Svar Direkt
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After the Quake: Energy Crisis Management in Japan

-A first assessment of challenges and lessons learned following the Great East Japan Earthquake on March 11, 2011

Den 11 mars 2011 drabbades Japan av den kraftigaste jordbävningen i modern tid. Den efterföljande tsunamin orsakade enorm förödelse och slog bland annat ut nästan en tredjedel av landets elproduktion. Denna rapport beskriver händelseförloppet efter katastrofen med fokus på den energibrist som följde och de åtgärder regering och myndigheter vidtagit för att hantera detta.

tillväxtanalys

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Förord

En hittills mindre uppmärksammad aspekt av den trippelkatastrof som drabbade Japan den 11 mars 2011 är att nästan 30 procent av landets elförsörjning initialt också slogs ut.

Nu till den japanska varma och fuktiga sommaren, då behovet av luftkonditionering får elförbrukningen att stiga kraftigt, så kommer betydande besparingsinsatser att krävas av det japanska samhället. Den omfattande kärnkraftsolyckan har också fått Japan, och delar av omvärlden, att överväga och i flera fall även besluta om en omställning bort från kärnkraft som energikälla. I fallet Japan diskuteras en radikal omställning mot förnybara energikällor även om kärnkraft kommer att kvarstå som en del av landets energimix.

Hur Japan, världens tredje största ekonomi, hanterar gapet mellan efterfrågan på och utbud av energi kan ge viktiga lärdomar och inspiration kring hur samhället kan ställas om mot en mer hållbar och mindre elintensiv riktning – och hur innovationer kan bidra till den omställningen.

Tillväxtanalys Tokyokontor har på plats sedan dag ett av naturkatastrofen följt utvecklingen för svenska myndigheters räkning och har även aktivt deltagit i ambassadens kristeam.

Rapporten har skrivits av Izumi Tanaka, analytiker med ansvar för området hållbar utveckling på Tokyokontoret. Temansvarig analytiker för hållbar utveckling, Martin Flack, och kontorschef och teknisk vetenskaplig attaché Anders Karlsson, Tokyo har bidragit med synpunkter.

Stockholm, juni 2011

Enrico Deiaco, avdelningschef, Innovation och globala mötesplatser

Preface

A less highlighted aspect of the triple disaster earthquake-tsunami-nuclear accident that hit Japan on March 11, 2011 is that around thirty percent of the electricity supply capacity of eastern and north eastern part of the country initially was knocked out.

At the onset of the hot and humid summer season when electricity demand surges due to the use of air-conditioning, despite extensive repair works, society is asked to save about fifteen percent on the electricity consumption. The series of extensive nuclear accidents have also initiated in Japan, and many parts of the world, to consider, and in some cases to decide on a path away from nuclear power as energy source. In the case of Japan a change towards more of renewable sources of electricity is being discussed even if nuclear power is likely to remain as a part of the electricity portfolio.

How Japan, the third largest economy in the world is handling the gap between demand and supply can provide valuable learning, as well as inspiration for how society can be transformed towards a more sustainable and less power consuming direction.

The Growth Analysis Tokyo Office has for the benefit of our stake-holders been following the development on site since day one of the crisis. We have also actively participated in the embassy crisis management team.

The report has been written by Izumi Tanaka, Analyst responsible for the area of Sustainable Development in the Tokyo Office. Theme responsible Martin Flack and Head of Office, Science Counselor Anders Karlsson has also provided feedback and comments on the text.

Stockholm, June 2011

Enrico Deiaco, Department Head, Innovation and Global Meeting Places

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1 Introduction: the Quake that turned out the light in parts of Japan

Japan is the world third largest economy, a highly developed country with industry, transport system and one of the worlds highest standards of living, all calling for a high demand for energy in general and using electricity as the energy carrier in particular. On March 11, 2011 a magnitude 9.0 earthquake struck the coast of Japan, followed by a devastating tsunami, which combined, led to one of the worst nuclear accidents in modern time. This report focuses on the electricity supply shortage following the triple disaster. All in all, 27 GW or roughly 30 percent of the total electricity generating capacity in eastern and north eastern part of the country was lost due to the halt of both nuclear and thermal power plants. Both the two major electricity companies, Tokyo Electric Power Company (TEPCO, hereafter) providing electricity to Tokyo and the prefectures in the vicinity and Tohoku Electric Power Company (Tohoku EPCO, hereafter) serving the prefectures most affected by the disaster were both heavily affected.

Following the massive earthquake, eleven nuclear reactors underwent automatic emergency shut-down procedure following the magnitude nine earthquake as they should when peak ground acceleration sensors detect vibrations above a set safety value. The nuclear power plants, Onagawa of Tohoku EPCO and Fukushima- Daichi (six reactor blocks, three in operation at the time of the earthquake) and Fukushima- Daini (four reactor blocks) of TEPCO were all stopped. A power cut due to the earthquake at Fukushima-Daiichi and Fukushima-Daini resulted in diesel generators to automatically start in order to provide power for the pumps to ensure the cooling function of the core. Due to the flooding caused by the tsunami, most of the generators did not start, causing loss of cooling power. As a result, an emergency status was declared, in accordance with the procedures established by the safety authorities, i.e. the Nuclear and Industrial Safety Agency（NISA under the Ministry of Economy, Trade and Industry (METI).

Table 1-1: Power plants damaged in Tohoku EPCO and TEPCO serving areas

unit: GW

Tohoku EPCO		**TEPCO**		**Jointly Owned**	
Nuclear Power Plant					
Onagawa	2.17	Fukushima-I and II	9.1		
Total	**2.17**	**Total**	**9.1**	**Total**	**0**
Thermal Power Plant					
Hachinohe	0.25	Hitachinaka	1	Shinchi	2
Sendai	0.44	Kashima	4.4	Nakoso	1.6
Shin Sendai	0.95			Kashima	1.4
Haramachi	2			Sumitomo Metal/Kashima	0.65
				Ksahimakita	0.65
				Kashimaminami	0.19
Total	**3.64**	**Total**	**5.4**	**Total**	**6.49**
Total Tohoku EPCO	**5.81**	**Total TEPCO**	**14.5**	**Total Jointly Owned**	**6.49**

Total 26.8 GW

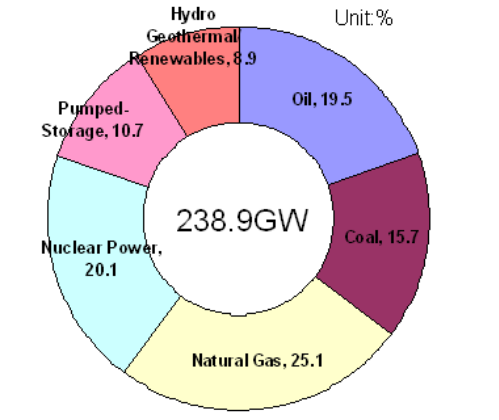
Source: Kaneko 2011

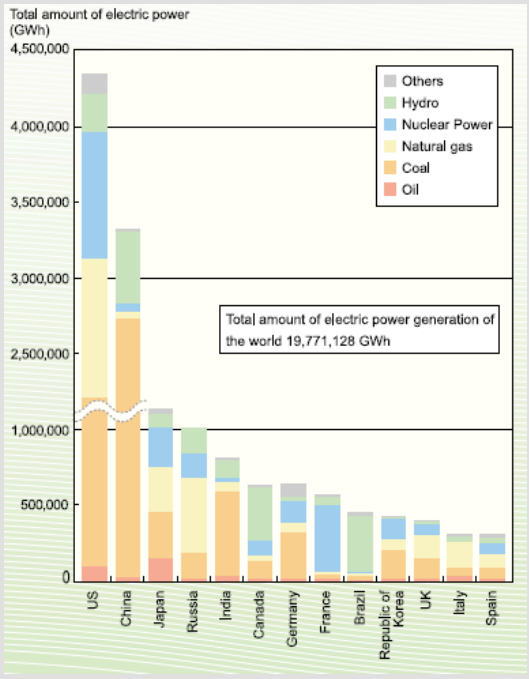
Whilst the nuclear emergency, for obvious reason, has caught most of the world's attention, as seen in the table above, the tsunami actually initially swept away a substantial part of thermal power as well. Both nuclear power stations and thermal power stations are

located close to the ocean, for the purpose of easy access to cooling water and shipments of fuel/coal (primarily made by sea). However, as the series of events have proved, both for thermal power stations and the nuclear power stations the critical functions were not sufficiently protected against a disaster like the tsunami experienced on March 11.

Box: The sources of electricity supply in Japan and the two electricity grids

Figure 1-1 Electricity supply of Japan- compared to other countries and detailed supply mix

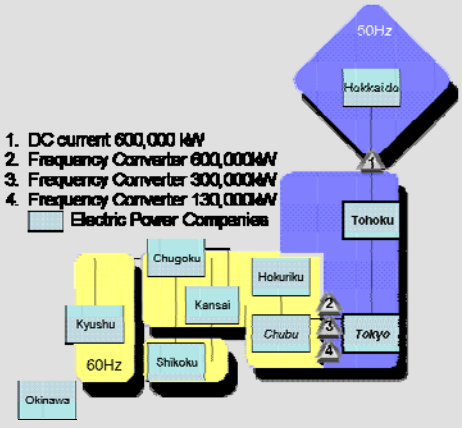




The electricity supply is dominated by fossil fuels like natural gas, coal and oil and by nuclear power. These sources represent more than 80 percent of total supply.

Source: Agency for Natural Resource and Energy, Japan, (2010), see also Tillväxtanalys 2010

Figure 1-2 Electricity Grid System of Japan



Japan is a small country with two electricity grid systems, with 60 Hz in the western part and 50 Hz in the eastern part with only three conversion points. This makes power interchange between western and eastern parts of Japan difficult and limits the amount of electricity that can be transferred to the eastern part of Japan from the western part where power plants are intact. The main limitation is both the number of conversions points as well as the capacity of the connecting power lines.

Source: Agency for Natural Resource and Energy, Japan, (2010)

The table below shows the list of significant events in relation to the electricity supply crisis management.

Table 1-2 List of significant events

Date	Event
March 11	East Japan Great Earthquake Occurred
March 14	Rolling black-out started by TEPCO
March 17	Experienced threat for possible massive black-out
March 25	Government announced shortage of electricity during summer months may be up to 15 GW
April 8	Government officially announced conclusion of rolling black-out Government announced 25% reduction target for large-lot users (contract electricity: 500 kW or more) during the summer months
April 25	TEPCO announced projection of supply capacity to be 52 GW in end of July
April 28	25% reduction target for large-lot users was eased to 15% reduction "across-the-board"
May 25	Approximately 30 categories to be exempted from reduction target were announced

Source: Created by the author based on Nikkei 2011

Below are the authorities surrounding the electricity regulation. Understanding their respective role is of relevance for understanding the chain of events.

- Based on the Clause 27 of the Electricity Utilities Industry Act, the responsibility and power to restrict use of electricity is placed on the Minister of Economy, Trade and Industry (METI). The Minister is in charge of the Agency for Natural Resources and Energy and therefore responsible for the energy and electricity issues.
- The power companies, in this case, TEPCO and Tohoku Electric, are responsible for balancing supply and demand and are in charge of planning and implementation of schemes such as rolling black-out.
- Electricity Supply-Demand Emergency Response Headquarters was established on March 13, with the Chief Cabinet Secretary as the chairperson, and later restructured as Review Meeting on Power Supply and Demand on May 16. Additionally, a Minister for Electricity Conservation Promotion was appointed.

With the triple crisis of the earthquake-tsunami-nuclear accident creating a significant gap between the societal demand and the available electricity supply, in order for critical functions for society to receive the electricity needed, it has been essential to introduce various measurers to curb the demand from uses that are less critical for society. These will be described below.

2 Short term consequences - due to loss of electricity supply

2.1 Initial measures taken and the results

2.1.1 Supply-side measures

Following the initial crisis period the following emergency measures were taken by both TEPCO and Tohoku EPCO to increase the supply capacity[1]:

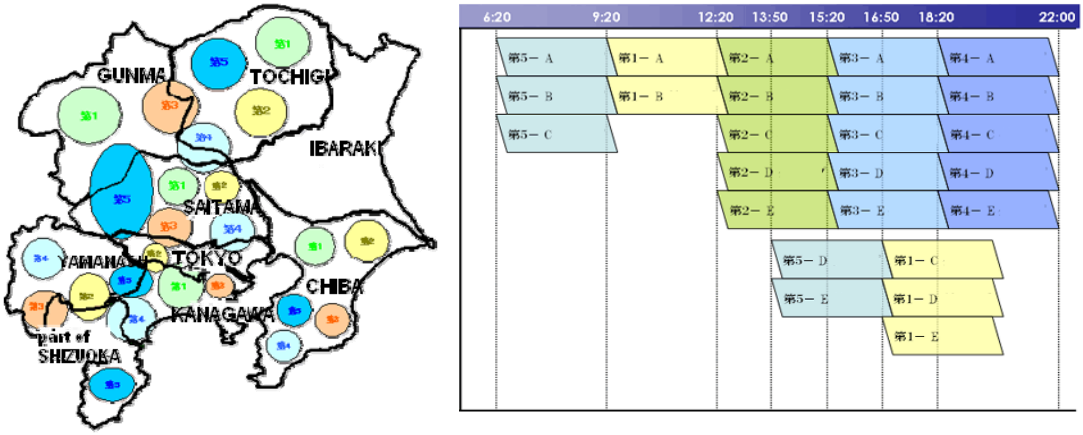
- restore operation of thermal power plants halted from the disaster
- restore operation of thermal power plants stopped for planned maintenance and for long-term planned shutdown
- purchase from Independent Power Producer
- power interchange from other electric utility companies

By the end of April, the supply capacity for TEPCO had increased from approximately 31 GW immediate after the disaster to approximately 42GW.

2.1.2 Demand-side

Since the reduction in power generating capacity became evident, TEPCO urged their users to conserve energy, based on a clause listed in the Terms and Contract of Electricity. On Saturday March 12, TEPCO announced the possibility of rolling black-outs starting the following day to avoid unexpected mass black-outs. Areas served by TEPCO, excluding the central areas of Tokyo, were divided into five and later into 25 groups and subgroups, each area experiencing up to three hours of black out at a time. The actual implementation of rolling black out started on Monday March 14 and continued until March 28. The warmer weather following that date called for less demand for electricity.

Figure 2-1 Image of Rolling Black-out



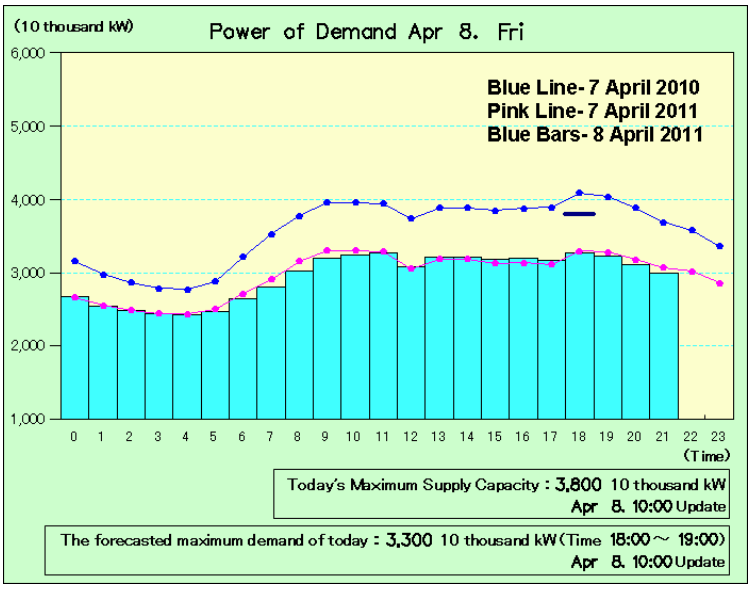
Source: TEPCO 2011a

[1] *Source: Electricity Supply-Demand Emergency Response Headquarters 2011*

2.1.3 Societal response to the shortage of electricity

After the announcement from TEPCO on the possibility for deficiency in electricity supply, the demand was significantly reduced. This was due to immediate effort by all users of the society; the residential, industrial and governmental users. Society responded in a very responsible way to the crisis at hand and "節電" setsuden" saving electricity, became a word of mouth.

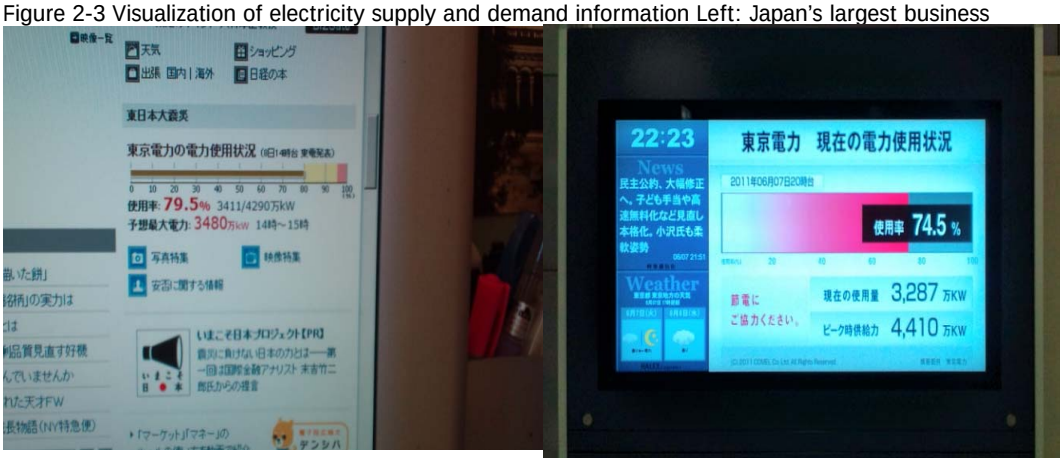
Figure 2-2 Example of reduced consumption



Source: TEPCO 2011b

To curb peak-demand, train operations were reduced, lighting at homes, offices, factories and in public places were reduced, neon signs turned off and the escalators and elevators stopped to name just a few of the efforts made. To date, both TEPCO and Tohoku EPCO are announcing the status of the projected supply capacity and demand and predicted demand-peak of the day, on a daily basis. The information is publicized in media and publically accessible places, such as on the TV news, in newspapers and display in trains and train stations, all in an effort to raise the awareness of the need for energy conservation.

Figure 2-3 Visualization of electricity supply and demand information Left: Japan's largest business

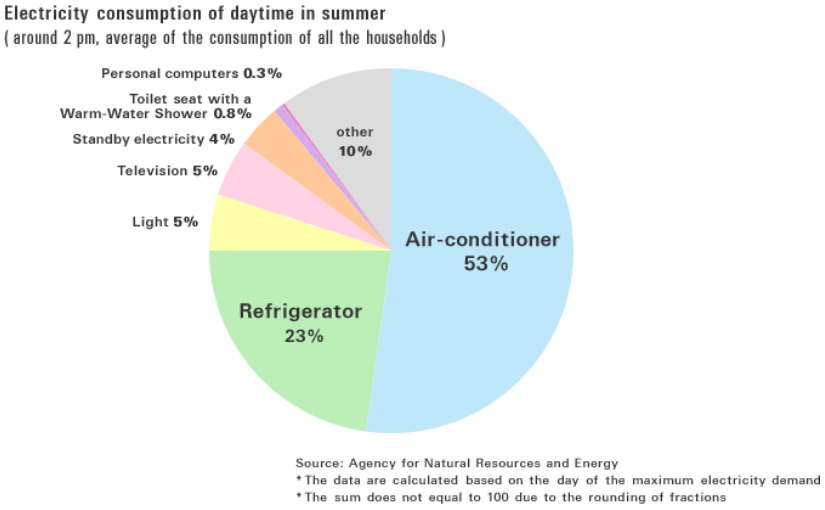


Source: Author's own photographs

2.2 Outlook for the long, hot and humid summer

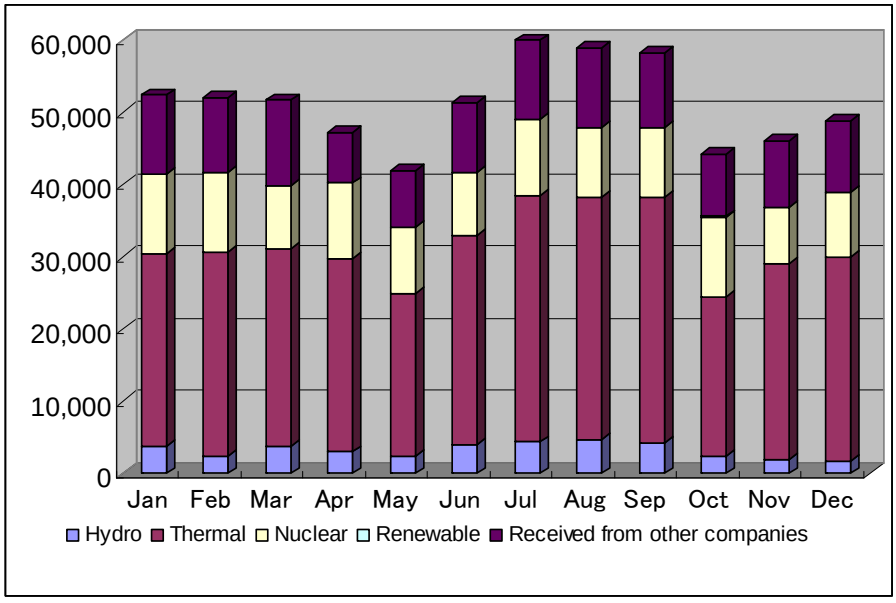
The energy demand from January to May shows a decreasing tendency with May being the month with the least electricity demand. In June, the demand increases with the peak in the summer months of July, August and September. The peak is a result of the use of electricity to operate air conditioners. To understand why air conditioning is such a big issue, Japan has a very hot and humid climate during summer, and for a typical household air conditioning would correspond to about half of the power use during summer. Also for industrial users air conditioning represent a substantial part of electricity consumption.

Figure 2-4 Average household electricity consumption during daytime in summe



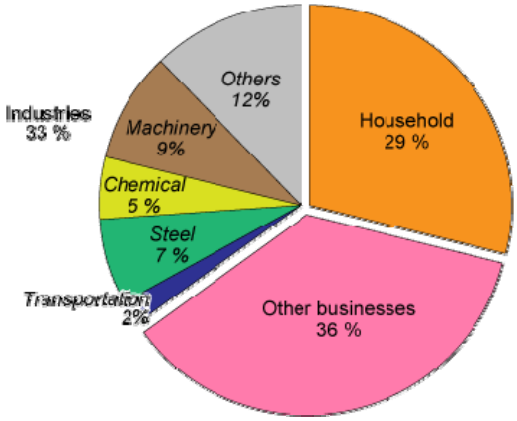
Source: TEPCO 2011c

Figure 2-5 Peak-demand of TEPCO January to December 2010



Source: Created by the author based on data from METI 2011a

Figure 2-6 Use of electricity by different sectors



Source: METI 2011b

2.2.1 Measures for supply-side

The Electricity Supply-Demand Emergency Response Headquarters has been meeting to consider short to long-term measures to handle the predicted electricity supply shortage.

Table 2-1 Forecast of summer demand and supply, unit GW unless noted

	TEPCO	**Tohoku EPCO**
Forecasted Demand *1	60	14.8
Forecasted generation capacity	55.2	12.3
Amount to be supplied by TEPCO to Tohoku EPCO*2	--	At maximum 1.4
Forecasted supply capacity	53.8	13.7
Deficiency against forecasted demand	10.3%	7.4%

**1 The predicted demand is based on the peak-demand measured in summer 2010, end of July for TEPCO and end of August for Tohoku EPCO when the Japan experienced hotter summer than on the average. The average peak-demand for summer months are 5.5 GW and 1.3 GW for TEPCO and Tohoku TEPCO, respectively.*

**2TEPCO will supply at the maximum 1.4 GW of its electricity generated to Tohoku EPCO, where most of the disaster-stricken areas are located.*

Source: Revised by the author based on Electricity Supply-Demand Emergency Response Headquarters 2011 and press releases of TEPCO and Tohoku TEPCO

The main measures proposed in the report from the Headquarters to handle the shortage are:

- continue to restore thermal plants halted due to the disaster and decrepit plants
- newly install emergency power supply, such as gas turbine
- newly contract private power generators to purchase electricity
- pumped-storage power generation

(Source: Electricity Supply-Demand Emergency Response Headquarters 2011)

To assist the implementation of the above measures, the Government Revitalization Unit, which normally screens wasteful governmental spending, has announced an ease of the

regulations such as noise and pollution control on in-house power generation along with easing regulations on labour patterns allowing companies, in agreement with the labour union, to shift working hours.

2.2.2 Measures for demand-side

The government formally announced on April 28 that it will seek a 15 percent across-the-board reduction in summer power consumption, a step back from its initial plan to seek a 25 percent reduction for volume users, after TEPCO made upward correction in its supply capacity. In the May 25 meeting of Review Meeting on Power Supply and Demand, the entities exempted from the 15 percent reduction was announced.

Additionally, the government plans to mandate cuts in consumption during parts of the day for major commercial and industrial customers with daily power-supply contracts of 500 kW or more. The cuts will be enforced between hours of 900 to 2000 from July 1 to September 22 for areas served by TEPCO and until September 9 for Tohoku EPCO areas, based on Clause 27 of the Electricity Utilities Industry Act. Intentional overuse will be penalized with fines at a maximum of 1 million yen (approximately 80,000 SEK). The purpose is to restrict the total power demand at a given time in an effort to prevent massive blackouts. The pressing issue is to reduce peak-demand rather than to reduce absolute demand. Though the government officially ended the implementation of rolling-black April 8 and have announced, in principle, that this measure will not be used during the summer months, it is still kept as a safety-net measure, should the effort to curb peak-demand fail.

Table 2-2 Exemptions and exceptions for 15 percent reduction

1)Exempted (no reduction target)	Medical institutions handling emergency patients	
	Emergency shelters established based on Disaster Relief Act	
	Restricted areas surrounding Fukushima-I Nuclear Power Plant	
Exceptions		Target*
2) Essential for safety of human lives	Medical facilities	0%
	Pharmaceutical and medical equipment related facilities	0%
	Elderly and handicapped care facilities	0%
	Waste water plant facilities operated by local governments	5%
3)Essential for stable economic and social activities	Data centre and information processing system of financial institutions etc.	0-10%
	Factories with clean room and electrolysis facilities	0-10%
	Railways (between hours 1200 and 1500)	15%
	(other times)	0%
	Air traffic facilities and terminals	5%
	Food wholesaler with refrigeration equipment	5%
4)Essential rebuilding of disaster stricken areas	Local government buildings and police stations	0%

**Remark: Target of 0% means not to exceed the amount electricity used in the previous year*

Source: Created by the author based on Nikkei 2011

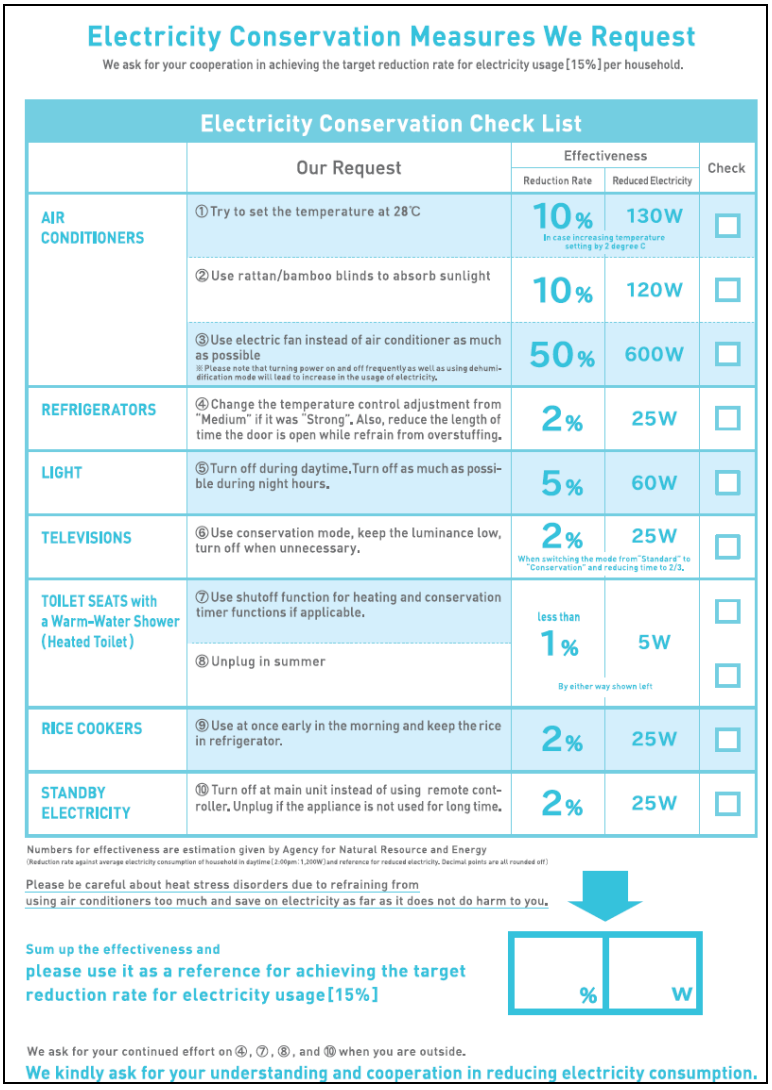
2.2.3 Societal response

The sentiment is that introduction and dissemination of new technology/system alone will not be enough as such, nor would it be possible to introduce these fast enough, to reduce peak demand. Thus, the importance of operation of existing facilities and behaviour changes are stressed both by the government and the utility companies. In the industrial sector, Nippon Keidanren, the confederation of industries, industrial associations and regional economic organizations, has established a voluntary action plan to reduce demand which has been agreed upon by over 600 of their members. The voluntary actions include, shifting working days and hours, relocation to outside of TEPCO and Tohoku EPCO areas, use of stored electricity for peak hours. For example, Japan Automobile Manufacturers Association announced that its member companies will shift their weekends, closing factories on Thursdays and Fridays and instead operating on Saturdays and Sundays.

In the public sector, for example, Tokyo Metropolitan government has announced to aim for 25 percent reduction in its usage by shifting working hours 30 to 60 minutes earlier along with other energy conservation efforts.

Unlike businesses and public entities, households cannot simply be ordered by the government to cut electricity usage. The government has however established a program to encourage households to conserve energy voluntarily. To participate in the program, households are asked to establish reduction targets and follow measures that will be suggested on a new, not yet opened, energy conservation portal administered by METI. The target is evaluated using electricity consumption data from the previous year and a prize will be awarded for achieve the goal. Also METI, TEPCO, as well as individual home appliance manufactures are giving suggestions to residential and industrial users to save on electricity use –“setsuden” in Japanese. Households have reacted with stoicism and a sincere effort to save electricity have ensued.

Figure 2.7 Check-list, here in Englis, for residential user conservation of electricity from TEPCO. The corresponding information is (of course) also available in Japanese on the company web-site.



Electricity Conservation Measures We Request

We ask for your cooperation in achieving the target reduction rate for electricity usage [15%] per household.

Electricity Conservation Check List

	Our Request	Effectiveness: Reduction Rate	Effectiveness: Reduced Electricity	Check
AIR CONDITIONERS	①Try to set the temperature at 28℃	10% (In case increasing temperature setting by 2 degree C)	130W	☐
	②Use rattan/bamboo blinds to absorb sunlight	10%	120W	☐
	③Use electric fan instead of air conditioner as much as possible ※Please note that turning power on and off frequently as well as using dehumidification mode will lead to increase in the usage of electricity.	50%	600W	☐
REFRIGERATORS	④Change the temperature control adjustment from "Medium" if it was "Strong". Also, reduce the length of time the door is open while refrain from overstuffing.	2%	25W	☐
LIGHT	⑤Turn off during daytime. Turn off as much as possible during night hours.	5%	60W	☐
TELEVISIONS	⑥Use conservation mode, keep the luminance low, turn off when unnecessary.	2% (When switching the mode from "Standard" to "Conservation" and reducing time to 2/3.)	25W	☐
TOILET SEATS with a Warm-Water Shower (Heated Toilet)	⑦Use shutoff function for heating and conservation timer functions if applicable.	less than 1% (By either way shown left)	5W	☐
	⑧Unplug in summer			☐
RICE COOKERS	⑨Use at once early in the morning and keep the rice in refrigerator.	2%	25W	☐
STANDBY ELECTRICITY	⑩Turn off at main unit instead of using remote controller. Unplug if the appliance is not used for long time.	2%	25W	☐

Numbers for effectiveness are estimation given by Agency for Natural Resource and Energy
(Reduction rate against average electricity consumption of household in daytime (2:00pm: 1,200W) and reference for reduced electricity. Decimal points are all rounded off)

Please be careful about heat stress disorders due to refraining from using air conditioners too much and save on electricity as far as it does not do harm to you.

Sum up the effectiveness and
please use it as a reference for achieving the target reduction rate for electricity usage [15%]

% W

We ask for your continued effort on ④, ⑦, ⑧, and ⑩ when you are outside.
We kindly ask for your understanding and cooperation in reducing electricity consumption.

Source: Website of TEPCO, (TEPCO 2011d) plus TEPCO pamphlet sent to households

3 Long term consequences and prospects

Even after the summer months, the efforts to increase supply capacity needs to be continued. The following supply-side measures are also mentioned in the 13 May report of the Electricity Supply-Demand Emergency Response Headquarters (then):

- Restoration and launch of thermal power stations (including joint stations and IPP)
- Construction and addition of thermal power stations
- Installation of emergency power supply equipment (such as gas turbines)
- Increase of interconnection lines between different areas (i.e. between western and eastern Japan with 60 Hz and 50 Hz frequency, respectively)
- Promoting the introduction of renewable energies (photovoltaic, wind power, geothermal energy etc.)
- Promoting the introduction of decentralized generation plants

(Electricity Supply-Demand Emergency Response Headquarters 2011)

Since a substantial amount of additional electricity supply will be generated from thermal power plants, the additional cost for the procurement of energy sources (such as natural gas) is projected to be approximately 100 billion yen (approximately 8 billion SEK) per nuclear power plant stopped per year (Ogimoto 2011). Additionally, carbon dioxide emission will increase due to enhanced use of thermal power generation. In the mid to long term perspective on the demand side, reduction of total demand, rather than curving peak-demand, and accelerating introduction and dissemination of technologies to increase energy efficiency is essential.

In the beginning of May, the Japanese Prime Minister Naoto Kan called to halt operations of Chubu Electric's Hamaoka Nuclear Plant in central Japan, intact from the disaster in March, until it can be better defended against a major tsunami. In response to this non-legally biding request, Chubu electric reluctantly agreed to do so on May 9, and halted operations of reactor unit 4 and 5 and agreed not to restart unit 3 which was off-line for regular inspection. Unit 1 and 2 were permanently shut down in 2009. The Hamaoka NP has been controversial for a long time, as it was discovered to be situated on a major fault line, and the probability of a magnitude-6.0-earthquake near Hamaoka NP is 84 percent within 30 years The probability of other nuclear plants being hit by a similar earthquake is believed to be much less, most of them below ten percent and the Prime Minister stressed that the request to halt operation would not be extended to other facilities. However, his action may affect the restart of plants after under-going regular inspection. Nuclear Safety Law allows nuclear reactors to operate only for 13 months before commencing scheduled safety inspections. At the time of press, 35 reactors are either stopped or taken out of operation for safety inspections. By spring 2012, all of the 54 commercial nuclear power plants will be either halted by the disaster on March 11 or be off he grid due to regular maintenance. The Prime Minister’s action to halt the Hamaoka nuclear power plant may spur prefectural governors, who approve the operations of nuclear power plants, hesitation to give approval for resuming operations of reactors coming off from maintenance, which may lead to further deficiency in electricity supply all over Japan. Already Kansai Electric Power Company, located in the western part of Japan has indicated their nuclear reactors currently off the grid may not be put on line soon, and they are requesting a 15 percent power saving goal..

The electric utility companies have been enjoying the comfort of a regional monopoly under the current Japanese electricity system, and in return they are responsible to ensure a stable electricity supply. Though receiving criticism from the private sector stating the discussion is much too early, METI and the Industrial Competitiveness Committee under the Industrial Structure Council of METI, has initiated the process towards reform of electricity supply structure, including deregulation of the market and separation of electrical power production from power distribution and transmission.

3.1 Policy and other implications

The series of incidences surrounding electricity supplies are already influencing existing policies and spurring discussions calling for a change of stance in some issues in Japan.

- From an early stage, the Basic Plan for Energy announced in June 2010 stating a target that nuclear power should make up 50 percent of the electricity supply, was declared to be re-evaluated. Prime Minister Kan has reiterated the government intention on 11 May, stating the Basic Plan for Energy is to be drafted from scratch focusing more on renewable energies and establishment of energy conserving society, though also stating to continue the use of nuclear power. (PressconfKAN2011).
- The reviewing process of the nuclear strategy, which was in the process, was officially stopped on 5 April.
- The discussion to review the New Growth Strategy Blueprint for Revitalizing Japan, established in June 2010 is to start by the end of May and to finalize suggestions by the end of the year.

As noted in the report from the Electricity Supply-Demand Emergency Response Headquarters, the promotion of renewable energies is to be fortified and has already a substantial momentum. However, this emergency situation the country currently faces calls for immediate increase of great amount of supply, and concrete plans to immediately accelerate renewable energy introduction is absent at the time of press, though the emphasis is expected to be placed on solar, wind, geothermal power generations.

4 Final thoughts: A brighter Japan to follow?

Japan is facing an electricity supply shortage of an unprecedented magnitude in a developed country in recent history. Though differing in natural environment (weather, seismic conditions etc.), supply capacity loss due to halt of nuclear, thermal or other power plants for any reason is a possibility also for Sweden. How Japan has and will handle the situation, e.g. how is the capacity loss compensated for, what policy tools are used and to what extent society voluntarily can conserve energy, these questions and others can provide valuable learning experiences.

Stated in plain words, in the author's opinion, the initial stage in the implementation of the rolling black-outs was a complete mess. Initial information, such as when, where and for how long, coming from both TEPCO and the government varied and caused much confusion. Also the decision to actually implement black-outs was not announced until very late the night before, and on some days, even on the day of, receiving much criticism. Additionally, inconsistency, such as customers in the same designated area experiencing inconsistency in implementation and no implementation, received objections from industries as it made it difficult for them to plan their operation in advance. Though the plans were available in advance, the actual implementation of the plan came through in a far from orderly manner. From this experience, the information flow and tools for announcement should be improved in Japan. Hence in this respect, there are also lessons to be learned for outside observers both in terms of how to do and how not to do in terms of introducing power shortage measures.

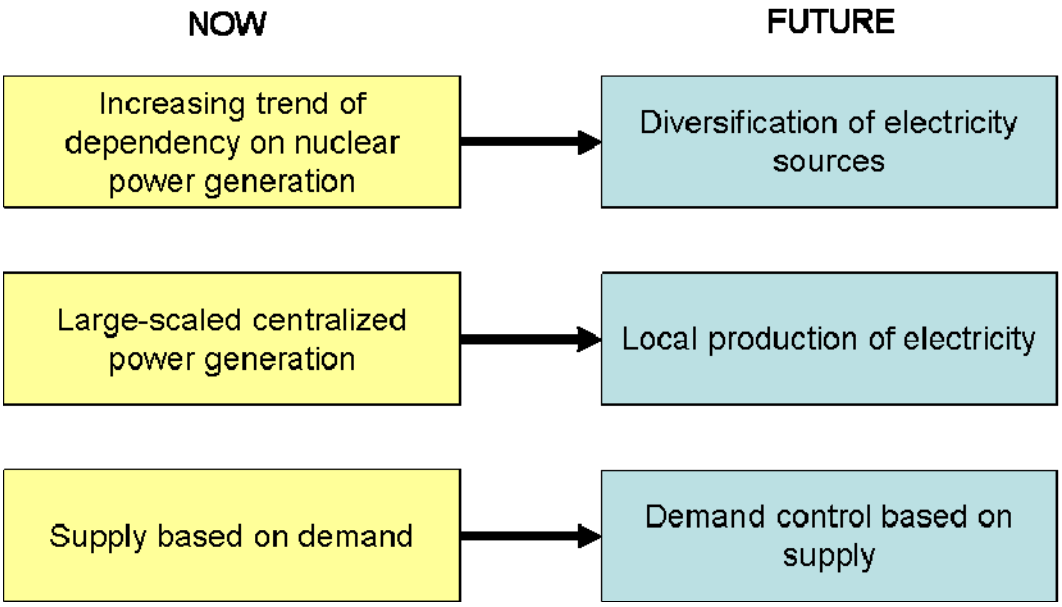
The inconvenience of having two, in practice, non-connected electricity grid systems has become painfully evident during the aftermath of the earthquake. Though it is not likely that the frequencies of eastern and western parts of the country are to be matched in the near future, emphasizing stability and security in the electricity grid system is an extremely urgent issue. Stability is important, in the short term, to accommodate to the electricity input from in-house power generators owned by private companies which TEPCO and Tohoku EPCO are depending on as part of the additional power source. Also, in the long-run, increased input from renewable sources, such as solar and wind power generations will require an updated electricity grid capable of handling a variable power supply. In addition to the grid, the vulnerability of natural gas supply network became evident from the disaster. Grid system to supply energy sources, not limited to electricity, as a whole, should be discussed and it would seem a necessity in the long term to modernize the grid system.

It is clear Japan is facing a turning-point in its history of electricity use. It is not solely the immediate effect of power plant shut-downs, but rather the uncertainty about the future of stable electricity supply on the whole that is the cause of concern. The decreased reliance on nuclear power is one major factor in this, but not the only one. A paradigm shift is needed.

The transformation of the electricity system will require large investments and may result in higher electricity prices. To limit negative impacts on quality of life and competitiveness of domestic industries in the long run, Japan must to resort to generating new knowledge, technology and innovation in energy conservation, creation and storage. This situation presents an opportunity for the future for Japan, given that the country possess most if not all of the relevant technologies needed. This may also in the long term lead to competitive

advantages in terms of the technologies being deployed also elsewhere. An equally, if not more, important opportunity, would be if the now by necessity imposed constraints on electricity use can lead to a life and working style using less energy and accelerate innovation in relevant technologies and systems, such as smart grids. Here lessons from Japan could become valuable lessons for the world.

Figure 4-1 Possible features of an electricity paradigm shift in Japan



Source: Created by the author based on Nikkei BP 2011

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