

Unclassified

ECO/WKP(2013)61

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

28-Jun-2013

English - Or. English

ECONOMICS DEPARTMENT

ECO/WKP(2013)61
Unclassified

RESTRUCTURING THE ELECTRICITY SECTOR AND PROMOTING GREEN GROWTH IN JAPAN
ECONOMICS DEPARTMENT WORKING PAPERS No. 1069

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JT03342507

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ABSTRACT/RÉSUMÉ

Restructuring the electricity sector and promoting green growth in Japan

The 2011 disaster and nuclear problems opened the door to a new energy policy, as they raised fundamental questions about the electricity system's ability to prevent and respond to accidents. In particular, the system has had difficulty coping with the shortages caused by the accident and the suspension of operations of nuclear power plants. Addressing these problems requires creating a more competitive electricity sector by reducing the dominance of the ten regional monopolies through ownership unbundling of generation and transmission and by expanding the wholesale market. It is also important to increase interconnection capacity, while introducing real-time pricing. The reduced role of nuclear power following the Fukushima accident makes it necessary to accelerate the expansion of renewable energy, which requires setting a sufficiently high and consistent price for carbon. Finally, the government should ensure the independence of the new Nuclear Regulatory Agency and create an independent regulator for the electricity sector to promote competition.

This Working Paper relates to the 2013 *OECD Economic Survey of Japan* (www.oecd.org/eco/surveys/japan)

JEL classification: Q40, Q41, Q42, Q48.

Keywords: Japanese economy, electricity sector, electricity shortages, nuclear power, renewable energy, ownership unbundling, wholesale electricity market, interconnection, real-time price, feed-in-tariffs, emissions trading system, energy efficiency, energy conservation, regional electricity monopolies.

Restructurer le secteur électrique et favoriser la croissance verte au Japon

La catastrophe naturelle et nucléaire de 2011, parce qu'elle a posé des questions fondamentales concernant la capacité du système électrique d'éviter et de réagir à des accidents, a ouvert la voie à l'élaboration d'une nouvelle politique énergétique. Ce système notamment n'a pu sans mal gérer les pénuries d'électricité provoquées par l'accident et par la suspension de l'exploitation des centrales nucléaires. S'attaquer à ces faiblesses nécessite la création d'un secteur de l'électricité plus concurrentiel, en atténuant la position dominante des dix monopoles régionaux ; pour cela, il faut dissocier la production du transport et dynamiser le marché de gros. Également, il est important d'augmenter les capacités d'interconnexion, tout en introduisant la tarification en temps réel. L'énergie nucléaire ayant un rôle moins important depuis l'accident de Fukushima, le Japon doit accélérer le développement des énergies renouvelables, ce qui impose de fixer un prix suffisamment élevé et cohérent pour le carbone. Enfin, le gouvernement doit assurer l'indépendance de la nouvelle Autorité de sûreté nucléaire et créer une autorité de régulation indépendante pour le secteur de l'électricité afin de stimuler la concurrence.

Ce Document de travail a trait à *l'Étude économique de l'OCDE du Japon, 2013* (www.oecd.org/eco/etudes/japon).

Classification JEL : Q40, Q41, Q42, Q48.

Mots clés : économie japonaise, secteur de l'électricité, énergie nucléaire, énergies renouvelables, marché de l'électricité de gros, interconnexion, tarification en temps réel, tarifs d'achat garantis, système d'échange de droits d'émission, efficacité énergétique, monopoles régionaux de l'électricité.

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RESTRUCTURING THE ELECTRICITY SECTOR AND PROMOTING GREEN GROWTH IN JAPAN

By Randall S. Jones and Myungkyoo Kim¹

Weaknesses in Japan's electricity market prompted the government to launch a reform programme in 1995 that led to the introduction of competition in power generation and retailing. However, the impact of liberalisation has been limited thus far and electricity prices remain high, contributing to the erosion of the competitiveness of Japanese firms in global markets. Still, until the 2011 disaster, Japan's "partially-liberalised" electricity sector (METI, 2011) performed well in terms of service quality and safety, providing a stable supply of electricity and attracting sufficient investment to meet rising demand.

The 2011 Great East Japan Earthquake raised fundamental questions about the electricity system's ability to prevent and respond to accidents. The International Atomic Energy Agency (IAEA) classified the nuclear accident as level 7, the most serious category, resulting in a "major release of radioactive material with widespread health and environmental effects".² While the accident was caused by a tsunami of exceptional magnitude, its severity focused concern on safety standards. Moreover, the inadequate response by the government and the Tokyo Electric Power Company (TEPCO), the operator of the Fukushima plant, intensified public anxiety about nuclear power. The electricity system has had difficulty coping with the shortages caused by the accident. For example, electricity surpluses in some regions could not offset shortages elsewhere due to inadequate interconnection facilities. In addition, weak market mechanisms forced the government to rely on inefficient policies, such as rolling blackouts and across-the-board cuts, to cope with shortages.

The tragedy of the Great East Japan Earthquake prompted the government to launch a debate on the country's energy strategy, including a reduced role for nuclear power. The shift away from nuclear makes it more important than ever to develop renewable energy sources, thereby promoting green growth. Expanding the role of renewables depends, in turn, on reforming the electricity sector. Given the higher price of renewables, it is important to promote efficiency to limit any rise in the already high electricity price. This section provides an overview of Japan's electricity sector and discusses the government's efforts to cope with the 2011 disaster. It then draws the lessons from the disaster for the electricity sector and examines the government's 2012 energy plans. An agenda for reforming the electricity sector and promoting green growth is presented in the final section, with recommendations summarised in Box 2.

The structure of Japan's electricity sector

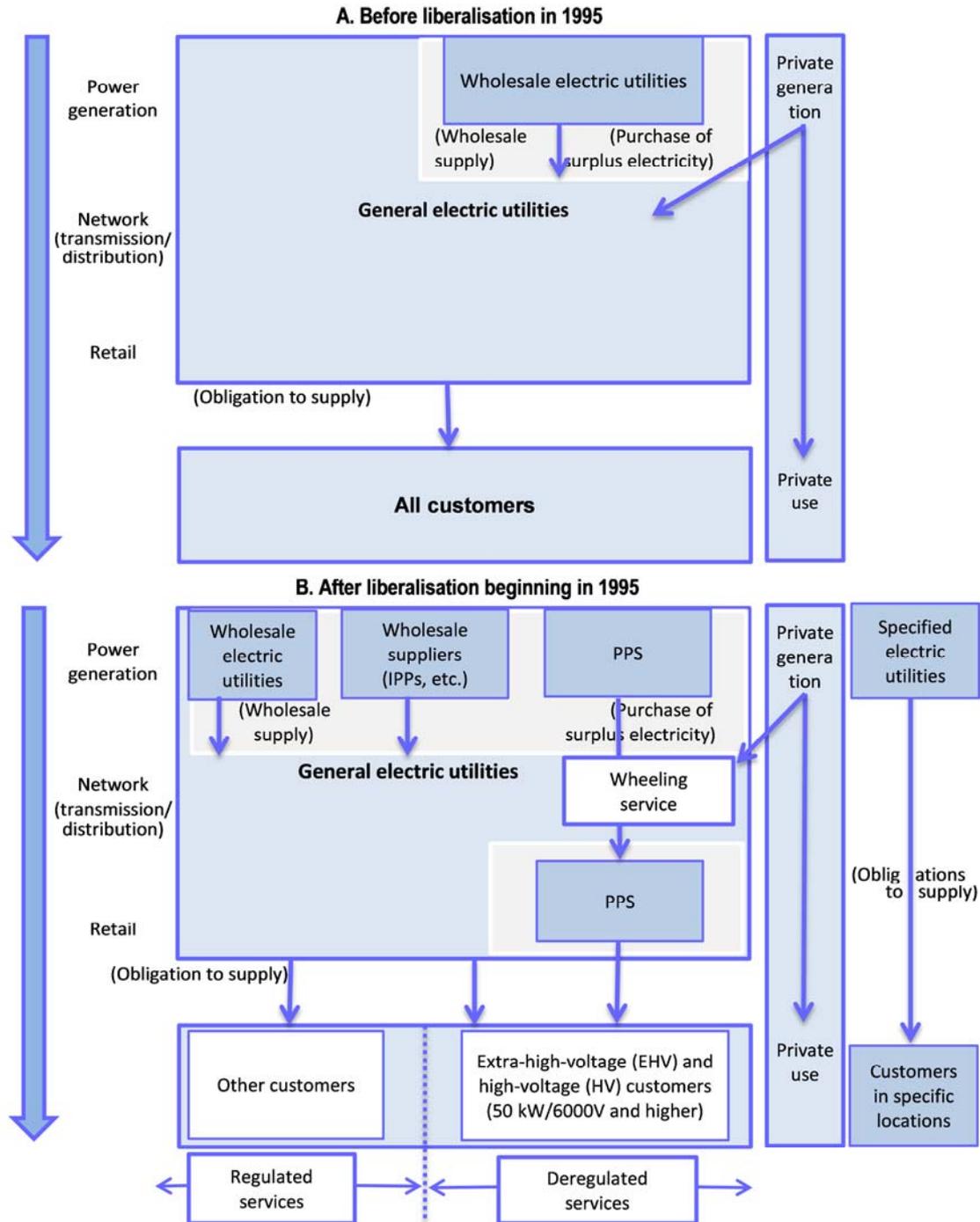
The gradual liberalisation of Japan's electric power system

Japan's electricity system was long dominated by ten vertically-integrated utilities, created in 1951, with monopoly power in their respective regions. These companies – known as general electric utilities – owned three-quarters of electricity generation capacity in 1995 and owned and operated the transmission

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1. Randall S. Jones is head of the Japan/Korea Desk in the Economics Department of the OECD and Myungkyoo Kim is an economist on the Desk. This paper is based on material from the *OECD Economic Survey of Japan* published in April 2013 under the authority of the Economic and Development Review Committee (EDRC). The authors would like to thank Andrew Dean, Robert Ford, Nathalie Girouard, Vincent Koen, and Satoshi Urasawa for valuable comments on earlier drafts. Special thanks go to Lutécia Daniel for technical assistance and to Nadine Dufour and Pascal Halim for technical preparation.
 2. The IAEA's scale of radiological events has eight levels from 0 to 7, with 7 defined as a "major accident" that requires the "implementation of planned and extended countermeasures".

and distribution networks. Together, they supplied 88% of Japan’s total electricity consumption, with wholesale electric utilities and private generators accounting for the rest (Figure 1).

Figure 1. Electric power system before and after liberalisation



1. The definition of each business is as following; *i) wholesale electric utilities* are firms with generation capacity of 2 million kW or above that supply electricity to the general electric utilities. J-Power and Japan Atomic Power Company are examples of such firms; *ii) wholesale suppliers*, such as IPPs, are firms other than wholesale electric utilities. They supply the general electric utilities based on contracts for 1 000 kW or more for at least 10 years, or for 100 000 kW or more for at least five years; *iii) power producers and suppliers (PPSs)* are firms that supply electricity to customers contracted for 50 kW or more, using

the power line networks of the general electric utilities; and *iv*) **specified electric utilities** are firms supplying electricity to certain defined areas using their own power generation and distribution facilities, such as power lines.

Source: TEPCO (2010).

Japan joined the international trend toward greater competition in the electricity sector in the mid-1990s, as part of the liberalisation of key sectors, such as finance, transport and telecommunications, as Japan tried to overcome the economic stagnation caused by the collapse of the bubble economy. In the electricity sector, reform was driven in part by pressure to reduce the gap between domestic and international electricity prices (Asano, 2006). After long debate, the government launched a gradual reform process that tried to balance enhanced efficiency with other objectives such as supply reliability, energy security and environmental protection. The first step was to allow new wholesale suppliers, Independent Power Producers (IPPs), to generate power and deliver electricity to the general electric utilities (Figure 1, Panel B). In addition, the utilities were allowed to procure electricity from other utilities, as well as the IPPs, thus expanding the wholesale market. Such reform opened the door to new entrants to challenge the utilities' regional monopoly position.

Competition was introduced in the retail market beginning in 1999 by allowing Power Producers and Suppliers (PPS) to deliver electricity directly to eligible consumers using the transmission network of the general electric utilities (Figure 1, Panel B). The threshold for retail choice was gradually lowered. By 2005, 63% of customers (those consuming 50 kW or more) were allowed to choose a supplier. However, the PPS's retail market share was still small at 2.8% in 2009.

The institutional infrastructure has evolved in line with market liberalisation. To promote transactions in the wholesale market, the Japan Electric Power Exchange (JEPX), a private non-profit organisation composed of 21 investors, such as the general electric utilities and new power generators, was established in 2003. Participation in the wholesale market is voluntary. The following year, the Electric Power System Council of Japan (ESCJ) was designated as a "neutral transmission system organisation". The ESCJ, a self-governing agency operated by private entities, such as the general electric utilities and IPPs, plays a key role in setting rules, providing market oversight and settling disputes to ensure fairness and transparency in transmission and distribution. The Ministry of Economy, Trade and Industry (METI) oversees the electricity sector, with overall responsibility for regulation and supervision.

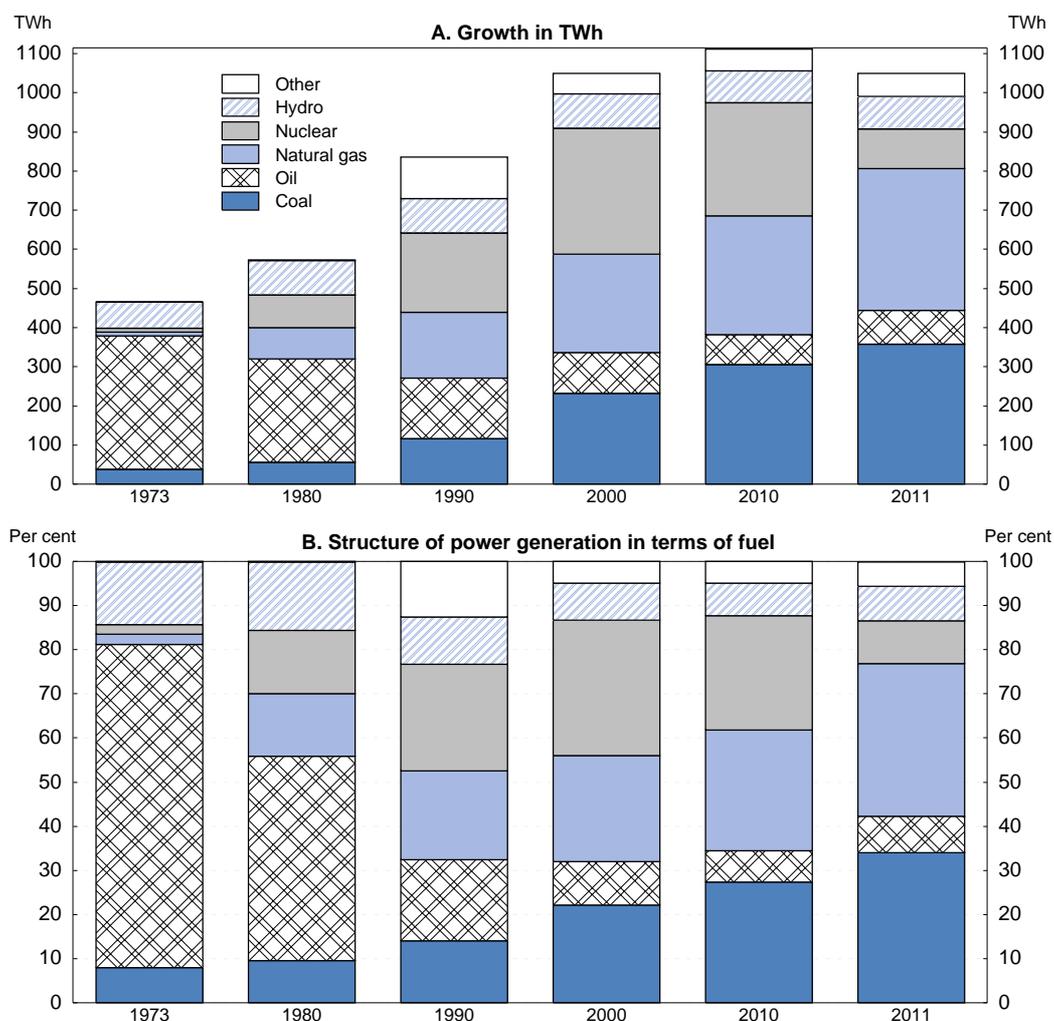
Successful liberalisation of power generation requires a level playing field among power suppliers, including a neutral transmission system. The general electric utilities, which own and operate the transmission network, must be prevented from subsidising their generation and retailing activities, which operate in competitive markets. In short, neutrality requires "unbundling" – separating the monopolistic network-related services (*i.e.* transmission and distribution) from the competitive commercial functions of generation and retail. There are various types of unbundling – management, accounting, legal (for example, creating a holding company structure) and ownership. Japan opted for the relatively weak option of accounting unbundling in 2003, which does not separate ownership but requires separate accounting for the different services. In addition, the government introduced rules of conduct, such as prohibiting discriminatory treatment. The price of using the transmission system ("wheeling tariffs") must be set in accordance with regulations established by METI and reported to it.

Supply, demand and price of electricity prior to the 2011 disaster

The development of electricity in Japan, the second largest electricity market in the OECD, was driven by coal and nuclear power, while the share of oil fell from 73% at the time of the first oil shock to only 7% by 2010 (Figure 2). Japan had a more balanced energy mix, with coal, natural gas and nuclear energy each accounting for about 30% of power generation in 2010. Despite the expanded role of coal and natural gas, the share of fossil fuels fell from 83% of generation in 1973 to 62% in 2010, due to the rising

dependence on nuclear power. The role of renewable energy (excluding hydro) has remained small, accounting for less than 3% in 2010 (Panel B). Investment has been adequate to keep peak supply at least 10% above peak demand in most years. However, the consumer price of electricity is high by international standards, particularly in the industrial sector, where it is second highest in the OECD (Figure 3). This is one factor eroding the competitiveness of Japanese firms.

Figure 2. Development of electric power generation in Japan



Source: IEA (2012a).

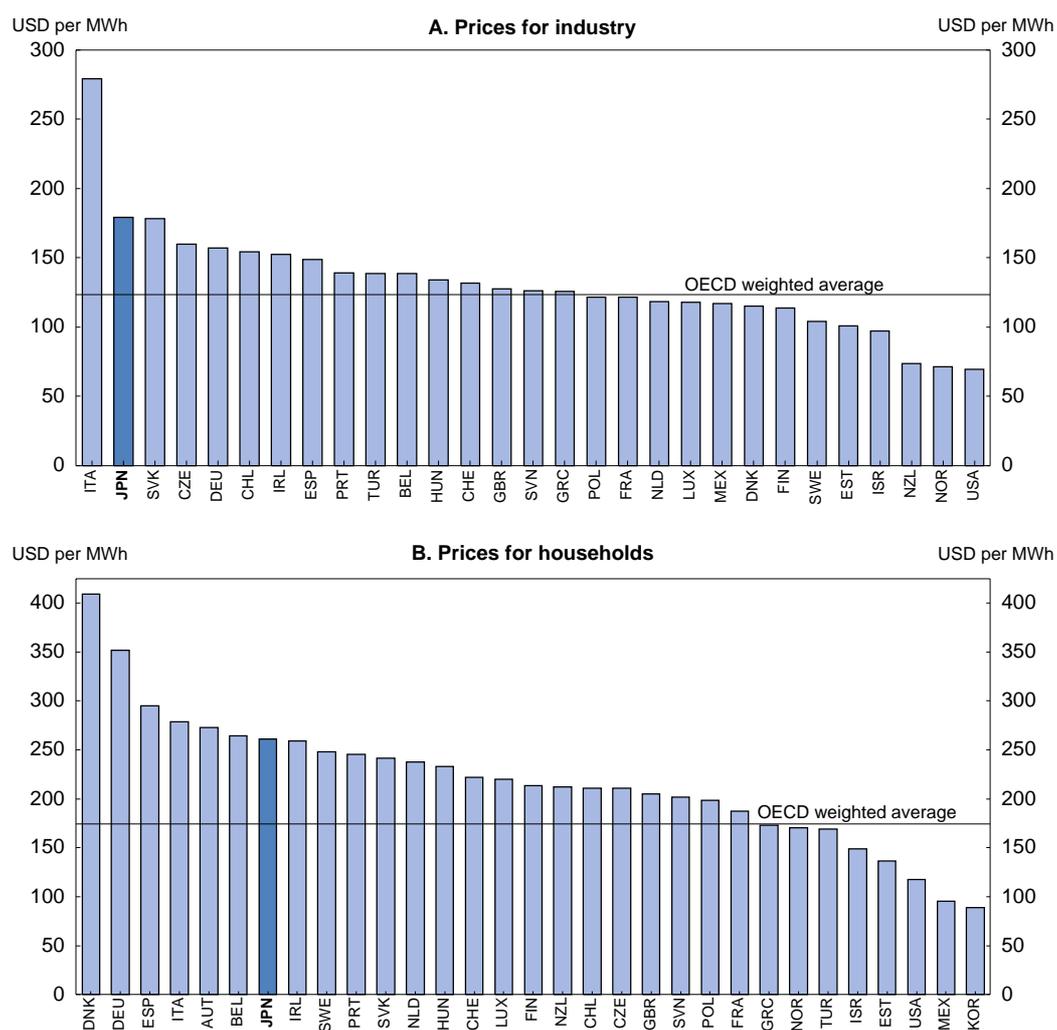
The response of the electricity sector to the Great East Japan Earthquake

The nuclear accident caused a loss of confidence in the safety of Japan's 50 nuclear power plants, prompting the government to change its energy strategy. Reactors that suspended operations for safety checks were left closed, leaving Japan with no operating nuclear plants in May 2012.³ The sudden stoppage

3. After confirming their safety, the government allowed two reactors in the Ohi nuclear power plant to resume operation in June 2012 to cope with an expected electricity shortage in the Kansai region during the summer.

of nuclear power, which had accounted for around one-third of total electricity production, reduced capacity more than 12% in the summer of 2011 relative to a year earlier, to 171 GW. As it was well below the peak summer-time demand of 180 GW in 2010 (Figure 4), METI expected significant energy shortages in parts of Japan, particularly in areas dependent on nuclear power. The government requested all electricity users in the Tokyo and Tohoku regions to cut consumption by more than 15% compared to 2010 (ANRE and METI, 2012). The reduction was legally mandatory for enterprises with supply contracts of 500 kW or more. Households living in the western part of Japan were asked to reduce electricity consumption by 10%, although there was no legal obligation.

Figure 3. Electricity prices in Japan were relatively high in 2011¹



1. Using market exchange rates. Prices include taxes.

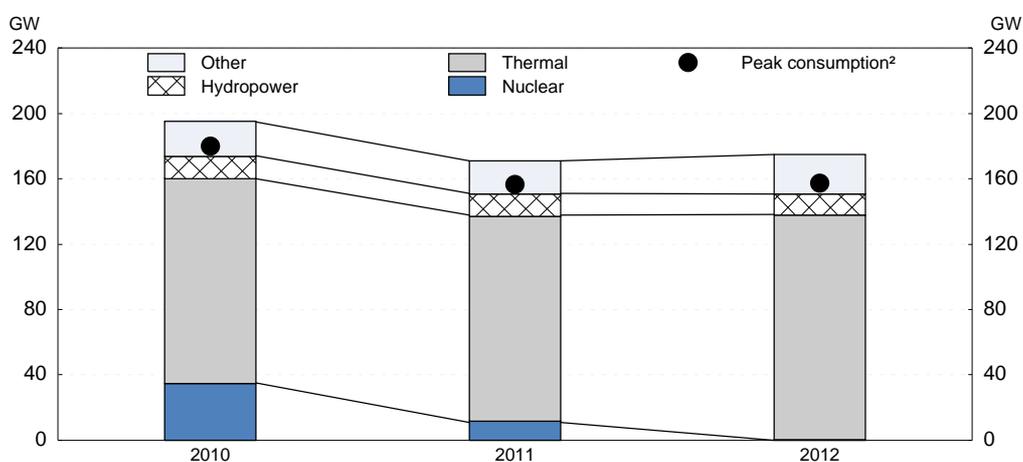
Source: IEA (2012b).

In the event, the energy saving target was exceeded, with peak consumption in the summer of 2011 falling by 13% relative to 2010, thereby avoiding shortages, thanks in part to a relatively mild summer, reducing demand for air conditioning. Most importantly, major consumers reduced consumption by 29% in the TEPCO service area (IEEJ, 2012). A survey found that manufacturers reduced energy consumption during peak periods by shifting production to weekends, early morning or late evening hours, thereby

avoiding the need for blackouts (Keidanren, 2011). Firms also installed on-site power generation equipment and purchased energy-efficient equipment. While these countermeasures helped, they raised energy costs and disrupted production chains and employees' lives. Between 60% and 80% of manufacturers in the Keidanren survey replied that their production, investment and revenue would be adversely affected if the tight supply-demand situation were to continue for two or three years.

In 2012, electricity supply capacity remained level, as the increase in thermal and other sources nearly offset a further fall in nuclear capacity (Figure 4). In May 2012, the government projected that while nationwide supply would fall only slightly short of demand during the summer, there would be shortages in four of the general electrical utility regions, including a 15% deficit in the Kansai region. The government, therefore, asked consumers to reduce energy consumption during peak times.⁴ With total consumption remaining close to the level of 2011 – about 13% below the 2010 level – shortages were once again avoided.

Figure 4. Electricity supply capacity has fallen since 2010¹



1. Excluding Okinawa.
2. In summertime in GW.

Source: Agency for Natural Resources and Energy and the Ministry of Economy, Trade and Industry.

The suspension of nuclear plants' operations was partially offset by higher imports of fossil fuels – oil, LPG, LNG and coal – to increase generation at thermal plants. Japan recorded a trade deficit in 2011 for the first time since 1980, with the additional energy imports accounting for about one-third of the deterioration in the balance. The trade deficit widened to around 1.5% of GDP in 2012. Higher imports, in turn, led to a hike in electricity prices. TEPCO, which supplies about one-third of the energy consumed in Japan, raised its electricity tariffs by 15% for firms in April 2012 and by 8.5% for households in September 2012, further pushing up already high energy prices. Other general electric utilities, notably those in Kansai and Kyushu, are expected to follow TEPCO in raising their tariffs as well. The renewed reliance on fossil fuels also has a negative environmental impact, including increased greenhouse gas (GHG) emissions.

4. In addition, customers in the Hokkaido, Kansai, Shikoku and Kyushu areas were asked to prepare for possible rolling blackouts.

Lessons from the Great East Japan Earthquake for the electricity sector

Weak safety supervision left Japan vulnerable to the nuclear accident

The March 2011 disaster revealed that weak safety supervision had left Japan vulnerable to a nuclear accident. The report to the Diet from the Fukushima Nuclear Accident Independent Investigation Commission⁵ in 2012 concluded that the “accident was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties. They effectively betrayed the nation’s right to be safe from nuclear accidents. Therefore, we conclude that the accident was clearly ‘manmade’. We believe that the root causes were the organisational and regulatory systems”. The report noted that researchers had warned about the high probabilities that tsunami levels would surpass the assumptions made at the time of the construction of the Fukushima plant in the late 1960s. Moreover, the then-regulator, the Nuclear and Industrial Safety Agency (NISA), and TEPCO had also been aware since 2007 that a tsunami could cause a total outage of electric power and that the breakdown of seawater pumps caused by a power outage would damage nuclear power stations significantly. The report stated that “There were many opportunities for taking preventive measures prior to March 11. The accident occurred because TEPCO did not take these measures, and NISA and the Nuclear Safety Commission (NSC) went along”. TEPCO instead chose “to aggressively oppose new safety regulations and draw out negotiations with regulators”.

The Commission also reported that the preventive measures required by NISA and implemented by TEPCO were not up to international standards. For example, the current Japanese standards for severe accidents are made on the basis of internal factors, such as human error, and exclude external factors such as earthquakes and tsunamis, even though Japan is very vulnerable to such disasters. From 2010, the regulators tried to upgrade accident prevention standards in line with global trends. However, the operator successfully lobbied with NISA to maintain lax safety standards rather than focusing on preparations against accidents. In addition, another study of the accident found that Japanese regulators and operators had not been very co-operative with the IAEA prior to the earthquake (Rebuild Japan Initiative Foundation, 2011).⁶

The regulatory failure stemmed largely from the fact that the agencies in charge of promoting the development of the nuclear industry and regulating it are not effectively separated. NISA, which was responsible for regulating nuclear power operators, was a subordinate institution of METI, which is responsible for promoting the nuclear industry. According to a government report to the IAEA in June 2011, “NISA’s lack of independence from METI, which promotes the use of nuclear power, hampered a quick response to the disaster at TEPCO’s Fukushima Dai-Ichi plant this year”. Japan had strong incentives to promote nuclear power. *First*, it was an effective option to raise Japan’s low energy self-sufficiency ratio of 4% in 2009, one of the lowest in the OECD area, and reduce its vulnerability to energy shocks. *Second*, nuclear energy would help Japan achieve its target for reducing GHG emissions, given that nuclear power does not generate CO₂. *Third*, the nuclear power industry was a potential growth engine for Japan, one of the few countries with experience in building and operating nuclear power plants.

5. This Commission, which was established with ten independent members in December 2011, carried out a comprehensive examination for six months on the Fukushima nuclear power plant accident (National Diet of Japan, 2012).

6. The peer-review system of the IAEA issued a report in 2007 on problems in Japan’s nuclear safety regulation, but the NSC issued a statement “dismissing the IAEA’s recommendations and claiming that the current nuclear regulation system had been functioning effectively to ensure safety at an outstanding level by international standards”.

Indeed, the previous Japanese Basic Energy Plan set a target of increasing the share of nuclear energy up to 50% of total electricity production in 2030.

Given the benefits of nuclear power, strong interest groups in industry, government and academia and local leaders supported the nuclear industry while deliberately disregarding the associated risks. The pressure to promote nuclear power, rather than focus on safety, inhibited regulators from taking aggressive actions against operators. In fact, the Commission's report criticises the regulators for not giving any specific instructions for enhancing safety measures and, instead, allowing operators to postpone preparations against disasters.

A market structure based on regional monopolies limited the supply response to shortages

Given the regional monopolies and the lack of interconnection capacity between regions, an electricity shortage in one region could not be effectively offset with surplus electricity from other areas. Indeed, the government requires the ten general electric utilities to achieve self-sufficiency, with the capacity to satisfy every demand within their service area, rather than connecting with other regions. For example, the interconnection capacity for TEPCO is 3.4 GW (1.0 GW from Chubu and 2.4 GW from Tohoku), amounting to only 6.3% of peak demand (Figure 5). Interconnections between regions were mainly intended as a back-up for security purposes, leaving the regions insufficiently connected to each other (Hatta, 2012 and IEA, 2008).

In addition to limited interconnection facilities, the division of Japan into two separate regions using different frequencies – 50 Hz and 60 Hz – restricts the transfer of electricity supply (Figure 5). As a result, TEPCO, which uses a frequency of 50 Hz, was effectively cut off from western Japan, which was not damaged by the earthquake and tsunami (Kawai and Morgan, 2012). Three frequency converter facilities (FCF) connect the two regions, but their total capacity was too small to cover the large electricity shortage resulting from the March 2011 disaster. Consequently, TEPCO was forced to implement rolling blackouts. The government estimates the direct cost of integrating frequency across Japan at about 10 trillion yen (2% of GDP). The lack of interconnection and FCF remains problematic as only two of 50 nuclear power plants are in operation as of April 2013.

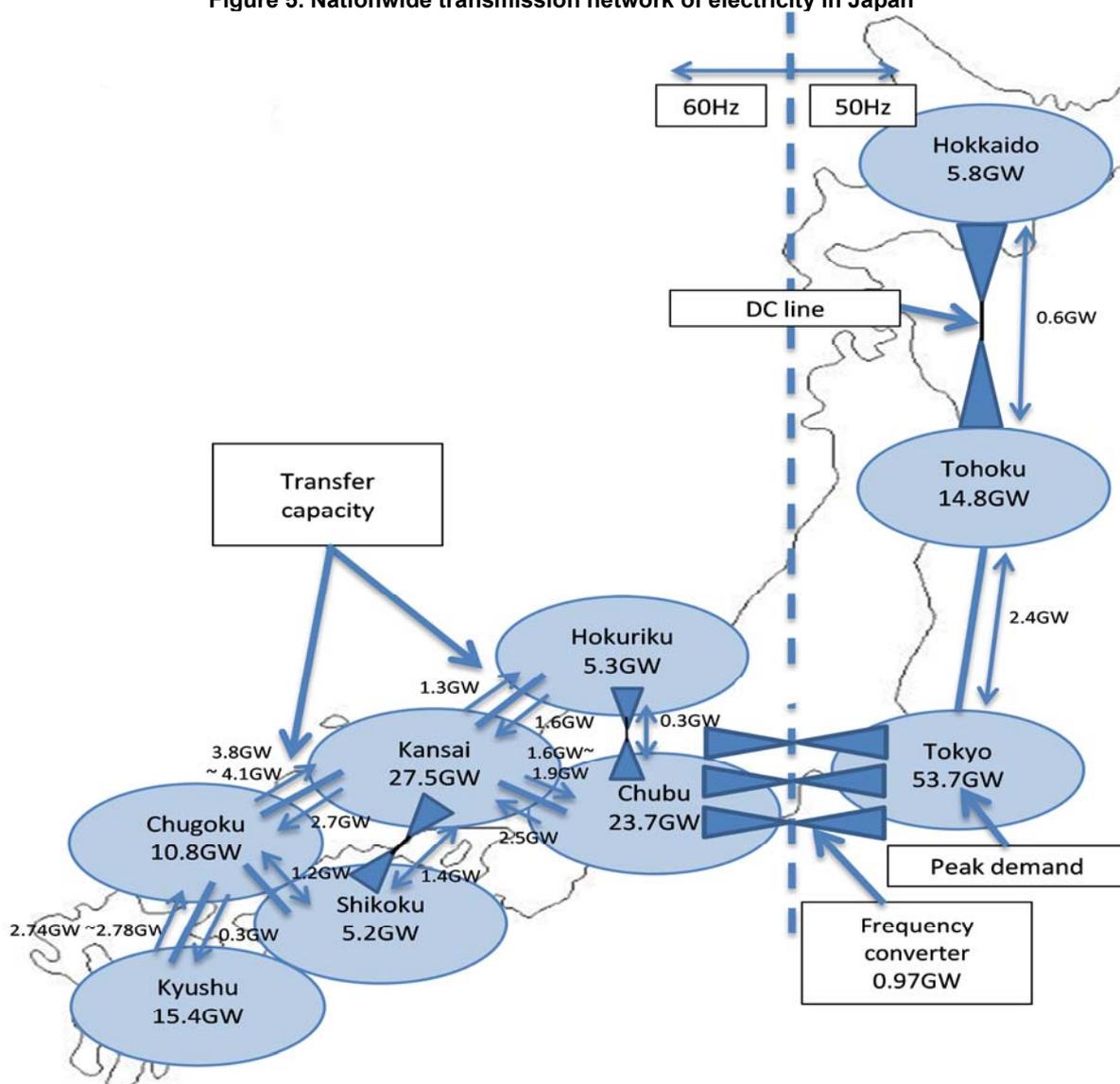
Weakness of the price mechanisms to adjust supply and demand

In addition to the segmented power network, the electricity system lacks an efficient mechanism to modify supply and demand in line with current conditions. The law stipulates that supply and demand must balance at all times to avoid blackouts. When that is impossible, due to accidents or unforeseen problems, utilities must modify demand. For example, in the two weeks following the earthquake, TEPCO implemented rolling blackouts to maintain overall balance by stopping energy supplies to a restricted area. Another option is mandatory energy saving by customers within designated areas. Under the Electricity Business Act, the Minister of METI can order energy saving “when it seems that if no adjustment is made to the supply and demand of electricity, a shortage of electricity supply will adversely affect the national economy, standard of living or public interest”. As noted above, the Minister ordered large-scale users with contracts for 500 kW or more within the TEPCO service area to reduce electricity consumption by 15% during the summer of 2011 compared to the summer of 2010 to cope with the electricity shortage.

However, these measures are not efficient, as they require every consumer to reduce energy consumption by a similar amount regardless of the cost of energy conservation or the services they produce. For example, during the blackouts in 2011, the energy supply to public services, such as hospitals and traffic signals, was halted with serious adverse effects (Hatta, 2012). Market mechanisms that reflect consumer preferences would have less negative economic impact than arbitrary instruments such as rolling

blackouts or forced energy savings. In a fully liberalised market, price movements help balance supply and demand based on the preferences of suppliers and consumers.

Figure 5. Nationwide transmission network of electricity in Japan



1. The numbers in the circles for each general electric utility show peak demand. The numbers next to the arrows show how much electricity can be transferred

Source: Institute of Energy Economics, Japan.

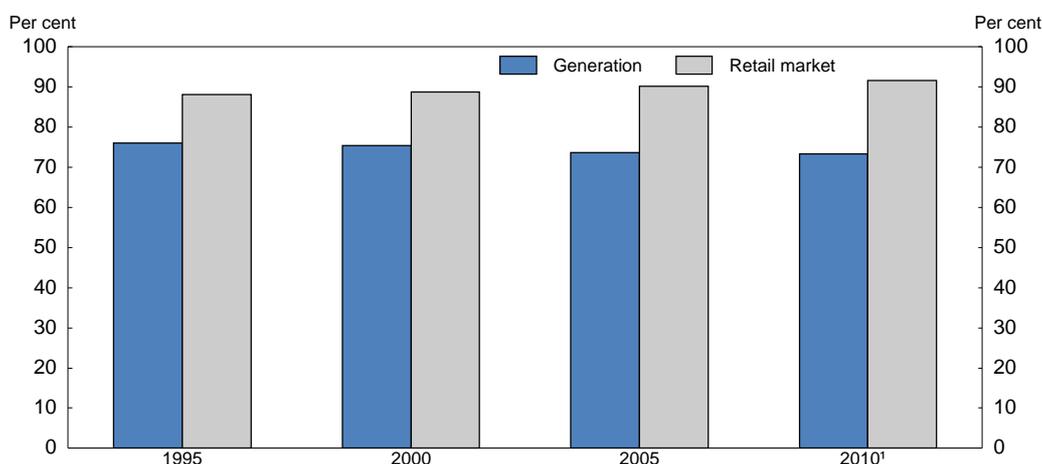
Despite electricity market reforms since 1995, the price mechanism does not work in Japan. Most importantly, the widespread reliance on “right-of-use-contracts” weakens incentives of both large-scale consumers and suppliers to modify energy consumption and supply in line with market conditions. Such contracts allow customers to consume as much power as they want at a fixed rate. The prevalence of such contracts reflects the domination of the retail market by vertically-integrated general electric utilities, with little incentive to adopt the “definite-quantity contract”, which specifies both prices and the volumes of transactions. With the price fixed under the right-of-use contract, consumers have weak incentives to

reduce their energy consumption even when an electricity shortage is expected. Similarly, suppliers have weak incentives to increase output when supply-demand conditions are tight. The lack of an effective price mechanism also discourages the utilisation of Japan's numerous private electricity generators in response to tight supply and demand situations.⁷ As a result, blackouts are inevitable when demand exceeds supply.

The continued dominance of regional monopolies hinders the development of market mechanisms

The slow and ineffective liberalisation pursued by the government since 1995 has left market mechanisms weak. In particular, the role and influence of general electric utilities has changed little, as they remain vertically integrated and regional monopolies. Indeed, their share of power generation has remained around 75% since 1995 (Figure 6). The dominance of the general electric utilities is reflected in the structure of the wholesale and retail markets. Trading volume in the wholesale market, the JEPX, which was established in 2005, still amounted to only 0.5% of power generation in 2010 (Figure 7), much less than in other wholesale electricity markets. According to the IEA (2008), spot turnover in successful power exchanges ranges from 20% to 70% of total demand.

Figure 6. The share of the general electric utilities in electricity generation and the retail market remains high



1. 2009 for the retail market.

Source: FEPC (2012).

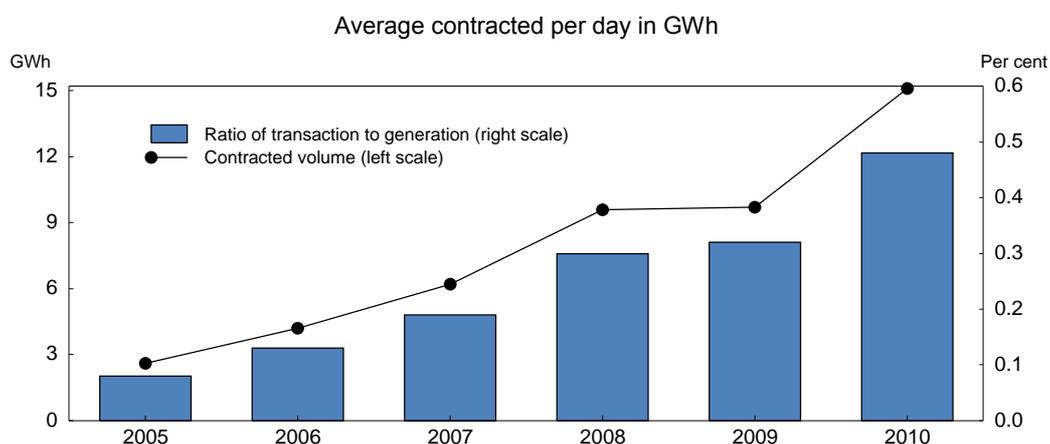
The general electric utilities also dominate the retail market. If the PPSs' supply does not meet the demand from their customers, the utilities make up the difference, while charging a penalty known as the imbalance fee on power suppliers.⁸ The heavy penalty for failing to meet the moment-to-moment matching discourages potential new entrants. On the other hand, if the PPSs have excess supply, it is taken by the general electric utilities with no compensation. The PPSs thus have no incentive to increase output above the demand from their own consumers, even when an overall electricity shortage is expected. While the

7. The lack of an effective price mechanism also discourages the utilisation of Japan's numerous private electricity generators in response to tight supply and demand situations. Given that most private electricity generators use oil, which tends to be more expensive, they prefer to rely on the general electric utilities instead of operating their own power generators. If the electricity price were to increase enough during tight demand and supply conditions, more private generators would be run.

8. The fee is set at 10 yen per kilowatt hour on shortages up to 3% and 30 yen or more per kilowatt hour on shortages above 3% (Hatta, 2012).

share of the PPSs doubled from 1.4% in 2004 to 2.8% in 2009 in the liberalised high-voltage segments, it remains small. Meanwhile, the share of the general electric utilities has risen slightly since 1995, reaching 92% in 2010.

Figure 7. Trading volume in the Japan Electric Power Exchange remains small



Source: JEPX and FEPC.

Japan's 2012 energy policy plans

Before the Great East Japan Earthquake, Japan had aimed at ensuring a stable energy supply and addressing global warming by increasing its dependence on nuclear energy. The review of energy policy after the disaster led to the *Innovative Strategy for Energy and the Environment* announced in September 2012, which focused on reducing the role of nuclear energy, while promoting renewable energy (Box 1). Renewable energy is key, along with improving energy efficiency, to achieving the *Strategy's* new target of reducing Japan's domestic GHG emissions by about 20% from the 1990 level in 2030, which is less ambitious than the previous target of a 25% reduction by 2020. The *Strategy*, which is intended as a map for future reform and is not legally binding, is currently under review by the new government.

This report came on the heels of METI's new basic policy on electricity system reform (METI, 2012), which argued that electricity reform is urgent on a number of grounds: *i)* the change in the energy mix with the decline in nuclear power; *ii)* the increase in energy costs; *iii)* the need to shift from ensuring enough supply to meet demand to focusing on containing demand; *iv)* the need for the public to choose the type of electricity and its supplier; and *v)* the importance of optimising supply and demand across regions by breaking down regional monopolies (Box 1). Three main reform objectives were spelled out:

- Ensuring the freedom of choice of electricity for all people.
- Allowing everyone to create electricity.
- Delivering electricity widely and neutrally.

This would open the electricity system to all consumers and suppliers and ensure supply-demand balance through competition and selection. In April 2013, the Cabinet decided on an electricity reform plan with major reforms planned by 2020, including the full liberalisation of the electricity retail market and legal unbundling.

Policies to restructure the electricity sector

The decision to reduce the role of nuclear power will fundamentally change the electricity sector, making it time to resume the liberalisation of this sector. Moreover, the increased role of renewables will help to accelerate green growth. This section proposes an agenda for reform that is summarised in Box 2.

Box 1. Recent energy policy strategies announced by the previous government

Innovative Strategy for Energy and the Environment (September 2012)

1. *Achieving a society not dependent on nuclear power as early as possible, based on three guiding principles.* These steps may "even enable zero operation of nuclear power plants in the 2030s":

- Strictly apply the rules limiting the operation of nuclear power plants to 40 years.
- Restart nuclear power plants only once the Nuclear Regulation Authority gives its safety assurance.
- Prohibit the planning and construction of nuclear power plants.

2. *Realisation of a green energy revolution*

- Electricity saving: reduce electricity use by 10% from its 2010 level by 2030.
- Energy saving: reduce total energy use by 19% from its 2010 level by 2030.
- Renewable energy: nearly triple its output from 110 billion kWh in 2010 to 300 billion kWh by 2030. Excluding hydro, renewable energy is to rise by a factor of almost eight (25 billion kWh to 190 billion kWh).

3. *Ensuring a stable supply of energy through:*

- Development of advanced thermal power generation, including LNG and coal.
- Intensive use of heat, including cogeneration systems.
- Technologies related to next generation energy, such as carbon dioxide capture and storage.
- Stable and inexpensive supplies of fossil fuels by strengthening comprehensive bilateral relationships with resource-rich countries and supporting the acquisition of upstream interests by Japanese companies.

4. *Bold reform of the electricity system*

- Promotion of competition in power generation and the retail market.
- Separation of generation from transmission and distribution, either functionally or legally, while enhancing the inter-regional and intra-regional power grids.

5. *Implementation of global warming countermeasures*

- Japan has a target of reducing its GHG emissions by 80% by 2050 and reducing domestic emissions by about 20% from their 1990 level in 2030.
- The government was to formulate its "Global Warming Action Plan" for the period from 2013 by the end of 2012.

Basic Policy on Electricity System Reform (July 2012)

1. *Reform of demand side (electricity retailing)*

- Full liberalisation of retail market by abolishing the general electricity utilities' regional monopolies.
- Abolishment of rate regulation.

2. *Reform of supply side (power generation)*

- Full liberalisation of power generation by removing regulations on the wholesale market.
- Revitalisation of the wholesale market by measures to activate transactions.

3. Reform of the power transmission/distribution sector

- Establish a nationwide system to utilise supply widely by reforming the current systems that control the supply-demand balance in each area.
- Ensure the neutrality of the power transmission/distribution sector in each area by functional or legal separation, while enhancing interconnection capacity between regions.

Upgrade supervision in nuclear power and in the electricity sector

Even with the plan to phase out nuclear power plants, Japan faces the issue of how to ensure their safety during the coming decades. An official report in early 2012 concluded that the “government lost credibility on nuclear policy” (Cabinet Secretariat, 2012). To resolve the conflict of interest, the government decided to establish a new nuclear regulatory authority, the Nuclear Regulation Authority (NRA), under the Ministry of the Environment in September 2012. The new authority combined NISA (which had been under the jurisdiction of METI) and the NSC (under the Cabinet Office) in order to unify nuclear safety regulations. The top priority is to ensure the regulators’ independence from interested parties so as to prevent “regulatory capture” and withstand the pressures noted above to promote nuclear power. One priority is to prevent a revolving door between the NRA and line ministries by prohibiting NRA officials from returning to ministry jobs.

Nuclear plants should be re-started only after comprehensive safety check-ups based on new standards set by the NRA. The NRA recently unveiled strict safety measures to protect nuclear power plants against natural disasters and terrorist attacks. All plants will have to meet the new rules, which are to be finalised in July, before being reviewed for possible re-opening. Some of the proposed measures have been implemented but others require expensive upgrades. For example, plants must have back-up control rooms away from reactor buildings and reinforce protective structures to withstand the impact of a jet aircraft crash. The NRA is also arguing for a more cautious evaluation of earthquake faults under nuclear facilities, which may result in the permanent closure of some plants. The ability of the NRA to enforce its new guidelines in the face of opposition from the operators of nuclear plants will be a test of its supervisory capacity and independence.

As noted above, the lack of independence between the nuclear regulatory body and METI was a major factor in the Fukushima accident. However, METI remains the regulatory body for the electricity industry, for example in setting rules for access to the network and electricity tariffs. Creating an independent sectoral regulator, along with the separation of generation and transmission (see below), would help ensure non-discriminatory third-party access to the transmission network (2004 *OECD Economic Survey of Japan*). Creating independent sectoral regulators provides a number of advantages, including (Jacobs, 2001):

- Clarifying the distinction between the government’s roles in promoting competition and encouraging growth.
- Improving transparency for market actors and consumers.
- Deepening expertise and technical skills in complex areas, such as energy.
- Enhancing stability and commitment to optimal long-run policy based on competition and consumer welfare.

Improve and expand market mechanisms in the energy sector

The 2012 Basic Policy on Electricity Reform proposed an ambitious agenda to create a competitive electricity market through reforms in electricity retailing, generation and the transmission network system. Achieving a competitive electricity market requires a number of reforms.

First, further unbundling of generation and transmission is essential. The accounting unbundling introduced in 2003, accompanied by government guidance and monitoring of transmission fees, has proven inadequate, as reflected in the still dominant share of the general electric utilities. As long as the general electric utilities provide power generation, transmission and retailing, they have little incentive to create a level playing field and operate in a competitive market. Consequently, the transmission charge imposed on PPSs by general electric utilities, which is regulated by METI, is criticised for preventing potential competitors from joining the market (IEA, 2008). Accounting unbundling has failed to ensure a level playing field for all market participants, reflecting how difficult it is for regulators to identify and prove the use of subsidies between power generation and transmission, given the complexity of the electricity business. Japan should introduce ownership unbundling, which will improve market access by improving the neutrality of transmission, while removing incentives to under-invest in transmission (Pollitt, 2007).

Second, interconnection capacity among different regions, including the frequency converters, should be expanded, thus breaking down the regional monopoly positions of the general electric utilities and creating a nationwide market, as envisioned in the 2012 *Basic Policy*. In addition, strengthening interconnection across regions would bring more players into the wholesale market, thereby promoting its development. For the market to function properly and set an appropriate price, it needs a sufficient number of transactions and participants. Otherwise, market participants will not be able to find counterparts for their intended transactions, prompting them to leave the market, thereby further shrinking it. A nationwide market would also improve the physical capacity to cope with sudden electricity supply disruptions in certain regions by utilising surpluses in other areas.

Third, the definite-quantity contract – which specifies both price and quantity – should be encouraged rather than the right-of-use contract, which gives consumers less incentive to modify consumption because electricity supply at the pre-set price is guaranteed. By changing to a definite-quantity contract, consumers will have more incentives to modify their consumption, thereby increasing trading in the wholesale market. As the share of definite-quantity contracts increases, real-time balancing should replace moment-to-moment balancing and the associated punitive charges for shortfalls in supply from the PPSs, which discourage the entry of new suppliers. If supply and demand have to be balanced in real time, the price will reflect market conditions precisely, thereby providing appropriate signals. Finally, as a dynamic wholesale market with more competitors develops and a unified national electricity market is established, Japan can move towards the *Basic Policy*'s ultimate objective of extending choice to all consumers.

Promoting renewable energy

The development of renewables has become more urgent following the 2011 disaster, given the reduced role of nuclear power. Moreover, accelerating the use of renewables would help increase Japan's growth potential by creating new industries and jobs, reduce GHG emissions and enhance energy security. Indeed, the 2010 New Growth Strategy envisioned 50 trillion yen (more than 10% of 2012 GDP) of new demand and 1.4 million new jobs through the development and diffusion of green technologies.

To compensate for the reduced role of nuclear power, the *Basic Plan* proposed tripling the amount of electricity produced from renewable sources, boosting it to 30% by 2030 (NPU, 2012a). This target is a substantial increase from the 20% objective in the previous energy plan, which was considered ambitious. However, such a policy would impose a heavy burden on consumers. For example, four studies published

by the National Policy Unit projected that household electricity prices would rise by 90% to 110% if nuclear power were completely replaced by renewables, although 10% to 65% of the impact on households' electricity bills would be offset by reduced consumption (NPU, 2012b).

Moreover, the technical feasibility of such an increase has been questioned, given the limits to expanding renewable energy. For example, the previous plan called for equipping 12 million households with photovoltaic power equipment – above the 10 million limit thought to be realistic. For wind power, the strategy called for installing capacity of 10 million kW by 2030, far above the estimated onshore potential of 6.4 million kW (IEEJ, 2011). The scope for offshore wind generation is limited by fishing rights granted to domestic firms. However, an IEA study estimated the realisable potential contribution of renewables in Japan at 244 TWh in 2020, equivalent to 24% of total electricity generated in 2009 (IEA/OECD, 2008). In particular, Japan has relatively large potential in hydropower (116 TWh), wind (35 TWh), solid biomass (28 TWh) and solar photovoltaics (26 TWh). Moreover, Japan has the highest number of patents related to renewable energy (OECD, 2010).

The government created a Renewable Portfolio Standard (RPS) in 2003 to raise the share of renewable energy in Japan. The RPS set a compulsory target of 1.6% of electricity from renewable sources, excluding hydro, by 2014. While the target has already been reached, the share of renewable energy, excluding hydro, was only 2.8% in Japan in 2011, well below the OECD average of 6.3% (Figure 8).⁹ Moreover, its share increased by only 1.4 percentage points in Japan between 1990 and 2011, compared to the OECD average of 4.5 points (Panel B). The development of renewable energy in Japan has faced a number of obstacles, including the priority accorded to nuclear power. Japan's 2010 Strategic Energy Plan set a target of 20% for renewables in 2030, with 50% from nuclear. Germany, in contrast, has a target of 50% for renewables in 2030 (DeWit, 2011).

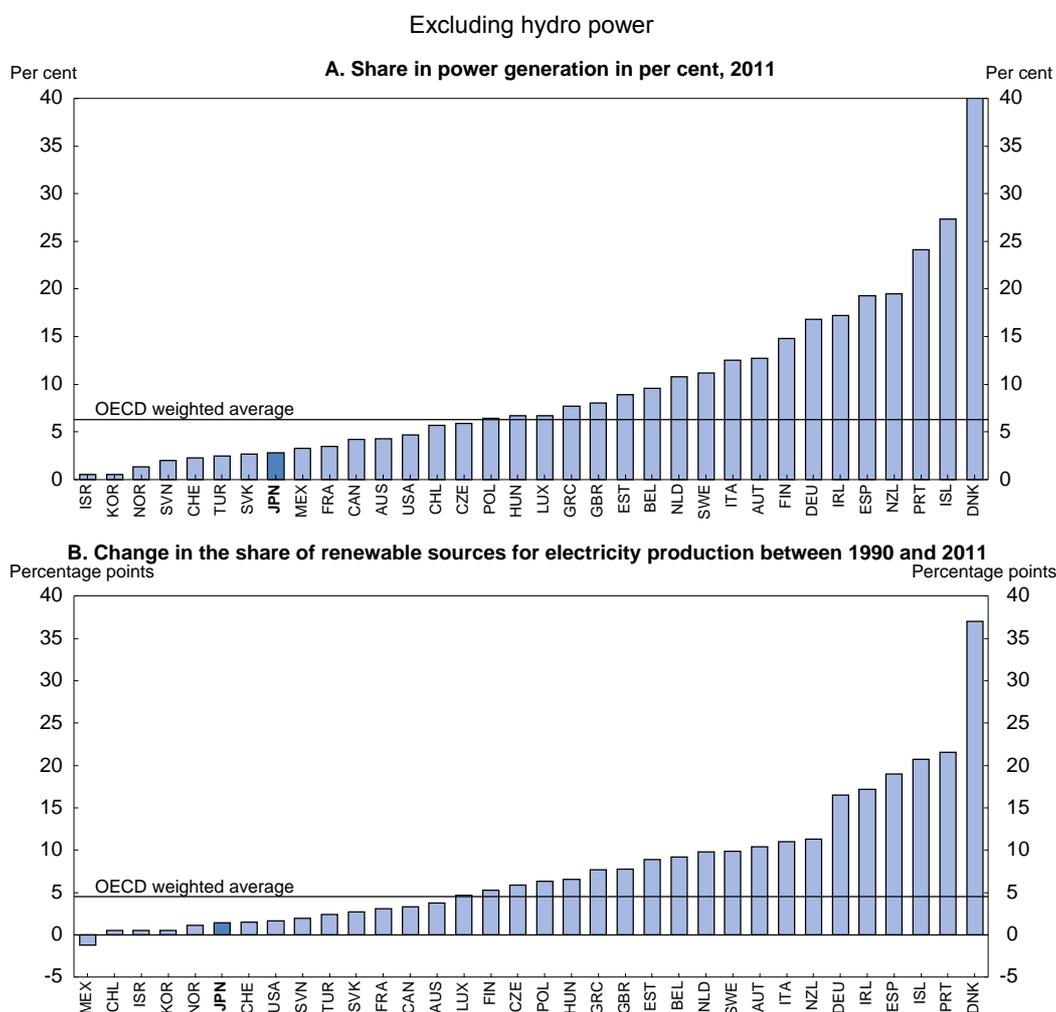
In 2012, Japan launched a feed-in-tariff (FIT) programme, which obliges the general electric utilities to purchase electricity from almost all renewable energy producers to promote renewable energy. Under this scheme, producers of electricity generated by renewable resources can sell that electricity at a fixed long-term price guaranteed by the government. The tariff is set high enough to make renewable energy profitable. For example, the price for solar photovoltaic was set at 42 yen per kWh for the next 20 years. It is estimated that the FIT scheme will enable solar and wind projects to achieve equity returns as high as 44% and 51%, respectively, the highest in the world (Bloomberg New Energy Finance, 2012). However, the exceptionally high returns to renewables and the high price, which is covered by a surcharge on all electricity customers, raises the risk of distortions. Maintaining incentives for R&D in a FIT system is also important. The experience of Germany's FIT that was introduced in 2000 suggests that while it is effective in promoting renewable energy, it reduced R&D intensity from around 3½ per cent of sales volume in 2001 to less than 2% in 2008 (Huenteler *et al.*, 2012). Gradually reducing the price for renewable energy purchased under the FIT would promote efficiency.

The development of renewables also depends on reforming the electricity system, as discussed above. The current structure is an obstacle to renewables, such as solar and wind power, which are volatile as they depend on weather conditions. Electricity generators relying on renewables need dependable alternatives to compensate for the variation in renewable energy. However, as noted above, the Japanese electricity market is segmented regionally by general electric utilities, with limited interconnection capacity, thereby limiting the scope to offset any shortages in renewables. Increasing interconnection capacity between regions is therefore essential to expand the role of renewables.

9. Including hydroelectricity, the share of renewable energy in Japan was 10.7% in 2011, still well below the OECD average of 19.1%. However, hydroelectricity generation depends significantly on natural characteristics and there is an obvious limit for increasing its capacity.

Expanding the use of smart grids is also important to effectively manage electricity systems that make greater use of renewable energy sources. Smart grids are typically described as electricity systems complemented by communications networks, monitoring and control systems, “smart” devices and end-user interfaces. Greater use of renewables increases the need for flexible management of electricity generation, transport and storage, given that the timing of supply and demand is one of the major obstacles to their increased use. For example, a study of wind power outputs in the United Kingdom showed that wind turbines worked at less than 6% of their capacity during four peak demand events in 2010. The smart grid provides opportunities to remedy local imbalances between demand for electricity and the supply of renewable energy. A study for the US state of North Carolina (over 9 million inhabitants) suggests that more than two-thirds of the load (baseload and peak load) could be provided from renewable energy if information and communications technology is used to enable electricity storage, wider geographic scopes of the grid, effective demand management and dynamic pricing (OECD, 2012b).

Figure 8. Share of renewable energy in power generation in Japan is low



Source: OECD/IEA Renewables Information Database.

In addition, enhancing the credibility of a new energy policy is also important to boost renewables. At present, there appears to be some scepticism about the current emphasis on renewable energy, in part due to concern about the cost of abandoning nuclear energy. Indeed, the government estimates that replacing

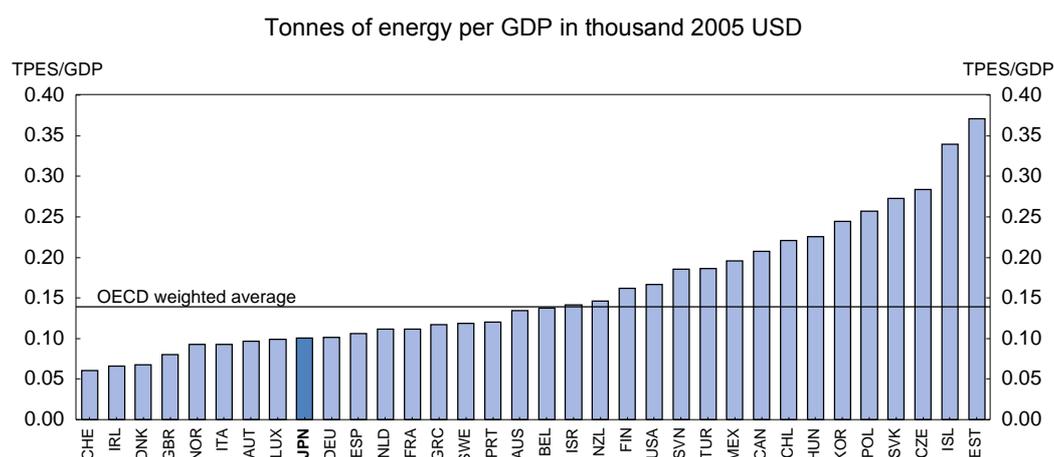
all domestic nuclear power plants by thermal power generators would boost electricity generation costs by over 3 trillion yen (0.6% of 2012 GDP) per year, increasing production costs in the industrial sector by 7.6 trillion yen per year and prompting opposition in the business sector. A new energy plan should be developed to enhance the credibility of the commitment to renewables. As in other green areas, clear and consistent policies over the long term are necessary to induce private investment (Croce *et al.*, 2011).

Perhaps most importantly, accelerating green growth and achieving the energy savings targeted in the 2012 *Strategy* requires an appropriate policy framework that promotes cost-effective industrial restructuring. The key is greater reliance on market instruments, which equalise marginal abatement costs across emitters, thereby promoting cost-effective emission abatement. The main market instruments for internalising the social cost of carbon are a carbon tax and an emissions trading scheme (ETS), which both put a price on carbon. Research in Korea, which recently passed legislation to establish an ETS, showed that the cost of achieving the GHG emission reduction target through ETS would be less than half as much as relying on regulation (OECD, 2012a). Furthermore, a carbon price is needed as soon as possible to kick start private investment and innovation in greener infrastructure and technologies. Both options for carbon pricing meet the efficiency criteria, as they encourage emitters to adopt the least expensive abatement solutions that cost less than the permit price or the tax.

Promoting energy conservation

Energy conservation should also be part of the strategy to cope with reduced output from nuclear power in Japan, which has achieved a high level of energy efficiency. In 2011, energy intensity in Japan (measured as energy inputs per unit of GDP) was the ninth lowest among OECD countries and less than two-thirds of the average of OECD countries (Figure 9). In 2012, the previous government set goals of reducing electricity use by 10% from its 2010 level by 2030 and total energy use by 19%. In addition to promoting renewables, a sufficiently high and consistent carbon price would also promote energy conservation. For example, a study by the National Institute for Environmental Studies estimated that doubling household electricity charges would reduce consumption by 30% (NPU, 2012b).

Figure 9. Japan's energy intensity was below the OECD average in 2011



Source: OECD/IEA World Energy Balance Database.

Other policies are important to meet the government's target of reducing energy consumption. For example, LED and other high-efficiency lightening will be disseminated to 100% of public facilities and institutions by 2020 and will account for all lighting by 2030. According to one study, replacing all lighting with LED will reduce power demand by the equivalent of seven nuclear reactors in Japan. In addition,

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Japan's "District Heating and Cooling" system technology could cut energy consumption by 40% compared to conventional means of heating and cooling (DeWit, 2013).

Box 2. Summary of recommendations to promote green growth and restructure the electricity sector**Upgrading supervision of the nuclear industry and electricity sector**

- Ensure that the newly-created Nuclear Regulatory Agency (NRA) is independent from line ministries responsible for energy issues.
- Require nuclear plants to meet the criteria to be established by the NRA before being allowed to reopen.
- Create an independent regulator for the electricity sector that is at arms' length from line ministries.

Improve and expand market mechanisms in the energy sector

- Introduce ownership unbundling to create a level playing field between regional monopolies and new entrants.
- Expand interconnection capacity, including frequency converters, to break down regional monopolies and create a competitive, nationwide electricity market.
- Shift to definite-quantity contracts and real-time pricing to promote a competitive, nationwide market.

Promote the role of renewable energy to accelerate green growth

- Ensure that the newly-established feed-in-tariff system provides appropriate incentives, including for R&D.
- Expand interconnections and use of smart grids to effectively manage electricity produced from renewable sources.
- Introduce carbon pricing through an emissions trading system in combination with a carbon tax to promote investment in green technologies, including renewables.

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