Industry (METI).

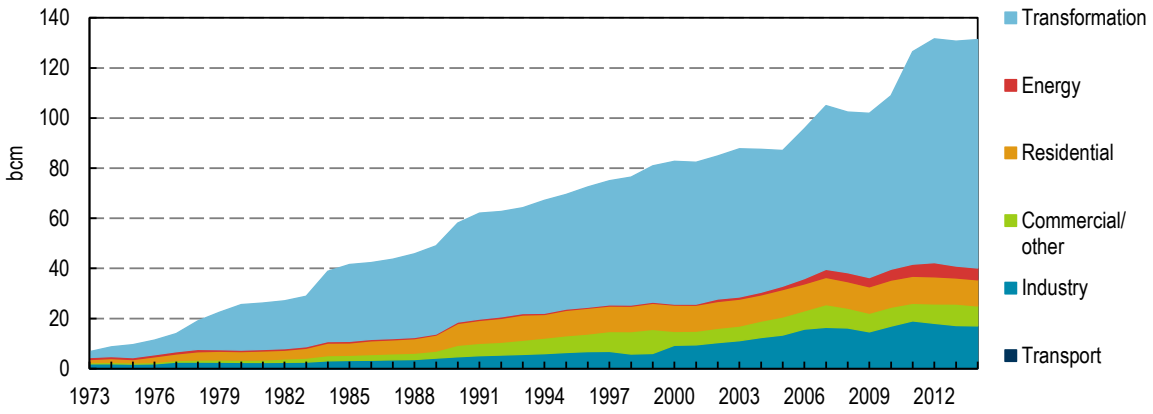
Natural gas supply and demand in Japan

Japan produces less than 3 billion cubic metres (bcm) of natural gas per year from its domestic gas fields. Japanese gas demand is mainly supplied by imports in the form of LNG, which makes Japan the world's largest LNG consumer (its share of global LNG trade is around 36%). In 2015, the country's total natural gas imports amounted to 117 bcm (85.5 million tonnes [Mt]), a slight decline from the previous year where it reached 125 bcm, but still a 15% increase compared to the pre-earthquake level.

Japan's gas demand for power generation has grown rapidly since the Great East Japan Earthquake in 2011, reaching 91 bcm (67 Mt) in 2014.

In 2014, the transformation (power generation) sector was the largest consumer of natural gas in Japan, representing about 70% of the country's total gas consumption, while the industrial sector and the residential sector represented 13% and 8% respectively (Figure 7).

Figure 7 • Natural gas consumption by sector, Japan, 1974-2014



Source: IEA (2016e), *Natural Gas Information*, (database), www.iea.org/statistics/.

Due to the strong gas demand for power generation, the largest importers of LNG in Japan are the electric power companies. In April 2015, Tokyo Electric Power Company (EPCO) and Chubu EPCO established a joint venture, JERA Co., which has become the world's largest single buyer of LNG (Table 1).

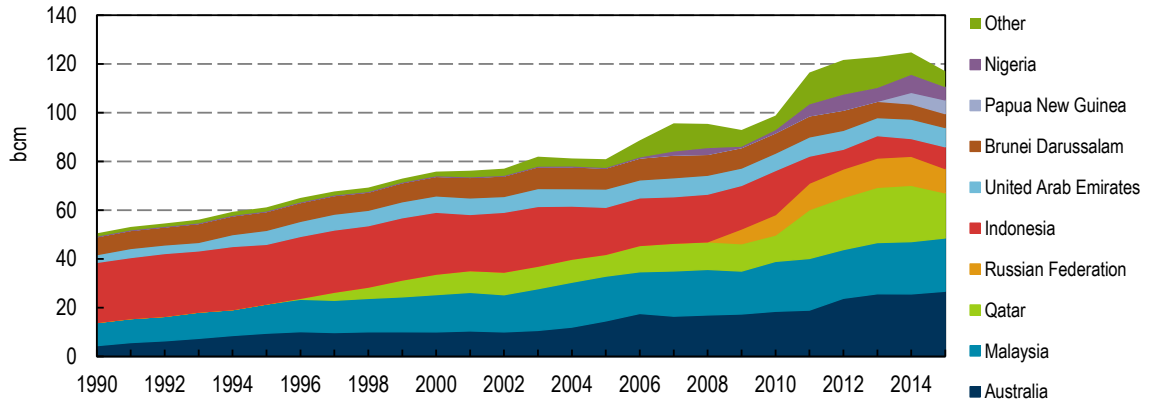
Table 1 • Importers of LNG in Japan (2014 FY)

Import company	Share of total (%)
Tokyo Electric	28
Tokyo Gas	16
Chubu Electric	15
Kansai Electric	10
Osaka Gas	9
Kyusyu Electric	6
Tohoku Electric	5

Source: Japanese Ministry of Economy, Trade and Industry (METI).

Natural gas supply sources to the country are well diversified. In 2015 Australia was the largest supplier, representing 23% of total imports, followed by Malaysia (19%), Qatar (16%), and Russia (8.5%) (Figure 8). Imports from Papua New Guinea (5%) also began in 2014, which started production earlier than planned. Furthermore, large quantities of LNG are expected to come from the United States after 2017, which is envisaged to encourage Japan's policy of diversifying its LNG import sources. According to the government, other new sources such as Mozambique and Canada could also potentially diversify supply sources further if proposed projects go well.

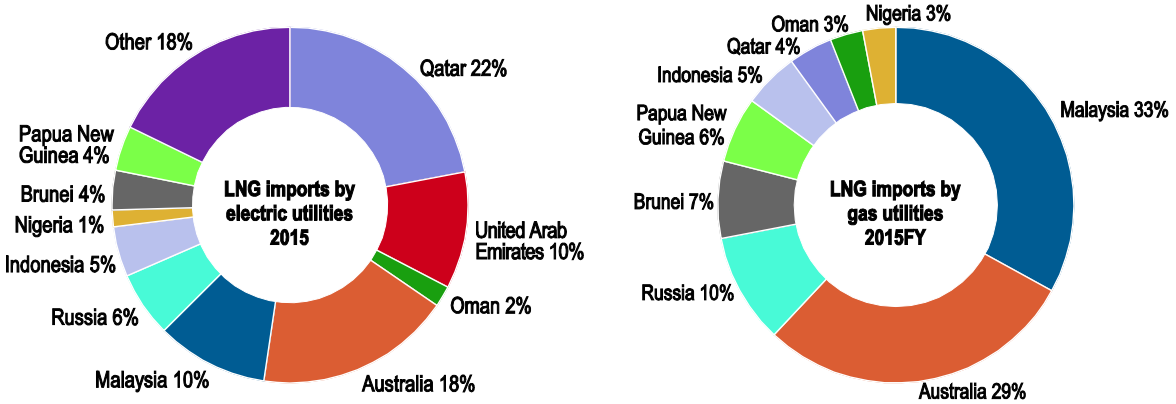
Figure 8 • LNG imports to Japan by source, 1990-2015



Source: IEA (2016e), *Natural Gas Information*, (database), www.iea.org/statistics/.

With regard to LNG import dependency on the Middle East (Qatar, United Arab Emirates and Oman), the total average rate including both Japanese electric utilities and city gas utilities was 26% in 2015. Based on city gas utilities only, this dependency decreased to 7%, and accordingly electric utilities' LNG import dependence on the Middle East was greater at 34% (Figure 9). In any case, these dependencies are still relatively low compared to Japan's import dependency of crude oil from the Middle East which was as high as 82% of total oil imports in 2015.

Figure 9 • LNG imports by electric and gas utilities in Japan, 2015



Note: FY = Financial Year. The financial year in Japan runs 1 April to 31 March. The graph displaying LNG imports by electricity utilities refers to the calendar year.

Source: Japanese Ministry of Economy, Trade and Industry (METI).

I. Global market context

Conventional LNG trade

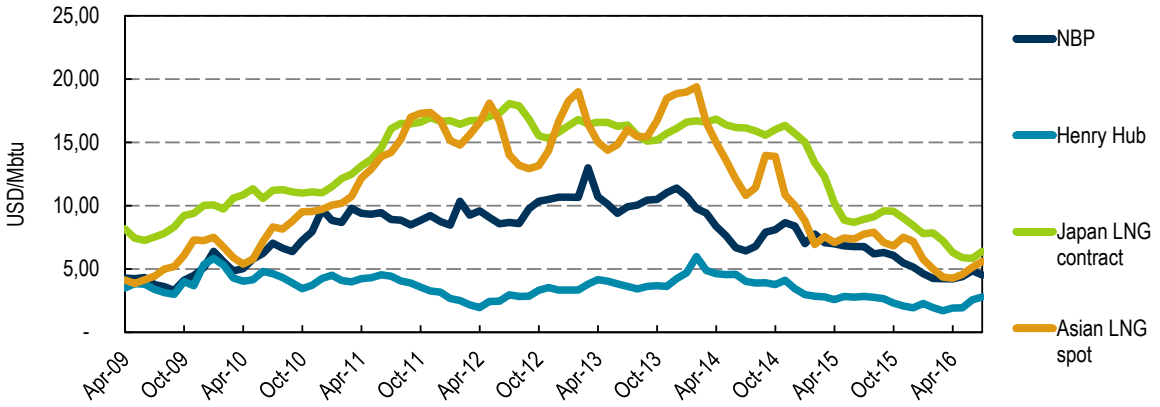
The Asia-Pacific LNG market tightened as a result of the sudden increase in LNG imports by Japanese electric utilities in response to the decline in power generation capabilities caused by the Great East Japan Earthquake and Tsunami, as well as the Fukushima Nuclear Accident.

In the conventional LNG trade, most contracts are on a fixed- and long-term basis and traditionally Asian LNG prices have been linked to Japan's crude oil import prices. Conventional LNG contracts also usually contain a destination clause that often restricts any reselling or rerouting of the LNG cargoes.

Japan's higher natural gas demand for power, a tighter LNG supply market over the preceding few years, and higher oil prices from 2009 to 2014 led to a significant increase in Asian spot LNG import prices, climbing from an average of USD 10 per million British thermal units (MBtu) before the earthquake in 2011 to around USD 18/MBtu in mid-2012 (Figure 10).

The price disparity between European, North American and Asian markets has also widened since 2008. In Europe, gas market liberalisation (unbundling, gas price indices, etc.) proceeded in the 1980s and 1990s, and in North America the gas price has dropped significantly in the wake of the shale gas revolution.

Figure 10 • Changes in natural gas prices, 2009-16



Source: NBP, HH and Japan LNG data: Bloomberg Finance LP; Asian LNG data: Platts ©2016 by McGraw Hill Financial, Inc.

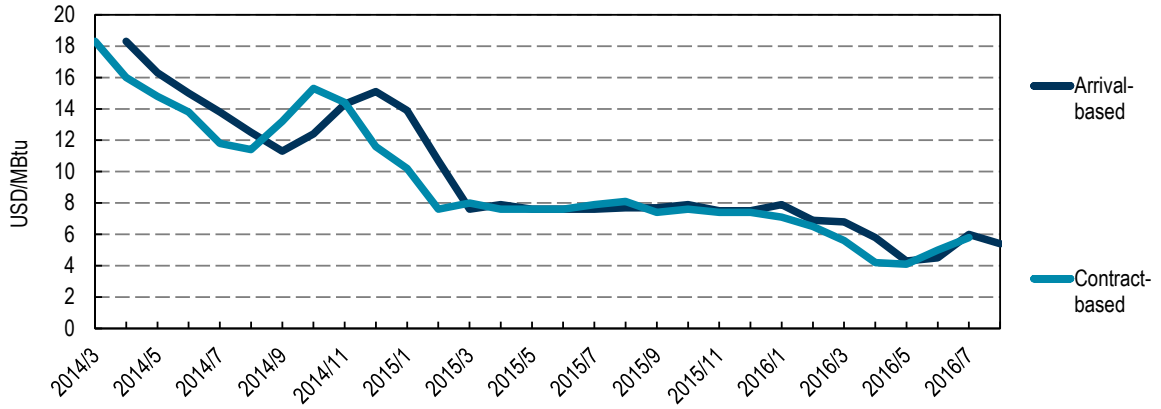
Given these circumstances, discussions over the need for more liquid, flexible and transparent market systems and new pricing systems instead of oil-indexation started in Asia in 2012-13. Since then, utilities in Asia have made additional efforts to seek new modes in procurement contracts and more flexible pricing, with some success. In parallel, market fundamentals both in supply and demand changed, easing the market, with new supplies from Papua New Guinea starting production earlier than planned, and nuclear power plants coming back on line and coal-fired power plants recovering in Japan.

Current trends in the LNG trade

The currently well-supplied gas market provides a major opportunity for natural gas consumers to secure more flexible market arrangements and new pricing systems. Oversupply in the global markets will generate more fierce competition, with flexible US and Qatari volumes searching for market opportunities putting extra pressure on the take-or-pay clauses in long-term contracts. In a market such as Europe, oil-linked prices and hub prices are currently showing similar levels, forcing some producers to follow a more flexible marketing approach and renegotiate existing contracts and introduce new price formulas. The availability of further LNG supplies will probably accelerate this process.

The average price of spot LNG imports into Japan contracted in October 2016 stood at USD 6.5/MBtu (Figure 11), a price level that reflected the saturated global market and the collapse in prices since the end of 2014. In such an environment, renegotiations between Japanese utilities and producers can be considered inevitable.

Figure 11 • Trend in spot LNG price for imports into Japan, 2014-16



Source: Japanese Ministry of Economy, Trade and Industry (METI).

With the changes in supply/demand fundamentals and private-sector efforts to increase flexibility in procurement, the use of spot and short-term contracts in overall LNG purchases in Japan has increased in recent years. This has also contributed to the growth in world's spot share, which reached nearly 30% of total LNG trade in 2015, from about 13% in 2005 (Figure 13). In order to enhance supply security and resilience in the long term, it is advisable for the private sector to explore the most appropriate balance ratio of spot/short-term contracts to long-term contracts. At the same time the Japanese government and private sector should use the currently well-supplied market conditions to encourage more flexible and efficient LNG trade through measures including further elimination of destination clauses.

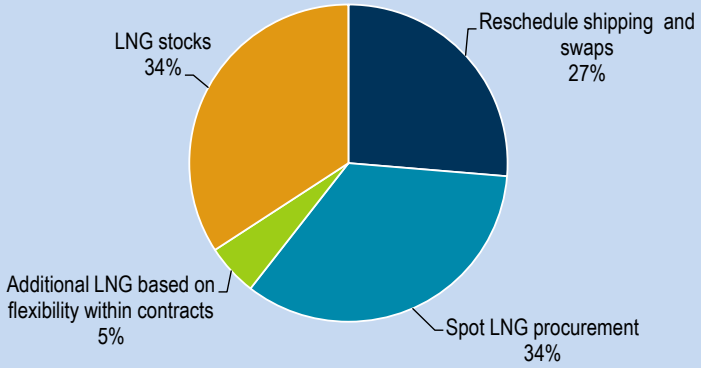
In an oversupplied market, it can be expected that purchasers with surpluses under long-term contracts could become spot sellers both within Japan and overseas. Such a trend could lead to a situation in which new and more flexible procurement models are needed, even though the significance of the conventional procurement model, in which purchasers conclude a long-term contract for each project, cannot be denied for the time being. Therefore, diversifying long-term supply contract portfolios should continue to be an important objective to ensure that flexibility exists within contracts to increase imports in an emergency situation, for example by leveraging upward quantity tolerance (UQT).

As Japanese companies have increased dependence on short term transactions, price hedging and discovery mechanisms are becoming more important. A subsidiary of Japan Commodities Exchange (TOCOM) started Non-Deliverable Forward transaction and Singapore Exchange (SGX) started offering Singapore SLinG. The role expected to Price Reporting Agencies (PRAs) in price discovery has been increasing as market players need more accurate price assessments for reference.

Box 1 • Flexibility required by Japanese gas utilities

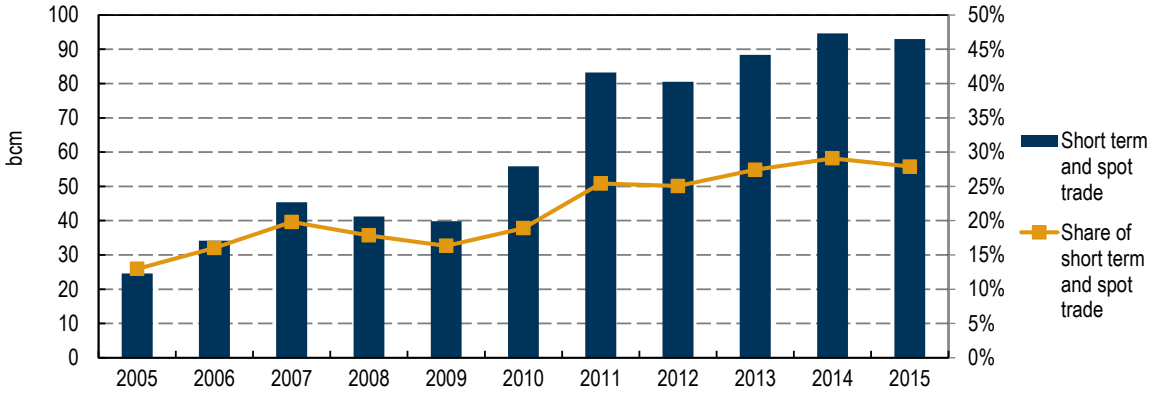
Concerning the composition of the emergency measures of the gas companies, the simulation conducted during the workshop highlighted the importance of the LNG spot market to replace the lost volumes, representing around 35% of the emergency measures package of the major city gas companies together.

Figure 12 • Hypothetical emergency response of the major city gas companies (%)



Such a high share stresses the importance of the availability of stable and flexible LNG supply-demand structures to be able to perform spot and short-term transactions rapidly. In this context a further removal of destination restrictions and more flexibility in contractual arrangements are a desirable and necessary development to increase the possibility of potential procurements from spot market in case of a disruption. Not only the gas market reform, but also the recent proposals from METI on a new strategy for developing a more flexible international LNG market, including developing an LNG trading hub in Japan, can be considered as an important steps in this direction. In addition to spot market volumes, the gas companies have also the possibility to swap contracted LNG together with the option of diverting cargos; this measure can eventually deliver around 30% of the volumes needed to replace the LNG losses. The simulation shown too that In the case of a larger impact, the city gas companies would import 5% of the needed volumes based on the agreed flexibility within the existing contracts (Upward Quantity Tolerance clause).

Figure 13 • Share of spot and short-term contracts in LNG transactions, 2000-14

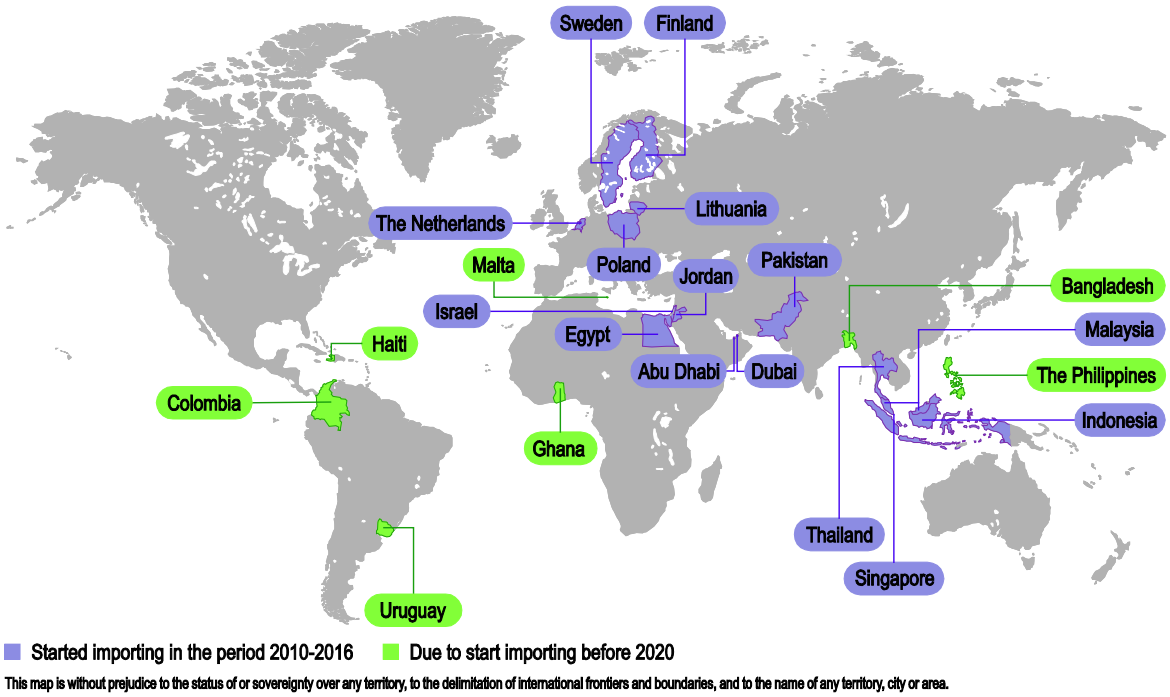


Source: GIIGNL (2016), www.giignl.org/publications.

Future of the LNG trade

The gas market is becoming increasingly globalised with the expansion of LNG trade. Global LNG export capacity is forecast to reach around 600 bcm in 2021, an increase of 45% compared to 2015. By 2021, LNG imports among non-OECD Asian economies (including China) are forecast to increase by more than 100 bcm. At the same time the LNG market is going through a transformation, as traditional LNG exporting countries such as Malaysia and Indonesia move from marginal exporters of natural gas to net LNG importers in order to meet their own rising domestic demand. Meanwhile, countries in the Middle East, Latin America, and Eastern Europe are also becoming LNG importers (Figure 14).

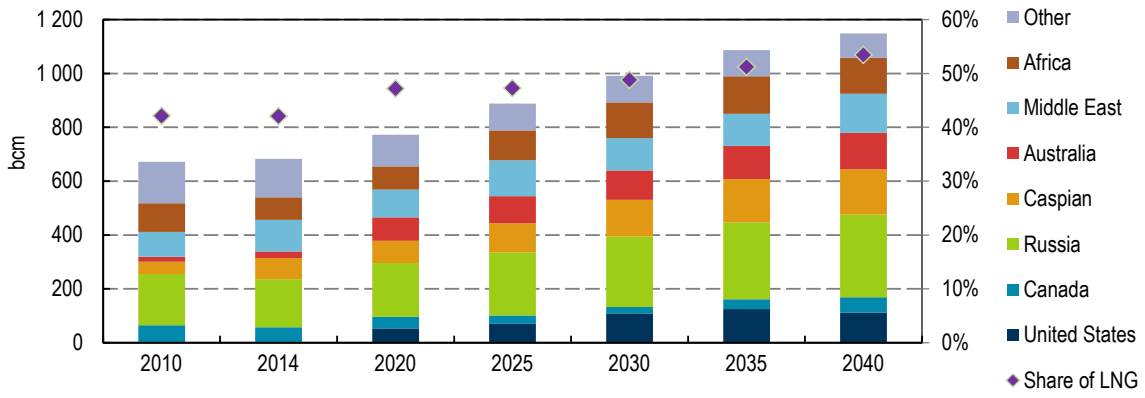
Figure 14 • New LNG import markets in the world



On the supply side, it is expected that Australia will replace Qatar as the world's top LNG exporter. A sharp increase in LNG volumes from North America will reach the market during the coming years, which will essentially be sold without a destination clause, accentuating the growing tendency for more destination flexibility in the global LNG market. As each LNG market in Asia, Europe and North America becomes multi-directional and increasingly integrated with each other, it is expected that inter-regional trade in LNG will grow substantially during the coming years and decades as projected in the New Policies Scenario of the *World Energy Outlook 2016* (Figure 15).

Given the increasing globalisation of the gas market, through the expansion of LNG trade, there is a growing need among producers and consumers for a better understanding of market developments and investment requirements, as well as for information transparency. With the LNG Producer-Consumer Conference, which has been held every year since 2012 in Tokyo, the government of Japan has been supporting an active dialogue among major LNG producing and consuming countries. This is in line with the objective of strengthening co-operation in creating a transparent and flexible LNG market, including the need for relaxation or elimination of destination clause in LNG contracts and for information transparency, such as on spare gas liquefaction capacity in producing countries, which would be crucial to know in case of sudden supply disruption.

Figure 15 • Global gas trade by exporter and LNG share in the inter-regional trade in the New Policies Scenario



Source: IEA (2016f), *World Energy Outlook 2016*, www.iea.org.

The currently oversupplied market is a result of legacy investment decisions taken long before the collapse in oil and gas prices, which were made on assumption of much stronger gas demand and prices. For the coming years the increasing gas liquefaction capacity will provide a substantial buffer, reducing security of supply risk and increasing the diversification of gas supplies, particularly LNG. Global LNG capacity additions will amount to an impressive 188 bcm between 2015 and 2021, 90% of which originate from the United States and Australia.

However, gas supply risks are not completely absent. Approximately 15% of total global LNG capacity is estimated to be unavailable today, as a result of outages, security concerns or lack of feed gas. In a persistently low-price environment, this kind of problem could become more prevalent, especially in countries dependent on oil and gas revenues, affecting supply security. At the same time, the increasing globalisation of gas through the expansion of LNG trade, and its deep interaction with the rest of the energy system, are creating a more

interconnected environment, where shocks in one region reverberate through another. Gas security challenges are evolving as the level of market globalisation evolves.

A good understanding of the investment flows in the global gas market is crucial to formulating and implementing a medium- and long-term security of supply policy. The current environment triggered a collapse in new investment in upstream gas activities and LNG export capacity, increasing the risk of tighter markets in the next decade. According to the *IEA World Energy Investment Report 2016* (IEA, 2016a), major oil and gas companies cut upstream spending by around 25% in 2015 and an estimated 24% in 2016. In the *Medium-Term Gas Market Report 2016* (IEA, 2016b), the IEA ascertained that during the first quarter of 2016, no new export projects had been sanctioned. This compares with more than 30 bcm per year of new capacity going to final investment decision (FID) between 2011 and 2015. In the medium term, the sharp cutback in investment will result in slower growth in global gas production, possibly leading to a re-emergence of concerns about security of gas supply.

Global gas prices are set to stay under pressure as a large amount of LNG export capacity is coming online just as demand slows. Based on the IEA analysis (IEA, 2016b), the process of market rebalancing is likely to take longer for gas than for oil. While the IEA expects global oil markets to start rebalancing in 2017, it does not foresee oversupply in traded gas markets to abate meaningfully before the end of the decade.

II. Gas market reform

Japan's gas and electricity markets are due to be reformed over the coming several years. The traditional system based on regional monopolies will give way to a more dynamic model where competition and market entry are encouraged and network operations are separated from other activities of the gas and power companies. The retail electricity market was fully opened to competition in April 2016 and the retail gas market is due to be opened up in April 2017. In further steps of reform to ensure equal access for all retailers to the electricity and gas networks, network operations are scheduled to be unbundled from the other activities of the traditional monopolies in the electricity sector in 2020 and in the gas sector in 2022.

The reforms in electricity and gas markets are expected to facilitate both the entry of new participants into the sector and entry of the former monopolies into each other's historical supply area. They may also lead to mergers and partnerships. An example is JERA, a company jointly owned by Tokyo EPCO and Chubu EPCO, which covers the energy supply chain from upstream investment and fuel procurement to power generation, although the companies remain as competitors in the retail market.

The reforms alter the structure and dynamics of the electricity and gas sectors, and can be expected to contribute to supply flexibility and security in the long term. As an indication of what may happen in the gas retail market after liberalisation in April 2017, since April 2016 around 300 non-electricity companies have entered the retail electricity market, and by the end of July 2016 around 1.5 million customers (around 3% of the total) had changed their retail supplier. New entrants include gas companies (such as Tokyo Gas and Osaka Gas), oil companies and telecom companies. Market opening has brought innovative tariff structures and services, such as packaging electricity and gas with each other or with telecom services. Over the long term, the government hopes that increased competition will result in lower electricity and gas bills for consumers and support the introduction of new services, including the sale of green power.

In liberalised electricity and gas markets, procurement costs for LNG directly affect the competitiveness of these companies and make the prediction of energy sales more difficult. In such a changing LNG landscape, Japanese companies need more market flexibility to optimise their LNG portfolios.

Anticipating the emergence of a fluid global LNG market, Japan, the world's largest LNG-consuming country, is striving to set up an LNG trading hub in the first half of the 2020s. The aim is to strengthen the bargaining power of Japan during procurement negotiations and to improve overall security of supply. Increasing liquidity could help reduce Asian LNG premiums from the levels seen in 2011-14. The IEA report *Developing a Natural Gas Trading Hub in Asia* (IEA, 2013) emphasised the need to remove existing constraints to creating a trading hub in Asia, so as to facilitate the exchange of natural gas and the development of a transparent price signal to increase investment in natural gas infrastructure.

The dominance of fixed- and long-term contracts linked to crude oil import prices has also hindered the establishment of a benchmark price for LNG that more accurately reflects the supply and demand of LNG. In order to enhance price stabilisation and transparency in the LNG market, the government of Japan is promoting fair competition by using benchmark prices supplied by multiple price reporting agencies (PRAs). In addition, as a step towards introducing the world's first LNG futures in Japan, the Japan OTC Exchange launched an over-the-counter (OTC) market for LNG in 2014. This can be seen as facilitating the establishment of an LNG hub in Japan.

Amendments to the Gas Business Act in June 2015 introduced a system aimed at greater third-party access to LNG terminals in order to promote market competition. This is also essential for creating a LNG trading hub in Japan. After April 2017, the following duties are to be imposed on LNG terminal owners: firstly, the owner must disclose information on LNG storage tanks, such as tankage availability (this could lead to the creation of an effective secondary market to resell the excess capacity – an effective secondary market could be a valuable tool for increasing market liquidity, minimising contractual congestion and preventing capacity hoarding); secondly, the owner shall not refuse third-party access requests without just cause; thirdly, the owner will be required to charge the same fee for all users, including the owner itself and third parties, under equal conditions. Furthermore, studies are currently underway to determine whether to also introduce third-party access to underground storage facilities.

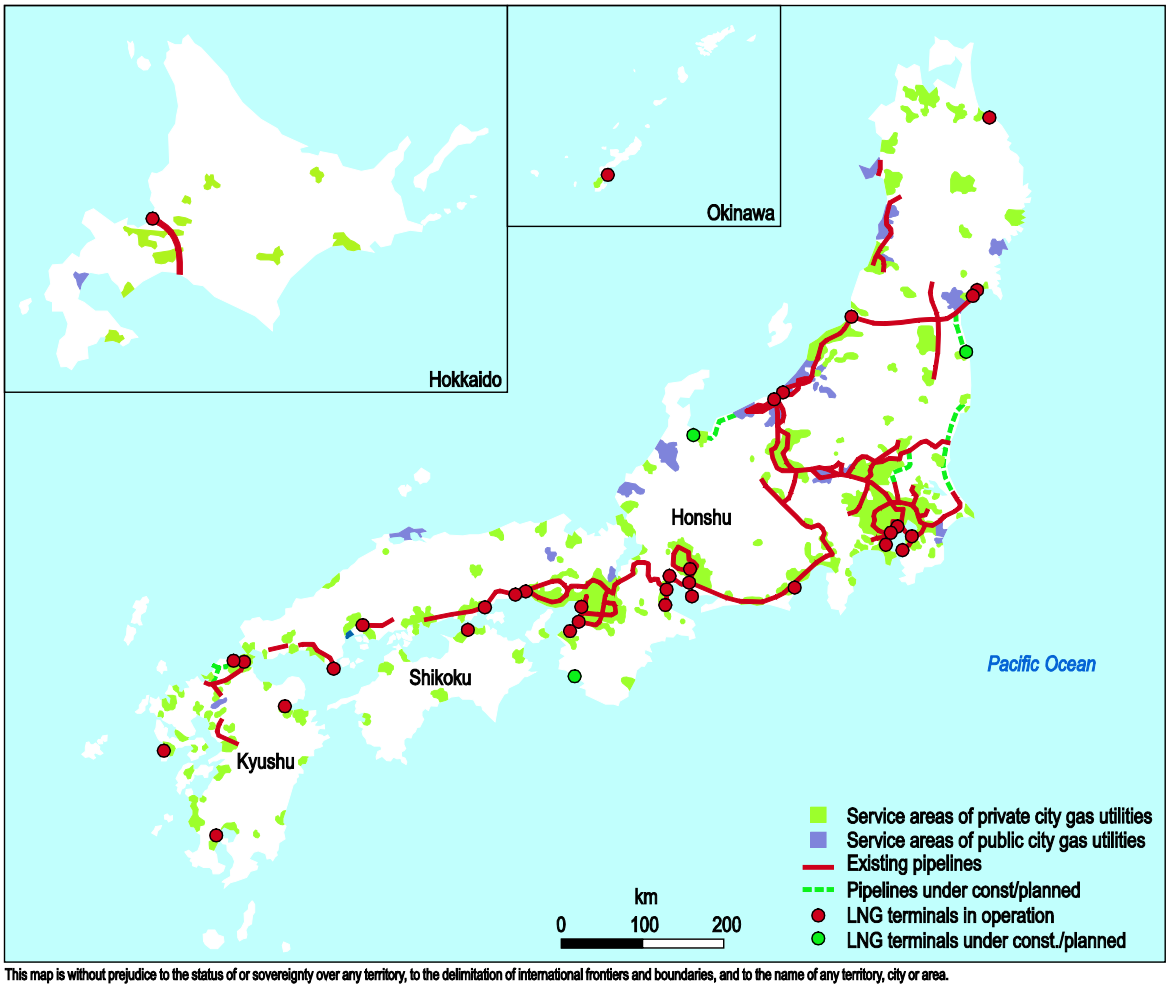
The government of Japan should fully implement the electricity and gas market reforms and ensure effective and transparent third-party access to LNG terminals and natural gas pipeline networks. It should also encourage the development of efficient, transparent and accessible mechanisms for reselling the excess capacity of the primary contractor on a competitive secondary market.

III. Gas infrastructure

LNG terminals

As Japanese gas demand is mainly supplied by imported LNG, numerous LNG terminals have been constructed, mainly in coastal areas near major urban and manufacturing hubs, and are owned and operated by electricity utilities, city gas companies, other industries such as oil companies, and local government (see Annex 1). Electricity companies own close to half of all LNG storage capacity, followed by gas utilities (over 40%). The start of commercial operations at the Hitachi facility of Tokyo Gas in March 2016 boosted the number of Japanese LNG import terminals to 35 (Figure 16, Table 2).

Figure 16 • Natural gas infrastructure in Japan



Source: *Gas Business Handbook*, The Japan Gas Association.

As of May 2016, the total nominal re-gasification capacity of Japan's LNG terminals represented around 274 bcm of natural gas per year (or 730 million cubic metres [mcm] per day), compared to a natural gas demand of 125 bcm in 2014.

Table 2 • Number of LNG terminals and tanks by category of utility, Japan (May 2016)

Utility category	Terminals	Tanks
Gas	12	46
Electric	9	49
Joint gas/electric	6	67
Others	8	28
Total	**35**	**190**

Source: Japanese Ministry of Economy, Trade and Industry (METI).

Three LNG receiving terminals were commissioned in the summer of 2016 to be expanded: the Chita Midorihama installation belonging to Toho Gas (220 000 cubic metres [m^3]), Kansai Electric's Sakai LNG facility (140 000 m^3) and the Ishikari LNG terminal of Hokkaido Gas (230 000m^3). In addition to these three expansion projects, two new LNG receiving terminals are currently under construction in Japan. The Soma LNG facility being built for Japan Petroleum Exploration (JAPEX) is due on stream in 2018; also Hokuriku EPCO is scheduled to start its Toyama Shinko LNG terminal in the same year.

LNG terminals are generally not equipped with reloading facilities that allow LNG importers to resell LNG to others once they have transferred LNG from cargo vessels to storage facilities. Ensuring a reasonable amount of reloading capacity at LNG terminals is an important factor for security of supply. The terms and conditions for third-party access to LNG terminals pursuant to the amended Gas Business Act are currently being discussed.

Reflecting upon experiences from the Great East Japan Earthquake, the city gas industry is adopting anti-tsunami measures for LNG terminals (waterproofing of facilities, installing backup power supply) and a system for sharing mobile re-gasification systems across a wide area.

Major LNG tanks are verified to satisfy the latest anti-earthquake standards and all production and supply facilities have been designed and constructed to have sufficient resistance against flooding following a potential tsunami.

Gas pipelines

Japan has no cross-border gas pipelines. Japanese gas markets are local, without a major gas pipeline network at the national level. As most of the domestic gas pipelines are built primarily to connect LNG receiving terminals on the coast with high-demand areas, the geographic coverage of the gas pipeline is only 6% or less of the national territory (the coverage is 18% when excluding forested mountains and fields). Total gas pipeline length amounts to 258 424 kilometres (km) throughout the country (Table 3). Around 85% of gas pipelines are low-pressure grids for local distribution, while only 5 063 km are high pressure. Projects to expand the high-pressure pipeline network are underway, such as the new Ibaraki-Tochigi line being constructed by Tokyo Gas. This, together with the work on the Hitachi LNG terminal and another new high-pressure line which is currently under study, would allow the creation of a high-pressure gas pipeline loop connecting terminals in the Tokyo Bay area, with the expectation of improving the stability of the entire supply infrastructure in the Tokyo urban area.

Although there are around 43 main interconnection points between areas, the trunk line networks are not necessarily connected to each other as they have developed separately around LNG terminals, based on longstanding regional monopolies. Currently, no single

entity operates the national transmission system in Japan, and each industry (mainly city gas companies and electricity utilities) owns and operates its gas pipelines and is obliged to ensure its natural gas supply to its distribution area.

The 2011 Great East Japan Earthquake and Tsunami damaged LNG terminals and gas supply networks in disaster-stricken Sendai, disrupting domestic gas supply particularly in the northeastern part of Japan. By utilising a gas pipeline from Niigata through Sendai, however, the city gas supply facilities on the Sea of Japan coast operated as a backup gas supply channel. This experience emphasised the importance of having stable gas transport routes that connect the Pacific Ocean and the Sea of Japan coasts, as well as the importance of developing pipelines that connect LNG terminals in different regions.

In order to promote gas pipeline development, the amended Gas Business Act empowers the Minister of Economy, Trade and Industry to order business operators involved in the development of pipelines to consult one another and to make an award against one of them, provided the operators have not applied for arbitration by the Surveillance Commission for Electricity and Gas. This is expected to lead to the connection of isolated pipelines and expand the city gas supply network. Such additional pipeline networks can serve as critical infrastructure to promote competition in the gas market and enhance security of supply.

In order to promote the overall optimisation of pipeline network development, METI is currently preparing the establishment of a committee comprised of experts in pipeline development and city gas utilities to discuss many issues in detail, such as the mutual connection between different areas and the required specifications. It is envisaged that the committee will be established early next year.

Table 3 • Japanese gas pipelines by category of utility, as of FY 2014

Utility category	Number of utilities	Length of pipelines (000 kms)	Share of domestic sales (%)
Major city gas companies	3 (Tokyo, Osaka, Toho)	137 (53% of total)	65
Wholesale (by pipeline)	122	76 (30%)	18
Semi-major city gas companies	6	29 (11%)	8
Wholesale (by tanker truck)	72	12 (5%)	1
Other (electric companies, etc.)	-	3 (1%)	8

Source: Japanese Ministry of Economy, Trade and Industry (METI).

Storage

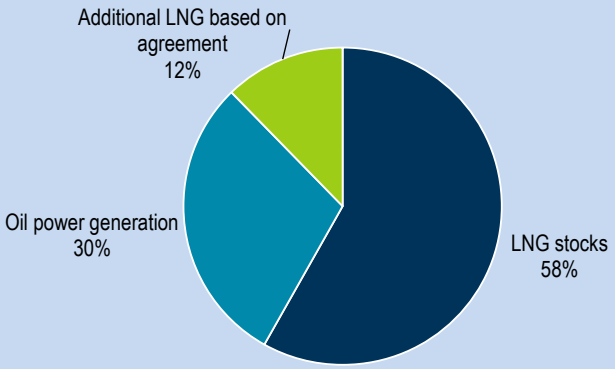
Japan has a total LNG storage capacity of 18.71 mcm (equivalent to around 11.5 bcm of natural gas storage capacity) within the LNG receiving terminals. With projects recently being completed at three terminals a further 0.59 mcm of new tankage has been added during fiscal year 2016. The country's total storage capacity meets close to 32 days of domestic natural gas consumption.

There is no legal obligation for industry to hold emergency stocks in the form of natural gas, LNG or alternative fuels in the country. Nevertheless, electric power companies and city gas companies hold a certain amount of commercial stocks based on supply obligations under the contracts with their customers. The companies adjust the level of commercial stocks to meet around two to three weeks of natural gas demand during periods of normal and high demand.

Box 2 • Integrated grid for resiliency

During the workshop a detailed example was presented of the eventual emergency response of an individual electricity company. The emergency exercise conducted showed that LNG stocks provided almost 60% of the lost LNG imports, demonstrating the importance of (operational) stocks to alleviate the impact of a disruption. For the main gas companies together stocks provide 35% of the needed volumes to replace the losses.

Figure 17 • Hypothetical emergency response of one of the major power companies in Japan (%)



With separate gas regions the stock level and the output rate differs per region, determining per region the use of the stored volumes in case of a disruption of the supplies. To make optimal use of the available operational LNG volumes, bringing for example some volumes to the most affected areas, an integration of the regional grids can be considered as a crucial step to increase the resiliency of Japan.

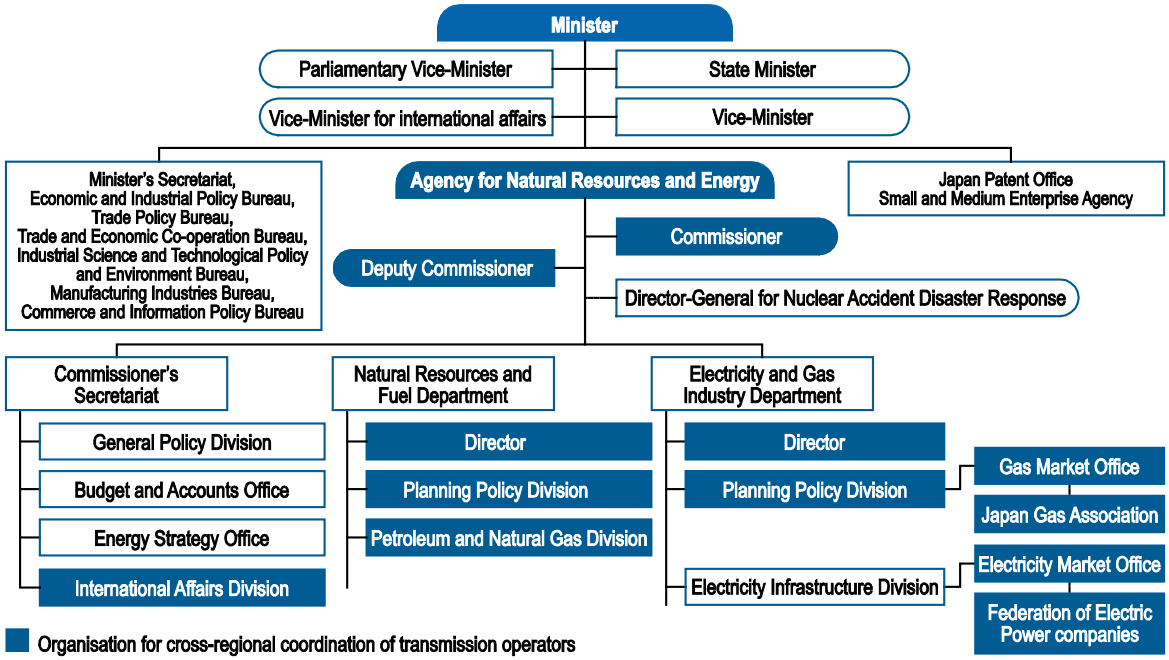
In addition to the commercial stocks in LNG terminals, Japan has five underground gas storage (UGS) facilities situated at depleted gas fields with a total capacity of around 1.4 bcm as of December 2011. Currently, these storage sites are mainly used for peak-shaving purposes and to balance seasonal fluctuations. All UGS facilities are owned and operated by domestic gas exploration companies which own mineral rights, using their storage facilities as part of their operation. The disconnectedness of Japan's pipeline network is a critical impediment to utilities benefiting from the large-scale use of UGS facilities, even if third-party access was granted. Increasing UGS capacity and clarifying the rules for its utilisation to enhance third-party access are also important measures to improve overall security of supply.

IV. Emergency response capacity

The Gas Business Act sets the rules for market activity and securing supply capacity for natural gas. According to Article 13 of the Act, "gas retailers" (defined as companies that are "supplying gas via pipelines") are obliged to secure sufficient supply capacity to meet the demand of their customers and, if they fail to do so, the Minister of Economy, Trade and Industry may order the gas retailers to take other necessary measures to secure supplies. Pursuant to Articles 19, 56 and 81 of the Gas Business Act, gas utilities (which include General and Specified Gas Pipeline Service Providers) are obliged to compile and submit plans on the supply of gas and the installation and operation of gas facilities every fiscal year. The gas supply plans cover gas supply and demand in a certain period, and the plans are evaluated by the Minister of Economy, Trade and Industry.

Japan has not established a formal National Emergency Strategy Organisation (NESO) structure for disruption to natural gas supply. However, in case of emergency, an emergency response team will be established under the Commissioner of the Agency for Natural Resources and Energy within METI, and is responsible for collecting information to estimate the impact (Figure 18). It also serves as an intermediary for adjusting cross-industry LNG allocation.

Figure 18 • Structure of gas emergency management in METI



Source: Japanese Ministry of Economy, Trade and Industry (METI).

In the case of stoppage of gas supply in an emergency or disaster, such as earthquake or flood, METI, the city gas industry and the electric power industry have established a system of information sharing and a mutual co-operation scheme for rapid recovery. Plans also exist for the establishment of an emergency management organisation within the city gas industry, currently under consideration.

Taking into account its high import dependency, Japan has developed a robust security of supply policy, including emergency response.

Key elements of Japan's overall gas security policy are: diversifying its long-term supply contract portfolio; ensuring flexibility to increase imports within contracts in an emergency (leveraging

UQT in term contracts and additional purchase from spot markets); and using existing commercial LNG stocks in industry. In the event that LNG imports are disrupted, the importing companies (seven electricity companies and nine gas utilities) would each take various measures in different phases (Table 4).

Table 4 • Japanese emergency policy measures, natural gas

Phase	Measures		
	Supply side		Demand side
	Downstream	Upstream	
Phase 1	Co-ordination at individual company level: 1. Use stocks on-hand; 2. Reschedule cargoes (with co-contractor, etc.); 3. Find new LNG supplier; 4. Fuel switching for electricity generation.	1. Co-ordination with LNG producing countries to procure additional supply (at company and government level); 2. Consult Japanese companies with upstream interests regarding diversion of LNG cargoes (government and JOGMEC*).	
Phase 2	Co-ordination at industry level: 1. Share LNG stocks among companies; 2. Transfer electricity among power companies.		
Phase 3	Co-ordination across industries.		1. Request voluntary efforts among consumers to save electricity/gas; 2. Legal restrictions on power usage.

Note: JOGMEC = Japan Oil, Gas and Metals National Corporation.

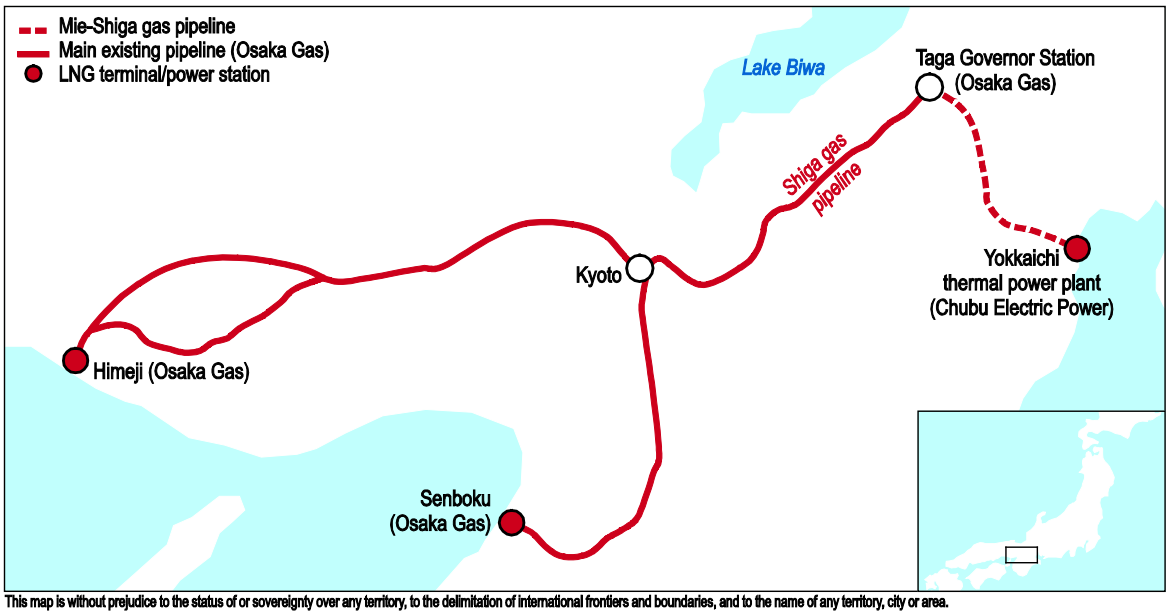
Source: Japanese Ministry of Economy, Trade and Industry (METI).

The emergency response measures require co-ordination at three levels: at individual company level, industry level and cross-industry level. Previous emergency responses, including those to the Great East Japan Earthquake and Tsunami and the recent earthquake in Kumamoto, have turned out to be effective with rapid co-ordination at all three levels.

In Phase 1, co-ordination will be conducted at the individual company level. The use of in-house LNG stocks and fuel switching would be the first measure for most electricity companies. In addition to the use of in-house stocks, they would also reallocate their gas imports through (a) reciprocal backup supply by arranging position swaps with project partners, (b) buying additional LNG either on the spot market or using the rights of UQT in long-term contracts, and (c) temporary allocation by adjustment of shipping schedules with the co-operation of sellers. In case of disruption and if needed, the government of Japan (and/or JOGMEC) could also ask Japanese companies who have upstream interests to divert LNG cargoes to Japan. In relation to this, it is noteworthy that the government is supporting Japanese enterprises to secure oil and gas upstream interests in order to achieve a 40% ratio of self-development by 2030 (the ratio is constantly growing and has reached 27.2% as of 2015).

In Phase 2, co-ordination will be conducted at industry level. As regards the city gas distribution industry, LNG transport through domestic pipelines to accommodate mutual need is not feasible at this stage, especially between the three major urbanised areas (Tokyo, Osaka and Nagoya) as the gas grid is not connected. However, in recent years a new pipeline project connecting the Osaka and Nagoya areas has enabled Chubu EPCO to obtain LNG supplies from Osaka Gas in case of emergency as a backup, and vice versa (Figure 19).

Figure 19 • Pipeline connection between Osaka and Nagoya areas, Japan



Source: Japanese Ministry of Economy, Trade and Industry (METI).

In Phase 3, co-ordination will be conducted at cross-industry level, which is mainly covered by demand restraint measures (see Section V, "Demand restraint and fuel switching", below).

The recent Kumamoto Earthquake in 2016 illustrates how emergency response to regional gas disruption is co-ordinated at industry level as well as with the government.

The Kumamoto Earthquake affected the southern part of Japan, where gas supplies were halted to over 100 000 households in the area. Immediately after the earthquake, the emergency response team of the Japan Gas Association (JGA) was established to provide mutual aid to support the emergency response team of Saibu Gas, the city gas utility in the Kumamoto area. With the emergency initiative established by the JGA emergency response team, other regional companies dispatched staff to Kumamoto to work as a JGA rescue team. They provided restoration services such as pipeline repair, temporary city gas supply, and gas valve leak testing. In total, 2 676 support staff from 22 other city gas utilities were dispatched and able to complete restoration of the city gas supply in 15 days.

The METI emergency response team provided instructions to the JGA emergency response team as well as to the electric power and oil industry. Instruction given to the JGA emergency response team included: effective use of mobile gas generators, reinforcement of the JGA rescue team, identification of key facilities such as hospitals and welfare facilities, and confirmation of need for priority supply. The electric power industry was instructed to increase the number of high-voltage power generator vehicles to provide emergency power distribution, and the oil industry was directed to carry out priority fuel supply to those vehicles.

Such co-ordination in response to an emergency situation may have been facilitated by the limited number of players acting as regional monopolies. Ongoing market reforms, which will bring about benefits to supply security in terms of market flexibility and transparency, might make the co-ordination of emergency response more complicated with a larger number of players in the whole supply chain. New participants in the market may be

smaller in size than traditional regional utilities. Government should monitor the impact of liberalisation of the gas market on emergency preparedness and ensure that new market entrants have suitable response capabilities.

One possible measure to maintain robust emergency response capacity under liberalised market systems is to create a NESO for natural gas supply disruptions. Such an institution should be able to stimulate more explicit improvement in situation awareness and engender effective and efficient co-ordination among relevant parties to ensure supply stability in emergency situations. A close co-operation with the existing NESO for oil supply disruptions may also be part of the new arrangement for natural gas supply disruptions.

V. Demand restraint and fuel switching

Demand restraint

In general, Japan's gas utilities as a whole have well-diversified LNG sources and are well prepared for possible supply disruption. That would not, however, be an excuse for a lack of preparation for demand-side response, should it be necessary. In particular, individual gas utilities and their customers can be significantly affected by specific cases of supply disruption, and it would be difficult for them to seek support from other utilities given the absence of pipeline connections in Japan, as shown in the previous section of this report.

A certain amount of flexibility exists in the contractual arrangement between gas companies and their customers. During a disruption to supply, gas companies would reduce gas supplies according to interruptible contracts. Tokyo Gas, which accounts for around one third of total market sales of city gas in Japan, is entitled to reduce gas supply to its customers consuming over 0.5 mcm per year in case of supply disruption, with the exception of priority customers such as hospitals, welfare institutions and government offices. Those interruptible contracts cover more than half of the entire supply by major city gas utilities. Tokyo Gas, for instance, also has over 200 mobile air-mixed propane gas generators to temporarily supply gas to priority consumers. They have actually seen use in such cases as the earthquake in Kumamoto in 2016. These facilities can be considered as robust security backup capacity, as Japan holds national liquefied petroleum gas (LPG) reserves of 1.5 Mt and industries are obliged to hold an equivalent of 50 days of import volume by law. However, the level of contribution from demand restraint measures differs by regional characteristics, customer profile and season.

As explained in Section IV, "Emergency response capacity", where regions have experienced serious emergency situations caused by earthquakes or floods, robust emergency response capacities have been demonstrated in those cases. Such emergency response often involved demand restraint, often involuntary. There were many cases of central and local governments distributing portable LPG-fired stoves to mitigate the impact of lack of access to gas services.

Although, based on such experiences, a certain level of preparedness in the government of Japan is noted, there should always be room for improvement. Government should, in co-ordination with the gas industry, consider how best to reduce gas demand during significant supply shortages and prepare with stakeholders suitable operational procedures for activating demand restraint measures, including identification of priority users in emergencies. In doing so, it would be desirable to include options to design a demand restraint mechanism that is more market oriented.

Demand restraint is not only about gas utilities, but also about electricity utilities. Indeed, the power generation sector represents nearly 70% of total gas consumption, and the share of natural gas-fired generation is almost 40% of entire power generation in Japan. Although the Japanese electric utility industry as a whole has well-diversified LNG supply sources, some electric power utilities have a high dependence on certain LNG-producing countries and regions. Under these conditions, LNG supply security directly links with electricity security in Japan. In case of major supply disruption, restraints on electricity demand and fuel switching in power generation would play a critical role.

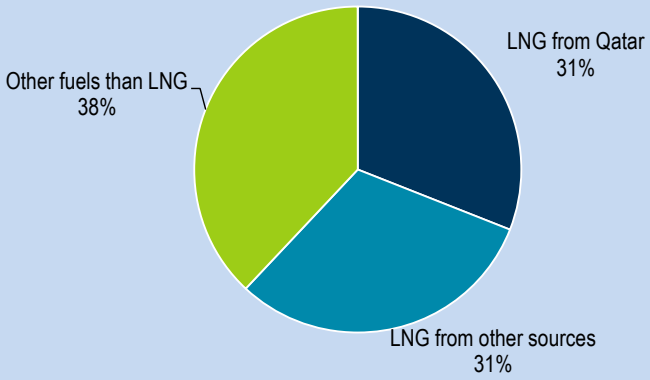
Measures to restrain electricity demand are called for not only in cases of major gas supply disruption, but also in such cases as extreme summer heat or a lack of power generation capacity

for various reasons. Electric utilities have interruptible contracts with large-scale customers, in particular those in manufacturing sectors who have flexibility in business operations.

Box 3 • Demand restraint and fuel switching needed in case of a LNG disruption

The simulation conducted in the workshop demonstrated that some individual major companies have a disproportionately high dependency on one of the suppliers. For the whole power sector the lost volumes consisted of 7% of the total energy mix. In the case of one particular major electricity company, the hypothetical disruption led to a loss of around 30% of its total supplies representing a loss of power generation for two months. In this specific case, it might be clear that substitution of the lost volumes by only rescheduling the allocation of cargos or by purchasing LNG through the spot market wouldn't be a sufficient response.

Figure 20 • Fuel mix of one of the major the major power companies in Japan (%)



After tapping into such flexibility resources, and where the electricity reserve rate is still expected to fall below 3%, the minimum requirement for stable power supply, METI would publicly launch a pre-prepared power-saving campaign. When the electricity reserve rate is expected to fall below 1%, the alert would be activated to let individuals be aware of the tight supply-demand situation through a direct email sent from the Ministry to their cell phones. As a last resort, mandatory demand restriction would be pursued by law. Pursuant to Article 27 of the Electricity Business Act, the Minister of Economy, Trade and Industry has the authority to issue an order to electricity retailers and/or large electricity consumers to restrict the use of electricity by limiting power usage or peak load when it is deemed necessary to resolve supply shortage.

In the summer of 2011, a massive electricity saving campaign was undertaken by government and utilities. All electricity customers were requested to save electricity during summer peak hours. In the areas of Tokyo EPCO and Tohoku EPCO, the target to reduce 15% from the previous year was set by the government. Large-scale users with contract capacity above 500 kilowatts were subject to mandatory demand restrictions under the Act activated in Tokyo and Tohoku areas. These measures shaved peak power demand of those large-scale users by 27% in the Tokyo area and 18% in the Tohoku area compared with the previous year. Peak demand from the entire customer base went down by 19% in Tokyo and 18% in Tohoku. Even the area provided by Kansai EPCO, which was not subject to the legal measures, saw a peak decline of 8% over the

previous year. The government of Japan should reflect upon these experiences which demonstrate a strong capacity for industry and society to reduce demand in case of emergency, and maintain policy tools so that they can be deployed effectively in case of possible future disruption.

Fuel switching

It is critical for the entire power system to have fuel-switching capacity in preparation for disruption to the supply of certain types of fuel. Such fuel-switching capacity can be achieved by a well-diversified power generation mix. The Japanese power system currently depends upon natural gas at an unprecedented level, and the contribution from nuclear power plants remains very low. This situation not only leads to additional supply security concerns, but also to sustainability concerns, as coal, oil and natural gas together have more than 80% share of power generation, leading to historically high levels of carbon dioxide emissions.

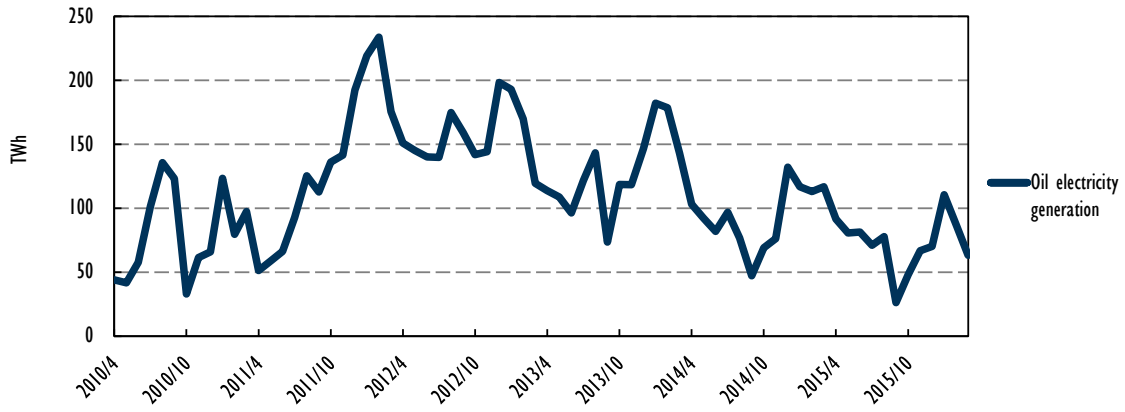
The government of Japan and the power industry should restore a better balance to the Japanese power generation mix, making additional efforts including restarting nuclear power plants that are certified safe by the new nuclear safety authority based on the new standards. Increasing deployment of renewable generation sources, such as solar photovoltaics and wind, is also a critical element in reducing dependency on natural gas imports. Indeed, in the "Long-Term Energy Supply and Demand Outlook" by the government of Japan, restarting nuclear power plants and increasing deployment of renewable sources are considered to be key factors for overall energy security, as greater diversification of power sources would contribute to raising resiliency in response measures in case of emergency.

In the longer term, gas-fired power generation will play an increasingly important role in providing flexibility to electricity systems with higher shares of variable renewables. As such power system transformation progresses, the nature of gas demand could be more rigid compared with the current power systems where a large portion of electricity is generated by dispatchable generation sources. Flexible gas-fired power generation is not the only source of flexibility to stabilise power systems. Better grid interconnections, storage technologies and demand response could also contribute, but now and in the near future, gas-fired power generation remains the major provider of such flexibility. The government should explore the implications of this for gas supply security and develop an appropriate electricity market design that can achieve both supply security and decarbonisation.

What has been highlighted since the earthquake in 2011 is the unique role provided by ageing oil-fired power generation plants as backup capacity. Although electricity saving and peak shaving after the Great East Japan Earthquake were significant, as detailed above, reductions in the size of demand were far less than those required to offset the losses in nuclear power generation. The share of oil-fired power generation in the power mix shot up in the 2011-14 period, with the peak at 18% in 2012. As identified in the *Global Gas Security Review 2016* by the IEA, oil-fired units accounted for most of the additional generation requirement in Q1 2012 (IEA, 2016g).

In 2013, oil power generation levelled off as a result of an increasing use of LNG by the power generators. In 2015 the share was back to the level of 9% of the total electricity generation, demonstrating that the increase of oil power generation has been a temporary development.

Figure 21 • Electricity generation by oil, 2010-16



Source: IEA (2016h), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics.

This oil-fired power generation supported the Japanese power system and helped avoid major black-outs. The government's long-term supply and demand outlook foresees oil-fired power generation having a 3% share of the power generation mix, maintaining its role as a peak-load generation source. Of the oil power plants in Japan, however, 66% will exceed 40 years of age in 2020 and that percentage will increase to 90% in 2030. As a prohibition on the new construction or replacement of oil thermal baseload power plants was agreed by IEA Ministers at the 3rd Ministerial Council in 1979, finding other alternatives for such backup power supply source could be a challenging task. It is not only the power generation plants; the whole logistical chain for maintaining the function of oil-fired power generators is ageing, and relevant industries cannot be sure whether they should invest in maintaining them. Government and the private sector should seriously consider the role of such ageing power plants and relevant supply chains, taking into account the balance between supply security in an emergency and the cost of maintaining additional backup capacity.

Annex 1.

LNG terminals in Japan, as of 2016

Table 5 • Japanese LNG terminals, as of October 2016

Terminal name	Location	Owner	Total volume (000 litres)	Tanks	Year
Ishikari LNG Terminal	Hokkaido	Hokkaido Gas	380 000	2	2012
Hachinohe LNG Terminal	Aomori	JXenergy	280 000	2	2015
Gas Bureau City of Sendai LNG Terminal	Miyagi	City of Sendai	80 000	1	1997
Shinsendai thermal power station	Miyagi	Tohoku Electric Power	320 000	2	2016
Joetsu Thermal Power Plant LNG Terminal	Niigata	Chubu Electric Power	540 000	3	2012
Niigata Terminal	Niigata	Nihonkai LNG (Tohoku Electric Power, Development Bank of Japan, Niigata Prefecture, JAPEX, etc.)	720 000	8	1984
Naoetsu LNG Terminal	Niigata	INPEX	360 000	2	2013
Hitachi LNG Terminal	Ibaraki	Tokyo Gas	230 000	1	2016
Futtu Terminal	Chiba	Tokyo Electric Power	1 110 000	10	1985
Sodegaura LNG Terminal	Chiba	Tokyo Gas Tokyo Electric Power	2 660 000	35	1973
East Ohgishima Terminal	Kanagawa	Tokyo Electric Power	540 000	9	1984
Ohgishima LNG Terminal	Kanagawa	Tokyo Gas	850 000	4	1998
Negishi LNG Terminal	Kanagawa	Tokyo Gas Tokyo Electric Power	1 155 000	14	1969
Shimizu LNG Sodeshi Terminal	Shizuoka	Shimizu LNG (Shizuoka Gas and TonenGeneral Sekiyu)	337 200	3	1996
Chita LNG Joint Terminal	Aichi	Toho Gas Chubu Electric Power	300 000	4	1978
Chita LNG Terminal	Aichi	Chita LNG (Chubu Electric Power and Toho Gas)	640 000	7	1983
Chita Midorihama LNG Terminal	Aichi	Toho Gas	620 000	3	2001
Yokkaichi LNG Terminal	Mie	Toho Gas	160 000	2	1991
Yokkaichi LNG Center	Mie	Chubu Electric Power	320 000	4	1988
Kawagoe Thermal Power Plant LNG Facilities	Mie	Chubu Electric Power	840 000	6	1997
Senboku I Terminal	Osaka	Osaka Gas	320 000	3	1971
Senboku II Terminal	Osaka	Osaka Gas	1 585 000	18	1977
Sakai LNG Center	Osaka	Sakai LNG (Kansai Electric Power, Cosmo Oil, Iwatani-Sangyo, and Ube Industries)	420 000	3	2006
Himeji Terminal	Hyogo	Osaka Gas	740 000	8	1984
Himeji LNG Terminal	Hyogo	Kansai Electric Power	520 000	7	1979

Terminal name	Location	Owner	Total volume (000 litres)	Tanks	Year
Mizushima LNG Terminal	Okayama	Mizushima LNG (JX Nippon Oil & Energy and Chugoku Electric Power)	320 000	2	2006
Hatsukaichi LNG Terminal	Hiroshima	Hiroshima Gas	170 000	2	1996
Yanai Terminal	Yamaguchi	Chugoku Electric Power	480 000	6	1990
Sakaide LNG Terminal	Kagawa	Sakaide LNG (Shikoku Electric Power, Cosmo Oil, and Shikoku Gas)	180 000	1	2010
Oita LNG Terminal	Oita	Oita LNG (Kyushu Electric Power and Oita Gas)	460 000	5	1990
Tobata LNG Terminal	Fukuoka	Kitakyushu LNG (Kyushu Electric Power and Nippon Steel & Sumitomo Metal Corporation)	480 000	8	1977
Nagasaki LNG Terminal	Nagasaki	Saibu Gas	35 000	1	2003
Kagoshima LNG Terminal	Kagoshima	Nihon Gas	86 000	2	1996
Yoshinoura Thermal Power Plant LNG Facilities	Okinawa	Okinawa Electric Power	280 000	2	2012
Hibiki LNG Terminal	Fukuoka	Hibiki LNG (Saibu Gas and Kyushu Electric Power)	360 000	2	2014

Source: Japanese Ministry of Economy, Trade and Industry (METI).

Acronyms, abbreviations and units of measure

Acronyms and abbreviations

EPCO	Electric Power Company
FID	final investment decision
FY	fiscal year (1 April to 31 March)
IEA	International Energy Agency
JAPEX	Japan Petroleum Exploration
JGA	Japan Gas Association
JOGMEC	Japan Oil, Gas and Metals National Corporation
LNG	liquefied natural gas
LPG	liquefied petroleum gas
METI	Ministry of Economy, Trade and Industry
NESO	National Emergency Strategy Organisation
OTC	over-the-counter
PRA	price reporting agency
TPES	total primary energy supply
UGS	underground gas storage
UQT	upward quantity tolerance

Units of measure

bcm	billion cubic metres
GWh	gigawatt hour
MBtu	million British thermal units
mcm	million cubic metres
Mt	million tonnes
Mtoe	million tonnes of oil-equivalent
m^3	cubic metre
km	kilometre
TWh	terawatt hour

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Gas Resiliency Assessment of Japan

This report summarises the findings from the "Gas Resiliency Assessment of Japan" workshop, organised jointly by the International Energy Agency (IEA) and the Ministry of Economy, Trade and Industry (METI) of Japan, held in July 2016. This initiative aimed to identify the natural gas supply security risks and challenges of Japan and to examine whether its existing policies to address these challenges are and will remain relevant in the near future. This report contains several recommendations to improve the resiliency of Japan.

In the energy system of Japan gas plays an important role, particularly so after the 2011 Great East Japan Earthquake, to compensate for the loss of nuclear power generation, which collapsed in 2014. Given its high import dependency, Japan has developed a robust natural gas security of supply policy.

The challenges around security of gas supply are rapidly evolving. The traditional view of gas as a stand-alone fuel is becoming less relevant. With increasing gas market globalisation and greater interdependencies between gas and the rest of the energy system, shocks in one sector or region can reverberate in others.