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Nikkei's Simple Economics on "Power Reforms and Daily Life"

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Publications selected:

[1] Ida, T. (2009) *Broadband Economics: Lessons from Japa*n, Routledge (Taylor & Francis Group): London.

[2] Ida, T. and R. Goto (2009) "Simultaneous Measurement of Time and Risk Preferences," *International Economic Review* 50.4: 1169-1182.

1. Concerns regarding the existing power system

The Great East Japan Earthquake of March 11, 2011 rendered over 20 million kilowatts of power unavailable from TEPCO plants.

According to our research conducted with Professor Makoto Tanaka of the National Graduate Institute for Policy Studies, more than 90% of households in areas to which TEPCO provides power said that their awareness regarding energy saving had increased after the earthquake and that they were cooperating voluntarily to save energy (e.g., by setting the thermostat on their air conditioners 1.5 degrees higher on average). Our trial calculations showed that their efforts saved 1 million kW (i.e., 2% of total demand).

The accident at the Fukushima Nuclear Power Plant No.1 has reduced confidence in nuclear power in Japan, which is a key power source. In addition, rising fuel costs caused by the suspension of operations at the nuclear power plants increased household electricity prices in these areas by 30%. Furthermore, this power crisis has created substantial disagreement among Japanese people. On one hand, 70% of households insist that Japan should abandon nuclear power in the future. On the other hand, 60% do not agree to an increase in power prices that would result from the increased fuel costs

at thermal power plants. In other words, there is a contradiction between accepting nuclear power and agreeing to the price increase that would result from its alternatives. In psychology, this type of internal conflict is called “cognitive dissonance.” When forced to choose from among difficult options, consumers tend to be more inflexible to change once they have made their initial choice because of actions arising from the principle of self-justification.

Traditionally, although Japan’s power industry has long provided the world’s most stable power through its regional monopoly and price regulation, concerns have been expressed about its existing power system since the earthquake. The Japanese government recently announced a basic policy to overcome this power crisis by allowing consumers to freely choose their power supply and by introducing the liberalization of the power industry without territorial restrictions. In this series, I examine the economics viewpoint of how these power system reforms may affect the lives of people in Japan.

2. Insufficient liberalization

Here, we review why electricity is not bought and sold as an ordinary good. Because power cannot be stored, it must be generated simultaneously and at the same rate as it is consumed. Thus, power companies must plan the construction of power plants in anticipation of long-term future (i.e., many decades) demand.

In order to transmit power, a power grid is required, the construction of which incurs huge fixed costs. If one company supplies power monopolistically over a region, the cost should be lower than under a non-monopolistic situation. This is called a natural monopoly. Based on this theory, the government has allowed certain power companies to enjoy regional monopolies in return for regulating the electricity prices they charge.

Subsequently, there has been technological innovation in small generators such as gas turbines. As the need for regional monopolies has been fading in the power generation sector, four power reforms have been conducted since 1995. First, the principle of competition was introduced in the power generation sector, and retail sales were liberalized for large target customers. In order to build a foundation for fair competition between old and new power companies, the wheeling system was created, where companies can pay predetermined fees to use another company's grid. Furthermore, measures were taken to ensure the transparency and neutrality of management, such as separation of accounting of the power transmission and distribution divisions.

Japanese power reforms were less radical compared to countries like the United Kingdom who took strong action to liberalize power retail sales nationwide. However, power prices dropped by almost 20% despite an upward trend in fuel costs. On the other hand, newer power companies won only small shares of the liberalized market. In addition, there was little cross-border competition in areas where existing power companies traditionally dominated. This is because the capacity of the grid that connects the power companies is insufficient, and nationwide supply and demand has not been sufficiently adjusted.

After the Great East Japan Earthquake, the Japanese government decided to force full-scale power reforms. Targets include establishing an agency by 2015 to operate the power system over a large area to strengthen the ability to adjust nationwide supply and demand; fully liberalizing the retail sectors by 2016; further neutralizing the power transmission and distribution divisions around 2018 to 2020 by making them legally separated entities; and eventually abolishing price regulations.

3. Advantages and disadvantages of liberalization

In 2016, all power consumers (including households) will be given the freedom to choose the power company they purchase power from. Currently, retail customers have agreements with monopolistic power companies in their respective regions and select power prices from their company's pricing options. Today, many residences, particularly all-electric ones, have access to a dual-power pricing system, where higher rates are charged in the daytime and cheaper rates are charged at night. However, the vast majority of households are still charged according to a single fixed price regardless of when they consume power.

Thus, what changes will occur after liberalization is complete and households can choose which power company to purchase power from? In addition to contracts with existing power companies that previously operated in other regions, entrants from other industries are also expected to offer power. Softbank has announced that it intends to enter the retail electricity market. The company has approximately 50 million telephone customers, and it can take advantage of its customer base by offering attractive discounts for combined telephone and power service packages.

In order to attract customers from existing power companies, new power companies will create price menus tailored to customers' consumption attributes and supply–demand characteristics. This is called "cream skimming," because it involves taking only the highest-value customers. Existing power companies are not expected to allow their customers to transfer: They must also create new attractive price menus.

Concerns remain that some consumers will be left behind in this competition. There may be households who are not able to use electricity at the same price as their current ones, because the supply obligations of existing power companies will be abolished after liberalization. To solve this, the government's current reform plan includes the condition that supply obligations imposed on the power transmission and distribution companies will continue for a certain period after liberalization so customers can purchase power for the same prices as the current regulated ones.

Furthermore, electricity is a daily essential; thus, it must be provided equally to all for reasonable prices regardless of where they live or how low their incomes are. The universal service system, in which operators provide services to households nationwide, must be the responsibility of all power companies (old or new) as a necessary competition expense. Such costs can be recouped by increasing the wheeling service prices that allow other players to use that company's grid. Thus, there are advantages and disadvantages to liberalization.

4. Demand adjustment through variable power prices

There are approximately 9,000 hours per year, 1% of which are critical peak hours, the period of highest power consumption (i.e., 15 mid-summer days during the daytime). This peak period is estimated to constitute 10 to 15% of the entire annual cost of power generation. Because this generation cost constitutes 60 to 70% of the entire operations costs of a power company, if peak demand can be controlled, power prices can be reduced by 5 to10% from their current level.

A market attains balance between supply and demand by setting higher prices when costs are high and lower prices when costs are low. Thus, power prices must be set high during peak periods and low during non-peak periods. The method of adjusting demand through variable prices is called “the demand response.”

The effectiveness of the demand response has long been the subject of controversy. Those who insist it has no or little effect argue that because electricity is an essential good, it does not response to price changes. Therefore, power supply and demand cannot be adjusted by adjusting prices.

This is partially correct. Electricity demand does not respond sensitively to price changes. Over 100 empirical case studies have been conducted in the United States, who has experienced several massive power outages and has high expectations for the response to demand. Japan is also gradually accumulating empirical data. These case studies show that a price change of 10% induces a demand change of only 1% (i.e., the price elasticity of demand is 0.1). However, because this price elasticity is highly statistically significant, from an academic viewpoint, it signifies power demand responses to price.

In order to effectively use the demand response, the use of smart meters measuring and recording hourly power consumption must be widely adopted. Social experiments measuring their cost effectiveness have begun in the United States and in Japan.

5. The effects of peak demand control

Power suppliers are in the process of installing smart meters for customers (including households) to measure their hourly power consumption. They aim to establish a next-generation grid (i.e., a smart grid) that can absorb surplus energy generated using variable renewable energy (e.g., solar and wind power). In addition, demand response will be used to control the peak demand by changing power prices.

The pioneering adopter of this concept was California, who experienced massive power crises in the early 2000s. The state installed smart meters in target homes and conducted over 100 social experiments in which the power prices varied by hour. However, the power saving effects varied from 0 to 50%. Ultimately, many concerns were expressed regarding the results amid criticisms of improper management.

In Japan, the Ministry of Economy, Trade, and Industry has started social experiments on the demand response using smart grids in four designated regions, starting with Kita Kyushu and Keihanna Science City (a special district for structural reforms in Seika-cho, Kyoto Prefecture). In the summer of 2012, these regions issued requests to their consumers to save energy during the peak hours for power demand and changed their per-kilowatt electricity prices by 50 to 150 yen. Furthermore, when setting the variable rates, revenue neutrality was imposed: Revenues remained constant to prevent power companies from profiting from the differences between the new and old rates.

The results were extremely interesting. It was found that the demand response can reduce peak demand by up to 20%, but simply raising the power price cannot achieve such a reduction despite the level of increase. Furthermore, this method was found to be most effective during the summer holiday period when family members stay home for longer hours. The effect drops drastically after the O-Bon festival in mid-August, after which family members return to work and school.

Over 90% of the households participating in this experiment were successfully able to save energy costs through a variety of techniques, such as changing their use of appliances such as air conditioners or washing machines from peak hours to off-peak hours. Therefore, if power demand is spread more equally throughout the day and the power companies' management becomes more efficient, power prices should be cheaper. The variable-rate plan also helps improve household finances.

6. Taking the stance of users

Since April this year, the major power companies, including TEPCO, have started a full-fledged installation of smart meters to measure power consumption over time. The installation costs, which total 1 trillion yen, will be shared by consumers through higher power prices, and power data collected from the smart meters will be made available to new power companies. The installation of smart meters is the first step for a demand response approach in which peak power demand can be controlled through variable electricity rates. However, there are problems to overcome.

In one social experiment conducted in California, under an opt-in system, only 20% of customers signed up for the variable-rate plan despite a 20% savings in energy. On the other hand, when an opt-out system was implemented, 90% of customers chose to stay with the new rate plan, and 10% energy savings was achieved. The total effect is calculated by multiplying subscriptions by the energy-saving effect; thus, the opt-out system (9%) achieved a greater effect than the opt-in system did (4%).

Therefore, it is desirable to employ an opt-out variable-rate plan, and many households can save electricity costs just by subscribing to this plan. Even if they are aware of the savings, they tend to continue with their current contract because of the inconvenience and time required to change contracts (i.e., switching costs). If consumers were to spend considerable amounts on installing smart meters but continue with their flat-rate contracts, their investment would not generate returns.

Based on this sort of economic psychology, social experiments to spread the use of demand response to adjust power supply and demand by changing power prices will be implemented in Yokohama, Japan. Various techniques to lower switching costs will be tested, such as notifying the households of both their flat-rate and variable-rate bills so they can compare between the two to see which is more economical and charging the household the cheaper bill for the first year despite their current rate plan (i.e., a bill protection system).

To date, power reforms have been planned and implemented primarily according to the logic of the power companies. However, consumers' voluntary willingness to participate is critical and essential to creating a mechanism in which consumers can enjoy energy savings.

7. The role of the wholesale market

Once the power market is fully liberalized, companies and individuals will be able to choose their power provider. On the other hand, major problems may arise if the power company they choose cannot provide power when it is needed the most. Because power cannot be stored and must be consumed when it is generated, new power companies need to have strong power supply capacities to be able to meet demand.

In order to stably supply power, such a company will require its own power plant or an agreement to use another company's plant, but this is difficult. The Tokyo Metropolitan Government intended to construct a 1 million kW thermal plant after the Great East Japan Earthquake, but it was forced to abandon the plan when it realized it would cost over 100 billion yen. Some power companies sell renewable energy, but they face difficulties in supplying stably power. Therefore, if the situation remains unchanged, it is possible that no new power company will enter the market.

How would new power companies be attracted to the market? The wholesale market holds the key. If the wholesale market can be used, companies without large-scale power generating facilities can still supply power because they can procure it from the market if necessary. On the other hand, companies with private power generators in their factories can profit by selling their surplus power to the market. Thus, the market is a mechanism that can fully realize companies' potential capacities while using the world's resources without waste.

Another role of the market is to make social systems efficient through competition. If the wholesale market is active, competition in the power generation sector grows, and the most efficient (i.e., low cost and high profitability) power plants nationwide will become the market leaders. The Ministry of Economy, Trade, and Industry has provisionally calculated that this would reduce electricity costs by 170 billion yen annually.

However, the wholesale market is still small, constituting less than 1% of the total retail power market. In such a small market, supply and demand causes prices to fluctuate drastically, making it impossible for new power companies to stably supply power. Therefore, the government is also studying the possibility of nurturing the wholesale market by requiring existing power companies with extra capacity to generate more power and sell it in this market.

8. The need for grid neutrality

In order to transmit power, a grid system is required. If a private company constructs its own grid system, it will incur a huge initial investment. This can prevent new prospective players from entering the market, and competition is not generated. In economics, industries such as the power industry that require a huge initial investment are called a “decreasing cost industry”: They are regulated by the government so they cannot freely increase prices, but they are allowed to have regional monopolies.

The network facilities that are essential to the provision of services, such as transmission and distribution grids, are bottlenecks. If these bottleneck facilities are monopolized, there is no way to grow competition even when both upstream and downstream industries are liberalized.

Thus, how can these industries be liberalized to generate competition? A “two-tiered system” has been devised, where only the bottlenecks are separated and made independent. Thus, both existing companies and new entrants pay network fees under the same conditions and compete based on their generation capacity and service quality.

Power reforms to date have opened up the grid systems of existing power companies to new power companies and have separated accounting processes for transmission and distribution. However, if these are separated only within the same company, neutrality remains insufficient. For future power reforms, a legal separation in which transmission and distribution divisions are established as separate companies through holding companies is under consideration. This method has been applied to NTT in the past.

If this method is applied to the power industry, it is important to block the flow of people, goods, and capital within the same group of companies so that the group interest will not affect the neutrality of the transmission and distribution division. Furthermore, these divisions must be regulated so that new power companies are not treated unfairly. Similar to the success achieved in promoting competition in the communication industry, filling in gaps between the corporate strengths of existing and new companies by applying different regulations for each may be helpful. Here, costs are estimated to be lower for existing companies considering increases in future demand, and connection fees (i.e., infrastructure use fees) are reduced for new companies.

A major concern is that power companies’ management foundations have weakened following the accident at Fukushima Nuclear Power Plant No.1. If the connection fees are set high, new power companies cannot enter the market, but if they are set low, it would affect the existing power companies’ management. Therefore, it is necessary to set the rules by which bottleneck facilities can be used fairly and efficiently.

9. Stable supply through market leverage

Liberalization would effectively improve the management efficiency of power companies, but it may cause uncertainty that will result in players refraining from investing in power plants and grids. Power companies have been obliged to guarantee the power supply in exchange for regional monopolies. After 2016, when the full-scale liberalization of the power retail market is set to be implemented, this obligation will be abolished and it will become the responsibility of the power retailers.

Concerns exist that power generation companies will run out of funds required to upgrade their power generation equipment. This process will take over 10 years in construction alone, because future capacity use cannot be predicted and there will be a cap on power prices (i.e., the missing money problem).

How can long-term investment be secured? The government is studying the possibility of establishing a “capacity market,” where grid operators and power retailers trade in “future generation capacity.” Whereas the wholesale power market trades in “current power capacity,” this capacity market trades the right to purchase “future power capacity.” If power retailers that are obliged to secure the power supply can set prices based on generation capacity, it may become easier for power-generating companies to calculate the expected return on their investments.

Although the Unites States and Europe have liberalized power long ago, they are still in the trial and error stage. Although Japan can refer to market prices that reflect the expected supply and demand for power when creating a plan for power source development, it is difficult to foresee the changes that will occur concerning regulations or systems. As a backup plan in the event that the capacity market does not function effectively, a mechanism is being considered in which the organization that adjusts power supply and demand (i.e., the agency operating the grid over a large area) that will be established in 2015 can participate in trading.

In recent years, new mechanisms has been devised so that goods previously considered untradeable in a market can be traded through a matching system for determining optimal trade combinations or auctions where buyers bid for goods. In fiscal year 2012, the Nobel Prize for Economics was granted to a researcher of one such market design. Economists must determine how the power supply can be stably secured while controlling uncertainty and speculation.

10. Parties responsible for production and consumption

The power system has often been studied from the perspective of the supplier. However, in this series, I have discussed this system from the point of view of the consumer. Finally, I discuss how future power reforms will affect our daily lives.

Traditionally, power was considered a good that must be consumed as it is generated and that requires huge fixed costs; therefore, it was not suitable for trade on the market. However, technological innovations are changing this situation. One example of this is smart grids (i.e., next-generation transmission grids) that adjust supply and demand by taking advantage of data provided by information communication technology such as smart meters (i.e., next-generation power meters), which capture changes to demand in real time.

Within homes, home energy management systems (HEMS), machines that learn the occupants' energy-saving behaviors according to their individual life patterns and realize automatic, comfortable, and economical energy saving, may become widely used. These mechanisms make adjustments to supply and demand possible not only through power generation and its transmission and distribution but also through price mechanisms at each stage (e.g., the retail and household stages).

Technological innovation is also changing the nature of electricity as a "good." Once home batteries become widespread, the inability to store energy will be reduced, and improvements to peak power shortage instances can be expected. If batteries can be connected to solar panels and charged and discharged as required, it will be possible to help distribute power between regions to more equally distribute the load throughout the country. There is still a long way to go until such technologies are widespread, but they should be introduced into newly built or renovated homes and buildings.

When consumers start generating and storing power, they become what Alvin Toffler in his book The Third Wave called "prosumers," because they are both producers and consumers. Because prosumers strategically participate in the trading of value, it is not the same as being self-sufficient. If prosumers can contribute to supply and demand adjustments, the stability and effectiveness of the power system should improve. This is the form that people-led power reforms should take.