Electricity Crisis and Behavior Change in the Residential Sector: Tokyo Before and After the Great East Japan Earthquake

Chiharu Murakoshi, Hidetoshi Nakagami and Sho Hirayama
Jyukankyo Research Institute Inc.

ABSTRACT

The March 11 earthquake and nuclear accident brought a major electricity shortage to Japan, especially the Tokyo area. Just after the quake, damaged power plants led to rolling blackouts. The specter of summer blackouts due to tight electricity supply loomed. The government ordered large facilities served by Tokyo Electric Power Company (TEPCO) and Tohoku Electric Power Company (Tohoku EPCO), to reduce peak weekday electricity consumption 15% from the previous year, and undertook a large scale campaign urging people to save power. Due to recovery of power plants and to conservation, summer rolling blackouts were avoided. However, there is no target date for nuclear power plant recovery. The electricity shortage is likely to persist.

We investigated household electricity consumption and conservation in TEPCO's service area in winter and summer of 2011. We found consumption decreased 8.6% in winter and summer, from 2010. We discuss actions taken and whether behavior changes occurred. By studying how people coped when first facing an electricity crisis, and analyzing public acceptance of measures, we can gain insight into behavior change. We also discuss the government and utility campaign for power saving through behavior change, and actions by businesses and merchants. The campaign urged 15% energy savings per household. TEPCO implemented "electricity forecast tool and alarm for individual use." Commercial buildings saved on lighting and air conditioning, and "Coolbiz" informal business dress diffused widely.

The electricity crisis persists but people may not continue their energy saving behaviors. We discuss policies to promote behavior change into the future.

Damage from the Disaster

The earthquake and tsunami that struck eastern Japan on March 11, 2011 caused power outages in wide regions of Tohoku and Kanto. Within the service areas of Tokyo Electric Power Company (TEPCO) and Tohoku Electric Power Company (Tohoku EPCO), 4.05 million and 4.40 million households respectively, lost power (METI 2011a). The two utility companies lost many power plants and there was fear of large scale power outages. Therefore, from March 14 to 28 TEPCO implemented planned outages, as a temporary measure to repair damaged power plants. Japan's peak electricity use normally occurs in summer. To prepare for the increased summer demand, on May 13 the government announced a target of a 15% reduction in summer peak electricity demand in the TEPCO and Tohoku EPCO service areas. The National Power-Saving Edict (METI 2011b), as it was known, was in effect from July 1 through the first half of September.

The structure of Japan's power generation in 2009 was liquefied natural gas (LNG) and nuclear both making up 29%, with coal-fired generation at 25%, hydroelectric at 9% and oil-fired generation at 8%. Of these, many nuclear and fossil fuel-fired power plants were idled due to the disaster. Major issues extending to nuclear plants persist after the disaster.

Before the disaster, generation capacities (certified generator power output) were 64,988 MW for TEPCO and 16,337 MW for Tohoku EPCO. Immediately after the disaster, capacity fell dramatically. TEPCO lost 14,896 MW and Tohoku EPCO lost 7,495 MW, corresponding to 22% and 45% of the normal total, and an additional 2,850 MW generating capacity was lost elsewhere. After the disaster, gas and coal-fired plants recovered and increased output, adding 2,201 MW of capacity, but nuclear power still has many unresolved issues.

Japan has 54 nuclear reactors for electricity generation, with a capacity of 48,960 MW. Each reactor is shut down every 13 months for regular inspection. Before the disaster there were 37 units operating, with a maximum output of 34,530 MW. Immediately after the disaster, 10 units (8,877 MW) shut down and one unit entered its scheduled inspection, so the total nuclear generating capacity fell to 24,447 MW. Since then, nearly all reactors have reached their scheduled inspection periods. Because there has been no publicly acceptable way to restart these reactors after inspection and maintenance is done, they remain off line. In February 2012, nuclear generating capacity had fallen to 3,138 MW. All nuclear reactors were shut down as of May 4, 2012 (JNTI 2012).

There have been many arguments about the necessity of nuclear power since the nuclear plant accidents caused by the tsunami: Japan should abandon nuclear power, continue operating nuclear plants, strengthen adoption of renewable energy, and exploit energy efficiency more thoroughly. The government has announced its intention to decommission reactors that caused accidents, to quickly restart all reactors shut down for scheduled inspection once their safety has been assured, and to limit the maximum operating time of a nuclear reactor to 40 years.

Government Electricity Conservation Measures

Because of the damage to nuclear power plants by the disaster, many pressing issues are in urgent need of government response. These include response to the nuclear accident, investigation of guarantees by TEPCO to victims, TEPCO's financial situation and support measures, securing power generation capacity, and thorough pursuit of electricity conservation and efficiency. Due to the uncertain future operation of nuclear power in Japan, the government must also reconsider its targets for CO_2 reductions. Wide ranging investigation of not only the electric power supply system, but also the whole energy supply and demand system are in progress. In this paper we focus on explaining electricity conservation measures.

Planned Power Outages

Just after the disaster, TEPCO divided its service area into five groups and implemented 3-hour rolling blackouts daily from March 14 to 28. Blackouts were carried out in some areas but not in others, and there was confusion about area boundaries. Dry cell batteries and flashlights flew off of store shelves. Because of both disruption in supply chains due to the disaster, and radioactive contamination due to the nuclear accident, bottled water sold out quickly and there

were food shortages, including vegetables, meat and dairy products. All these events co-occurring caused great worry. The impact of electricity conservation at home was explained at a later stage in the disaster response, but having gone through these experiences is thought to have influenced people. Furthermore, many people in the Tokyo area have friends and relatives in the heavily affected Tohoku areas, and the continued broadcast for days of the unimaginable images of tsunami damage helped many people understand the circumstances.

The National Power-Saving Edict

The government announced that it was seeking a uniform 15% cut in peak power consumption for the TEPCO and Tohoku EPCO service areas. Furthermore, for large customers contracted for 500kW or more, it issued the legally binding National Power-Saving Edict, calling for a 15% peak power cut from July 1. At the same time, although it was not mandatory, the government also requested cooperation in the service area of Kansai Electric Power Company (KEPCO) to reach a 10% cut. KEPCO had no earthquake damage, but was included because it relies on nuclear power to a high degree. In mid July of 2010, during its summer peak, three of its reactors were shut down for regular inspection and other reasons. On July 1, 2010, its nuclear generating capacity was 6,596 MW, but by the end of that month it fell by nearly half, to 3,371 MW (JNTI 2012). There were also forecasts of drops in power supply in other utility companies' service areas because they too had nuclear power plants shut down, as well as troubles at thermal power plants. The call to conserve electricity spread widely throughout Japan. In response, besides implementing energy efficiency measures, industries shifted factory operation times from weekdays to night, early morning, and vacation days. Public facilities implemented a wide range of measures, such as cuts in lighting, elevators and escalators run on intermittent schedules.

The Call for Electricity Conservation

In order to cut summer peak demand, the government called for various demand-side measures to be taken (Table 1). Business facilities were requested to develop and carry out electricity conservation plans. Electric utility companies were instructed to post the daily electricity forecast on their homepages, indicating their reserve capacity ratio. For households, there was a public information campaign using websites and other media. The homepage of the Ministry of Economy, Trade and Industry (METI) introduced representative electricity conservation measures, announced conservation targets, and carried out a program to distribute coupons to those who reached the targets, in which 150,000 people participated.

Changes in Electricity Consumption

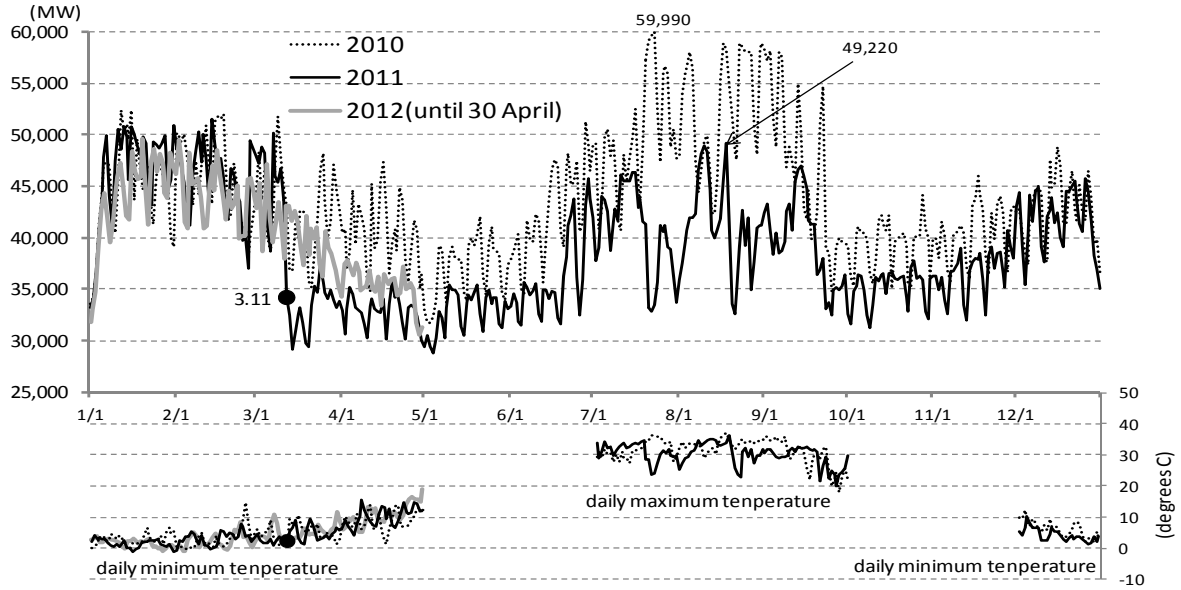
Daily Peak Power

TEPCO's 2010 peak power demand was recorded at 59,990 MW in July. The summer of 2010 was extremely hot, so peak power demand exceeded the 2009 value of 54,500 MW, and was second only to the peak demand of 2008 of 60,890 MW. In contrast, the 2011 value of 49,220 MW dropped 18% from 2010 (Fig. 1).

Table 1. Government Call for Electricity Conservation

Target	Items carried out	Notes
Large customers (contract ≥500kW)	Requested voluntary preparation and implementation of plans to curb peak power use	e.g., adjusting or shifting operation, business hours
Small customers (contract < 500kW)	Offered a menu of examples of measures	e.g., lighting, air conditioning, office equipment measures
	Encouraged preparation and publication of voluntary action plans to reach targets	~ 100,000 businesses did so in Tokyo, Tohoku, and Kansai
	Held seminars and visits to individual supporters of electricity conservation	~150,000 site visits made and ~10,000 seminars given in Tokyo and Tohoku
Households	Offered a menu of examples household electricity saving measures	
	Used various media to call for conservation	Newspaper ads (4 times), TV commercials (4 periods) in Tokyo and Tohoku
	Distributed materials to elementary and junior high schools for electricity conservation education	Distributed to ~ 4,300 schools in Tokyo and Tohoku
	Offered a participatory program to support conservation, "Household Electricity Savings Proclamation"	~150,000 participants in Tokyo and Tohoku
General applicability	Media campaign for electricity savings	e.g., newspapers, TV, internet, etc.
	Made electric power supply and demand data visible consistently (electricity forecast)	Eight utility companies did: Tokyo, Tohoku, Chubu, Kansai, Hokuriku, Chugoku, Shikoku
	Informed the public of impending tight electricity supply (electricity supply-demand warning)	Warning system implemented in Tokyo and Tohoku, and prepared but not used in central and western Japan

Figure 1. Change in TEPCO Daily Peak Power and Temperature



Until the disaster, 2011 peak power was expected to be similar to 2010, but after March 11, demand decreased greatly, due to outages caused by power supply shortages, and electricity conservation activities. This trend was clearly visible until November, but in December, peak power demand approached 2010 levels. In 2012, there has not been a large difference from the year before. The winter peak occurs in January, so there had been concern over winter electricity supply shortages, but from December on, daily peak power demand was the same as normal. This can be attributed to public awareness that supply shortages had temporarily been avoided. Shut down of TEPCO's and Tohoku EPCO's nuclear plants finally reached a stable point on August 6, and the National Power-Saving Edict was lifted in September. We can see strong concern returning over power shortages in the summer of 2012, but electricity conservation consciousness has decreased during the winter. A follow-up study is needed to see how much and in what areas this consciousness has decreased. However, from fall 2011, shutdowns of nuclear plants for regular inspection continued, and after inspection and maintenance these plants have not been restarted. As of May 4, 2012, all nuclear plants were shut down.

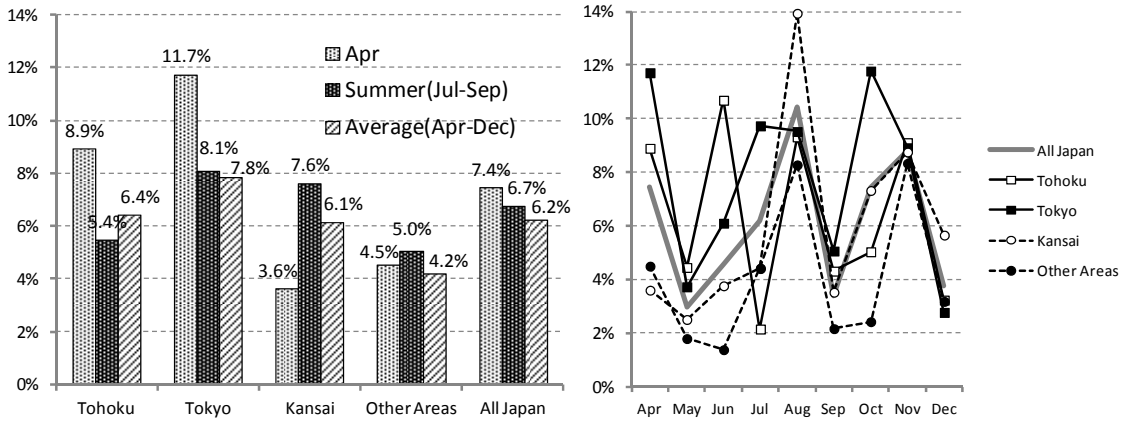
Conservation Ratio of Household Electricity Consumption

An electricity conservation ratio (ECR) was calculated using utility company data or utility bills for household electricity supply or consumption, normalized for temperature, and compared with the previous year's consumption. ECR compares total electricity consumed over one period with that for a base period, adjusted for heating and cooling degree days. Just after the disaster, the ECR for April 2011 was 7.4% for Japan, with 11.7% and 8.9% in TEPCO's and Tohoku EPCO's service areas, and roughly a 4.5% ECR in other regions (Fig. 2). In Kanto and Tohoku, people directly experienced earthquake and tsunami damage, power outages, as well as food and other shortages, so their awareness of electricity conservation rose at once. Besides government measures, media ran continuous coverage of the nuclear plant accidents and conditions in the disaster areas, so residents of Kanto and Tohoku understood that the damage was close to home. Also, there were obvious signs of the call to save electricity evident in daily life. For example, lighting was dimmed or off in places like train stations, public building lobbies, hallways, workplaces, stores and amusement centers. These conditions are thought to have influenced household electricity conservation. However, it is interesting that for other regions not directly damaged by the disaster, a 4.5% energy savings was still achieved.

During summer (July through September) the ECR was 6.7% for Japan as a whole, 8.1% for TEPCO, 7.6% for KEPCO, 5.4% for Tohoku EPCO, with 5.0% ECR in other regions. In comparison to the ECR shortly after the disaster, ratios in the TEPCO and Tohoku areas decreased somewhat. Tohoku EPCO serves a cool region so cooling demand was already low, and even for TEPCO cooling electricity usage is only about one third of that for heating, so there was less room for summer energy saving, compared to winter. In contrast, for KEPCO the summer ECR increased. Kansai was not in the disaster zone, so there was little direct impact shortly after the quake. But in July, the maximum generating capacity of KEPCO's nuclear plants fell by half. Concern about electricity supply led to heightened awareness of conservation.

Nine months after the disaster, the average ECR for all of Japan was 6.2%, smaller than the winter ECR, but persisting. In spring and fall there is almost no demand for heating or cooling so there is little room for savings from these end uses expected in June at Tohoku EPCO.

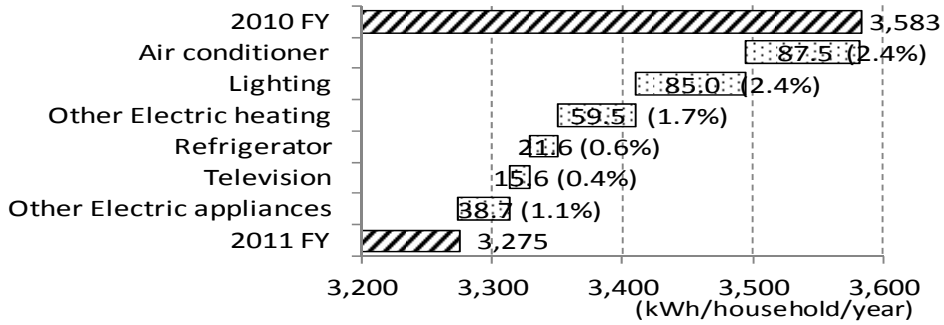
Figure 2. Post Disaster Household ECR, Normalized for Temperature (Estimated from Supplier Data)



Source: Federation of Electric Power Companies of Japan, http://www.fepc.or.jp/library/data/demand/index.html

In the latter half of this paper we show the circumstances and results of summer and winter electricity saving activities, focusing on TEPCO's service area. Based on these results, we estimated the degree to which each measure contributed to reducing electricity consumption. The ECR for each measure was determined from existing experimental data or from simulation results, and multiplied by the implementation rate to give the amount of energy saved per type of equipment. Of the total 8.9% ECR, heat pump air conditioners and lighting contributed the most, at 2.4% each. In order to estimate the amount of saved electricity in the year after the disaster, we used the time period equating to the Japanese fiscal year, April to the next March. We had not yet received the results for February and March 2012, so these were estimated from past trends and temperatures. Therefore, the ECR values differ from those shown in Figure 2 (Fig. 3).

Figure 3. Breakdown of Yearly Electricity Savings in TEPCO's Service Area



Survey of Implementation Status of Electricity Conservation

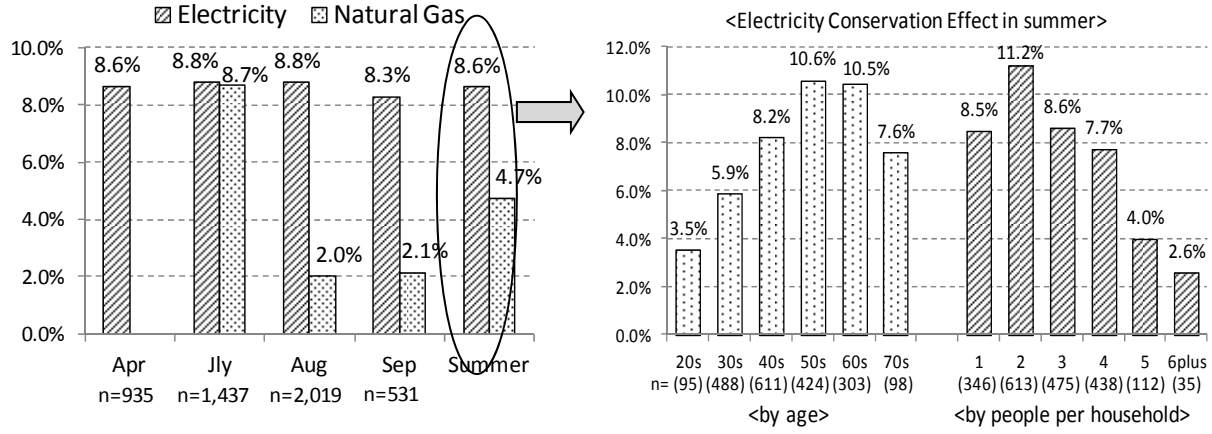
A survey about changes in household electricity consumption and implementation of conservation measures was carried out in May and September 2011, within TEPCO's service area. In the summer, consumption of natural gas was also addressed. Respondents were age 20 or older, both sexes. For the "winter" (April) and summer (July-September) periods, valid

responses were received from 1,120 and 2,060 people, respectively. Average ECR for the sample, with distributions by age of head of household and by household size are shown in Figure 4, and the distribution of ECR among households is shown in Figure 5.

Electricity usage in April, shortly after the disaster, fell 8.6% compared with the previous year (normalized for temperature), or 31 kWh/month per household. This was somewhat smaller than TEPCO's overall ECR (Fig. 2). The difference can be attributed to under representation of women and the elderly among survey respondents. Compared to TEPCO's service area, the sample had fewer elderly and single people and more males and ages 20 to 59. The government target of a 15% or larger cut in usage was reached by 30% of households, with 17% achieving cuts of 25% or more. The survey found that households that had power outages had slightly smaller reductions than those without outages. There may have been a rebound effect for those experiencing power outages, but it is likely that when sudden outages occur it is difficult for people to implement planned electricity conservation. A 12.2% decrease for households already strongly aware of electricity conservation before the disaster was much greater than the 6.6% decrease for households that were initially less aware. The more conscious of energy efficiency the person was, the higher the savings were.

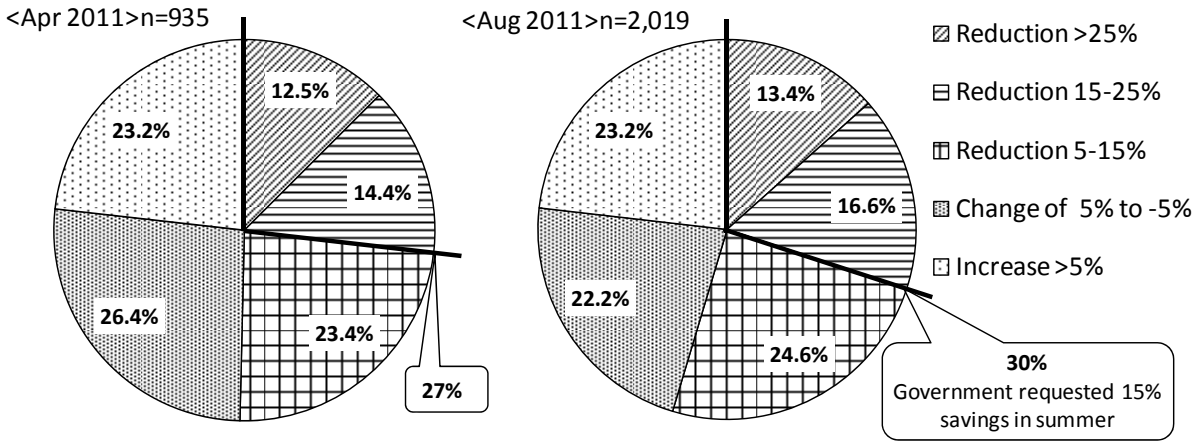
For the summer period, essentially the same decrease as for the winter period, 8.6%, or 32 kWh/month per household, was obtained. This was the same decrease observed in the overall TEPCO service area for that period (Fig. 2). Just as in the winter sample, 30% of respondents cut electricity use by 15% or more during August. The conservation ratio for natural gas averaged 4.7% during the summer period, and was particularly high in July. The supply of natural gas has not been impacted by the disaster, but there seems to be a ripple effect, due to an increase in awareness of electricity conservation in general.

Figure 4. Survey Results for ECR (Temperature Normalized)



From the variation in summer ECR by age of the head of household and also by household size (Fig. 4), we see that young people and those with large families had the lowest ECR, while families with heads in their 50s and 60s, and two-person families had the highest ECR. This may be due to occupancy times, where young people spend less time at home, so they do not have much chance to conserve energy at home, while senior citizens and large families have high occupancy, and so even if they conserve, their base load is high, leading to a relatively small percentage decrease. Also, their electricity use may be difficult to control.

Figure 5. Distribution of Household ECR, from Survey Results



In Europe and America energy conservation effects have been reported between -5.5% and 32%, depending on the kind of feedback given. On average, real-time plus feedback is 12%, real-time feedback is 9.2%, daily/weekly feedback is 8.4%, estimated feedback is 5.8%, and enhanced billing is 3.8% (Ehrhardt-Martinez, Donnelly & Laitner 2010). Compared with these numbers 8.6% is very high. Being shocked by the disaster, even if just temporarily, people's awareness of energy conservation changed, and it was possible to attain near 10% energy savings in the short term.

Change in Energy Conservation Awareness and Energy Conservation Actions

Table 2 shows the level of awareness of electricity conservation pre and post disaster. Around 20% of the sample reported being acutely aware from before the quake, while 60% were aware to some extent. After the disaster those acutely aware increased to 48% in May and 38% in September. Fewer than 20% said there had been no change in their level of interest, but only 4% in May and 0% in September reported carrying out no energy saving actions at all.

Table 2. Pre and Post Disaster Change in Interest In Saving Electricity (%)

(x/y = May results/September results)		After 3/11 (n=2,060)				
		became acutely aware	became aware	no change	no longer aware	Total
Before 3/11 (n=1,120)	had been acutely aware	18.6/13.5	1.7/1.1	3.6/5.0	NA/0.1	23.8/19.8
	had been aware	**23.6/20.6**	28.4/33.3	6.2/9.2	NA/0.0	58.1/63.2
	had not been aware of much	**4.9/3.4**	**8.8/7.8**	2.1/3.0	NA/0.0	15.8/14.2
	had not been aware	**0.5/0.4**	**0.8/0.8**	0.9/1.4	NA/0.2	2.2/2.9
	Total	47.6/37.9	39.7/43.1	12.7/18.6	NA/0.4	100.0
Change in awareness	awareness increased	**38.7/**				
	no change					
	awareness decreased	1.7/1.3				

more positively than before(57/47%)

Note: Darker cells indicate higher change of awareness.

Using cross-tabulation to look at individual change in awareness pre and post disaster, some people answered that they have about the same awareness before and after. Defining them as having had no change in awareness, 39% in May and 33% in September reported an overall increase in awareness. Meanwhile, when we overlay the idea that those with higher awareness of energy conservation will achieve higher energy savings, assume that those showing high interest both pre and post disaster will actively carry out conservation measures, and add these people to those whose interest increased post disaster, we can consider that in May 57% (18.6+38.7%) and in September 47% (13.5+33.0%) of respondents carried out energy conservation measures more positively than the year before.

Winter Period (Immediately Post Disaster) Electricity Saving Measures

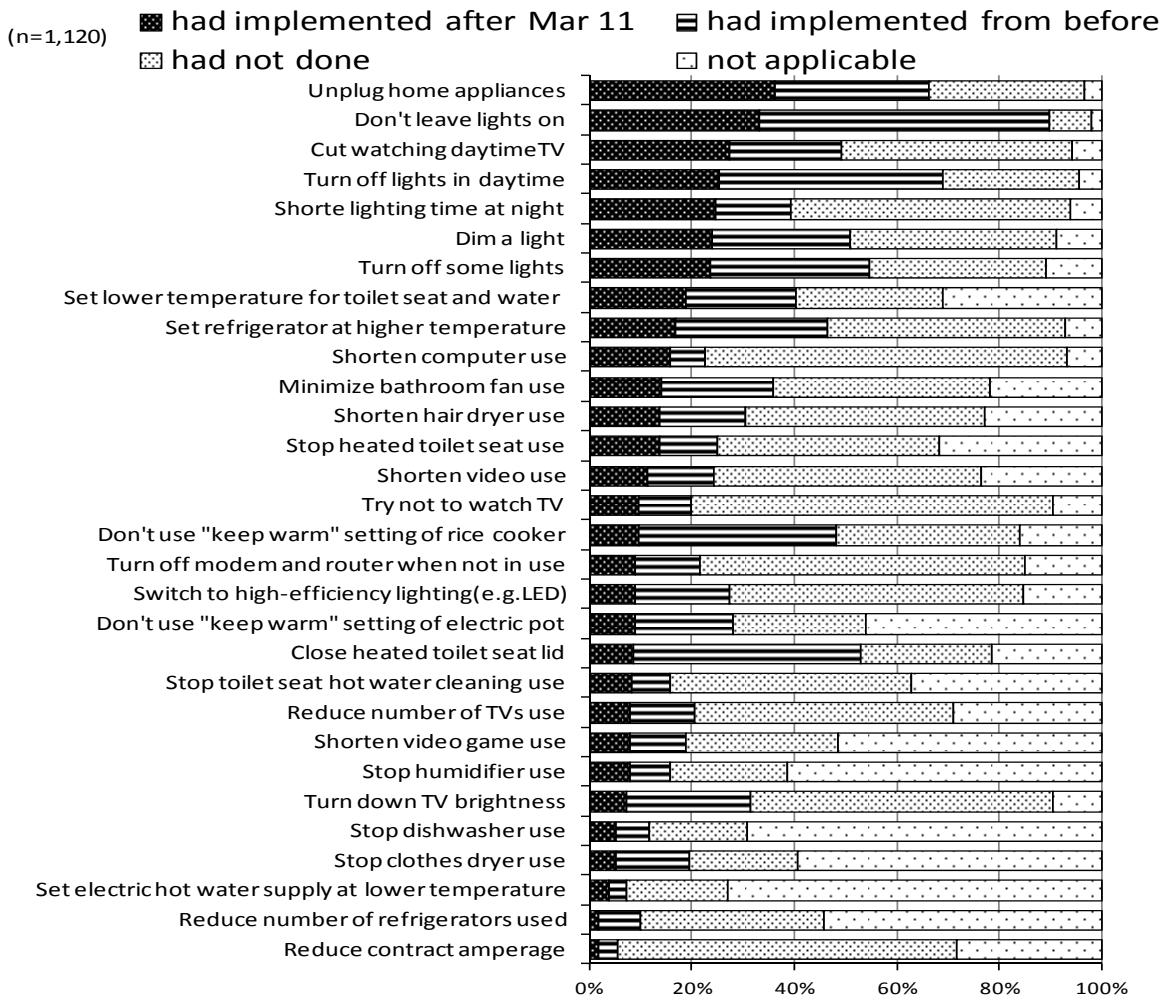
Rates of taking various actions to save energy for space heating are shown in Table 3. The most frequently taken action was to "wear extra clothing," at 41%. We can see that many people stoically refrained from heating, avoided heating during the day, set the temperature lower, refrained from heating at night, and reduced the area they heated. On the other hand, 27% made no change in heating behavior, and 10% substituted another heat source for electric heat. In Japan, central heating is not prevalent. Heating of individual rooms is done with heat pump air conditioners, floor heating, or other space heaters. Before the disaster, the households in this survey used the following mix of heating equipment: heat pump air conditioner (51%), electric heater (25%), gas heater or floor heating (19%), and kerosene heater (31%). Among these, 46% heat only with electricity, while 23% use gas or kerosene with electricity, for a total of 69% using electric heat. We can see that many people saved electricity by limiting their use of electric heat.

Table 3. Rate of Actions Taken to Conserve Heating Energy (Winter Survey) (n=1,120)

Wore extra clothing	Refrain from heating during the daytime	Set temperature lower	Refrain from heating at night	Reduce area heating	Substituted other heat source electricity	Others	No change
41.1%	34.7%	24.7%	24.1%	12.9%	10.2%	2.9%	26.6%

Rates of taking various actions to conserve electricity unrelated to space heating (from the winter survey) are shown in Figure 6. The most frequent actions taken after the disaster include unplugging equipment when it is not in use, not leaving lights on, decreasing the time the TV is on, not using lights in the daytime, shortening lighting time at night, adjusting lighting levels, and decreasing the number of lights. Each of these actions was done by over 20% of households, often reducing lighting and standby electricity consumption, together with space heating. On the whole, measures taken before the disaster tended to be taken after the disaster to a high degree. Actions not taken pre disaster but taken after it included shortening the lighting time at night, decreasing the time the TV is on, and shortening the time of computer use. Also, actions often taken pre disaster that were not often begun after included things like closing the lid on the heated toilet seat and not using the "keep warm" setting on the rice cooker.

Figure 6. Rate of Implementing Non Space Heating Measures (Winter Survey)



In addition to saving electricity, some peak shifting also occurred. Some people changed the time of day for using the following appliances: clothes washers and dryers, rice cookers, vacuum cleaners, microwave ovens, and dishwashers (Table 4).

Table 4. Appliances with Change in Time of Use (Winter Survey) (n=1,120)

Cloth washer and dryer	Rice cooker	Vacuum cleaner	Microwave oven	Dishwasher	Others
12.5%	9.3%	6.9%	4.7%	2.1%	0.3%

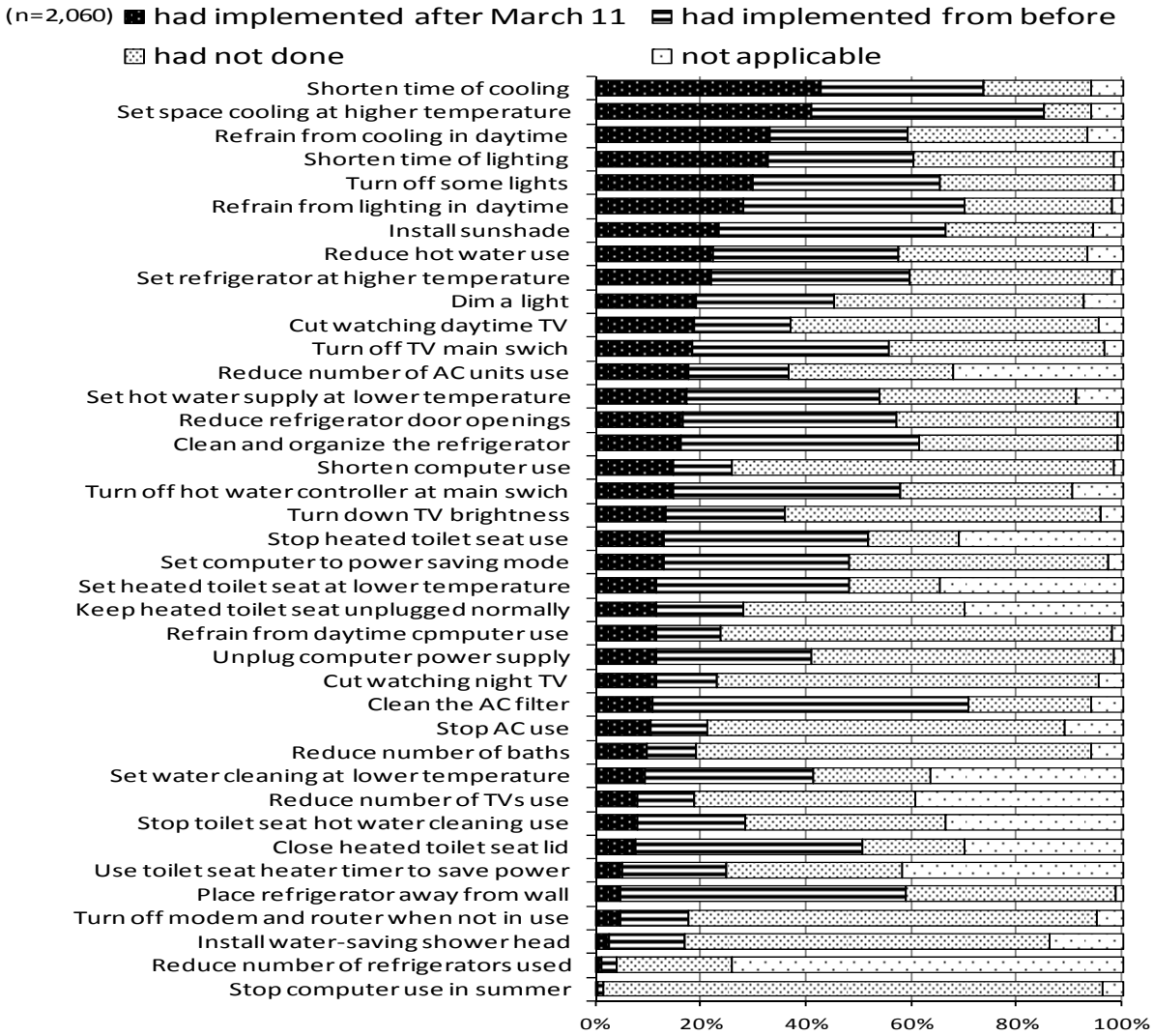
People reported that various services were useful in implementing electricity savings. The following were reported useful by high proportions of respondents: electricity forecast, 60%, email notification of tight supply, 40%, electricity consumption labels on individual equipment, 40%, alarm when the breaker is about to get tripped, 38%, email alert when people use too much electricity, 27%, and comparison of electricity usage with other households, 27%. In contrast, only 8% reported that an energy audit by a specialist was useful. Electricity forecasts began on

TEPCO and Tohoku EPCO websites just after the disaster, and have spread to nearly all electric utility companies in Japan. Other services are pending, including installation of smart meters.

Summer Electricity Saving Measures

Our summer survey asked about electricity saving actions in 39 categories (Fig. 7). Measures often begun during this period included shortening the hours of cooling at night, and setting the temperature higher, which were both done by more than 40% of respondents. Adding those who said they were already doing this before and continued to do so, 74% and 85%, nearly everyone, did these two actions. Other frequent measures were refraining from AC use during the day, shortening the hours of lighting use, and decreasing the area to be lighted, each of which exceeded 30%, showing that the top measures this time were related to cooling and lighting.

Figure 7. Rate of Implementing Electricity Conservation Actions (Summer Survey)



Measures done by more than 20% include refraining from lighting during the day, installing a sunshade, reducing hot water use, and raising the refrigerator set temperature. When added to the proportion of respondents who had also done these things before, they generally exceed 60%. Further, there were 19 measures begun this time for 10 to 20% of respondents. Many of these measures were things normally done by many people already, for example, cleaning the AC filter, opening the refrigerator less often, cleaning and organizing inside the refrigerator, turn off the main power supply when not in use (for TV, water heater), decreasing the set temperature or turning off the heated toilet seat, and decreasing the water heater set temperature. On the other hand, there were also measures that had low rates until now, below 20%, and continued to be rare. These included stopping AC use, shortening the hours of computer use, refraining from watching TV at night or in the daytime, and using fewer AC units.

In the September survey, 28 of the 39 measures were begun in this period by 10% of respondents. With these behavior changes, 8.6% of electricity use and 4.7% of gas use was conserved, but will this trend be sustained? In a survey done in England, Mabin (2009) reported that behavior changes related to conservation, once taken, persisted for at least three years, but that this varied with the ease of taking the measure. For example, measures like turning off lights had a low defection rate, while measures like turning down the heat had a high defection rate.

Persistence of Summer Electricity Saving Measures

For each of the 39 actions, the survey asked whether people planned to continue in the future. The results were, on average, that 46% said they would continue next year and beyond, 0.9% said they would continue next year but not beyond, 18% said they would not continue next year, while 33% said they didn't know or it didn't apply. In other words, 47% said they would continue their actions next year, and nearly all of them plan to continue the year after also. These results include actions taken before the September survey period. When we look only at the 16% of people who took actions only during this period, 79% answered they will continue next year.

Highly persistent actions were setting the cooling temperature higher, and shortening the hours of cooling at night, both exceeding 30%, refraining from AC use during the day, installing a sunshade, shortening hours of lighting use, decreasing the area to be lighted, refraining from lighting during the day, raising the refrigerator set temperature, cleaning and organizing the refrigerator, and opening the refrigerator less often, all exceeding 15%. All these ranked at the top of actions begun during this period. Very few people answered that they would not continue them next year. The actions people often said they would not continue were those related to computer use, such as stopping computer use during summer, refraining from computer use during the day, and turning off power to the modem and router when not in use, as well as other things that might cause hardship in daily life, such as reducing the number of units where there are several refrigerators in use, and refraining from watching TV during the day.

Conclusion

In Japan, for some time now encouraging household energy efficiency has been an important topic. However, a number of tests of measures such as feedback have just recently begun, and only a few smart meters have been installed. Against this backdrop, the March 11

Great East Japan Earthquake, in addition to damaging power generators, influenced wide-ranging aspects of daily life. People experienced many impacts: power outages right after the disaster, the government's call to conserve electricity, media coverage of nuclear accidents and grave conditions in the disaster zone, and implementation of electricity saving in public facilities, workplaces, stores, and elsewhere. These short and long term changes in society have had a large influence on energy conservation.

We investigated household electricity consumption and conservation measures in TEPCO's service area in winter and summer of 2011. The research explores three areas, 1) end user interest in energy conservation practices, 2) end user changes in application of practices pre and post event, and 3) likelihood of application of practice.

The electricity conservation ratio (ECR) for all Japan over the nine months from April to December 2011 was 6.2%. In the particularly heavily damaged TEPCO and Tohoku EPCO service areas, ECRs were 7.8% and 6.4%, while in the undamaged rest of Japan, the ECR was 4.2%. ECRs just after the disaster, for April, were particularly high, with record levels of 11.7% and 8.9% for TEPCO and Tohoku EPCO. KEPCO was not in the disaster zone, so its ECR for April stopped at 3.6%, but for the summer period, with concern over tight electricity supply due to nuclear plants being off line, an ECR of 7.6% was recorded. These levels correspond to effects observed in Europe and North America from daily or weekly feedback.

From the time of the disaster onward, awareness of electricity conservation instantly increased and households carried out various actions to save energy. Nearly everyone in the sample answered that they had taken some kind of action, especially during the summer, and measures most often taken were restraining the use of lights and cooling or heating. These measures contributed 69% of the decrease in electricity consumption.

As for the persistence of energy saving actions, 79% of people surveyed who took actions said they planned to continue those actions next year. However, trends in daily peak power from the end of 2011 into 2012 show some regression of electricity conservation ratio. The summer of 2012 will again bring concerns over tight electricity supplies, and it is not known what will become of the current conservation effects, so we plan to continue this survey research. From societal change due to the great disaster, we have seen that a nearly 10% electricity savings has been achieved by households, due to changes in consumer awareness. How this will develop in the future is a topic that merits continuing study. At the same time, in order to preserve this increased awareness, it is important to implement feedback and direct pricing, measures that lead to heightened awareness of energy conservation.

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