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Energy Security and Global Warming Measures under a Deregulated Electricity Environment

Junichi Ogasawara*

Abstract

In the late 1990s, many countries, particularly developed countries, started to deregulate their electric power markets. However, since around the late 2000s, demand increased for measures against global warming, prompting governments to intervene in power generation investment by setting national policies. In particular, with the rapid growth in renewable energy capacity in the 2010s, many countries adopted a complementary arrangement called the capacity mechanism. Moreover, since the types of power generation methods that could be chosen were limited, the dependence on certain types of energy such as gas-fired thermal power and solar power increased, creating new risks for the power supply. Instead of pursuing simple market mechanisms, a framework that encompasses diverse political issues in a compatible manner should be considered.

1. Deregulation of Electric Power

Before the advent of deregulation, business operators who were granted permission from the regulator constructed and operated power generation, transmission, and distribution systems under government supervision, whereby electricity prices were determined according to the supply cost method to enable them to recoup the cost of doing business. This arrangement has now been restructured to allow other operators to enter the market under the principle of market competition; this is called electricity deregulation. The power transmission sector remains regulated, still being subject to rules and regulations with respect to obligations such as supply-demand balancing and prices which must be determined according to the fully distributed cost method. However, the power generation and retailing sectors have, in principle, incorporated the market principle in all areas except for those related to the safety and security of energy.

Deregulation of the power generation business often entails the establishment of a wholesale electricity exchange for the purpose of prompting competition. In Japan, the Japan Electric Power Exchange (JEPX) has been established, in which zonal day-ahead spot transactions and hour-ahead transactions are conducted. Since wholesale electricity prices are made known to the public through exchange transactions, those prices often serve as an index price, which can influence negotiated transactions outside the exchange. In the day-ahead spot transactions, where sellers and buyers tender for electricity, deals are struck at the price and amount determined by the intersection of the

* Senior Research Fellow, Manager, Electric Power Group, Assistant Director, Electric Power Industry & New and Renewable Energy Unit, The Institute of Energy Economics, Japan

demand and supply curves drawn for each transaction time zone[1]. In a healthy market, the sellers, i.e., power producers, determine their bidding prices based on the variable costs associated with operating their generating facilities. Consequently, deals are struck at market prices at which supply matches demand and the variable costs are the greatest or, in other words, marginal.

In the regulated framework, the power source configuration was often determined through discussions with the business operators in accordance with regulatory policies such as energy security and global warming measures. However, under the deregulated environment, the power producers invest in those power generating facilities that they believe will result in the most profitable outcome. From the 1990s to the early 2000s, when energy prices were relatively low, gas-fired thermal power generation was the most competitive type of power generation, and so developed countries saw a boom in investment in gas-fired thermal power plants. Later, as energy prices went up, coal-fired thermal power generation became more competitive. As can be seen from these examples, investments in power generation are often influenced by changes in energy prices and do not necessarily conform to national policies such as energy security and global warming measures advocated by the government. Accordingly, since the late 2000s, when the need for measures to combat global warming began to be actively discussed, the government has increasingly been making various policy interventions in the electric power business.

2. Policy Intervention in the Power Generation Business

2-1 Power Generation by Renewable Energies

Examples of global warming measures include supporting renewable energy power generation and regulating CO_2 emissions from power generating facilities. Support for renewable energies takes the form of subsidies, RPS[2] and FIT[3]. By selling electricity generated from renewable energies through the FIT scheme, the seller can make large profits depending on the price levels, accelerating the introduction of renewable energies. Since around 2010, the cost of solar power generation facilities has fallen, causing a spike in expected profits in some locations with respect to the FIT set price. As a result, countries that introduced a FIT system experienced an investment boom in solar power generation, leading policymakers to quickly review and change the FIT system.

In Japan, the FIT system was introduced in 2012. As the FIT rate for solar power was set high, there was a rapid surge in solar PV, with its output and FIT certified capacity reaching 42,800 MW and even 70,880 MW, respectively, as of December 2017. This increase in renewable energy capacity, which is not based on the principle of competition, tends to drive other sources of energy out of the market, significantly influencing the mechanism of price formation. Particularly, if power

[1] In Japan, in units of 30 minutes.

[2] Renewable Portfolio Standard: Retailers of electricity are obliged to purchase a certain percentage of electricity generated by renewable energies.

[3] Feed in Tariff: Purchase prices of electricity generated by renewable energies are fixed for each type and guaranteed to be purchased over a predetermined period. Recently, Feed-in Premium is also practiced which affords a premium to a wholesale market price.

generation by renewable energies is backed by subsidies like the FIT system, since the cost of power generation by renewable energies comes from outside in the form of a levy on wholesale electricity transactions, the true cost of supplying electricity may significantly differ from the price of wholesale electricity. Furthermore, since electricity charges may be pushed upward due to the reduced use of the network or increased levies, the “death spiral” situation may occur in which customers start leaving the market[4].

2-2 An End to Coal-Fired Thermal Power Generation

The UK Government introduced what was called a carbon price floor (CPF) in accordance with its policy of phasing out coal-fired thermal power generation. As a result, since around 2015, the variable cost of gas-fired thermal power generation has become lower than that of coal-fired thermal power generation, and the electricity output from coal-fired thermal power plants has fallen sharply. This is part of a national policy to bring an end to coal-fired thermal power generation by 2025. More and more governments, mostly those of EU countries, now adopt policies aiming to cease coal-fired thermal power generation in view of global warming, which is another example of a policy intervention that is not related to the wholesale electricity market. Furthermore, the financial and insurance sectors, too, have seen a growing movement aimed at ending coal-fired thermal power generation. Indeed, some insurance firms have stopped underwriting insurance policies for coal-fired thermal power plant projects, which are indispensable to construct such power plants. This is one of the factors, other than the market principle, that make it difficult to sustain coal-fired thermal power projects.

2-3 Capacity Mechanisms

When the electric power pool was launched in the UK in 1990, a mechanism was attached to recover the fixed cost through a capacity payment system. However, in this pool, market power could easily be wielded, and the tone of the market was such that a steep rise in energy prices would yield easy profits within the wholesale market. Accordingly, many continental European countries which deregulated their electricity markets following the UK’s footsteps did not choose the combination of the electric power pool and the capacity payment system.

In the 2010s, the price of natural gas came down, but because of the expanded introduction of renewable energies backed by government policies and the stagnant demand for electricity after the 2008 financial crisis, there was an electricity glut. This caused the load factors of thermal power plants to remain low, increasing the risk of investing in large-scale power generating plant projects. As a result, it has become difficult to invest in facilities with a generating capacity exceeding 300 MW in developed countries. On the other hand, the installed generating capacity of renewable energies continued to increase due to favorable policies. However, since their outputs depend heavily on the weather, it is considered that thermal power generation capacity, especially that from gas-fired thermal power plants, will remain essential in the years to come. As a result, more and

[4] Severin Borenstein and James Bushnell. See p. 26-27 of “The U.S. Electricity Industry after 20 Years of Restructuring” May 2015.

more countries are adopting the capacity mechanism, which facilitates the recovery of fixed costs of gas-fired thermal power plants.

However, because it is not clear whether profits can be earned through the capacity mechanism until three to four years before the start of operation, and because few systems allow profits through the capacity mechanism on a long-term basis, it has been difficult and will remain so, to sustain large-scale projects requiring a long-standing commitment such as the construction of whole new infrastructure on vacant sites including gas pipelines and substations.

3. New Risks and the Market Principle

3-1 Dependence on One Specific Supply Capacity

In the US, as the gas price remains low, an increasing number of coal-fired thermal power plants are being decommissioned, resulting in a significant increase in the ratio of gas-fired thermal power plants in the power supply in some areas. In the US, gas is supplied through pipelines. However, because gas-fired plant operators purchase gas under low-priority contracts called non-firm purchase, or simply because of troubles related to gas supply systems, gas-fired thermal power generation is often forced to stop operating during cold weather. In the US, this difficulty in supplying gas to gas-fired thermal power plants is now recognized as a new risk to energy security, and measures are being sought including the development of analysis methods.

In the state of New York, under the constraints of New York City on fuel procurement and electric power transmission, there are many thermal power plants with dual fuel-fired boilers, which can burn both natural gas and oil for power generation, to be prepared for emergencies. In January 2018, when a cold snap hit North America and gas supplies became tight, their plants continued to provide a stable supply by raising the ratio of oil in the fuel mix. Although these mixed fuel-fired thermal power plants usually have low load factors, they are able to maintain their equipment as they obtain revenues from the capacity market. They are fired up when supply is tight such as in January, thus contributing to the security of power supply. In Japan meanwhile, it was decided that old oil-fired thermal power plants were not worth keeping for extended use, and many of them are now being demolished in various areas.

In the absence of alternative means, dependence on a specific type of fuel may threaten the security of power supply. At present, with the supply becoming ever tighter, curtailment of demand through energy saving or load rejection may be expected. However, this approach as one aspect of the market principle is questionable. In recent years, natural disasters have caused damage to supply facilities. If thermal power plants sustain such damage, the request to save energy may remain in effect for a long time. Another important issue is whether some redundancy in supply capacity should be permitted.

3-2 The Duck Curve

The rapid introduction of renewable energies, mostly from solar power, has been witnessed so far in California ISO's service area in the US and Kyushu Electric Power's service area in Japan. If the capacity of solar power generation grows, the net load ([power consumption] − [variable renewable energy such as solar power]), which needs to be followed by generators subject to load-dispatching instructions, will peak twice a day, in the morning and the evening. Since most thermal power plants take several hours to restart once stopped, it would be extremely difficult to operate them solely according to the market principle by throttling their output down during the day time after the morning peak and then throttling them back up for the evening peak. It is difficult to incorporate load-following capability into the prices of wholesale electricity transactions, which lie outside of the generation reserve margin. The US RTO intends to incorporate the value of output adjustment for short-time responsiveness by determining wholesale prices every five minutes. However, in Japan, where wholesale prices are determined every 30 minutes, sudden changes in output are difficult to cope with.

3-3 Fewer Options and the Market Principle

In developed countries, options concerning the construction of new power generating capacities are limited. If it is necessary to construct new thermal power generating capacity, the choice is in effect limited to gas-fired thermal power plants. However, if a newly constructed gas-fired thermal power plant seeks to make a profit under the market principle, it must do so from the difference in fuel cost between new and highly efficient plants and old and less efficient plants, the latter being the major determinant of market prices. The capacity market should facilitate the recovery of fixed costs of gas-fired thermal power plants, but, if the capacity market becomes the main instrument for recovering fixed costs, then the "market mechanism" may be neither valid nor effective. If fixed cost-type supply capacities with small variable costs become major players in the market, it will be important to decide whether or not market transactions based on the marginal price principle should be allowed to continue.

Moreover, since there has been a massive introduction of renewable energies backed by national policies, there is an excess of supply in developed countries. With the coal-fired thermal power plants still operating while the power supply remains in excess, coal-fired thermal power generation with its low fuel cost, except in the US, has a competitive edge in the market, making it harder for gas-fired plants to stay operational. In order to handle fluctuations in renewable energy output, it is better to put priority on starting gas-fired thermal power plants. However, since the load-following feature of the regular supply capacity cannot be given added value within the framework of wholesale electricity transactions, coal-fired thermal power generation will be given priority. California's ISO and MISO, which have a higher ratio of renewable energies introduced in the US, are doing modified short-term optimization, in which load-dispatching instructions are issued based on the result of optimization calculations performed so as to maintain the supply-demand balance for several hours. This practice may provide some insight into these problems.

As described above, as a result of policies to intentionally bias the power source configuration,

the security of electricity supply has become increasingly difficult to maintain simply by depending on conventional market principles and mechanisms. In the future it will be necessary to discuss what sort of complementary mechanisms are needed to reduce such risks and when the system should be drastically changed.

3-4 Problems Involving the Scope of Application of the Market Principle

Traditionally, wholesale electricity transactions have been conducted based on power in kWh integrated for a time interval of 30 or 60 minutes. In recent years, kW values, which are viewed as values of supply security, are traded in the capacity market. Now, values of adjustment capacity, which are placed on standby as reserve capacity and exploited when necessary, are traded as ΔkW values. On the other hand, small-scale power generating facilities and large-scale power generating facilities have different response performance (inertial force, etc.) regarding the voltage and frequency stabilities. It is true that there are these features that cannot be considered in wholesale three electricity transactions. So far, renewable energies with different performance requirements have been treated the same as others simply because their share is small. However, we have now reached the point where we should begin to discuss whether to add value to these features or whether to require renewable energies to provide the same level of equipment performance.

Writer's Profile

Junichi Ogasawara

He joined IEEJ in 1995. He has held many senior positions in IEEJ. His specialized field of research is: Energy Supply & Demand Analysis and Forecasting, Research on deregulatory reforms of electric industry. He has authored numerous publications.