Working paper/PM
2012:15

Energy Crisis Management

Following the 2011 Natural Disaster in Japan

How can a society, it´s government, business sector and individuals, cope with a sudden an widespread loss of electricity? This question, and how to answer it, became vital for Japan when the triple-disaster struck in March 2011 and a Tsunami caused massive destruction along large parts of the country´s east coast. The "societal experiment" unraveling in Japan, with the country having to make hard choices on the future energy mix provides opportunity for policy learning for all industrial countries world-wide, including Sweden.

growth analysis

Dnr 2011/227
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Förord

Hur kan ett samhälle, dess regering, företag och enskilda individer, hantera ett plötsligt och omfattande bortfall av elektricitet? Vilka politiska åtgärder finns till hands för att balansera utbud och efterfrågan efter de nya förutsättningarna och går det att planera för alla eventualiteter? Dessa frågor ställdes Japan abrupt inför när trippelkatastrofen slog till i mars 2011 då en tsunami orsakade massiv förstörelse längs stora delar av landets östkust.

Samtliga Japans 54 kärnreaktorer har sedan det inträffade stängts ner vilket tillsammans med bortfall av termisk elenergi orsakade en förlust av elproduktion på omkring 30 procent i världens tredje största ekonomi. I denna rapport beskrivs hur en bred uppsättning åtgärder sammantaget gjort att Japan trots detta kunnat undvika en situation av allvarlig brist på elkraft. Det har handlat om planerad implementering av existerande krishanterings-strategier men också, på grund av katastrofens omfattning, om akuta insatser för att minska efterfrågan och öka utbudet av elenergi.

För Sverige är det relevant att följa och lära av det ekonomiska och sociala experiment som pågår i Japan just nu. Många svåra val måste göras vad gäller framtidens energiförsörjning och samhällets alla sektorer måste vara delaktiga i den processen. Redan nu går det att dra vissa slutsatser av Japans erfarenheter som är av värde för utvecklingsarbetet med Sveriges krishanteringsverktyg.

I rapporten poängteras vikten av effektiva beslutskedjor och tydlig ansvarsfördelning. Vikten av samt metoder för tydlig kommunikation gentemot allmänheten är ytterligare ett område där det finns lärdomar att dra för Sverige av det Japanska exemplet. Slutligen har de olika energibesparings kampanjer som lanserats av regeringen visat sig vara en mycket värdefull pusselbit både i att skapa förståelse och acceptans för andra viktiga åtgärder och i att åstadkomma faktiska minskningar i elförbrukningen.

Rapporten har författats på uppdrag av Energimyndighetens avdelning för Trygg energiförsörjning. Huvudförfattare är Izumi Tanaka, analytiker vid Tillväxtanalys kontor i Tokyo, med betydande bidrag från Anders Karlsson, tidigare kontorschef i Tokyo. Stöd och kommentarer har givits av Kaoru Tomihisa, assistent vid Tillväxtanalys kontor i Tokyo, samt Martin Flack, analytiker och temaasvarig för hållbar utveckling vid Tillväxtanalys kontor i Stockholm.

Stockholm, november 2012

Enrico Deiaco, avdelningschef Innovationer och globala mötesplatser

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Summary

Any industrialized society is dependent of a stable supply of energy. With electricity being the primary high quality energy carrier, this translates into the need of a stable electricity supply system. On 11 March 2011, the fourth most powerful earthquake since 1900, followed by a powerful tsunami hit Japan, the third largest economy in the world. (USGS 2012) Over 15 800 lives were lost, major infrastructure was destroyed, and society was sent into a state of temporary shock. The power supply system also took a major blow; both thermal power and nuclear power station operations were disrupted. Most notably the triple core meltdowns at the Fukushima Daiichi Nuclear Power Station resulted in the second worst civil nuclear accident in history after Chernobyl.

The aftermath of the Great East Japan Earthquake resulted in a severe unbalance between electricity supply and demand. The Fukushima Nuclear accident uncovered profound faults in the safety culture of nuclear power in Japan, leading to at one stage all of Japans 50 nuclear power plants (54, including four now-decommissioned reactors at Fukushima Daiichi) being taken off the grid due to the lack of societal trust in their secure operation.

With demand for electricity being highest in summer, due to cooling of houses, Japan has now the built up experience of two summers after the crisis. What lessons can be learned?

Some learning may pertain only to Japan, others are generic, of relevance to any industrialized society struck by a sudden supply-demand unbalance:

- Methods to disseminate information, such as well visualized supply forecast and real-time supply and demand balance and methods of communicating the information to the general public was handled well in Japan.
- Incentives provided to the consumers for saving electricity “not only in a hurry”, but through habitual and lifestyle changes was seen as of major importance.
- Innovation to accelerate diffusion of energy saving products, technologies and services could be noted. Whilst with great suffering economically, the measures the companies took were not just of conservation nature, some were innovative also leading to improved efficiency in the future, and may give competitive edge.

What mistakes can Sweden learn from?

- Lack of clear responsibility and line of communication between the parties involved such as the government, energy agency and electric power companies caused much confusion. Better risk communication should have been prepared for between different stakeholders.

In addition to assessing the situation as simply a policy learning experience, there are opportunities for Sweden to contribute to the development of a new energy system in Japan, both in terms of providing policy knowledge, as well as in new businesses. There are now discussions on a de-bundling of the electricity grid system. Additionally, the feed-in-tariff starting 1 July 2012 is a tailwind of momentum for increased renewable energy sources.

Sammanfattning

Varje modernt industrisamhälle bygger på en trygg och tillräcklig energiförsörjning. Den 11 mars 2011 drabbades Japan av den fjärde kraftigaste jordbävningen i världen sedan år 1900, följt av en kraftfull tsunami. Mer än 15 800 människoliv gick till spillo, viktig infrastruktur slogs ut och det japanska samhället hamnade i ett tillstånd av chock.

Även energissystemet drabbades hårt; både termiska kraftverk och kärnkraftverk slogs ut. Mest allvarligt var givetvis härdsmältan och det stora radioaktiva utsläppet från kärnkraftverket i Fukushima Daiichi. Kärnkraftsolyckan i Fukushima är den allvarligaste civila kärnkraftsolyckan efter Tjernobyl.

Naturkatastrofen resulterade i en stor obalans mellan tillgång till och behov av elektricitet. Kärnkraftsolyckan i Fukushima Daiichi visade på allvarliga brister i säkerhetskulturen kring kärnkraften i Japan, och det förlorade förtroendet hos allmänheten resulterade att vid ett tillfälle stod Japans alla 50 kärnkraftverk stilla (de fyra havererade Fukushimareaktorerna ej medräknade)

Med ett stort elektricitetsbehov, som på grund av behovet av luftkonditionering är störst under den varma fuktiga sommaren, så har Japan nu två års erfarenhet att bygga på. Vilka är lärdomarna? Vad är specifikt för Japan och vad är överförbart till Svenska förutsättningar?

- Det är centralt att det finns utvecklade metoder för att sprida information, exempelvis tydliga visualiseringar (via hemsidor, sociala media och andra kommunikationskanaler) som visar balansen mellan utbud och efterfrågan av elektricitet i realtid. Detta har visat sig avgörande för att påverka människors inställning till de besparingsåtgärder som genomförts och därmed också deras faktiska beteende.
- Åtgärder för att stimulera konsumenterna att ändra sin energiförbrukning, inte bara kortsiktigt utan även sådana beteendeförändringar som kan stimulera till en mer energisnål livsstil.
- Främja innovation av energibesparade produkter och tjänster. Den svåra tid många japanska företag gick igenom har även lett till förbättringar, effektiviseringar och innovation som förväntas driva på en strukturomvandling av energisektorn och den japanska industrin i syfte att stärka landets långsiktiga konkurrenskraft.

  Vilka misstag kan Sverige lära sig av?

- Bristen på en tydlig beslutsordning och ansvar mellan regering, ansvariga energimyndigheter och företagen skapade stor förvirring. En mer professionell och tydlig kriskommunikation hade minskat företagens och människornas oro.

Utöver ovanstående lärdomar av direkt relevans för det svenska krishanteringsarbetet pågår i Japan en intressant utveckling inom energipolitik i bredare bemärkelse, väl värd att studera närmare. Till exempel diskuteras i Japan att öppna upp elmarknaden och att dela upp den i olika funktioner – generation, transmission och distribution – vilket förväntas förändra villkoren för såväl producenter som konsumenter i framtiden. Nya styrmedel diskuteras också utifrån behovet att öka effektiviteten och ställa om produktionen mot mer

förnybara energislag. Den nyligen införda inmatningstariffen är ett sådant exempel. I detta finns möjligheter både till politiklärande och till handelsutbyte mellan Japan och Sverige.

1 Introduction- Trend in supply shortage and nature of the crisis

"My fellow citizens, as you are already aware from reports on TV and on the radio, today at 2:46 PM an enormously powerful earthquake of Magnitude 8.4 struck, with its seismic center off the Sanriku coast. This has resulted in tremendous damage across a wide area, centered on the Tohoku district. I extend my heartfelt sympathy to those who have suffered."
Statement by Prime Minister Naoto Kan on Tohoku district - off the Pacific Ocean Earthquake, Friday, 11 March 2011 at 16:55

"Let me say it again. Without any doubt, this is a moment of true crisis for Japan, and a true test of us, the Japanese people. But remember our nation's past. Despite those who dismissed us as a small island nation, thanks to the strength of the people and the efforts of every individual, we built up the country and achieved miraculous economic growth. Despite this earthquake and tsunami, it is vital that we do not give in to despondency. We will rebuild Japan let that be the resolve with which we face this crisis together."

Excerpts of Message from the Prime Minister Naoto Kan, Tuesday, 18 March 2011[1]

At the time of writing the report it is a little more than one year and a half after the Great East Japan Earthquake at 14:46, March 11, 2011. Over 15800 lives were lost, major infrastructure was destroyed and society was sent into a state of temporary shock. As one of the major consequences of the earthquake was first, the initial disruption of parts of the energy supply chain as thermal and nuclear power plants came to a halt. However, the biggest disruption came from the accident at the Fukushima Daiichi Nuclear Power Plant, the world's most severe nuclear accident after Chernobyl. The aftermath of the accident uncovered profound faults in the governance and safety culture of Japanese nuclear power, leading to a complete halt of all 50 nuclear power plants in Japan, excluding the accident ridden, now-decommissioned Fukushima Daiichi I- IV reactors.

In Japan, the electricity consumption peaks in the hot and humid summer due to the need for air-conditioning. Hence, Japan has now the experience of two summers of peak electricity consumption under supply constraints. What has been the experience of Japan? What instruments to cope with the power unbalance has worked, and what has not? What are the policy lessons for Sweden?

The purpose of this report is to answer precisely these three questions. Preliminary result from the situation during summer 2011 was reported in "After the Quake: Energy Crisis Management in Japan" published in June 2011.

1.1 Content and outline

The report is outlined as follows: In this first chapter, the nature of the electricity crisis is discussed; basically the sudden and medium term shortage of electricity supply, causing an unbalance between supply and demand. In chapter two, we describe the electricity system in Japan, and how the lack of connectivity of the grid caused an even more severe crisis. In

[1] *List of Prime Minister Kan's speeches can be found at* http://www.kantei.go.jp/foreign/kan/statement/index_e.html

chapter three to six we discuss the situation and the policy measures utilized to overcome supply deficit directly after the crisis, during the summer 2011, winter 2011/2012 and the summer of 2012. In chapter seven, the impact the crisis had on policy making will be discussed. Finally in chapter eight, overall conclusions are presented. However, to simplify for the reader, for chapter's three to six, some relevant conclusions for that part is present at the beginning of the chapter.

1.2 Trend in electricity supply shortage

The earthquake on 11 March 2011 in the north-eastern part of Japan, officially named the Great East Japan Earthquake caused tremendous damage to the Japanese society. Undoubtedly, the most direct and detrimental damage caused mainly by the tsunami was the lost lives of more than fifteen thousand persons. However, the series of unfolded events, originally caused by the earthquake and tsunami, related to the Fukushima nuclear power plant accident and to the electricity system in general not only affected the disaster-affected areas but sent ripples throughout the whole country of Japan. It was and still remains to a challenge to overcome, beyond the sorrow of lost lives and properties. For the world, perhaps the most profound lesson of the disaster will be the vulnerability of the energy system.

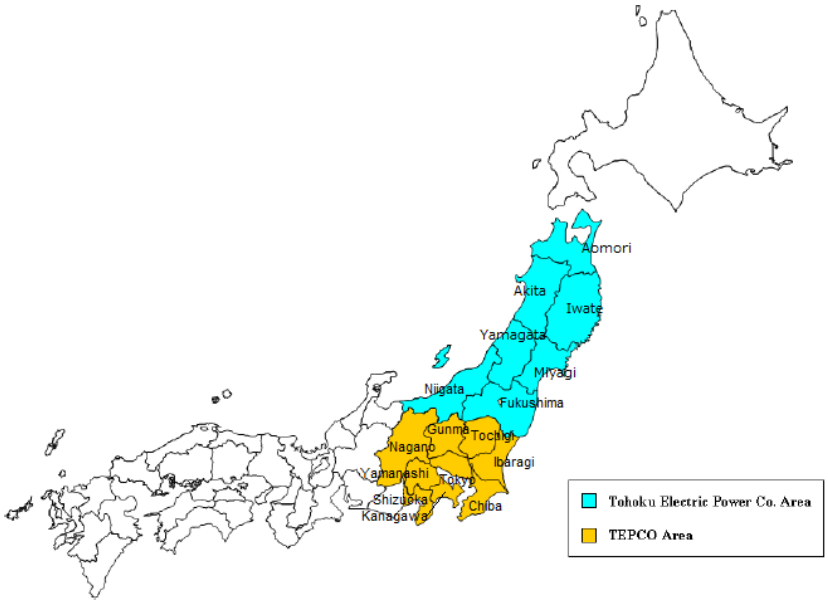


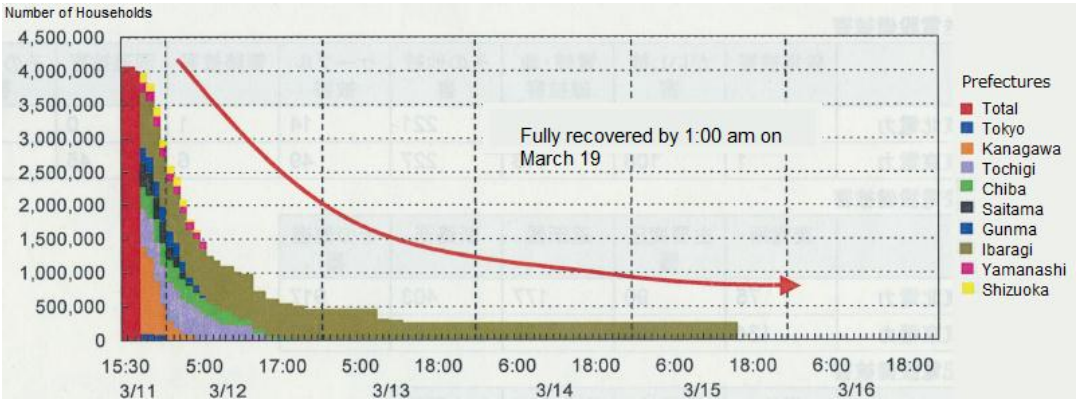
Figure 1 Areas Served by Tokyo Electric Power Company (TEPCO) and the Tohoku Electric Power Company (Tohoku EPCO).

Source: IEA 2011a

Immediately after earthquake and tsunami, 26.8 GW, or roughly 30 per cent of supply capacity of eastern and north-eastern part of Japan generated by both nuclear and thermal plants in the disaster stricken areas were down (Tanaka 2011). The Tokyo Electric Power Company (TEPCO), the operator of the Fukushima Daiichi Nuclear Power Plant, the Tohoku Electric Power Company (Tohoku EPCO) and a private company, J-Power, are the three power generation companies directly affected by the accident.

Within first half day of the disaster, over 8.5 million customers were out of electricity (Figure 2). Though the numbers immediately declined substantially, most of the black-out

was mainly in result of transmission lines and equipment physically being damaged and physically halting transmission of electricity, as opposed to lowering of frequency caused by instantaneous imbalance of supply and demand due to lack of supply from power generating facilities being down (Table 1). "If it was not for the highly automated Japanese transmission and distribution electricity grid system, the whole entire TEPCO and Tohoku EPCO serving areas could have been without electricity for a substantial period of time," noted Junichi Ogasawara, one of the interviewees



Source: Altered by the author based on Ogasawara 2012a

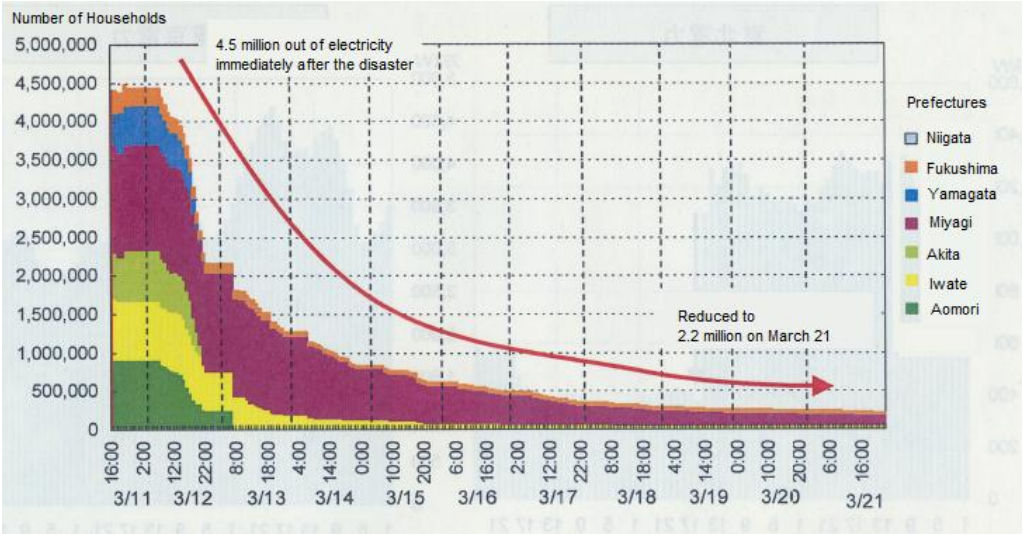


Figure 2 Number of households without electricity (Top: KEPCO and Bottom: Kyushu EPCO)

Source: Edited by the author based on Ogasawara 2012a

Table 1 Summary of damages to the facilities/equipment

Transmission facilities/equipment

	Transmission Line Tower	Insulator	Transmission Line	Other (Transmission Line)
TEPCO	1	108	116	227
Tohoku EPCO	37	28	9	221

	Cable	Conduit Line	Cable Tunnel	Others
TEPCO	49	6	45	10
Tohoku EPCO	14	1	0	10

Transformation facilities/equipment

	Substation	Transformer	Circuit Breaker	Disconnection Switch	Others
TEPCO	134	156	33	268	162
Tohoku EPCO	75	90	177	403	917

Distribution facilities/equipment

	Pole	High Voltage Line	Pole-mounted Transformer	Others
TEPCO	9946	212	699	18
Tohoku EPCO	33909	20523	8714	220

Source: Translated by the author based on Ogasawara 2012a

Now, the thermal plants affected are now already back online including some of the old, already retired power plants, which were forced to be utilized in the summer months with the highest demand. Japanese ordinance on nuclear power plant operation calls for a regular maintenance of power plants every 13 months, and none of the 50 nuclear power plants (note, four of the six Fukushima Daiichi reactors are officially decommissioned) are operating on commercial bases since 4 May 2012 except for two reactors in Ohi plant which resumed operation (Figure 3). In order to restart, all plants are to go under a stress test, with approval by the Nuclear and Industrial Safety Agency (NISA), Nuclear Safety Commission of Japan (NSC), Minister of Economy, Trade and Industry and the local government where the plant is located. As of 19 September 2012, NISA and NSC were dissolved and a new authority, Nuclear Regulation Authority was inaugurated. I t will be this authority which will be conducting approval procedures for the restart. Though both Ohi plants have successfully concluded all steps of the stress test, some stakeholders, including municipalities located near and served by the Ohi plants, regarded the operation temporary to meet the demand during the summer months. Different stakeholders, the cen-

tral government, local government hosting the nuclear power plants, experts, industrial community and etc. have voiced different opinions in restarting of the plants and it has become a political issue to determine restart of commercial operation.

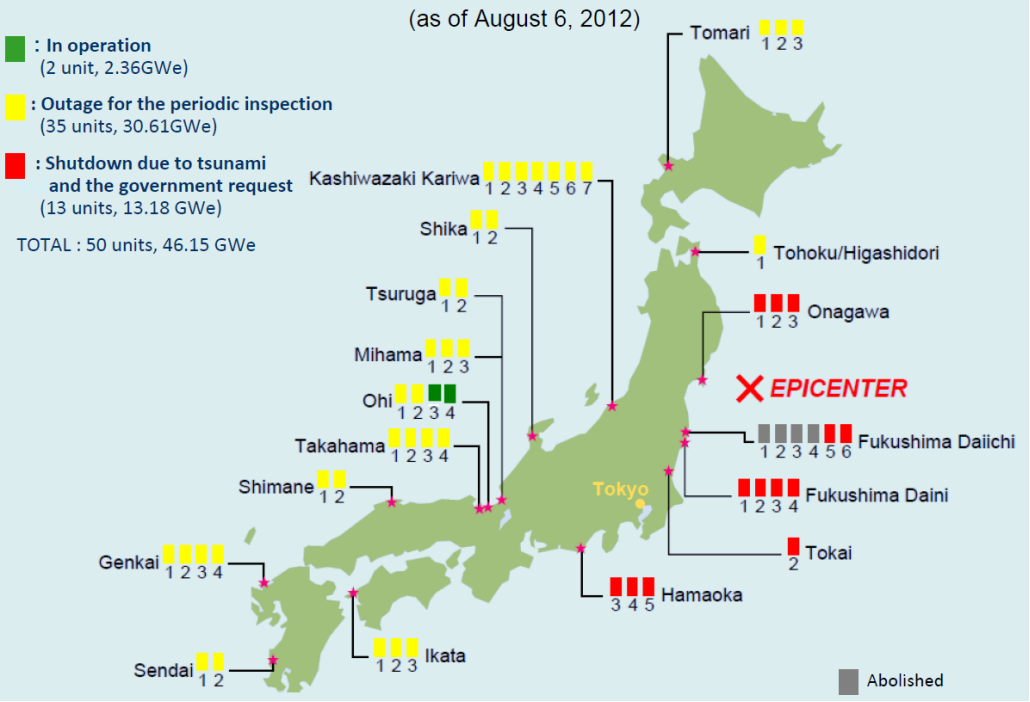


Figure 3 Current status of the nuclear power plants (as of 6 Aug 2012).

Source: Japan Atomic Industries Forum, Inc http://www.jaif.or.jp/english/

On 14 September 2012, the Cabinet decision of "Innovative Strategy for Energy and the Environment" was announced. This strategy will be discussed further in chapter eight. Even with the future energy mix is determined; the fate of the plants in a short term is still unclear as of September 2012. At present, both the governmental accident investigation report (ICANPS), as well as the parliamentary investigation report (NAIIC) has pointed out profound problems with the safety culture of nuclear power governance in Japan, as well as technical errors leading to the accidents [2]. Whilst technical issues can (relatively) easily be addressed, changing an organizational culture may take time. This may imply that nuclear power will face a less dominant role in energy mix in the future, hence, also implying that the issue of the energy management will change. Additionally, recent figures announced by the Federation of Electric Power Companies of Japan on sales by ten major power utilities in July dropped by 6.3 per cent due to a decline in demand. This, of course, is result of efforts to cut down electricity use by households and the business sector paying off, but can be also claimed as evidence reactivation of two reactors at Ohi nuclear plant was not necessary. The public perception on the necessity of nuclear power plants is quickly changing also (Japan Times 2012a).

[2] *For details of the investigation, refer to NAIIC http://www.naiic.jp/en/ and ICANPS http://icanps.go.jp/eng/*

A list of some of the significant events from March 2011 to September 2012 is compiled in Table 2.

Table 2 List of significant events

2011	March	Earthquakes, tsunami and accidents at Fukushima Daiichi Nuclear Power Plant
		Rolling black out implemented (14-18, 22-24 and 28 March)
	May	Minister of Trade, Economy and Industry Kaieda requests halt of Hamaoka Nuclear Power Plant
	July - September	Legally-binding Article 27 implemented and request for energy conservation in all sectors in TEPCO and Tohoku EPCO areas (1 July – 9 September)
	September	(Then) Prime Minster Kan announces need of "Stress Test" on all Nuclear Power Plants
	December-March 2012	Request for energy conservation in KEPCO and Kyushu EPCO areas (without numerical goal 1 December – 30 March, with numerical goal in KEPCO 19 December to 23 March)
	December	Prime Minister Noda declares Fukushima nuclear accident contained
2012	February	Discussions electricity market reform commended
	May	TEPCO's special 10-year turnaround plan officially endorsed by the government
	June	Ministerial meeting approves restart of Ohi 3 and 4 reactors
	July	Government approves price hike by 8.46% in residential sector
		Commercial operation of Ohi reactors starts

Source: Edited by the author based on Ogasawara 2012a

Box 1: Shortage in oil and gas distribution

Shortage in electricity was not the only energy crisis faced by the country in the wake of the disaster. Both oil and gas were affected, as well (**Error! Reference source not found.**). However, the magnitude of the crisis was far less compared to that of electricity shortage. Therefore, this report will focus on the electricity supply-demand crisis.

Table 3 Oil and Gas Shortage

Oil

- Localized shortage of petroleum products supply (gasoline, diesel, kerosene)
- Shut down of crude oil processing facilities （1400kB/D, 31% of Japan Total）
- Damage to infrastructure for supplying fuel; roads, rail, storage facilities, gas stations etc.
- Damaged refineries
- Temporary reduction of compulsory oil stock piling quota （70days→67days→45days）consisting of both refined products and crude oil
- Restrain export, Increase import, grant aid from China(20kt oil)

Gas

- City gas supply halted to 460,000 users in devastated areas
- Shut down of LNG receiving terminal
- Additional LNG procurement, additional supply from producers: UAE, Qatar, Russia etc.
- 99% Recovery of gas supply systems by end of April）

1.3 Nature of the crisis

Since 11 March 2011, Japan is continuously facing challenges in balancing supply and demand; however the nature of the crisis differs greatly from time to time and regions in Japan. Note, Japan has been and continuing to compensate power generation by nuclear energy with additionally installed and re-starting moss-balled thermal power generation using fossil fuel, in particular Liquid Natural Gas (LNG). From many aspects including having to import additional fossil fuel leading to one of the worst trade balance and from climate change perspective, it is by any means not an ideal situation and in a sense, Japan remains to be in a state of crisis. However in this report, "crisis" indicates when supply and demand balance is in jeopardy, even with utilizing additional electricity generated by the added thermal power plants. This report will cover the measures and effect/result based on the following categorization:

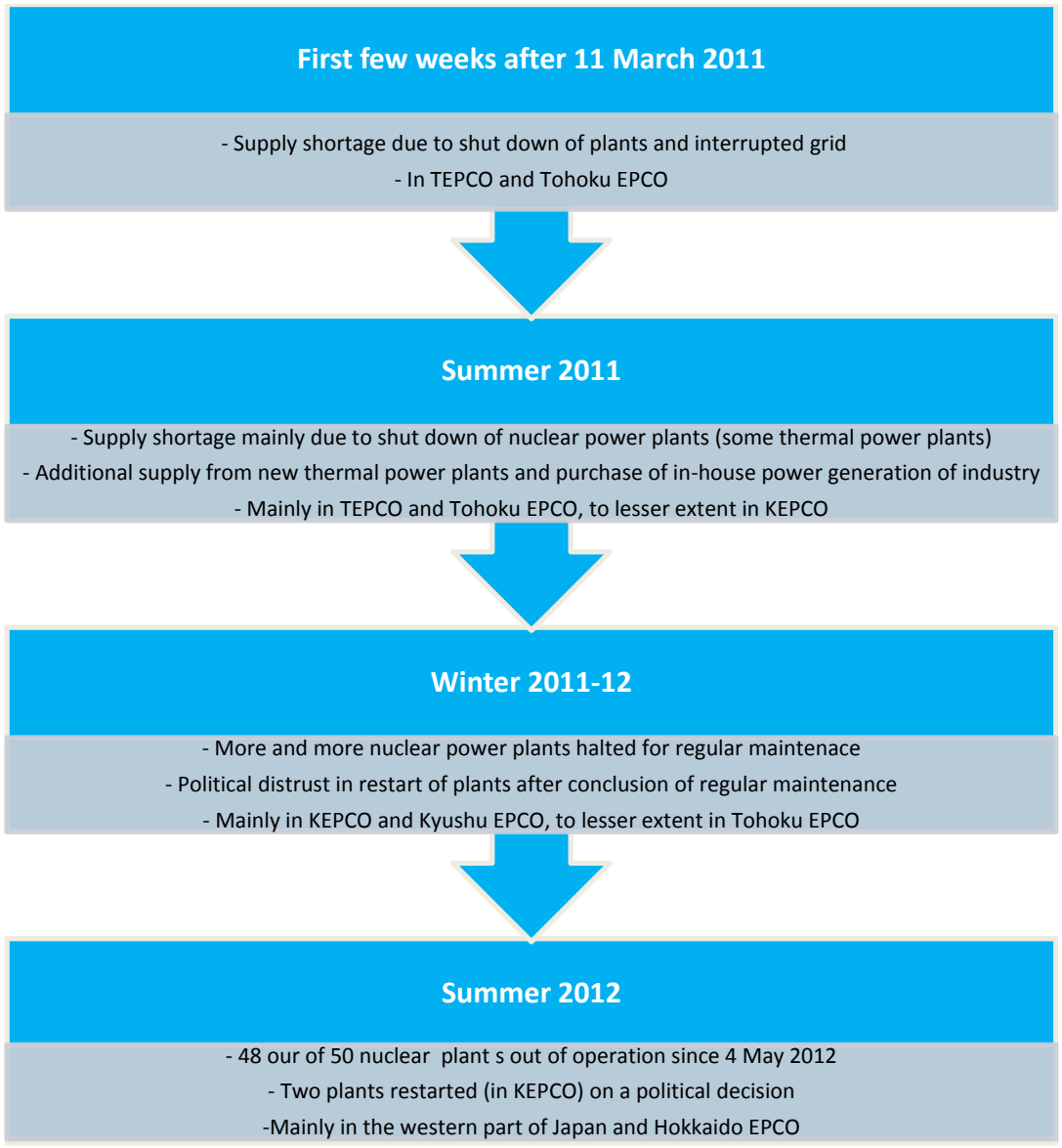
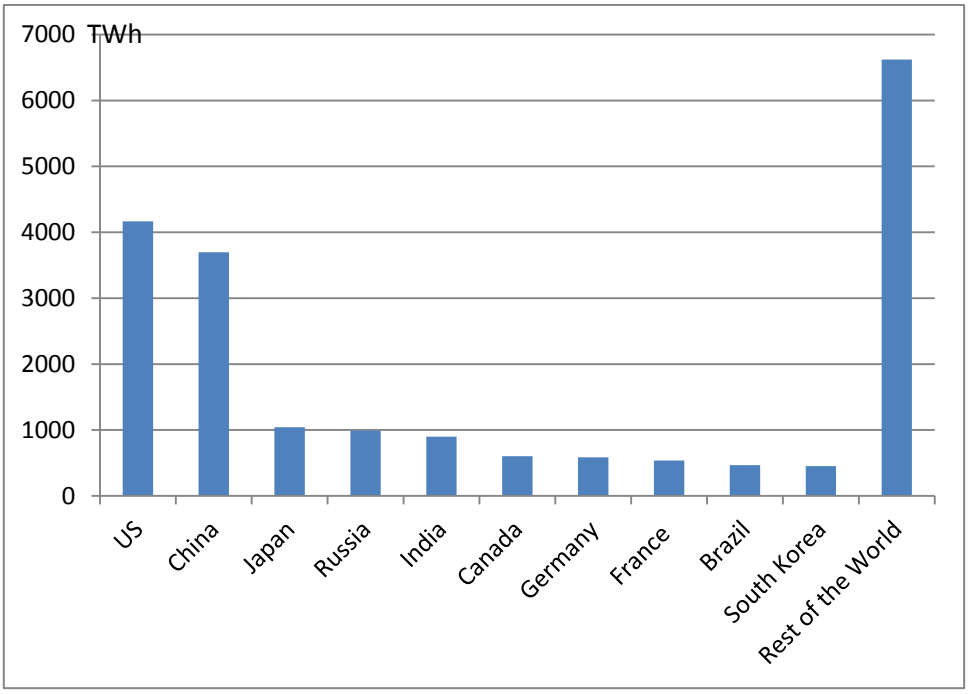


Figure 4 Trend of crisis

2 Background - Electricity system of Japan

Japan is the third largest electricity consumer in the world, following the US and China (Figure 5). The source for electricity power generation is highly dependent on fossil fuel and nuclear power; supply mix of 955,100 GWh generated in 2009 consisted of 29 per cent liquefied natural gas, 29 per cent nuclear, 25 per cent coal, 8 per cent oil, 7 per cent hydro, 1 per cent pumped-storage, and 1 per cent renewable sources (Figure 6).



Source: IEA 2011b

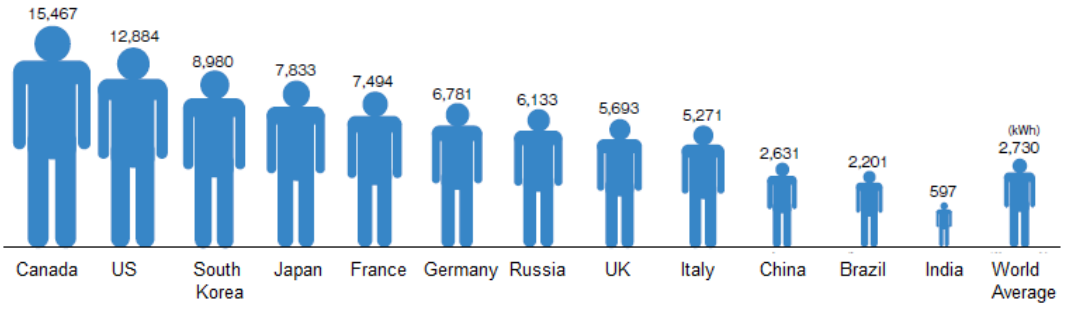


Figure 5 World electricity production and electricity consumption per capita 2009

Source: IEA 2011b

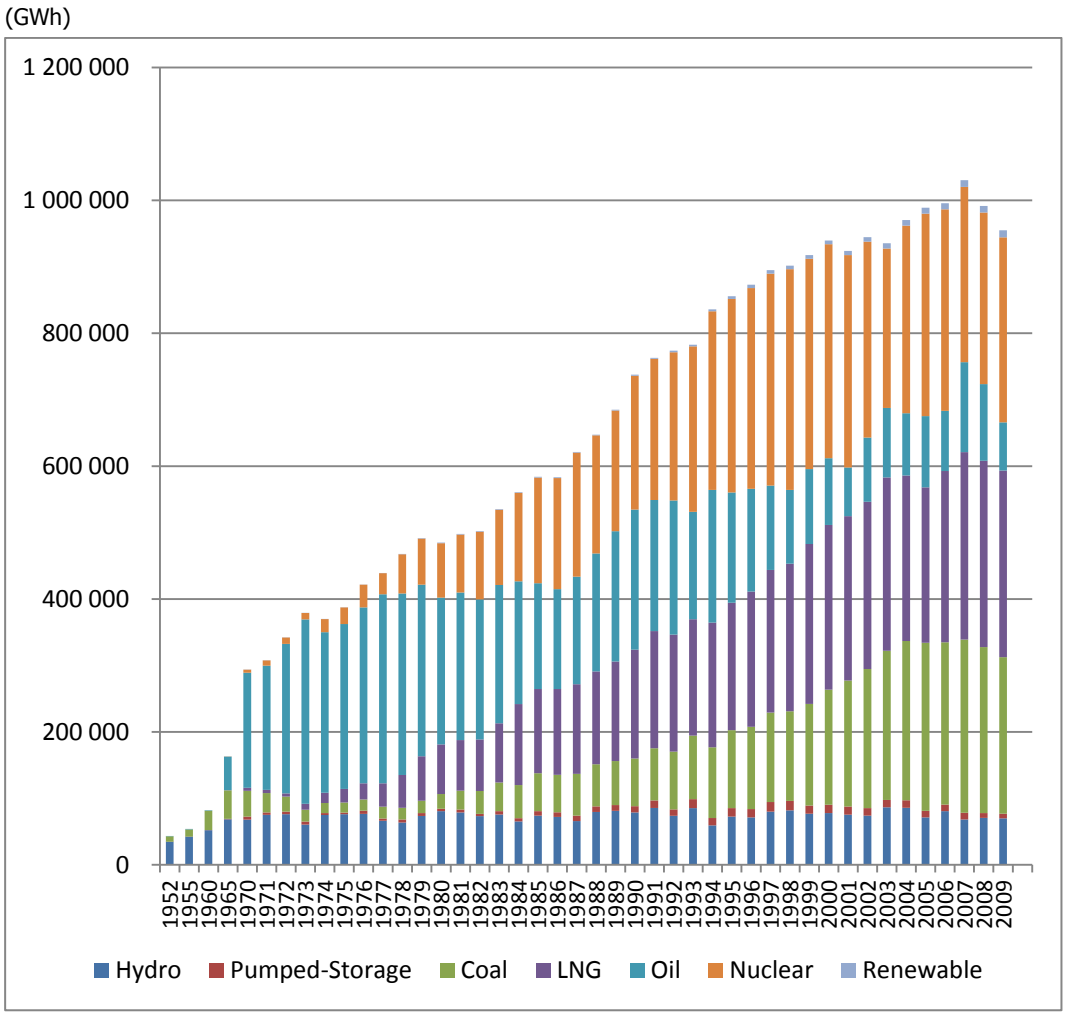
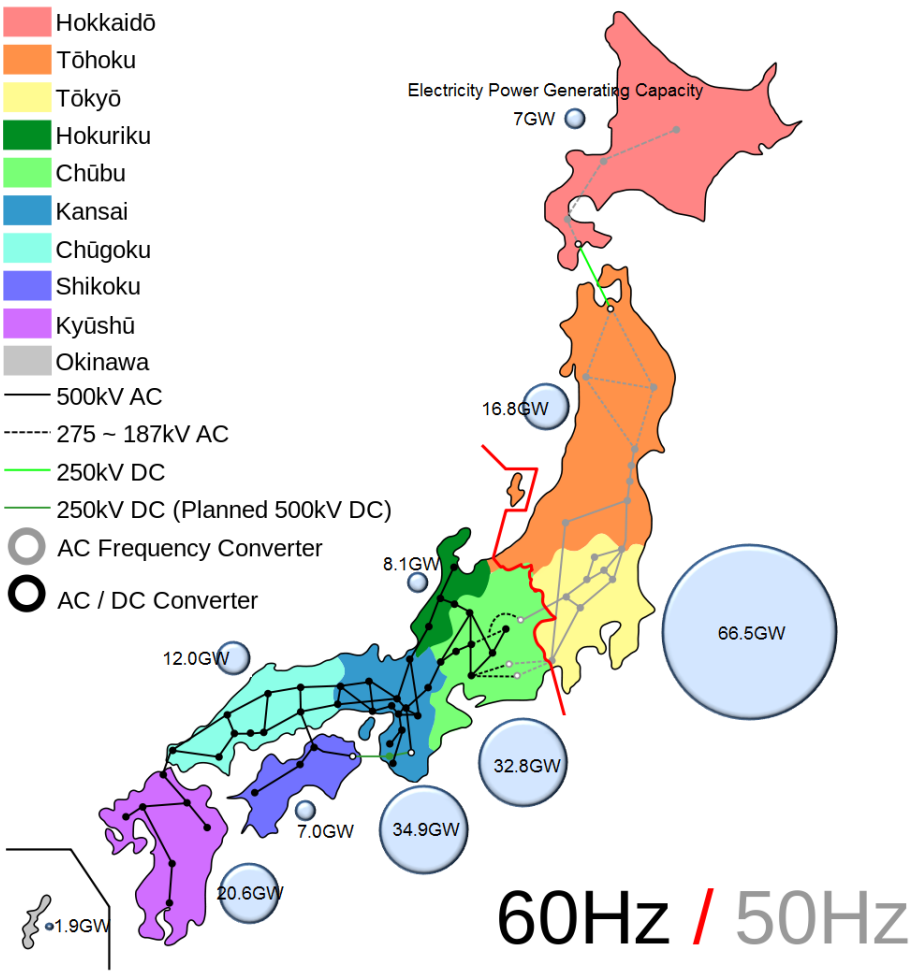


Figure 6 Electricity production

Source: Translated by the author based on METI 2010

Japan is also an island country with no connection of electricity grid to any other country, this for more of the historical or geopolitical reasons basically, rather than technical. Additionally, the country's electricity grid line is divided in two with one in the western part with 60 hertz frequency and 50 hertz in the eastern part of Japan. This limits transfer of electricity between the two regions as there are only three conversion plants with capacities of 600, 300 and 130 MW. The Japanese electricity system is not unbundled and the ten utilities companies with 100 per cent private capital all handles the entire process from procurement of fuel to collection of electricity fee and have a de-facto regional monopoly over the area they serve (Figure 7).



Remark: Electricity power generating capacity in fiscal year 2011

Figure 7 Electricity grid and interconnection and electricity power generating capacity

Source: Created by the author based on Callum Aitchison, "The Power Grid of Japan" and FEPC 2012

On the average, Japan's electricity consumption rises during the summer months of July through September as temperature and humidity rises (Figure 8). This is result of use of air-conditioners, in all sectors, industry, public administration, commercial and residential. For instance, in private homes there is often one air-conditioner per room. During the winter months, the use of electricity rises mildly as source of heat is not solely dependent on air-conditioners running on electricity, but use of kerosene heater is very common in Japan. 29 per cent of electricity consumed in Japan is from residential use, while industrial/commercial and transport uses consist 59 per cent, respectively (METI 2010).

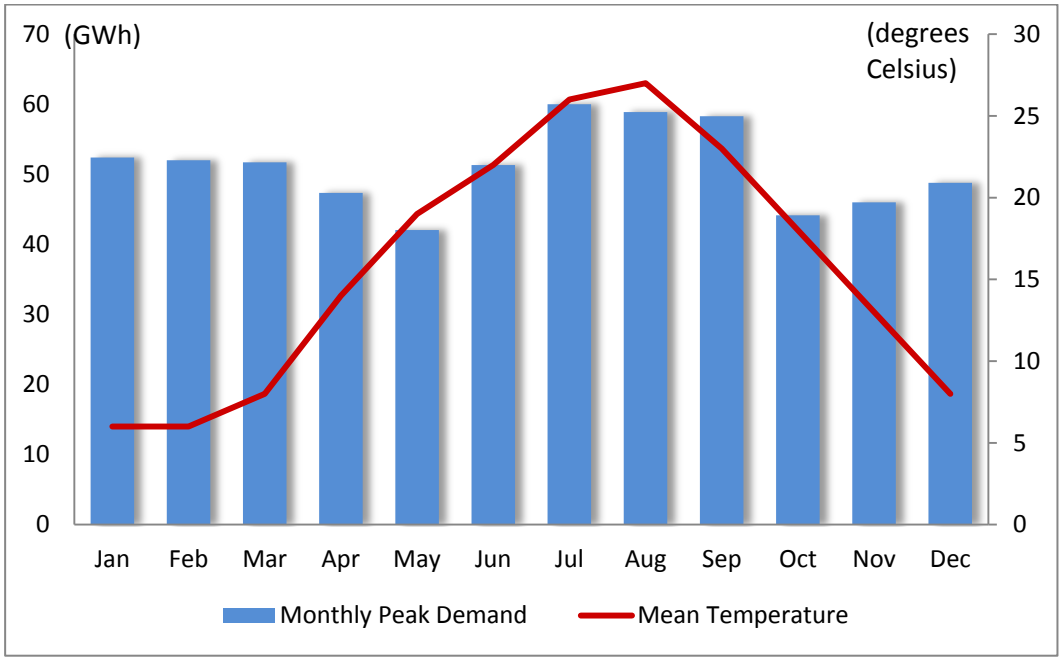


Figure 8 Average temperature and monthly peak demand in 2010

Source: Created by the author based on TEPCO 2011a and data from Weather Channel

Though there are many bright signs of increase in renewable energy such as introduction of an ambitious Feed-in-Tariff (FIT) replacing Renewable Portfolio Scheme (RPS) in July 2012 or ease in regulations for installation of renewable energy facilities, renewable energy in the Japanese electricity mix is merely 9.9 per cent, including hydro power and 1.2 per cent excluding hydro in fiscal year 2010 (METI 2010). The wholesale market was liberalized in 1995 and 1999, but with the electric utility companies owning and having control over the use of electricity grid, the situation has not been so favourable towards other Power Producer and Suppliers (PPS). Since 2000, market for users contracted for 50kW or more has been liberalized, covering 63 per cent of the entire market. However, even after over ten years of liberalisation, PPS other than the ten utility companies are only supplying 3.42 per cent of the entire supply (Kifune 2011).

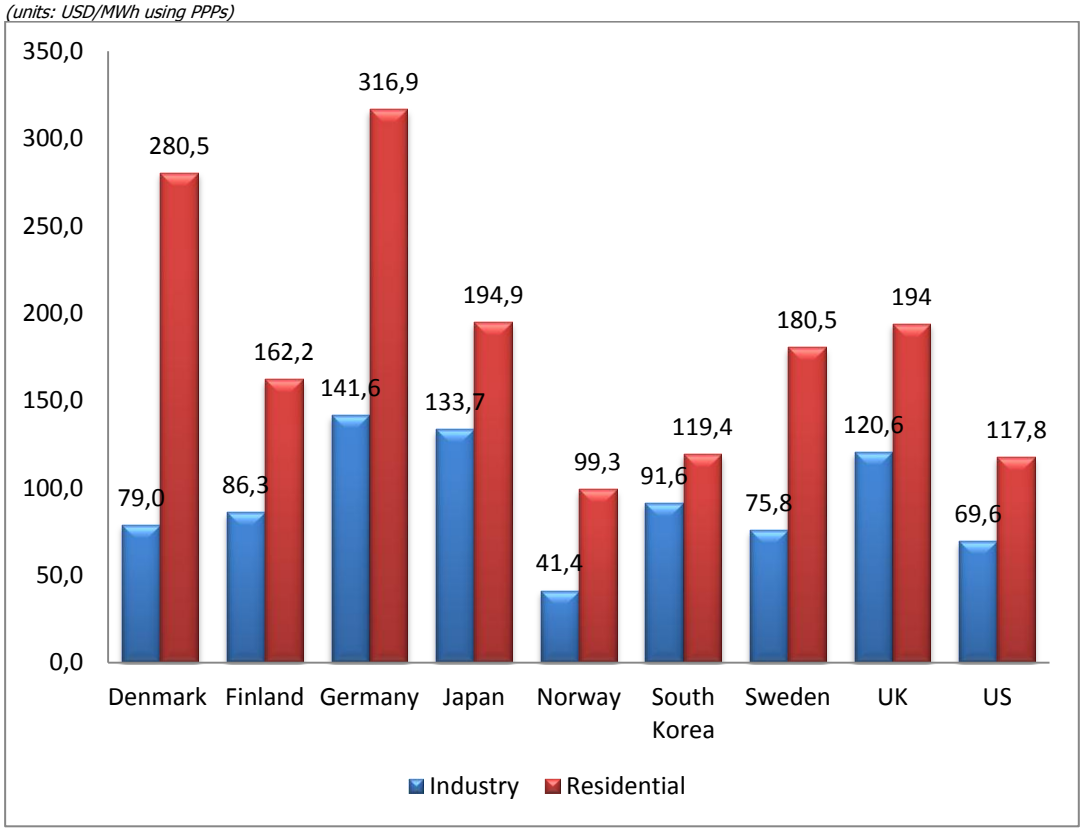
Policies surrounding energy issues, including FIT scheme, will be described in more details in chapter eight.

Japan is one of the very few countries in the world with no part of electricity business is ran publicly; all parts of the operation is now ran by private entities. However, all ten electric utility companies are well-protected by a pricing scheme which guarantees return on the cost/investment. The utility companies are free to pass personnel, fuel, facility repair, company hospital and various other costs, in addition to a margin, on to consumers. The margin is calculated by applying a rate of return, which currently stands at three per cent, to the total amount of a utility's assets including power plants. This scheme has driven power companies to increase their assets as much as possible and has favoured large scale plant investments, for example by building nuclear plants to reap greater profits. The utilities' trade partners also has benefited from the system. The ten power utility companies are "best customers" because having low or no incentive to save, they pay the asking prices. The Ministry of Economy, Trade and Industry, the authority approving electricity pricing

is not required to check the cost projections in details as long as the utilities are making efforts to lower electricity rates.

This, in additional to regional monopoly, has left very little incentives for cost reduction or efficiency improvement in their operation, making them one of the most powerful industries in the country. Though it may not be the sole reason for the phenomenon, Japanese electricity consumers pay at one of the highest rates among the developed countries (Figure 9 Comparison of electricity pricing). There has been a report projected electricity costs for businesses has exceeded the actual total by about 600 billion yen (approximately SEK 50 billion) over the last 10 years.

(units: USD/MWh using PPPs)



Remark: Data from 2011 except for 2009 for industry for South Korea

Figure 9 Comparison of electricity pricing

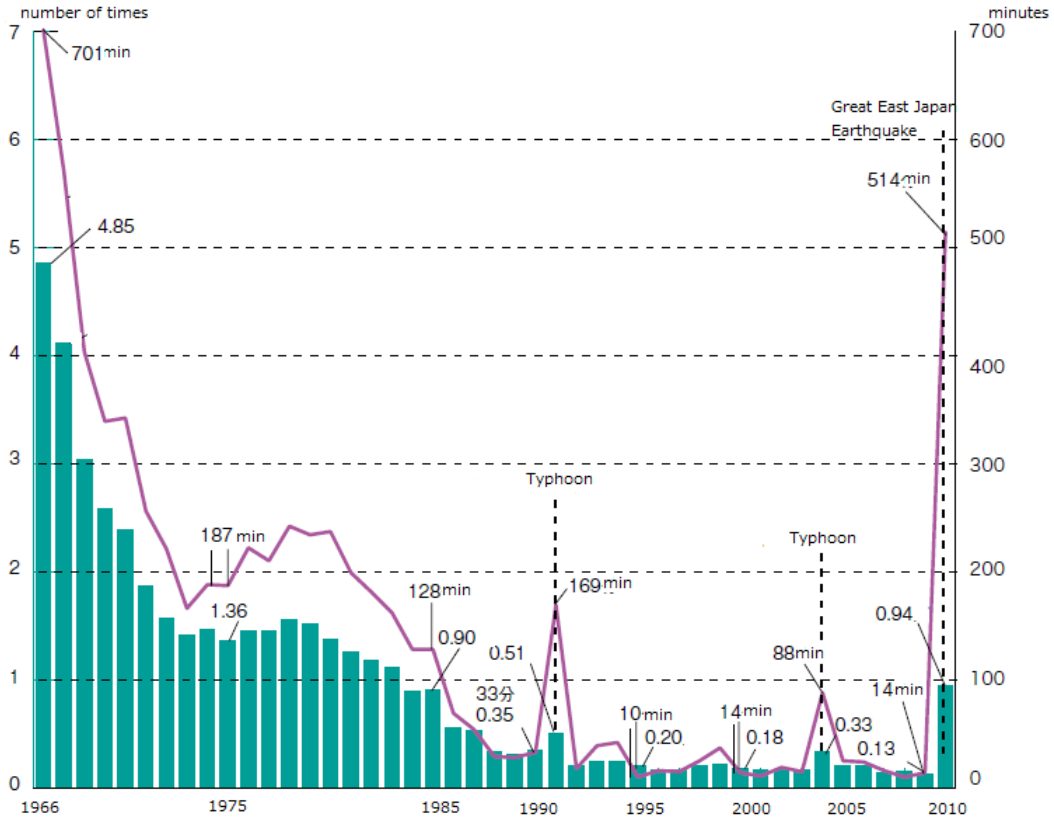
Source: IEA 2012

Discussions and actions towards the reform of the electricity system in Japan is lagging almost twenty years behind compared to that of in Europe. For example such topics as ownership de-bundling, functioning and liberalized market for all sectors are now finally being discussed in an expert committee assigned by the government. Discussions such as integration of markets in the geographical region are yet to start.

Is Japanese electricity system in for a change in the wake of electricity crisis? Though there is evidence towards reform, it is too early to draw any conclusions at time of press.

The current standing electricity system has brought some positive aspects. Japan considers eight to ten per cent surplus supply in the weekly forecast and three per cent surplus in the

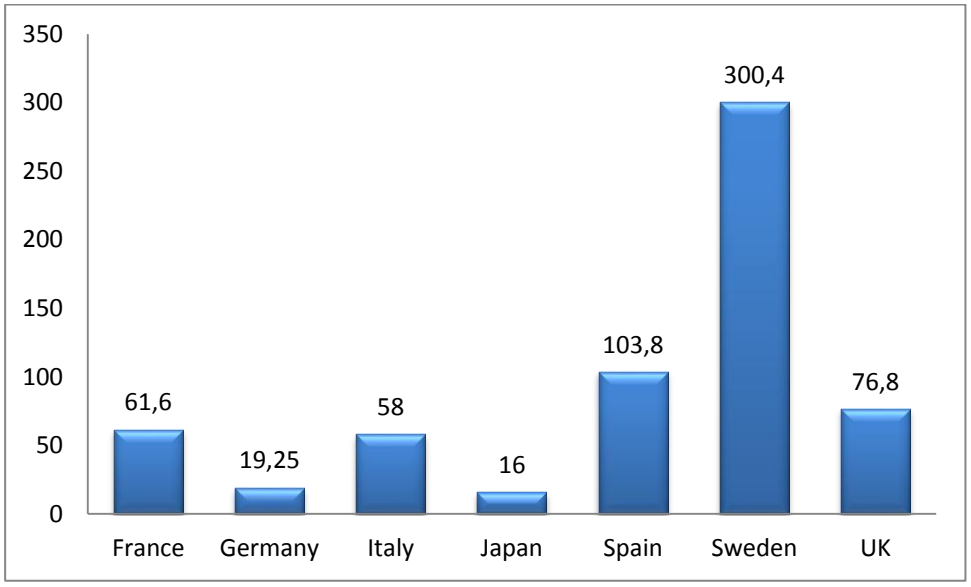
daily forecast to be a safe margin, considerably lower compared to about 15 per cent required surplus for many other countries. This is because Japan's closed and regionally monopolized market with highly centralized and stable facilities for power generation allows the utility companies to estimate the supply and demand with high accuracy. Also in the 1980s when the demand for electricity was on the rise, it was not so difficult to obtain funding for investment in the transmission/distribution system. Japan has an advanced automation system for electricity transmission and distribution, having one of the lowest rates of interrupted electricity service in the world (Figure 10).



Remark: Japanese fiscal year fiscal year 2010 is April 2010 to March 2011 and includes the Great East Japan Earthquake.

Figure 10 System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) of Japan

Source: FEPC 2011



Remark: SAIDI in 2007 including extreme weather except for Germany, which excludes extreme weather.

Figure 11 Comparison of System Average Interruption Duration Index (SAIDI)

Source: Created by author based on JEPIC 2011

Box 2: Was Japan Prepared?

Japan has faced electricity shortages before. In summer of 2002, a whistle-blower revealed short-comings in the nuclear power plant management, i.e. there had been systematic falsification of safety records as well as neglected maintenance of the Nuclear power plants under the operation of Tokyo Electric Power Company (TEPCO). In September 2002, all 17 nuclear power plants of TEPCO were halted in order to comply with governmental regulations and follow-up on procedures as well as to re-gain confidence of the public. Even with all TEPCOs 17 nuclear power plants offline, the winter demand was lower than its maximum supply capacity without nuclear power generation. Then TEPCO and the government took approximately eight month to prepare for the shortage to come for the summer months in 2003 (recall, TEPCO is responsible for approximately 40 per cent of electricity power generation capacity in Japan). Actions taken by both the government and TEPCO are summarized in Figure 12.

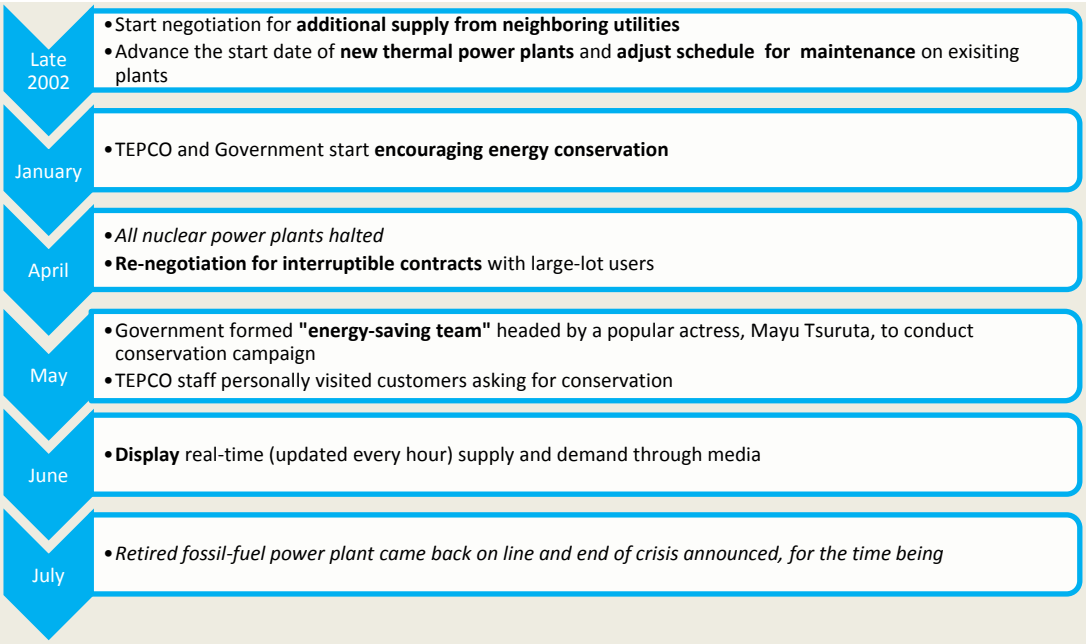


Figure 12 Series of measures taken to balance supply and demand in 2002-2003 by TEPCO and the government

The majority of measures taken were campaigns calling for conservation to the general public and to the industrial customers. Media was extensively used to disseminate the message. This incidence marked the first time the utility's load curve was made public. Also, re-negotiating the conditions of interruptible contracts with large-lot users was a measure utilized to curb industrial consumption. Recall TEPCO is a very loyal, non-bargaining customer for many of the companies, ranging from manufactures providing equipment and facilities of power plants to TV broadcasters selling commercial time to TEPCO. Industrial customers met the request from TEPCO, for example, by shifting their production activities to non-peak hours (including weekends), halting operation during the critical period and increasing production at plants outside of TEPCO area.

The summer of 2003 ended up to be one of the coolest in the history and the peak demand was far less than anticipated at 57GW. TEPCO estimated 1.4 GW and 1.3GW savings were achieved through adjustments in its contracts with large-lot users and through other conservations, respectively, totalling to approximately 4.5 per cent of 60 GW of TEPCO's peak demand (IEA 2005).

3 Events immediately after the natural disaster

- Rolling black-out was implemented to counter-measure a possible massive black-out.
- Details of the rolling-black out can be found in the previous report.
- Except for one incidence, where projected demand reached 97% of projected supply, there was no threat of massive black-out.

Immediately after the disaster, demand declined sharply in result of both black out and reduced economic activities due to the earthquake (Figure 13).

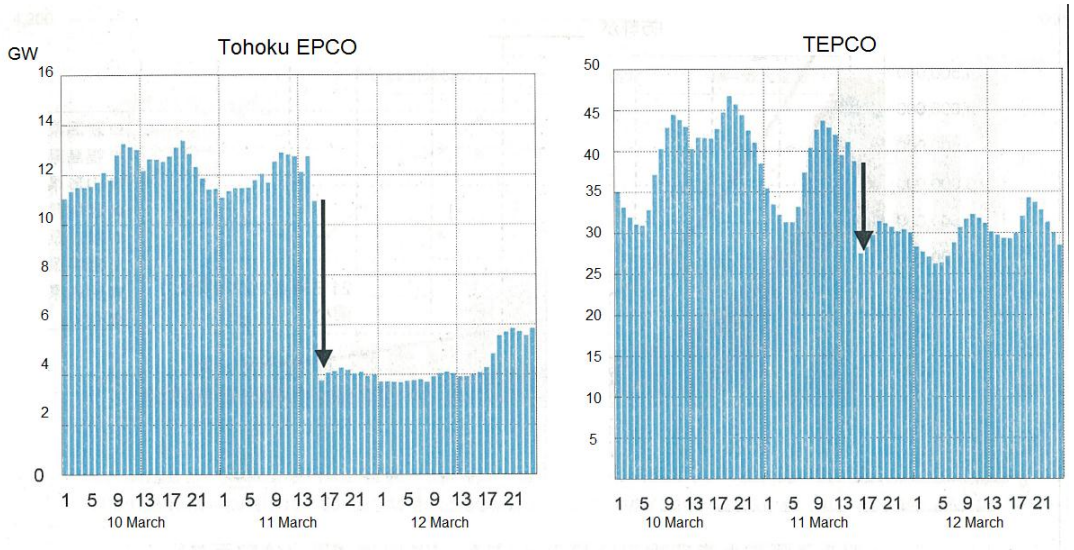


Figure 13 Electricity demand in Tohoku EPCO and TEPCO areas

Source: Ogasawara 2012a

Already on 12 March, 2012, TEPCO, as an emergency measure, announced the possibilities of rolling black-out. The interruptible contracts with large-lot users which was utilized during the crisis in 2003 were not enough to supress enough demand to counter-measure a possible massive black-out (Table 4).

Table 4 Number of interruptible contracts with large-lot users per utility company

	Interruptible Contract (as needed)*		Interruptible Contract (planned)*	
	Number of Contracts	Amount of Electricity	Number of Contracts	Amount of Electricity
TEPCO	1050	174	5550	255
Tohoku EPCO	17	18	492	42

** Names are both tentative translations. Two types of interruptible contracts are available for large-lot users in exchange for cheaper electricity price. "As needed" contract mandates reduction in consumption in hours' notice, while "planned" contract allows longer lead-time and only during peak-hours.*

Source: METI 2011a

Rolling black-outs were implemented for nine days over three weeks until it was announced it was no longer a needed option of measure on 8 April. In addition to the enforcement of rolling black out as a measure to curve demand, the visualization of supply- demand balance and forecast and an intensive media campaign asking for energy conservation was implemented. There was one day when the expected demand reached over 97 per cent of expected supply capacity and the Minister of Economy, Trade and Industry has all working population to go home to curve industrial electricity consumption. Other than that single day, imbalance of supply and demand was successfully overcome by rolling black-out and stoic energy conservation by the society.

The details of initial measures taken after the disaster can be found in the previous report, "After the Quake: Energy Crisis Management in Japan."

4 Summer 2011: The first hot summer

- Supply shortage of 10.3 and7.4 per cent was projected for TEPCO and Tohoku EPCO, respectively
- Energy-saving strategy included
    - mandatory rationing for large-lot users
    - information campaign, including on technical assistance
    - installation of emergency power supply (gas turbine using LNG)
- Though measures were taken to reduce peak-demand, absolute consumption was reduced, as well.

4.1 Supply and Demand Projection

Recall summer months of July to September are the months with the most electricity consumption in Japan on the average (Figure 8). In the disaster affected areas served by power utility companies of TEPCO and Tohoku EPCO, projected supply deficit was reported by the Review Meeting on Power Supply and Demand (tentative translation) (Table 5). Note in other parts of Japan not directly affected by the disaster, the majority of nuclear power plants remained in operation and did not face electricity shortage in summer 2011 (Figure 14). However in two regions served by KEPCO and Kyushu EPCO, a milder shortage was anticipated, due to high reliance on nuclear power plants than other regions. This section will concentrate on situation that of TEPCO and Tohoku EPCO.

Table 5 Forecast for TEPCO and Tohoku EPCO for summer 2011

unit: GW, unless noted

	TEPCO	Tohoku EPCO
Forecasted Demand	60	14.8
Forecasted generation capacity	55.2	12.3
Amount to be supplied by TEPCO to Tohoku EPCO*	--	At maximum 1.4
Forecasted supply capacity	53.8	13.7
Deficiency against forecasted demand	10.3%	7.4%

Remark: Regions served by Tohoku EPCO include Fukushima, Miyagi and Iwate Prefectures where reconstruction activities are taking place. Though TEPCO was facing shortage also, it was determined TEPCO to provide electricity to ease the constraint in those areas.

Source: Tanaka 2011

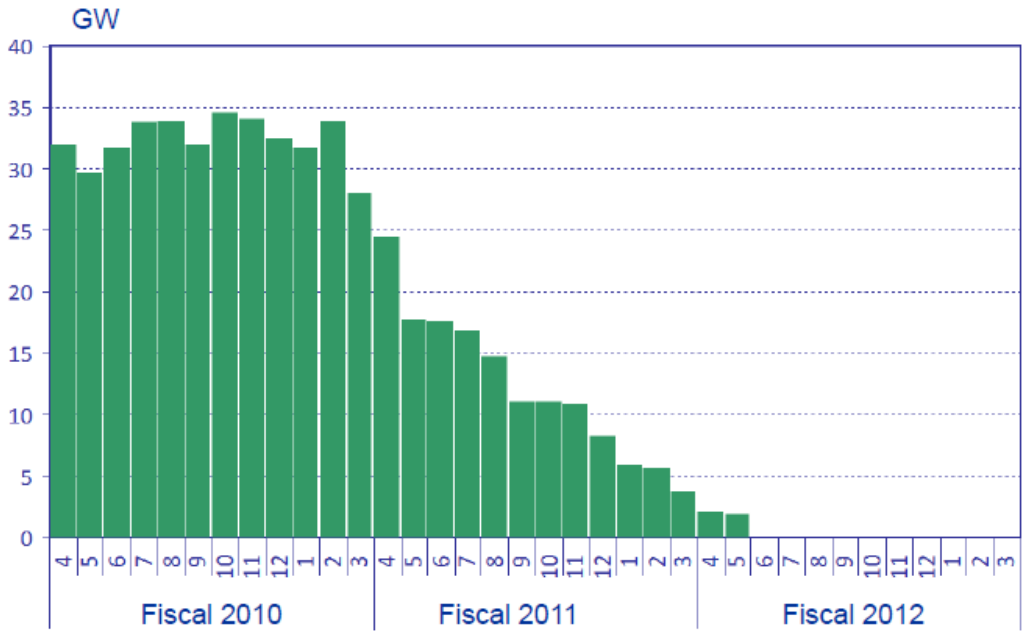


Figure 14 Trend in operation of nuclear power plants in Japan

Source: Takahashi 2012

4.2 Measures Taken

Rolling black-out conducted immediately after the disaster caused much trouble to industrial operations. Industries strongly demanded not to use rolling black-out as one of the measures for the summer months, which were agreed by the government. The measures taken to overcome the supply deficit in the TEPCO and Tohoku EPCO serving areas are characterized as following:

1. Establishment of mandatory, legally-binding reduction target for large-lot users with contract with 500 kW or more
2. Extensive campaign to raise public awareness for "setsuden" or energy conservation, including information on technical assistance
3. Installation of additional emergency power supply

All entities of the civil society, regardless of contracted electricity wattage, were "requested" to reduce their electricity consumption by 15 per cent compared to usage that of 2010. This "request" was not mandatory or legally-binding. However, for major commercial and industrial customers with contract for supply of 500kW or more, a mandate to cut peak-time consumption between hours of 900 to 2000 from 1 July to 22 September 2011 (later changed until September 9) for TEPCO 1 July to 9 September for Tohoku EPCO, based on Clause 27 of the Electricity Utilities Industry Act. The upper limit of power use was to be reduced by 15 per cent compared to the maximum power use (per hour) for the above-mentioned period and time in 2010. 2011 summer was the first time in 37 years, to utilize the article.

The Electricity Supply-Demand Review Meeting (then called Electricity Supply-Demand Emergency Response Headquarters) consisting of members of the cabinet has announced

the decision to implement Article 27 on 13 May 2011. Letters explaining the implementation of the scheme was sent out to all targeted customers and approximately 20 meetings (with capacity of 400-1600 seats per meeting) were held to explain Article 27 and its implementation to the stakeholders.

Exemptions and exceptions were made for approximately 14,000 entities in evacuation areas and business establishments located around Fukushima Daiichi Nuclear Power Station or facilities indispensable for securing people's lives and health (hospitals, water and sewage facilities, etc.) for stable economic and social activities (railways, clean rooms, data centres, etc.) and for restoration and reconstruction in the disaster affected areas (local government offices, etc.).

Also, a scheme to reduce peak-load by teaming up with business establishments, not limiting to large-lot users, was introduced. The scheme allowed to group different business operations as one entity and to meet the reduction target as one unit.

Intentional overuse was set to be penalized with fines at a maximum of one million yen (approximately 80,000 SEK) for every hour the target was not met. Only monetary penalty is stated and disconnection is not considered as a penalty. The demand-side measures taken are compiled in Figure 15**Error! Reference source not found.**

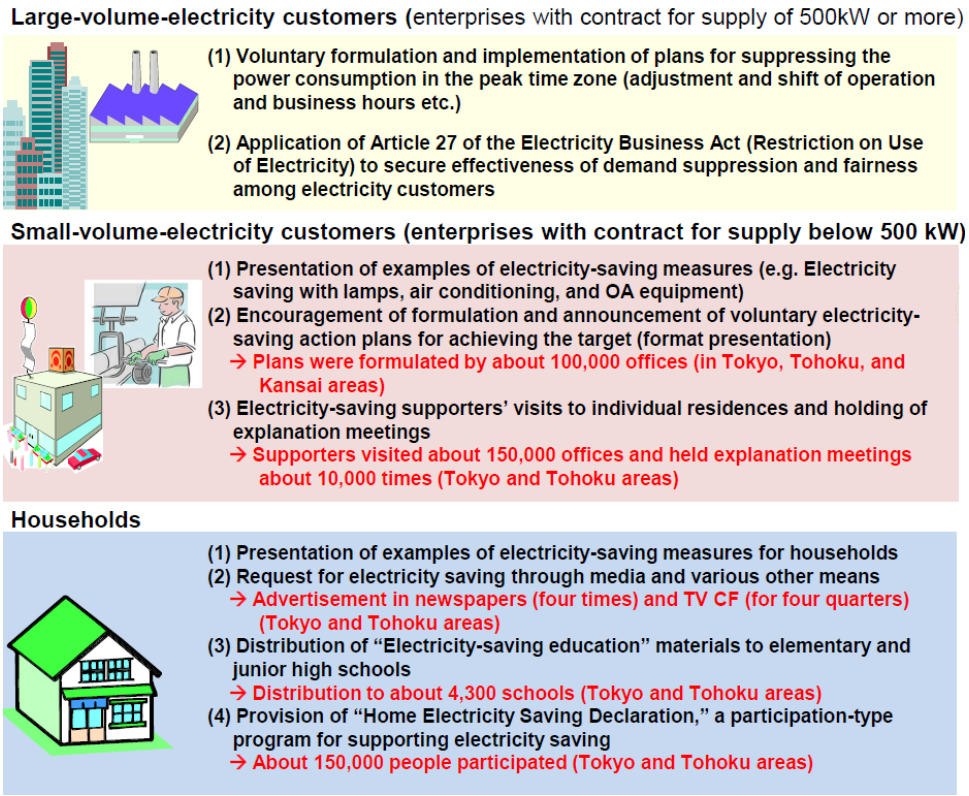


Figure 15 Summary of demand-side measures taken

Source: METI 2011b

For supply-side measure, the government took initiatives by ease of regulations on constructing power plants. Addition of thermal power generation facilities fired by LNG to supplement the electricity supply lost due to the disaster exempt from Environmental Im-

pact Assessment Act. Additionally, periodic inspection of thermal power generation stations under the Electricity Business Act was allowed to be postponed for, at most, one year. Another measure implemented by the government was to promote instalment and use of in-house power generator. METI requested enterprises with in-house power generation plants to sell the electricity and provided grants for investment in equipment and fuel cost. 10 billion yen (approximately SEK 800 million) in first supplementary budget of fiscal year 2011 was allocated. As a result, from about 10,000,000 kW and 4,000,000 kW installed capacity in area TEPCO and Tohoku EPCO areas, respectively, about 1,600,000 kW and 200,000 kW in excess electricity was sold to the grid, respectively.

Utility companies added power generation capacity. Disaster-affected thermal power stations were restored in TEPCO and Tohoku EPCO areas. Additionally, thermal power stations that have been stopped for a long time were restarted. By the summer, TEPCO restarted operation of facilities for 850,000 kW, Tohoku EPCO 350,000 kW and Chubu EPCO 750,000 kW (METI 2011b).

4.3 Response and Results

4.3.1 Result in Supply and Demand Balance

In result of implementation of both supply and demand measures, the supply surplus rate during peak-demand was, for the most part, stable. For TEPCO, the surplus rate was over ten per cent, while Tohoku EPCO managed to be over five per cent for the most of the days, including supply received from other utilities (TEPCO and Hokkaido EPCO). On 8 August 2011 when excessive rain caused to stop hydro power generation of 1 GW, the surplus rate dropped to 3.9 per cent in Tohoku EPCO (Figure 16).

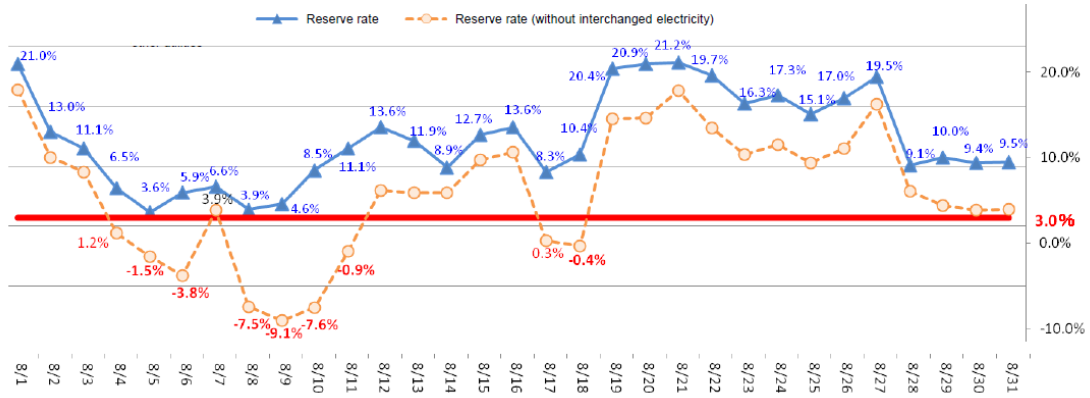


Figure 16 Supply surplus ratio in Tohoku EPCO

Source: METI 2011b

Tohoku EPCO was not the only utility company experiencing unexpected/ unplanned shutdown of power plants. Capacity reduction caused by unplanned shutdowns (average) in July and August ranged from 1.4 to 7.1 per cent (2.9% reduction on average of nine electricity utilities (METI 2011b).

4.3.2 Result in Peak-Load and Absolute Reductions

Demand-side measures taken have led to success reduction of peak-demand, as anticipated. Recall all entities, commercial or residential had been requested to reduce 15 per cent of their peak-load in 2010. Large-lot users, which had legally-binding target, have significantly outdone the other groups by accomplishing 29 per cent reduction in comparison of max peak-load and 27 per cent reduction comparing two days in 2010 and 2011 with similar temperatures. Other commercial users also accomplished over 15 per cent requested, however, in the residential sector in TEPCO jurisdiction, 15 per cent goal was not met (METI 2011b) (Table 6).

Table 6 Result of reduction of peak-load per consumer group

	TEPCO			Tohoku EPCO		
Type of Users	Large Lot	Other Industrial	Residential	Large Lot	Other Industrial	Residential
Target	-15%	-15%	-15%	-15%	-15%	-15%
Comparison of Max Peak-Load	-29%	-19%	-6% (Target Not Met)	-18%	-20%	-22%
Comparison of Peak-Load with Similar Temperature	-27%	-19%	-11% (Target Not Met)	-18%	-17%	-18%

Source: Edited by the author based on METI 2011b

Though the measures taken were all towards reduction of peak-load, reduction in total electricity used was also achieved (Table 7, Table 8).

Table 7 Result of reduction of total electricity use

	July	August	Total
Large-Lot Users (500kW or more)	12.8%	15.4%	14.1%
Other Industrial Users	12.9%	18.2%	15.7%
Residential	5.8%	17.0%	11.8%
Total	11.0%	16.8%	14.0%

Source: Edited by the author based on METI 2011b

Table 8 Percentage of reduction in total electricity use

Reduction	Manufacturing Industry	Non-manufacturing Industry	Total
20 % and more	13.3%	42.2%	25.7%
15-20%	15.0%	15.6%	15.2%
10-15%	21.7%	15.6%	19.0%
0-10%	35.0%	24.4%	30.5%
Increase	15.0%	2.2%	9.5%

Source: Edited by the author based on METI 2011b

Change of electricity sales from the previous year (kWh in August) was -17 per cent in both TEPCO and Tohoku EPCO. Though energy conservation played a central role in the reduction, average temperature in summer 2011 was 2.1 and 2.6 degrees Celsius lower in TEPCO and Tohoku EPCO respectively, which also had an influence on the reduction in consumption (METI 2011b) (Figure 17).

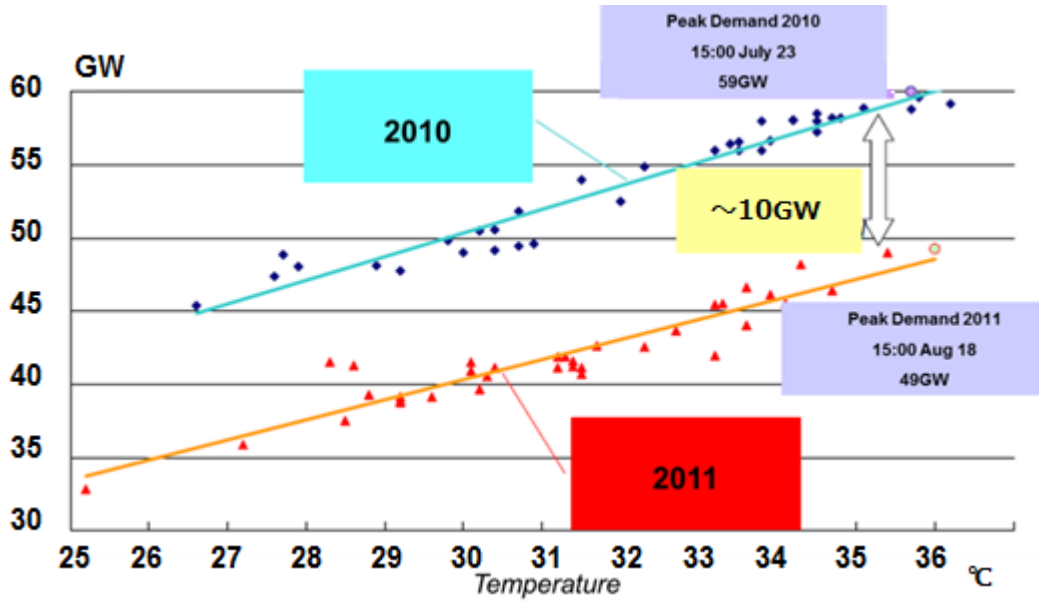


Figure 17 Comparison of electricity consumption and temperature

Source: Translated by the author based on TEPCO 2011b

An analysis of cause of reduction shows conservation effort was the greatest aspect in the reduction in TEPCO area while the lower temperature during the summer months was the largest factor for the reduction in Tohoku (Figure 18).

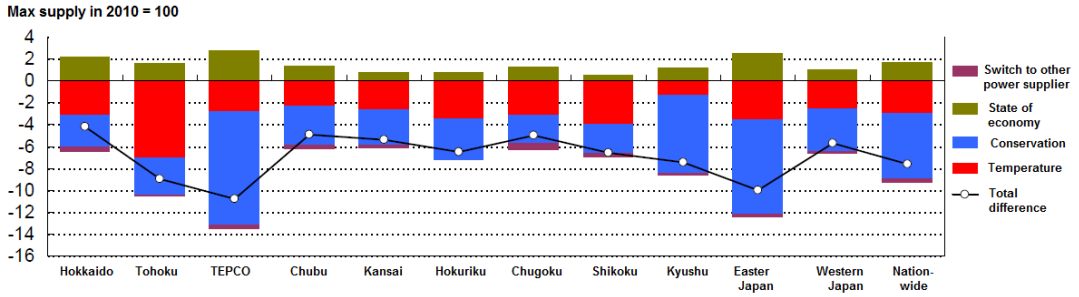


Figure 18 Analysis of factors of reduction

Source: Translated by the author based on Ogasawara 2012b

4.3.3 Societal Response to the Measures

Response from the Industry

As noted in the previous section, the industrial effort to curve peak-demand was impressive. Response, both from large-lot users subject to Article 27 and those not included responded by implementing different measures for "setsuden" or electricity conservation. For example, some companies shifted from daytime of the weekday to night time and on weekends and holidays. Japan Automobile Manufacturers Association, which all major automotive manufactures as members of, shifted their weekends from Saturday and Sunday to Thursday and Friday. As automobile manufacturing involves many suppliers, this was a big influence in reducing electricity consumption during peak day and time. Many companies and some local government, including Tokyo Metropolitan government, shifted working hours earlier along with other energy conservation efforts.

Nippon Keidanren, the confederation of industrial associations, announced voluntary action plan for energy conservation agreed upon by over 600 companies/organizations. Approximately 80 per cent of their member companies pledged reduction of 25 per cent or more of their peak-demand. This action plan is featured non-mandatory targets with a pledge to announce the result to the public. Not meeting the target and the fact made public results in "losing face." Same terminology used for climate change issues and "voluntary" by Japanese companies usually means strong commitment.

Article 27 was in effect between 1 July and 9 September, shortened from originally anticipated end date of 22 September due to mild summer. The Article was enforced between 9:00 and 20:00 on weekdays, totalling up to 550 hours. The large-lot users subject to the Article were 18,859 entities, 15,290 and 3,569 in TEPCO and Tohoku serving areas respectively. All entities were asked to submit Report on Use of Electricity (tentative translation). 18, 734 entities responded and 831 or about 4.4 per cent of them had at least one hour of violation. The number includes 125 entities which failed to respond to the request by the government to submit the Report on Use of Electricity. For those entities, data provided from the electric utility companies were used to judge the effort. Before fine was imposed, the subjected entities were given an opportunity to present the case in written form and as needed, phone interviews were conducted to judge each case as intentional or unavoidable and unintentional (METI 2012a).

Case Study: How Coca-Cola Japan saved 33 per cent power by implementation of rolling blackouts of vending machines

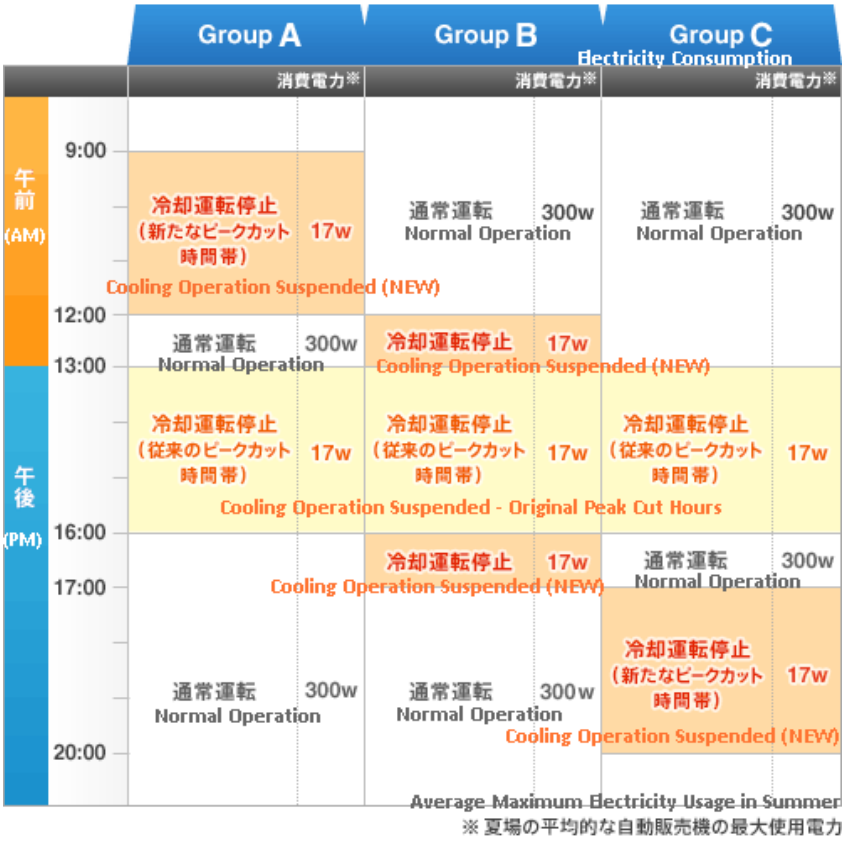
Coca-Cola Japan tackled a difficult task to achieve 33 per cent reduction of maximum electricity power compared to the same term last year, triggered by a statement by the Governor of Tokyo – "by using vending machines, we are using additional electricity and wearing out our economy. " For an outsider, such a statement may seem strange, but there are approximately five million wending machines in Japan, the highest number per capita in the world, with about half of them selling soft-drinks.

To avoid having their service shutdown, Coca-Cola Japan implemented rolling blackouts on approximately 250,000 of their vending machines located in the area covered by TEPCO from early June to September.

Vending machines were divided into three groups and were suspended for 2-3 hours taking turns. In addition to the short suspension from 13:00-16:00, which were implemented from before the earthquake, it meant that one third of their vending machines were always under suspension during the hours of 9:00-20:00. The grouping system enabled the vending machines to maintain relatively cool while saving electricity by 33 per cent.

When the cooling function is suspended for one hour, the product temperature rises 1°C. Coca-Cola Japan was prepared for drop in sales and increased complaints from customers, but did not receive a major impact in sales and was also received favourably from the public.

使用電力削減プラン Electricity Usage Reduction Plan



Source: Coca-Cola Japan Website http://www.cocacola.co.jp/vending/setsuden.html (in Japanese)

Response from Households

Though the non-legally binding target of 15 per cent was not met by the residential sector, different measures and initiatives to change life-style consuming less electricity were taken. Based on a survey conducted by the government, approximately 80 per cent surveyed their household took actions to save electricity and over 90 per cent answered they will continue to take actions. Most took actions on self-controlling lighting and air-conditioners/fans. In the same survey, approximately six per cent of the total responded they took unreasonable actions, possibly indication of non-sustainable energy conservation actions (Figure 19).

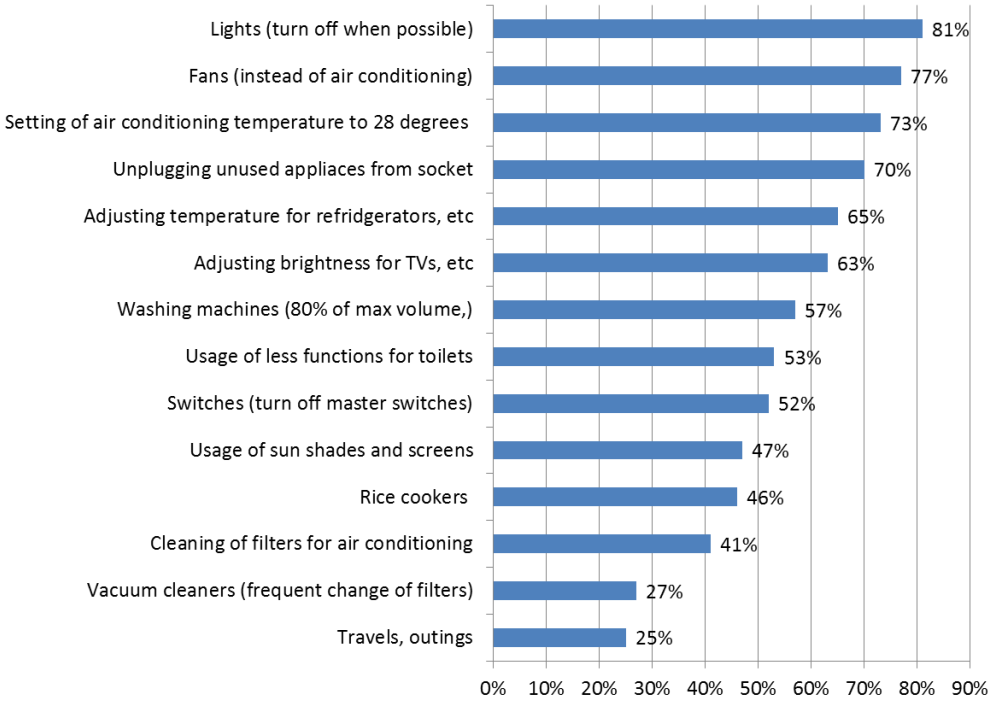


Figure 19 Efforts of electricity saving in households

Source: METI 2012b

One of the measures taken by the government for summer 2011 was to raise awareness on information related on supply and demand, such as supply-demand forecast and hourly reporting of electricity use. The result in the exposure of such information was quite high, out of 2970 interviewed for another survey, 65 per cent answered they saw such information often, 29 per cent said sometimes, and only six per cent answered they did not see it much or at all.

Many studies have been conducted to gain understanding of effectiveness of information dissemination. However, many are limited to research on percentage of reduction or level of awareness of the information provided among the general public. There is one study by CRIEPI, which looked into the correlation of information on electricity usage, such as the 'electricity forecast' and 'supply-demand balance,' and the actual action towards energy conservation. The study aims to analyse the schemes of information dissemination during the peak summer months in 2011 and to seek for an effective method for future infor-

mation campaign. According to this study, 94 per cent of the people interviewed answered they were well-exposed to information on electricity consumption. The researcher analysed interviewed subjects can be divided into two different types: those 'understood' the information provided and took energy conserving effort and those only 'saw' the information and did not ease nor strengthen their effort based on the information provided. The latter was the majority among the interviewed. The conservation in absolute amount of electricity used, regardless of day or the week or the time of the day, should be positively looked upon. However, the future challenge remains to be how to clearly provide information so it leads to energy conservation only during the peak-demand and not to promote pain-enduring conservation throughout the day.

The same study also analysed the motivation for energy conservation and the continuity of such actions after supply-demand stabilizes. The motivation for energy conservation by consumers is categorized into three categories; normative, information and economic. The normative motivation is characterized by consumers' wish to contribute to the society. The information on electricity, which increased tremendously during the crisis, became motivation for conservation. And lastly, economical advantage by consuming less electricity was another motivation for consumers. The study performs a covariance structure analysis and concludes normative, information and economic motivations have contribution ratio of 0.55, 0.22 and 0.25 respectively. The study has also looked into the motivation of energy conservation and its contribution ratio to the continuity of the energy conserving actions. Here, actions of conservation are grouped into two categories, those that are pain-enduring and those that are creative and ingenious. The former is characterized by performing the action even it may impose uncomforting or inconvenient conditions (i.e. leaving air-conditioning off in high temperature) and the latter by performing of measures not necessarily leading to worsening of the living or working environment (i.e. higher temperature setting of refrigerator or turn off TV when not being watched). In the study, the researcher concludes continuity of energy conservation actions are motivated by information provided. Though normative motivation may have impact in consumers' decision to take actions, it had a negative contribution towards the continuity of energy conservation (Nishio 2012).

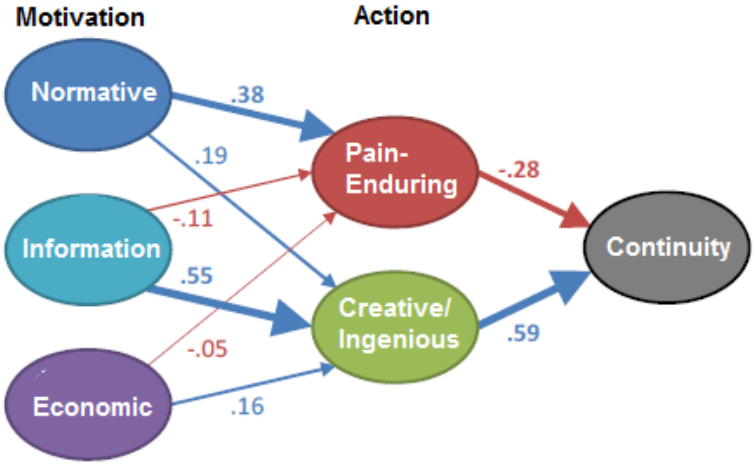


Figure 20 Relationship between motivation and continuity of energy conserving actions

Source: Nishio 2012

The government analysed the situation for the residential sector, non-legally binding targets can lead for reasonable actions to conserve electricity by providing them different "menus" of electricity conservation. Also, though conservation at kilo Watt hour bases or the absolute value was accomplished, effect on peak-demand shift was not as successful, which remains to be an issue for campaign in the future.

4.3.4 Effect on Business Operation

Implementation of mandatory reduction through enforcement of Article 27 on large lot users and non-legally binding 15 per cent reduction for other consumers resulted in much burden to the Japanese economy. Recall the industries did ask for an alternative measures to rolling black out as a tool to balance supply and demand, but the legally binding cap also placed burden on their operation.

Many surveys were conducted to understand the burden on business operation. One conducted by the Agency for Natural Resources and Energy interviewed 30 large-lot users and conducted a written survey on 230 commercial consumers with contract less than 500 kW. The study reports for manufacturing industries, much effect was seen in their manufacturing operation. In some case, extra cost of 1 billion to 20 or 30 billion yen (approximately SEK 83 million, 160 or 250 million) to cover for labour fee for shifting work hours to night time and weekends, cost for fuel for running in-house power generation and adjustment in production schedule was borne. For less energy intensive, non-manufacturing industries, greater effect was seen based on less expensive efforts, such as reducing lighting and use of elevators and managing temperature on air conditions (Table 9) (METI 2012b).

Table 9 Effect of energy conserving effort in summer 2011

Increase in Costs due to Implementation of Electricity Saving Efforts		
	Manufacturing Industry	Non-manufacturing Industry
Facility replacements and repairs	8.2%	14.1%
Fuel for in-house power generation	0.0%	0.7%
Personnel expenses, utility costs	11.3%	1.5%
Others	12.4%	5.2%

Disadvantages to Management from Electricity Saving		
	Manufacturing Industry	Non-manufacturing Industry
Poor customer service	7.2%	17.0%
Decrease in trade and sales due to relocation of business partners	3.1%	3.0%
Impact on production volume	20.6%	3.7%
Increase in burden of employees due to change in work hours	27.8%	9.6%
Less holidays due to implementation of weekend shifts	7.2%	0.7%
Increase in overtime pay	13.4%	1.5%

Remark: approximately 230 SMEs interviewed with cooperation from the Japan Chamber of Commerce and Industry in October 2011

Source: METI 2012b

There are other surveys conducted by industrial associations, local government, building owner and government-related organizations reporting on the actions taken by companies to reduce peak-load and absolute consumption. However, there is very limited data showing the effect on their business operation. One study conducted by Central Research Institute of Electric Power Industry (CRIEPI), formerly a common research institute of utility companies now a non-profit foundation, has looked into burden to the industries from the

cost perspective; the study researched the actual measures taken by companies and the cost and effect on business operation. The report concludes, for large-lot users, the average cost to take energy conservation actions was 15 million yen (SEK 1.25 million), with 50 per cent of the cost coming from the operation of in-house power generation. Other cost bearing actions were increase in labour cost due to shifting working hours and reduced production. For less energy-incentive commercial users, mostly non-manufacturing, 8 million yen (SEK 670,000) was the average cost for their actions. 80 per cent of the cost was on installation of energy efficient lighting and air conditioning systems. However, there were more than half of the respondents reporting the additional energy conserving actions did not bear cost or the cost saving (i.e. by less electricity consumption) exceeded the investment (Kimura 2012). Though the actual survey sent out to the subjects does include questions on cost per action item (i.e. investment in energy-efficient lighting, installation and operation of in-house power generator, increase in labour fee due to time shift etc.), the report does not disclose the data.

There is no data showing numbers of bankruptcy in direct correlation with the implementation of the Article. However, along with strong exchange rate for yen and their own effort to save electricity, burden was big on smaller-sized manufactures not subject to the Article. For example, extra economic burden was placed on SMEs to meet the production schedule of larger companies which altered their working pattern. From the point of view of the well-being of the working population, shifting location and time of work had put some extra stress to their families, such as the vacations not matching that of their children.

5 Winter 2011-2012 (December 2011- March 2012)

- *No signs of restarting halted nuclear power plants for regular maintenance, and more to be stopped to meet the regulation for 13-months mandatory check-up.*
- *A minor imbalance was projected in KEPCO and Kyushu EPCO serving areas where the dependency on nuclear power generation is high. Non-binding numerical target was imposed. All utilities managed to maintain balance of supply and demand. It has become evident, "setsuden" or energy conservation and reduction of demand is becoming well-rooted in the society.*

Many lessons had been learned from the two phases in electricity conservation; one immediately after the disaster and another from experiences from the summer, when the electricity demand is highest in Japan. Rolling black out implemented during the weeks following March 11 disaster, caused confusion and burden to the society but the Article 27 which only targets the large-lot users, turned out to have a great impact on other industries and to the society. For winter 2011-2012, based on the projection, there will be neither implementation of rolling black out nor establishment of legally-binding reduction targets. Fortunately, though the political landscape showed no sign of off-line nuclear power plants to come back online, utility companies have successfully recovered thermal power plants damaged from the disaster and installed emergency power supply utilizing ease of regulation of environmental assessment for such plants. Threat for power shortage was rather limited and KEPCO and the Kyushu EPCO serving areas where the dependency on nuclear power generation is high faced non-legally binding reduction targets. For all other areas, no numerical target was set. The supply-demand balance was projected as indicated in Figure 21. Note, both KEPCO and Kyushu EPCO are located in the western part of Japan where six of the ten utility companies are located within the 60 Hertz frequency. The projected supply deficit was expected to be off-set by supply surplus in the other utilities in the same frequency zone.

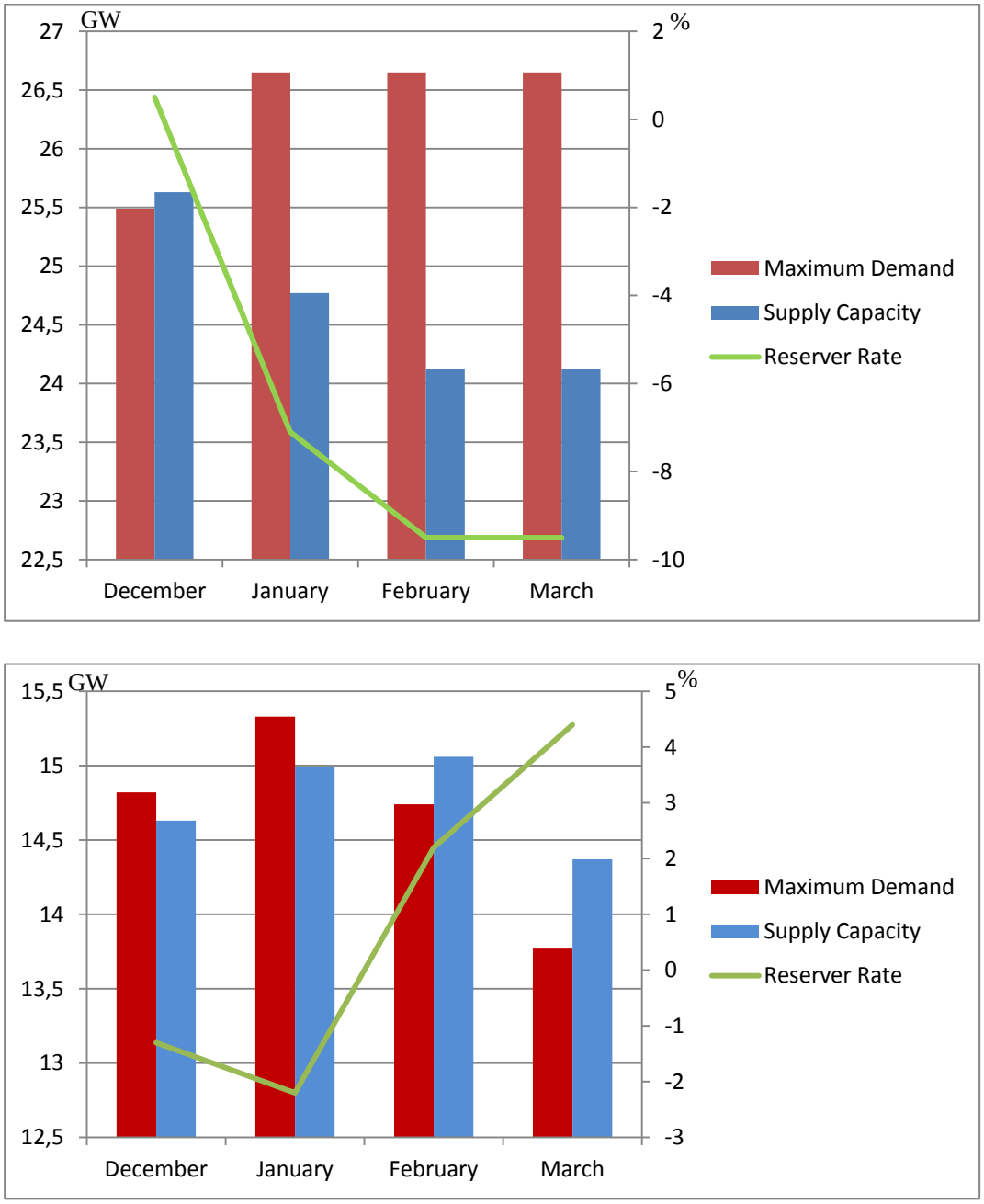


Figure 21 Projection of supply-demand balance for winter 2011-12 (Top: KEPCO, Bottom: Kyushu EPCO)

Source: METI 2011c

As with the summer 2011, the demand during the winter months turned out to be lower than projected. It has become evident energy conservation has become well-rooted in the Japanese society. The confidence in the reduction of demand was taken into account in the demand projection in the following summer. However, there was an incidence surfacing a possible serious issue on the supply side. There was an accident in a thermal power plant in Kyushu EPCO district in February which took 2.2 GW off the grid for one day, resulting to lower supply surplus to below five per cent. On this occasion, power exchange from

neighbouring utilities was able to cover the risk for deficit and no other measures (such as rationing) were taken. However, it has surfaced the threat of such incidence on supply side can be dangerous, in the case when supply surplus is estimated too low.

6 Summer 2012: Another summer has come

- *All 50 nuclear power plants halted since 5 May 2012. But a political decision was made to restart two reactors at Ohi Nuclear Power Plant which had already passed all necessary testing.*
- *Non-legally binding, "request" for reduction with numerical target was applied to KEPCO and Kyushu EPCO. Rolling-black out was presented as an alternative option and utilities were instructed to prepare for implementation, should the need arise.*
- *New schemes utilizing electricity pricing and market were announced, such as auctioning of nega-watt and new and expansion of interruptible contract, while measures such as visualization continued.*

6.1 Supply – Demand Balance for Summer 2012

6.1.1 Electricity Supply – Demand Review Committee

More than one year from March 11, 2011, another summer has come but this time with none of the 50 nuclear power plants in operation posing threat of supply shortage in all areas of the country, except for the areas served by Okinawa EPCO without ownership of any nuclear power plants. The government, through the Energy and Environment Council, National Policy Unit, announced the "Supply and Demand Measures this Summer" on May 18, 2012. The measures are based on the recommendation of the Electricity Supply – Demand Review Committee, an independent body to verify and make recommendations on the electricity supply-demand outlook. Six meetings were held from April 23 to May 12, 2012 and conducted interviews with electricity utilities, companies, economic organizations, experts and others. The committee also had access to information from a collection of reports based on the Electricity Business Act. Transparency was an important aspect of the committee and all references and proceedings were made public.

6.1.2 Supply and Demand Balance Outlook

As of May 5, 2012, electricity generation from nuclear power plants has halted and thermal power generation consist majority of the source for electricity. On 1 July 2012, based on a political decision on 16 June 2012 to restart two of the nuclear power plants stopped for scheduled 13-months maintenance, first of the two reactors in Ohi Nuclear Power Plants has been restarted. Criticality was reached again on 2 July 2012 and the plant started to generate electricity to the grid on 15 July 2012. Another reactor followed the procedures to restart after the first one was stably producing electricity. Supply shortage is most evident in the western part of Japan (with frequency of 60 Hz), particularly with KEPCO with the high percentage of nuclear in their energy profile. Supply capacity by nuclear power generation has decreased by 11.8 GW compared to the summer 2011 while other means of power generation, mainly thermal power generation, have increased by 10.7 GW. Accordingly, supply capacity this summer was expected to be 170.3 GW, almost at the same level as last year.

Table 10 Verified supply capacity before restart of Ohi NPP

	2010 Summer	2011 Summer	This summer
Nuclear power generation	34.8GW	11.8GW	0
Thermal power generation	125.4GW	125.1GW	137.8GW
Hydropower generation	13.7GW	13.8GW	12.7GW
Pumped power storage generation	21.4GW	20.6GW	19.7GW
Geothermal generation, Photovoltaic generation	0.3GW	0.3GW	0.7GW
Flexible interchange	0	0.7GW	0
Others	▲0.5GW	▲0.8GW	▲0.5GW
Total	195.2GW	171.4GW	170.3GW

Source: METI 2012c

Table 11 Electricity supply – demand outlook for summer 2012

	Eastern Japan (50Hz)	Western Japan (60Hz)	Total
Supply Capacity	77.3GW	93.0GW	170.3GW
Expected Demand	74.5GW	96.2GW	170.8GW
Gap between Demand & Supply	+2.8GW	▲3.2GW	▲0.5GW
Reserve Margin	+3.7%	▲3.3%	▲0.3%
Peak Demand in 2010	80.0GW	99.7GW	179.6GW
Peak Demand in 2011	66.5GW	90.1GW	156.6GW

Source: METI 2012c

6.1.3 Reduction in demand projection

In drawing supply-demand projection for summer 2012, the concept of 'anticipated reduction in demand' was accounted for. An analysis was conducted by the utility companies based on investigation on the factors of reduction and a comprehensive survey to consumer of all sectors. Anticipated reduction is identified as reduction realizable by conservation efforts with low stress to the consumer and at low cost or at low stress to the consumer and at recoverable higher cost.

6.2 Reduction Target

The announcement by the government on May 18, 2012 also indicated numerical targets for each of the nine utility companies. KEPCO serving areas of metropolis such as Osaka, Kobe and Kyoto, faced the largest supply deficit of 15 per cent. However, after the decision to restart Ohi NPP was announced, a new numerical target was announced. Ohi Number 3 Plant, the first of the two to come back on line, along with pump-storage hydro increased supply capacity by 1.7GW (Table 12).

Table 12 Numerical target for utility companies in the western part of Japan

	Date Announced	Chubu	KEPCO	Hokuriku	Chugoku	Shikoku	Kyushu
Target Without Ohi NPP	18 May	-5 %	-15%	-5 %	-5 %	-7 %	-10 %
Revised Target after Ohi No.3 online	22 June	-4%	-10%	-4%	-3%	-7%	-10%
Revised Target after Ohi No. 3 and 4 online	25 July	No numerical target	-10%*	No numerical target	No numerical target	-5%	-10%

Target based on 2010 figures

Source: Created by the author based on press releases of Ministry of Economy, Trade and Industry

None of the regions will face mandatory peak reduction in accordance with Article 27 of the Electricity Business Act as areas served by TEPCO and Tohoku EPCO did in summer of 2011.

According to the projection, TEPCO and Tohoku EPCO faced no threat to the supply-demand balance. This is mainly the result of both power conservation which has well-rooted with the general public and the companies, in addition to restart of already retired fire-powered plants, installing new gas-turbines and buying electricity generated by in-house power generators in industrial consumers' ownership. Extreme weather in the summer can greatly alter people's behaviour, especially the use of electricity-powered air conditioning. Though weather predictions are counted in for demand predictions, there is a risk of expected conservation may not be met. The old power plants are at the risk of sudden breakdown due to its age and increased use of thermal power plants sky-rocketing amount in purchase of additional import of liquefied natural gas (LNG) for their operations and causing increase in greenhouse gas emission. For fiscal year 2011, there was an increase of 11-15 million tons of natural gas compared to 2010 and the increment can be as much as 20 million tons in 2012. Japan's custom-cleared LNG import rose by 83.183 million tonnes in fiscal year 2011, a 17.9 per cent increase from fiscal year 2010. The cost of its procurement was 5.4 trillion yen (approximately SEK 400 billion), an increase of 52.2 per cent from fiscal year 2010 (Reuters 2012). TEPCO had filed for the increase in electricity bill by the average of 17 per cent for commercial users and 10 per cent for residential users. The percentage of increased approved by the government ended up to be on the average 14.9 and 8.46 per cent for commercial and residential consumers, respectively. Furthermore, discussions of restart of currently off-line nuclear power plants due to regular maintenance are progressing very slowly and meeting great amount of opposition from the

public. Reliance on environmental un-friendly and expensive means of power generation may have to endure beyond this summer and increased cost for electricity is slowly affecting industrial operations and competitiveness of Japan-located companies. Increased LNG import is clearly one of the reasons for a trade deficit in Japan and the issue of increased carbon dioxide emission due to replacement of nuclear power plants with LNG-fired thermal power plant is also an issue. The crisis is far from over.

6.3 Measures

6.3.1 Basic Policy for the Measures

The measures to be taken resemble those taken by the government and TEPCO and Tohoku EPCO in summer 2011; the measures included visualization of supply and demand trend and mainly providing incentives to provoke voluntary actions by the general public and by businesses. The government announced the basic policy behind the measures to curve possible supply-demand, as follows:

1. Further promotion of visualization and use of market mechanism

   Ex: Shared conservation targets, installation of smart meters and varying pricing scheme, steam-lining of energy conservation

2. Promotion of investment for energy conservation by consumers (change in structure of demand)

   Ex: Financial instruments (subsidies etc.) to promote and further accelerate introduction of energy conserving facilities, HEMS/BEMS (home- / building energy management systems), fuel cells and etc.

3. Promotion of fortification of supply capacity by multiple stakeholders (change in structure of supply)

   Ex: Use of financial instruments and de-regulation to promote installation of power generating facility, including renewable energy, by entities other than power utilities,

6.3.2 New Measures for Summer 2012

Some new actions plans for peak-cut measures enforced for summer 2012 in addition to, measures already implemented, are summarized in Table 13.

Table 13 New measures for summer 2012

Measures on the Demand–Side
Auctioning of Negawatt (for special high-voltage and high voltage large-lot commercial users) KEPCO will be conducting auctioning of Negawatt, or amount of electricity to be conserved, in the case predicted supply shortage. KEPCO will offer lot of energy to be conserved and ask users to participate in the auction to purchase the lot.
Expansion of interruptible contracts (for Special high-voltage, high voltage large-lot and small-lot commercial users) Multiple numbers of utility companies are extending special contracts giving the utility companies the right to interrupt supply with notice of different timing. (for example, KEPCO is adding a contract allowing interruption with one week notice in addition to already existing contract with one day notice)
Establishment of seasonal and new peak-hour pricing schemes (for low-voltage users) TEPCO are KEPCO are implementing new peak-hour pricing, to be used by 410 and 9700 customers, respectively, while Kyushu and Shikoku EPCOs are conducting test demonstration for such pricing scheme. Additionally, KEPCO and Hokkaido EPCOs are providing rewards for residential customers achieving certain level of conservation between months of July and September.
Demand-side Management (DSM) using aggregator (for special high-voltage and high voltage large-lot commercial users) TEPCO announced a call to participate in a plan to collectively conduct demand management to realize a large-scale conservation. Contracts were signed with five different operators (aggregators). KEPCO also has established DSM for customers using Building Energy Management Service (BEMS).
Establishment of de-centralized and green electricity market Allowing for sales of small-sized power generation to the grid.
Expansion of purchase of excess electricity from in-house power generation Announced a scheme to account electricity sales by in-house power generation as energy conserved, in addition to providing subsidies by the government for new installation or re-starting of in-house power generation.
Measures on the Supply-Side
Reduction of testing fee for smart meters (for low-voltage customers) Testing fee reduced from 670 yen to 370 yen per meter (approximately 51 SEK and 30 SEK)
Ease of regulations on pre-marketing trade in wholesale electricity market From 20 June 2012, ban on pre-market purchase on the wholesale electricity market was uplifted.

Source: Translate by the author based on METI 2012d

6.3.3 Alert by Using Mobile Phones

Alerting electricity user of possible supply deficit against projected demand has already been used during summer 2011, but continued to fortify the information dissemination system using mobile and smart phones.

There are two ways mobile phone users can receive information on electricity forecast, supply surplus and other information regarding electricity supply and demand. One method is to subscribe to a mail distribution service or install an application called "Supply-Demand Constraint Announcement Service (tentative translation)". This application is operated by the Ministry of Economy, Trade and Industry and provides information such

as electricity forecast and actions to take to conserve electricity, in addition to warning system in the case of supply shortage. Based on the forecast the evening before at 18:00, if the supply surplus is below three per cent, a first announcement is made alerting subscribers. At 8:30 the following day, if the situation improves and surplus is above 3 per cent, alert is cancelled. If it remains to be between 1 and 3 per cent, then the second announcement is made and if below 1 per cent, second announcement with probably time of rolling black-out is announced. Same information is available on a web page accessible by non-smart phone mobile phones. Another method is to subscribe to the e-mail services operated by utility companies to receive similar information and alerts.

1. Consumption ,updated every five minutes (unit 10,000 kW)
2. Supply Capacity
3. Today's Demand/Supply ration

Figure 22 Screen-shot of Supply-Demand Constraint Announcement Service

There is another serviced called Early Alert Mail, broadcasted by all available mobile phone carriers to all applicable phones in their service area (Figure 23). This service requires no registration by the mobile users to receive the information and is automatically switched on upon purchase of the phone to receive such emergency information as earthquake, tsunami, call for evacuation, eruption, missile warning, terrorism is provided. It can be turned off at the users' will. Not all phones, especially the older models, are able to receive Early Alert Mail. The same information is provided through other media and public announcement systems used by municipalities.

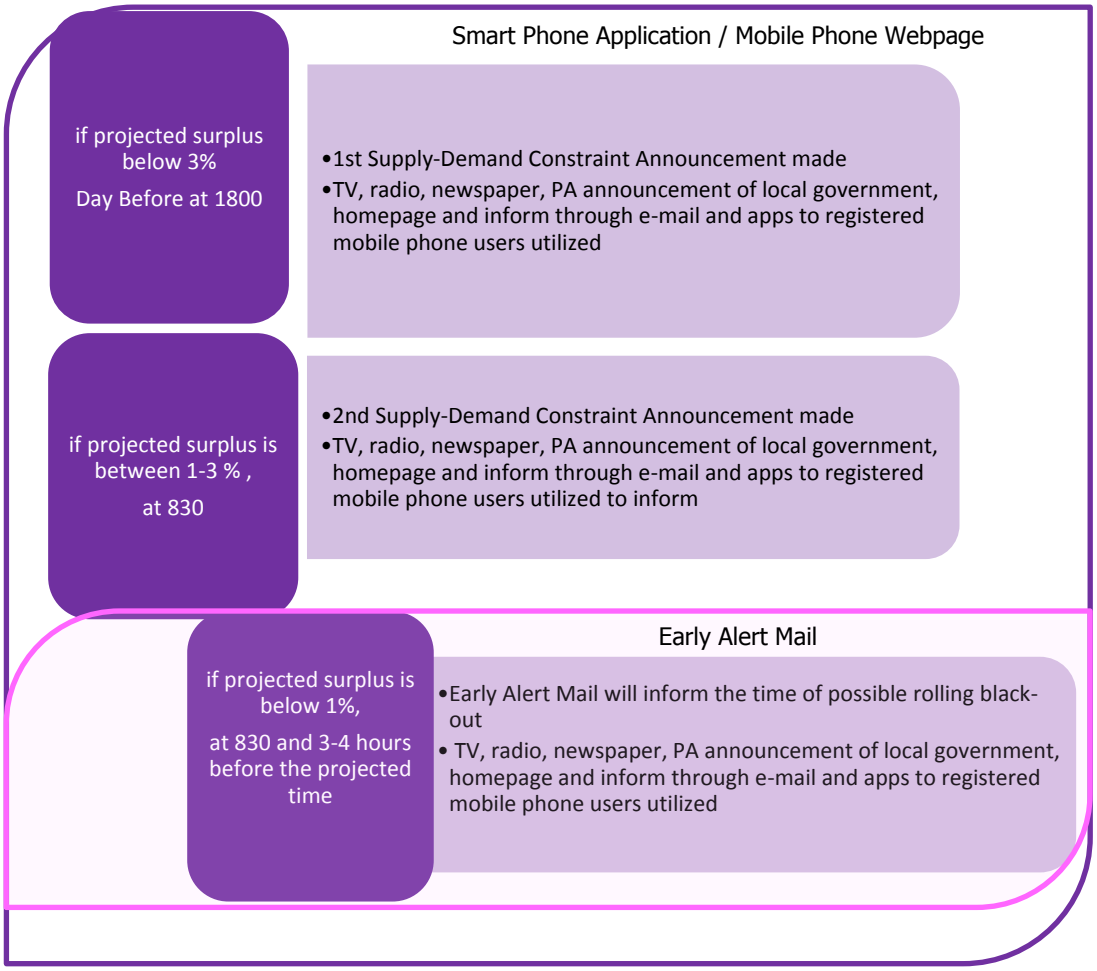


Figure 23 Alerting scheme using mobile phones

Source: Created by the author based on METI 2012e

6.3.4 Rolling Blackout as Safety net

Initially, when the first announcement of prospects of supply-demand balance excluding restart of two nuclear power plants made on 18 May 2012, the government instructed to KEPCO and Kyushu EPCO to prepare for rolling black out as safety-net should there be disruption in supply-demand balance. There were many lessons taken from rolling black-out took place immediately after the disaster. Additionally, the nature of "rolling black-out" as known previously was altered. Rolling black has not been used as a tool to be used continuously, rather a tool to be implemented on a temporary and on extreme emergency basis. Also, it is usually conducted as a set of instruments in "stick-and-carrot" manner, for example rolling black out and subsidies to install energy efficient appliances, i.e. rationing and market-based instruments, as seen in California's 20/20 rebate programme.

In KEPCO serving regions, a postcard was sent out to all consumers to inform the mechanism implementation of rolling black-out, including how it is announced, group and sub-group of where their residing area belongs to, how black-out time is allocated and etc.

On the supply side, the new IC system was installed to allow for even smaller grouping in cutting the electricity distribution. Note the electricity grid, up to the distribution line going into customers building, is owned by the utility companies which have regional monopoly. The upgrade was done with a little investment on the physical grid itself, but rather on the computing system managing the system.

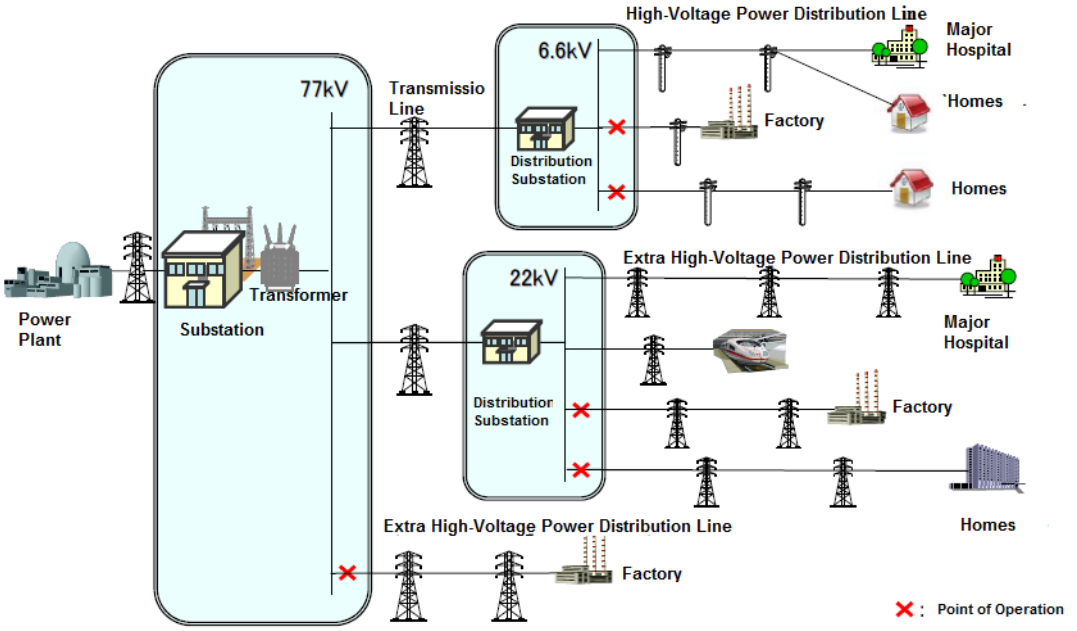


Figure 24 Image of rolling black-out

Source: Translated by the author based on http://www.kepco.co.jp/pressre/2012/pdf/0622_4j_02.pdf

6.3.5 Immediate reporting on Peak-Load

The non-legally binding request for peak-cut for the summer concluded on 7 September 2012 in both KEPCO and Kyushu EPCO serving areas. There is no detailed analysis available at the time of press, however the preliminary reporting from KEPCO on the comparison of peak-load between 2010 and 2012 was announced. In conclusion, on the average reduction of three GW, or eleven per cent compared to 2010, was achieved (Figure 25). (There already was five per cent decrease between 2010 and 2011) Since 2010 was an extremely hot summer and 2012 was not, energy conserving actions may not be the only reason for the reduction. Additionally, there were only two days when the supply surplus dropped to five to ten per cent. There was no incidence of alert system, which was to be executed when surplus reaches below three per cent.

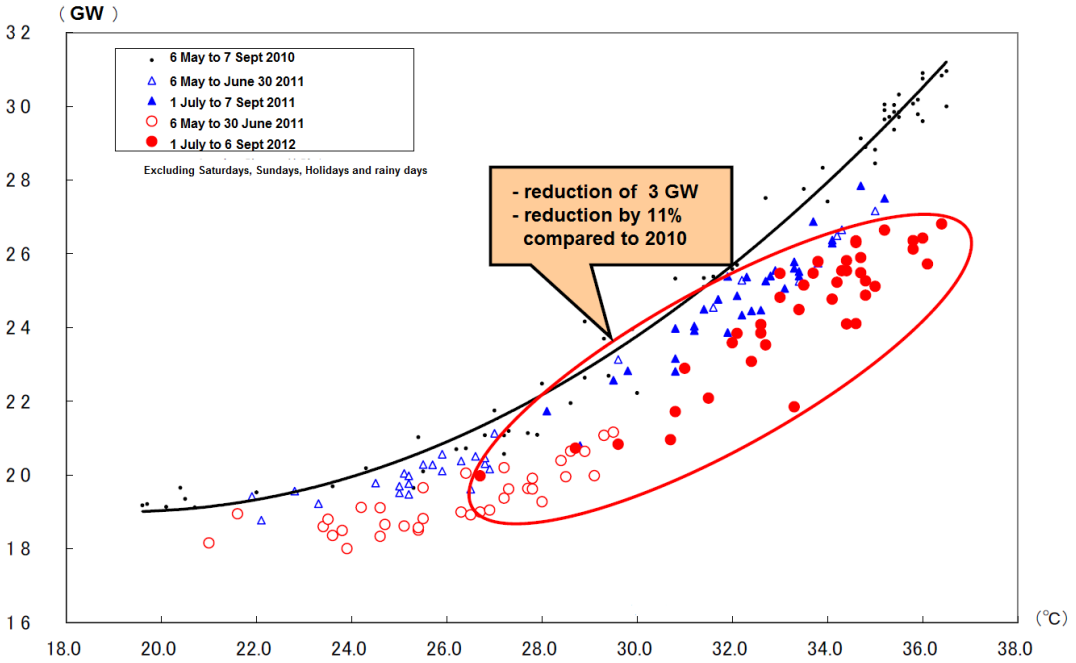


Figure 25 Correlation of temperature and electricity consumption 2010, 2011 and 2012

Source: Translated by the author based on KEPCO 2012

6.3.6 Cost-benefit analysis of measures taken by KEPCO

Cost of the measures taken by KEPCO and the effect, the reduction in electricity consumption achieved is summarized in Table 14. The measure taken in the residential sector proved to be cost effective compared to the measures taken towards commercial users. However, unlike menus provided for commercial users, the energy conservation campaign towards residential sector is not able to reduce large amount of electricity in a hurry.

Table 14 Cost and achieved reduction by measures taken by KEPCO in summer 2012

	Demand –Side Measures					
	Commercial Users					Residential Users
	Interruptible Contract A[*1]	Interruptible Contract B[*1]	Demand Cut Plan[*2]	Nega-Watt Plan	BEMS Aggre-gator	"Setsuden[*3]" Trial
Reduction Achieved (kW)	440,000	1,930,000	590,000	120,000	5000	10,000
Cost (SEK)	333 million	1,250 million	83 million	Not en-forced	Unable to disclose[*4]	12.5 million
SEK/kW	59	66.7	83.3			20.7
SEK/kWh	11.9	3.33	1.42			1.1

**1 Interruptible Contracts vary in the lead-time of stopping supply of electricity supply.*

**2 Demand Cut Plan rewards commercial consumers 1000 yen (SEK 83.3) per kW of peak-load conserved in comparison to the peak-load of the previous year.*

**3 A campaign conducted to encourage residential sector to "setsuden" or to save electricity.*

**4 In consideration not to disclose information on private contract between aggregator and the users of the system, the information are not disclosed.*

7 Policy Implications

There is no doubt the series of events following the earthquake, tsunami, nuclear accidents and power shortage experienced by Japan is having a tremendous effect on its policy making. The situation in past a year and a half has influence policies on how we use energy (ex: energy conservation), make energy (ex: renewable energy), manage energy system (ex: new regulatory entities) and on growth and climate policies. By far, the greatest impact on policy is the review of Basic Energy Plan announced in 2010, which called for increase in the ratio of nuclear power generation. The process to draw a new energy policy, as well as strategy for nuclear power (including nuclear fuel cycle) and climate change countermeasures, will follow after the establishment of Innovative Strategy for Energy and Environment and the new Basic Energy Plan. This new strategy has been discussed with the leadership of the Energy and Environment Council created on 7 June 2011 to conduct "bold reform with no sanctuaries" on energy and environment under the chairmanship of then Minister of State for National Policy Motohisa Furukawa (Figure 26, Figure 27). In this section, influenced policies and policy making processes will be reported in the sequence of their announcement or enforcement.

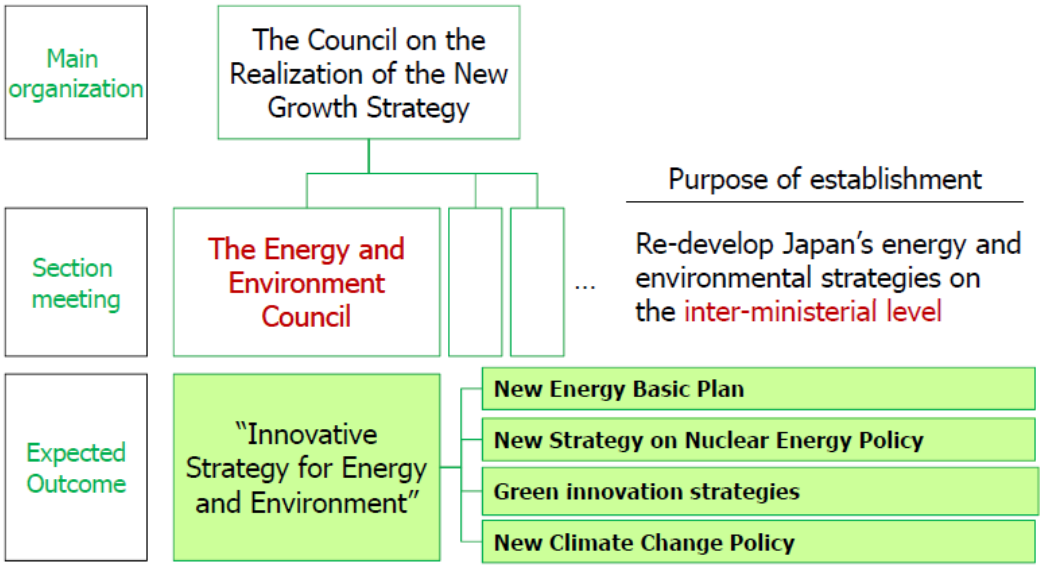


Figure 26 The Energy and Environmental Council

Source: Oi 2012

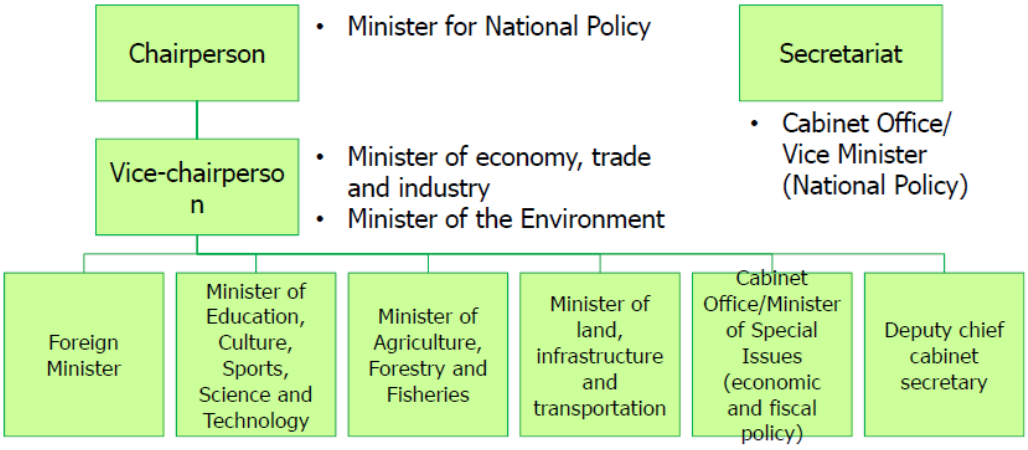


Figure 27 Composition of the Energy and Environmental Council

Source: Oi 2012

7.1 Cost-benefit evaluation of policies implemented

There has been some preliminary estimation conducted on accumulation of the government spending, as noted in the Action Plan to Stabilize Energy Supply-Demand announced in November 2011, on the countermeasures for electricity shortage (cost) and the actual and estimated reduction in electricity consumption (benefit). Note some of the measures were already present before the disaster and the electricity crisis however, for some of them, the amount allocated and the timing of implementation has changed. The measures are summarized into the following three categories.

- Visualization and utilization of market mechanism (visualization and market)
- Promotion of investment in energy conservation by consumers (demand)
- Fortifying supply potential by multiple suppliers (supply)

The first estimation was conducted in November 2011. In the budget for fiscal year 2011 (April 2011 to March 2012) including supplementary budget, 235.3 billion yen was allocated to directly contribute to peak-cut and 579.4 billion yen for indirect measures (approximately SEK 20 billion and SEK 50 billion, respectively). The financial measures are estimated to reduce 16.2, 19.4 and 21.7 GW of peak-demand in summers of 2012, 2013 and 2014 respectively. Second assessment was conducted at the end of fiscal year 2011, in March 2012. Approximately 53 per cent of the allocated SEK 49 billion was implemented before March 2012. The budget for fiscal year 2012, April 2012 to March 2013, additional SEK 8 billion is allocated for measures directly towards peak-cut and SEK 16 billion for related, un-direct measures (NPU 2012c).

Table 15 Budget allocated in 2011 and its effect

	Budget (million SEK)			Effect (GW)			
Actions WITH budget allocation*1	Budget 2011	Implemented in FY 2011	Carried over to FY 2012	End of FY 2011	Estimate FY 2012	Estimate FY 2013	Estimate FY 2014
Demand							
Energy conserving equipment (High efficiency motor)	1258.33	433.33	8.33	0.17	0.49	0.49	0.49
Energy efficient housing (insultion etc.)	15200.00	13000.00	1658.33	0.04	0.17	0.23	0.23
HEMS/BEMS	2500.00	0.00	2500.00	0	0.26	0.87	0.87
Battery (Lithium-ion)	1750.00	0.00	1750.00	0	0.03	0.06	0.06
Energy conservation based on energy conservation survey	66.67	58.33	8.33	0.07	0.07	0.07	0.07
Sub-Total	20775.00	13491.67	5925.00	0.28	1.02	1.72	1.72
Supply							
Promotion of renewable energy (with budget)	9858.33	7425.00	91.67	0.08	0.07	0.1	0.12
PV Homes	12858.33	3016.67	9658.33	0.75	0.75	1.17	1.17
Promotion of in-house power generation and co-generation	3650.00	983.33	2191.67	0.11	0.42	0.46	0.46
Residential fuel cell	1141.67	808.33	658.33	0.01	0.01	0.01	0.01
Sub-Total	27508.33	12233.33	12600.00	0.95	1.25	1.74	1.76
Total (actions with budget allocated)	48283.33	25725.00	18525.00	1.23	2.27	3.46	3.48
			53%				
Actions WITHOUT budget allocation*1	Budget 2011	Implemented in FY 2011	Carried over to FY 2012	End of FY 2011	Estimate FY 2012	Estimate FY 2013	Estimate FY 2014
Visualization and market							
Assessment of electricity contract *2	--	--	--	--	2.8	2.8	2.8
Expansion of interuptable contract (for summer peak time)*2	--	--	--	--	2.5	2.5	2.5
Expansion of interuptable contract (for emergency)*2	--	--	--	--	1.8	1.8	1.8
Demand							
Energy conserving equipment (LED lights, high-efficiency household equipment)	--	--	--	--	1.68	3.27	4.81
Supply							
Increase in supply by utility companies (thermal, pumped-storage)*1	--	--	--	--	4.09	4.09	4.09
Renewable energy (PV, Wind)	--	--	--	--	1.08	1.45	2.23
Total (actions without budget allocated)	--	--	--	--	13.95	15.91	18.23
Grand Total	**48283.33**	**25725.00**	**18525.00**	--	**16.22**	**19.37**	**21.71**

**1 The actions noted in the Action Plan to Stabilize Energy Supply-Demand consists both actions with budget allocation and those without.*

**2 Measures taken by utility companies*

Source: Created by the author based on NPU 2011a and NPU 2012b

Table 16 Estimated amount of reduction by budget allocated in FY 2011

(GW)

	2012	2013	2014
Visualization and utilization of market mechanism	7.1	7.1	7.1
Promotion of investment in energy conservation by consumers	2.7	5	6.53
Fortifying supply potential by multiple suppliers	6.42	7.27	8.02
Total	**16.22**	**19.37**	**21.65**

Source: Translated by the author based on NPU 2011a

7.2 Action Plan to Stabilize Energy Supply-Demand – budget allocation and estimate of the benefit/effect

The Action Plan to Stabilize Energy Supply-Demand was announced by the Electricity Supply-Demand Review Meeting reporting to the Energy and Environment Council on 1 November 2011 to counter-measure the possible supply deficit and cost increase due to shut-down of nuclear power plants. It provides further details on the actions from the list of measures announced on 29 July 2011 to balance supply and demand by the Energy and Environment Council. The Action Plan suggests utilizing variety of policy measures, including budgetary and regulatory restructure, to realize reform in the energy structure. The aim is to minimize use of demand suppression measures such as rolling black-out or restriction on use and stabilize supply and demand, to stop industrial hollowing and ease to the general public.

In the Action Plan, a summary of government budget for supply-demand stabilizing measures and their anticipated results are presented, as noted in the previous section. Also in this Action Plan, Action Plan for Energy Regulation and Regulatory System Reform, which is described in details below, was indicated.

7.3 Action Plan for Energy Regulation and Regulatory System Reform

28 items for reform including those to streamline electric power system reform, renewable energy promotion and strengthening energy efficiency improvement are indicated in this Action Plan. After its announcement in November 2011, each Ministry designated to be in charge of suggesting and implementation of the policy streamlined in the action plan reported back to the Energy and Environment Council. Some of the measures were recognized as measures already demonstrating effects for summer 2012, such as review of contracts on back-up power supply for in-house power generation, establishment of variety of peak pricing, exemption of regulations (example: environmental assessment) for installation of PV and stationary lithium-ion battery (NPU 2012d).

7.4 Report on Cost Verification Committee

This committee was established to estimate the power generation cost of various means of power generation from varying sources, including nuclear, coal, LNG, oil, wind, PV, geothermal, biomass and combined heat. The actual cost and estimates are presented for

years 2010, 2020 and 2030, as urged by the interim report of the Innovative Strategy for Energy and Environment. The Committee had three aims; the first aim is to re-evaluate the cost of nuclear power generation. After the nuclear disaster in Fukushima, there were criticisms cost of nuclear has been historically estimated too low. Second aim is to re-evaluate the cost of power generation by renewable energy sources, including future sources/methods to be. The third aim is to provide objective data as input for the scenarios on reduction of dependence on nuclear, which is to be presented to the society as a bases of discussion for the Innovative Strategy for Energy and Environment. Such cost verification was last conducted in 2004.

There were new aspects to the process introduced. This report marked the first effort in integrating societal cost, such as cost of risk of severe accidents as experienced in Fukushima and cost of green-house gas reduction measures, in the case of thermal power plants. Other societal cost includes subsidies and financial incentives provided by the government to the municipalities agreeing to host nuclear power plants, as well as public research and development funding. Inclusion of cost estimate of co-generation and energy conservation is also a new initiative. The past cost assessment were conducted from the supplier or the utility's point of view and had not provided estimation of cost reduction in the consumer point of view. The details of the calculation methods were also made public with the report. This included exact excel sheets which were utilized to calculate the numbers, including an opportunity for users to alter baseline information, such as life-time of facilities, change in fuel prices and etc.

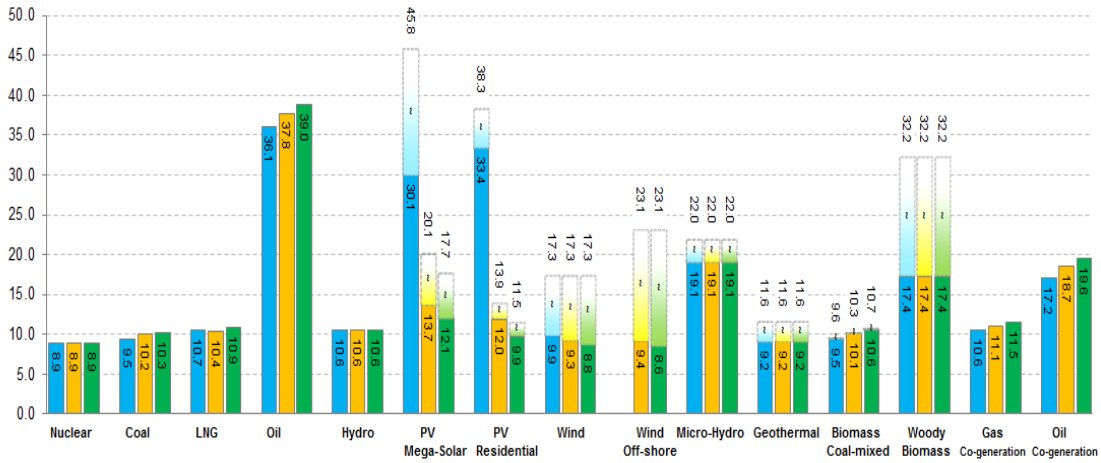


Figure 28 Cost per kilo-watt hour of electricity produced from different sources

Source: Translated by the author based on NPU2011b

7.5 Act on Purchase of Renewable Energy Sourced Electricity by Electric Utilities - Feed-in-Tariff

In the morning of 11 March 2011, Act on Purchase of Renewable Energy Sourced Electricity by Electric Utilities featuring the Feed-in-Tariff scheme was approved by the Cabinet. Though the disaster in the afternoon of the same day did not have an effect on the actual decision to implement this policy, there is no doubt, the disaster and the series of events following had a tremendous influence in designing the details of the measure and

the public opinion supporting the process. The Act passed the Diet on 26 August 2011 during the 177th Diet Session. The scheme is to complement already existing structure of surplus purchase of small-scale photo voltaic power generation.

The implementation of the Act, which obliges electric utilities to purchase electricity generated from renewable energy sources such as solar PV, wind, hydro (below 30MW), geothermal and biomass based on a fixed-period contract at a fixed price, started on 1 July 2012. The certification of entities and the method of generation are conducted by the Minister of Economy, Trade and Industry. Once approved, electricity supplied from the certified entities shall be purchased and electric utilities are obliged to allow grid connection. Refusal of grid connection was the one of the problems in the previous scheme under Renewables Portfolio Standard.

The rate and duration of purchase differs by type of energy source and the scale of installation. Types of power generation especially benefitting any of the three goals of global warming countermeasures, improvement of energy security and fostering related industries is to receive preferential price and/or duration. In addition, to intensively promote renewable sources, special consideration is taken for the first three years from the enforcement of the Act. Decision on the rate and period is the responsibility of the Minister of Economy, Trade and Industry based on the consultation to the newly established independent committee of members appointed by the authorization of the Diet. Additionally, Minister of Agriculture, Forestry and Fisheries, Minister of Land, Infrastructure, Transport and Tourism, Minister of the Environment and Minister of State for Consumer Affairs are consulted before the decision. The pricing scheme is reviewed every year and for fiscal year 2012 was decided as follows.

Photo Voltaic	10kW or more	below 10kW	below 10kW (combined PV and battery etc.)		
Price (yen)	42	42	34		
Duration (years)	20	10	10		

Wind	20kW or more	Below 20kW			
Price (yen)	23.1	57.75			
Duration (years)	20	20			

Hydro	1,000kW - 30000kW	200kW - 1,000kW	Below 200kW		
Price (yen)	25.2	30.45	35.7		
Duration (years)	20	20	20		

Geothermal	15,000kW or more	Below 15,000kW			
Price (yen)	27.3	42			
Duration (years)	15	15			

Biomass	Methane Gasification	Unused Woody mass	Woddy mass	Non-woody Waste	Recycled Woody mass
Price (yen)	40.95	33.6	25.2	17.85	13.65
Duration (years)	20	20	20	20	20

Figure 29 Price and duration for purchase (1 July 2012 to 31 March 2012)

Source: Translated by the author based on webpage of Agency for Resources and Energy http://www.enecho.meti.go.jp/saiene/kaitori/kakaku.html *(in Japanese)*

Cost incurred by the utility in purchasing by FIT scheme is transferred to the entire electricity customers as "Surcharge for renewable energy" generally in proportion to their electricity usage. The residents of disaster stricken areas are exempted from the surcharge until 31 March 2013.

7.6 Bill to Partially Amend the Act on the Energy Conservation Law

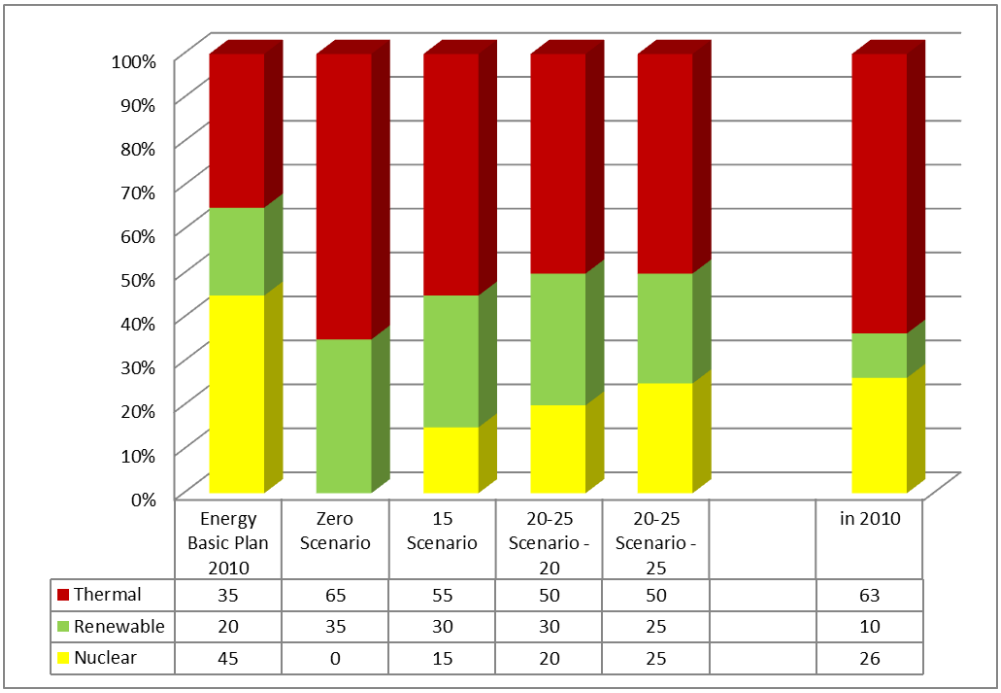
There are two measures to be realized by the amendment to the already existing law on energy conservation. The first measure calls for promotion of peak-cut efforts by industries and the second is the application of top-runner method to construction materials.

The amendment aims to promote and encourage efforts made by consumers to reduce the consumption of electricity purchased from utilities during peak demand hours using storage batteries, energy management systems (BEMS or HEMS), in-house power generation and air-conditioning system utilizing stored heat and/or gas. The proposed measure plans to provide incentives to the entities by providing a scheme so such efforts can be reflected in their mandatory reporting of energy consumption and conservation. Currently, top-runner method is applied to 23 products including passenger vehicles, air conditioners, TV sets, fluorescent lumps and refrigerators. The new measure calls to add products such as windows, insulators, bathroom and kitchen facilities to be subject to the top-runner method. All new residential and commercial buildings will be obliged to conform to the regulation by 2020.

The bill was submitted to the 180th Diet Session, which convened between 24 January and 8 September 2012, but did not pass due to lack of time.

7.7 Innovative Strategy for Energy and Environment

The standing Basic Plan for Energy announced in 2010 called for increase in nuclear power generation by 2030, from 26 per cent in 2010 to 45 per cent in 2030. The Energy and Environmental Council within the National Policy Unit, led by the Minister of State for National Policy Motohisa Furukawa, initiated a national consultation for the Innovative Strategy for Energy and Environment. After verification of the cost of power generation by sources, conducted by the Cost Verification Committee, the suggestion for three scenarios to base the discussion was announced on 29 June 2012. With the given three base-scenarios of zero per cent, 15 per cent or 20 to 25 per cent of power generation by nuclear power, a national debate/discussion has started. The discussion originated with the general consensus of the need to reduce dependence on nuclear energy in the medium to long term. However, the point of discussion were the time needed for the reduction of dependency, level of reduction and choices of alternative energy sources to cover for nuclear power.



	Energy Basic Plan 2010	Zero Scenario	15 Scenario	20-25 Scenario - 20	20-25 Scenario - 25		in 2010
Thermal	35	65	55	50	50		63
Renewable	20	35	30	30	25		10
Nuclear	45	0	15	20	25		26

**Though numbers are shown separately for 20 and 25 per cent scenarios, in the consultation, it is discussed as a single scenario, "20-25 Scenario."*

Figure 30 Proposed energy mixes for 2030

Source: Data from National Policy Unit, NPU 2012e

The process of national discussion took an unprecedented form (for Japan, at least) to best encourage involvement by the general public. In July 2012, a website and pamphlets, including for kids, called "Let's talk about future of energy and environment" were created. Public comments were solicited through mid-August 2012 and they were accepted both in a written form and also at eleven public hearing sessions were conducted throughout the country. Additionally, method of "deliberative polling" study was conducted by a government committee in August as one of the means of collecting public opinion in seeking to formulate a new energy mix. The polling involved a two-day discussion event among about 290 randomly selected people, and checked their opinion three times, twice before the debate and once after. The government conducted the polling, developed by Stanford University professor James Fishkin, for the first time to hear public opinion on the three government-proposed options for nuclear energy's (Japan Times 2012b). A detailed analysis of all forms of public consultation by means of public hearings, written public comments and poll conducted by media was reported to the Energy and Environmental Council on 4 September 2012 (NPU 2012f).

**Very limited information available in English*

Figure 31 Webpage of "Let's Talk About the Future of Energy and Environment"

Source: http://www.sentakushi.go.jp/

On 14 September 2012, the Energy and Environmental Council adopted the Innovative Strategy for Energy and Environment. Upon introduction of the strategy, the administration stated it would "mobilize every policy resource available to achieve the abolition of nuclear power plants in the 2030s." The zero-scenario was chosen; strict compliance of a 40-year lifetime limit to the nation's 50 reactors and pledge not to build new ones, were two aspects of the Strategy reflecting the general public's voice for the abolition of nuclear power. The Strategy also touches up on the country's stance on reprocessing spent nuclear fuel to obtain plutonium. In spite of the announcement to phase-out nuclear (i.e. the zero-scenario), there was no change announced regarding the country's plan to process spent fuel and its plan to stockpile plutonium. Also there was no mention of change in its Monju plant, a prototype fast breeder reactor, which is aiming to use plutonium fuel retrieved by reprocessing spent fuel from ordinary nuclear power plants. Unsurprisingly the Strategy appeared contradicting to eyes of many; though the Japanese government indicated it would like to phase-out nuclear, at the same time, declaring to process spent fuel to obtain platinum.

To top off the surprise of what it appears to be conflicting strategies, on 19 September 2012 just five days after the adoption of the Innovative Strategy for Energy and Environment, the Cabinet decided not take up the policy in its entirety, instead endorse a statement which read: "The government will promote energy and environment policy under constant examination and review, in dialogue with affected local governments and the global community, as well as seeking understanding from the general public (Asahi Shimbun 2012)." This signified that the Strategy has no legal status. An election is expected to take place relatively soon in the Lower House, which the Prime Minister has the power to adjourn. With only around 20 per cent in the public poll showing support for the current Prime Minister Noda's regime, Diet may be dissolved much early than the remaining one

year term of office. Aiming to win the popularity of the general public, the most popular zero-scenario was chosen by the Energy and Environment Council, but received a strong opposition for the business community. This is the reason why the Cabinet had failed to endorse the Strategy which called for phase-out of nuclear power. Only within the first week, the ambition of zero-scenario had been watered down. Should there be a change in the government, the status of this non-legally binding Strategy may be up for discussion.

8 Conclusion

The energy crisis and lack of electricity supply Japan has faced was unprecedented in many aspects. First of all, the crisis experienced at the wake of earthquake, tsunami and the incidences at the nuclear power plants were resulted by multiple short-comings such as reduction of supply capacity and interruption in the infrastructure. Then the country had a few months to prepare for the summer, when electricity is consumed the most. Furthermore, the government has failed to establish regulatory framework fast enough to communicate to the public well enough resulting in continued halt of all 48 out of 50 (remaining) nuclear power plants in the country, expanding the supply shortage to areas not directly affected by the initial natural disaster and the nuclear accidents at Fukushima Daiichi Power Plant.

Though there are many aspects that may not be so relevant in the case of supply shortage in Sweden[3], the following are some lessons that maybe applicable in case of electricity shortage in Sweden.

Visualizing information and methods to disseminate information, such as supply forecast and real-time supply and demand balance and methods of communicating the information to the general public is one of the traits in the Japanese handling of the crisis which Sweden can learn from. Also, the **incentives provided to the consumers for saving electricity** are another aspect that may be of interest for Sweden. The two above measures are important not just to save "electricity in a hurry," but for the habit and lifestyle to stay for continued energy conservation even after the crisis has ended. Shift of peak-demand was emphasized but resulted in reduction in the absolute amount. The Japanese case proved most consumers are ready to respond to a crisis with a little guidance in order to quickly contribute.

Policies implemented to support and further accelerate diffusion of energy saving products, technologies and services are also methods that should be noted. The crisis caused to hurry the market introduction of otherwise too expensive products and convinced companies to further conduct cost savings and innovate the product and services provided. Japanese companies overcame yet another energy crisis, as they did in the oil crises in the 1970's. Though it was with great suffering economically, the measures the companies too were not only enduring less light or less comfortable working, but some were creative, innovative and some even leading to cost efficiency in the future, may give competitive edge in a long run.

What mistakes can Sweden learn from? **Lack of clear responsibility and line of communication** between the parties involved such as the government, energy agency and electric power companies caused much confusion to the society. In the case of Japan, especially at the early hours of the crisis, there were mixed messages coming from the government and utility companies. Though it was a crisis of a magnitude never experienced before, risk communication should have been prepared for between different stakeholders.

[3] *Which has an electricity grid connected to that of other countries and having an open electricity market with many different players in the system compared to the Japanese system which is monopolized by regions and is not connected the grid of any other country,*

8.1 Opportunities for Sweden

In addition to assessing the situation as a learning experience for Sweden, there may be opportunities for Sweden to contribute to the development of the new energy system in Japan. There are signs of slow but eventual discussions continuing regarding the once abandoned idea of de-bundling of the electricity grid system. Additionally, feed-in-tariff has been implemented starting 1 July 2012 is a tailwind for momentum for increased renewable energy source, establishing smart grid and a de-centralized energy system. Vigorous discussions on the future energy system are being conducted, including changes in the Japanese mind-set that supply capacity need to meet the peak demand. The lucrative business scheme of electricity companies, which was only known and pointed out by few experts before, are now known and understood by broader public. Historically, heat and power cogeneration has not been well promoted in Japan, as the country had not regarded heat as an important carrier for energy. Sweden's experience with heat utilization, establishment of infrastructure for heat and using renewable sources for heat production is something Japan can learn from. Though there are still criticisms in the process, transparency in energy policy making on its way. Japan is slowly but surely, and finally going through what some may call "energy democracy." Viewing from a broader perspective, Sweden is able to share the process and experience with such process.

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