Nihon Keizai Shimbun
(Japan Economy Newspaper),
January 25th, 2013, morning edition
Originally written in Japanese

Can the smart grid save us from the power crisis?
Aiming for a dynamic pricing that is easy on consumers' wallets
The importance of constructing a foundation for systemic reform of the electricity market

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Publications selected:
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In March 2011, Japan was hit by an earthquake of unprecedented scale and subsequently suffered the terrible accident at the Fukushima Daiichi Nuclear Power Plant. Successively, operations were suspended at nuclear power plants across the country. Even today, the Japanese people are threatened by a serious power crisis, besides already being trapped in a long period of economic stagnation. Therefore, Japan must prepare to draw on all of its knowledge and abilities to deal with this national crisis. Hence, I believe that the establishment of a smart grid (next-generation power grid) is the key to solving Japan's current power crisis.

The smart grid is a next-generation energy system that makes use of information and communication technology (ICT) to efficiently eliminate discrepancies between the demand and supply of electricity. Moreover, ICT can contribute toward reducing the greenhouse gas emissions. Plans to introduce the system are going ahead in areas such as California, where it is hoped ICT will control demand and help solve the serious shortage of electric power that has resulted from the failure of systemic reforms. In all its homes, California has completed the installation of smart meters (next-generation electricity meters), which can measure the amount of electricity used in short time intervals. The state plans a full-fledged launch of dynamic pricing in 2014 to control the consumption of electricity during peak periods.

Japan has been similarly active in this field. In April 2010, the Ministry of Economy, Trade and Industry, and the Next-Generation Energy and Social Systems Convention initiated the "Smart Community Pilot Project" in four Japanese cities, namely Yokohama City, Toyota City in Aichi Prefecture, Keihanna Science City, and Kitakyushu City. The trial program began in earnest this year, and the initiative will continue with a vision to expand it throughout Japan by 2014. In addition to setting a range of dynamic electricity

pricing, the technology being used in the Japanese initiative surpasses that in the US field tests, in certain ways. The Japanese trial includes large-scale installation of equipment for photovoltaic power generation and for charging and discharging electric vehicle batteries.
In this article, I will introduce some of the findings from the Japanese smart grid trial program. Further, I will explore the manner by which knowledge gained from the trial would contribute to development of policies that address the power crisis and to the foundation for systemic reform of the electricity market.

Dynamic electricity pricing is a pricing mechanism that changes prices in accordance with imbalances in the demand and supply conditions for electricity, thus incentivizing consumers to use electricity more efficiently. As Japan has been slow in installing smart meters, it is currently unable to ascertain the amount of electricity being consumed in homes and commercial establishments during different time periods. Therefore, the country has been unable to fully launch a system of dynamic pricing. Japan has traditionally used a flat-rate pricing system that does not change with the season or time period. Time-of-use (TOU) pricing is only limited to some all-electric households.

Dynamic electricity pricing includes the following types: ① critical peak pricing (CPP), which raises electricity prices only when the electricity demand-supply balance is under strain; ② peak time rebates (PRT), which increases prices but pays rebates to households that save electricity; and ③ real time pricing (RTP), which synchronizes retail prices with wholesale prices. For the US, it is estimated that 10% to 15% of the cost of electricity generation per year goes toward providing the electricity consumed in the peak 1% time period. Therefore, if the demand for electricity during the peak period can be controlled, the costs of generating power can be kept down, thus helping to solve the power crisis.

However, many voices against this approach argue that because electricity is a necessity with little price elasticity, its demand cannot be reduced even if the prices increase during peak periods. Is this claim really true? Certainly, a 10% increase in the price of electricity may only bring about a 1% decline in demand, yet this is a statistically significant result. If the marginal price in the peak period increases to 5 or 10 times the off-peak price, it would be possible to reduce electricity demand by an amount sufficient to deal with the power crisis. Based on the data from more than 100 field tests carried out in the US over a period of 10 years, a five-fold price increase reduces the peak demand by 10%, and a ten-fold price increase reduces it by 20%.

In addition, critics assert that household electricity bills will rise due to the increased cost of electricity during peak periods. However, this assertion is incorrect. When the system is launched, electricity prices will rise during peak periods, but they will also fall during off-peak periods. Even if households do not try to save energy, the system has been constructed to be revenue-neutral. In practice, it has been reported that many households end up reducing their electricity expenditure under this pricing system because it encourages energy-saving practices.

Last summer in Kitakyushu City, 200 households living in apartments took part in Japan's first full-fledged field test of dynamic electricity pricing. Five prices for the peak periods were established (15 yen, 50 yen, 75 yen, 100 yen, and 150 yen per kWh). From all the test households, a few were randomly selected to be subject to the pricing during peak

periods. The Kitakyushu City field test was extremely significant not just for Japan but also internationally, because it was the first test to utilize five pricing levels. In contrast, the US tests used only one or two peak prices.

The graph at the end of this article shows the results of the research on the reductions in demand for electricity achieved during peak periods in Kitakyushu City, jointly carried out by Koichiro Ito of Stanford University and Makoto Tanaka of the National Graduate Institute for Policy Studies. They conclude that the higher the price during the peak period, the greater the reduction in demand. Specifically, the demand decreased by 9.0% when the price of electricity during the peak period was set at 50 yen, by 9.6% at 75 yen, by 12.6% at 100 yen, and by 13.1% at 150 yen.

The test households in Kitakyushu City were already subscribed to a time-variant pricing system and it must be concluded that their power saving effects were significant. A reduction in demand of 9.1% was achieved in time-variant pricing field tests carried out in Tokyo in 2011. In other words, if a time-variant pricing is introduced to achieve additional power saving of 9.1% in typical households that had already been using the conventional flat-rate pricing dynamic CPP system, then the demand during peak periods would decrease by a total of about 20%.

Additionally, it was found that Kitakyushu City households where the variable CPP system was introduced reduced their electricity bills by an average of 12.6%. It can therefore be said that dynamic electricity pricing was easy on the wallets of these households.

Even in Japan, where energy-efficient technology is more advanced than it is in the United States, we can expect to achieve a reduction in demand during peak periods by more than 10% through dynamic electricity pricing. Electricity prices in Japan have been trending upwards since the suspension of operations at nuclear power plants. The introduction of this sort of pricing policy could help to reduce household electricity bills.

Despite these advantages, it is impossible to calculate the psychological burden on those households that are sensitive to time-variant electricity pricing. Some households may occasionally be forced to endure discomfort caused by limiting their use of air conditioning. At this point in time, when we must rely on manually manipulating consumers' demand response by forcing them to endure hardships, it has to be emphasized that smart grid technology is still in its development stages. However, if we can continue to develop automated demand response technology that can learn the consumers' daily patterns of electricity consumption and control their use of appliances to minimize electricity expenditures, we can expect to become a power-saving society whose consumers will not be forced to endure such hardships.

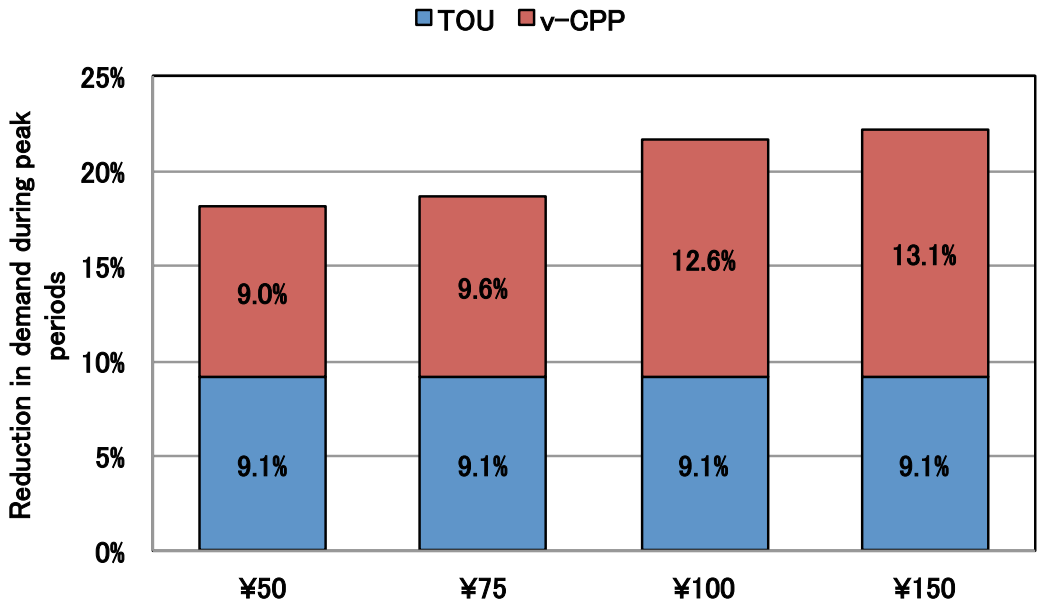
Japan leads the world in its utilization of technology by its exemplary linking of electric cars to smart homes through battery charging and discharging devices. I am optimistic not only for the rapid arrival of an age of automation, but also about the large presence of Japanese companies in this field.

Smart grids will impact the complete deregulation of retail electricity prices that is planned in Japan for 2014. The introduction of smart meters will enable detailed pricing in accordance with consumers' electricity usage and also trigger the entry of new electric power companies that target specific customers into the market. In addition, a smart grid

can absorb surplus new energy, such as weather-dependent solar energy, and may lead to an increase of systems and businesses that promote the local production and local consumption of energy.

Moreover, a smart grid encourages the efficient consumption of electricity. This would increase the management efficiency at electric power companies through reductions in imports of primary energy and of surplus power-supply equipment. Furthermore, it could be possible to utilize sensors and ICT technologies, such as cloud computing, to offer consumers a combination of energy, medical and nursing services, which would enhance the convenience offered by smart homes. Therefore, it is important for Japan to gain the management skills that can change this crisis into an opportunity. Now, it is time for the nation to utilize all of its capabilities and take on the challenge of implementing this social reform.

The reduction in demand from dynamic CPP during peak periods in Kitakyushu City



TOU values are the percentage reductions achieved in the field tests in Tokyo in 2011. The variable CPP values are the percentage reductions achieved in the field tests in Kitakyushu in 2012. Together, they show that the power saving for a typical household would be approximately 20%.