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Review

Environment Friendly New Energy Supply System

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1. Introduction

In February 2005, the Kyoto Protocol was enforced, and Japan was expected to reduce greenhouse gases by 6% on average, in comparison with the year 1990, during the 5 years from 2008 to 2012. However, the increase of energy demand was larger than the measured energy saving, and the amount of greenhouse gases increased at a high rate of 7.4% in fiscal 2004 against expectation. With the limitations experienced on the effective measures to decrease greenhouse gases, deployment of new energy sources is expected to become one of the effective measures against global warming. In addition, along with the expanded use of renewable energy, the possibility of the creation of new industries, namely new businesses, is also expected.

On the other hand, a number of issues are yet to be resolved for use of these new energy sources. The biggest issue is not technical but economic. Politically arranged investments have been made for new energy technology development, and the technology has dramatically advanced. However, while power generation technology has advanced much, it is economically inferior to traditional generators and systems of electric power companies. However excellent for environment a system is, the system itself cannot finally expand in the real sense without depending on certain personal willingness, if it is not economically superior.

Toward the popularization of the new energies, our political target is set to a rather high level, but it is very small compared to our energy consumption. As a matter of fact, such a small amount cannot give any large-scale cost reduction through mass production. As a limit on the decrease of power generation cost can be seen, what is important is to build adequate supply systems that are economically compatible.

In this article, fundamentally based on the above philosophy, new energy sources will be discussed mainly from the viewpoint of business possibility.

2. Environment Surrounding New Energy

New energy shares about 1.3% of the primary energy in fiscal 2002, and our government has set a target to raise this to 3% by fiscal 2010. Within the new types of energy, power generation systems that are considered for electricity generation, such as photovoltaic power generation, wind power generation and biomass power generation, are given the highest target.

2.1. Technology trend

2.1.1. Photovoltaic power generation The installed photovoltaic power generation capacity at the end of fiscal 2003 was 1.134 million kW, and the target for fiscal 2010 is set at 4.82 million kW. Photovoltaic power generation in Japan is ranked as the highest in the world and shares about 50% of the world total. This has been achieved thanks to the increasing political support, which has helped decrease the cost considerably. However, the governmental support is expected to end in fiscal 2006.

On the other hand, the current cost for photovoltaic power generation is 50 Yen/kWh, which is rather high. To recover the initial investment, it is said that it will take about 20–30 years even assuming the highest selling price of 20 Yen/kWh for household use. In the future, it is expected to extend its use to business establishments in addition to households, but it is absolutely necessary to achieve further reduction in cost to make this attractive from the viewpoint of the unit selling price of electric power. Currently, photovoltaic power generation using a new chemical semiconductor material with the cost lower than in using silicon crystal is being researched, and it is expected to bring significant cost reduction if successful.

2.1.2. Wind power generation The installed capacity of wind power generation at the end of fiscal 2004

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was 0.956 million kW, and the target for fiscal 2010 is set at 3 million kW. Wind power generation started around 1990, and in the initial stages electric power companies and local governments installed some experimental or demonstration units. The power purchasing system by electric power companies was legally authorized in 1998. Since then, business-based wind power generation has been popularized rapidly. In addition to that, owing to its symbolic value and rather easy maintenance, citizen groups and non-profit organizations also introduced them. These days, its scale is steadily increasing. At the initial stages, its generating capacity was about 250 kWh but now it has grown to the 2000 kW class.

Incidentally, wind power generation is especially concentrated in the Hokkaido, Tohoku and Kyushu areas where wind conditions are favorable. Under these circumstances, in some areas, concerns have been raised that the popularization and further increase of wind power generation may have adverse effects on the frequency, etc. of the electricity lines, because of which large-scale introduction of wind power generation is being withheld. To tackle this drawback, studies to stabilize the output power from wind generators by using batteries in parallel are being pursued, but the additional investment needed may lower the economics and this may threaten to slow down the introduction of wind power generation.

2.1.3. Power generation from waste and biomass power generation The installed capacity of power generation from waste and biomass at the end of fiscal 2002 was 1.61 million kW, and the target in fiscal 2010 is set at 4.5 million kW. Biomass includes various types wastes generated from sources such as wood, agriculture, farming and fishing and from the food industry. Almost all the biomass energy originates from the heat generated by the burning of waste, and the above-mentioned target is mainly achieved through power generation from waste. With regard to waste disposal facilities, concentration and scaling-up have been carried out, especially of nonindustrial waste, to take measures against the emission of dioxin since latter half of 1990s, and at the same time thermal recycling by electric power generation has been recommended. The system suffers from the drawback of low generation efficiency (about 10%), but recently some power generation systems with higher efficiency, such as the super-waste power generation system or the refuse-derived-fuel (RDF) power generation system, are being introduced.

In addition to the power generation from waste, the wooden biomass power generation plants are increasing. This system can supply electricity at lower costs, and, as stated below, the system can be authorized by the renewable portfolio standard (RPS) certification, which has established this system as a power generation business. It has the superb feature that it supplies more stable output power than generators that are liable to be affected by natural conditions, such as photovoltaic power generators and wind power generators.

On the other hand, with regard to the use of wet-type biomass, i.e. creating biogas including about 60% CH_4 gas as the fuel for power generation, the gasification technology has already been established, but the system has to solve the considerable cost problem incurred for collection and transportation. For this reason, the system is just at the introductory stage in that mainly public facilities are only partially involved in it. Under these circumstances, livestock excrements and disposed food are not yet well utilized.

2.2. Birth of the RPS system The RPS system means a system that makes it obligatory for the electric power suppliers to utilize not less than a certain amount of the 'new energy electricity or the like' depending on their sale of electric power based on the 'Special Measures Law with regard to the Utilization of New Energy or the like by Electric Power Suppliers'. This law was enforced in April 2003. The term 'new energy electricity or the like' means electricity generated using wind power, sunlight, geothermal energy, hydro (water flow-type hydropower generation of not more than 1000 kW) and biomass. The electric power suppliers are required to perform their obligation, to generate by themselves the 'new energy electricity or the like', to purchase the 'new energy electricity or the like' or to obtain the 'new energy electricity or the like equivalency' (RPS certification).

Before the enforcement of the RPS system, the new energy generation, whose generating unit cost is higher than that of fossil fuel, had been popularized with voluntary support from the local electricity suppliers. In this voluntary system, the new energy electricity was purchased with fixed-rate, more favorable prices than usual in accordance with the type of new energy, such as sun light, wind power and nonindustrial waste. The RPS system has eliminated the unit price difference between the fossil fuel power generation and new energy power generation. In this way, it has become possible to operate a power generation business with new energy in the full-scale, free-trading market.

The total capacity for the required RPS certification is 12.2 billion kWh (approximately 1.35%) in fiscal 2010. In fiscal 2004, the total supplied amount was 4.91 billion kWh [1] compared with the required amount of 3.6 billion kWh. The annual required amount is set forth rather low compared with the total planned amount of power consumption as a transitional measure until 2009, but to achieve the target in fiscal 2010, it will be necessary to increase the supply 2.5 times, which, it is said, is difficult for some suppliers to comply with. The

target value of the requirement in and after fiscal 2010 will be decided in the next fiscal 2011.

As for the price of RPS certification, its upper limit decided in the market is 11 Yen/kWh or less. The price level in fiscal 2004 was 4.8 Yen/kWh on average (minimum 4.0 Yen/kWh to maximum 8.0 Yen/kWh). The price of the RPS certification largely depends on the size of the given required amount charged to each electricity supplier. Because of the fact that the RPS certification is one of the major income sources for the new energy suppliers, the trend is, to increase the required amount seeking RPS certification.

2.3. Advancement of deregulation of electricity The Electricity Utilities Industry Law was amended in May 1999, and the retail selling of electricity was partially liberalized (specially high voltage not less than 2000 kW) in March 2000. Thereafter, the deregulation had advanced step by step, and in April 2005 the deregulated range included consumers using electricity up to 50 kW at high voltages. This means that the deregulated market shares 60% or more of the total. Furthermore, the complete deregulation for the consumers of less than 50 kW is planned to be reviewed in 2007 or later.

In accordance with the deregulation, already 23 specific-scale power producers and suppliers (PPSs) have been established [2]. The birth of PPSs is creating a new possibility for the new energy. The PPSs normally generate electricity or purchase it from other suppliers and sell it to retail consumers, but they may also depend on the new energy electricity generators if the conditions meet their requirement. In other words, the new energy electricity generating companies can expand their business to customers other than the electric power companies.

There are some examples in which the unit retail price of electricity rises in the competition among the PPSs and electric power companies. Some local governments have switched to PPSs as their customers of their nonindustrial waste electricity for better revenue. By the electricity deregulation, the price of electricity has become nonmonopolized.

3. Major Points for Popularization of New Energy

3.1. Independent business model The first point for the popularization of new energy is to establish a system that does not adversely affect the traditional electric lines. Actually in some areas, to avoid possible adverse effect on the traditional electric lines, the purchase amount is allotted in a smaller quantity for wind power generation than expected, and some wind power generators cannot operate their business because they cannot obtain the bidding or lose in the lottery. The basic reason is the quality problem faced by the electricity lines caused by the increase of wind power generation. But in the advancement of the price competition in the age of electricity deregulation, it is not clear how long the electric power companies might continue to purchase the new energy electricity with the favored price. To further popularize the energy, it is necessary to establish a business that does not depend on these purchase allocation and favored purchasing systems.

In particular, it is necessary to make it possible to sell new energy electricity not only to the electric power companies but also to the PPSs. For this purpose, the new energy electricity should be generated under a controlled plan. At this moment, the biomass power generation and wind power generation alone are admitted as commercial electric power for sale. However, the wind power generation is considerably affected by the natural environment, and because of its output fluctuation, it is not possible to sell its power to customers other than electric power companies. For its further popularization, it is necessary to improve the quality to a level equivalent to that at which the PPS or the wholesale power exchange can be selected as the customer.

The quality target of electric power is the demand–balance standard given to the PPS, i.e. the 30-minute-balancing rule (to control the generated power to support the demanded power within the allowance of plus or minus 3% for 30 min). The PPSs are controlling their power source targeting to comply with the 30-min-balancing rule. Actually, as they are adjusting immediately before fluctuation of demand in such a way that by using an adjustment power source, the new energy electricity generation may not be required to strictly comply with such a rule. But, ultimately it should be in accordance with the 30-min-balancing rule in the course of increase of new energy power sources. For instance, wind power generation may suddenly stop because of a trouble. If the new energy power is some thousand kilowatts within the total figure of some hundred thousand kilowatts, it can be measured just before the occurrence of the adverse effect, but if the new energy power increases up to the level of some tens of thousand kilowatts, it may be difficult to countermeasure it just before the occurrence of the adverse effect.

The image of the improved business model under the planned power generation is as illustrated in Fig. 1. Because the electric power can be sold at a higher price owing to the possibility of the planned power generation, there is a business possibility in which additional investment for stabilization of output power may be compensated. In addition, it may be an advantage to be able to construct power plants without considering the electric power company's purchasing allocation.

3.2. Local production for local consumption The term 'local production for local consumption' means

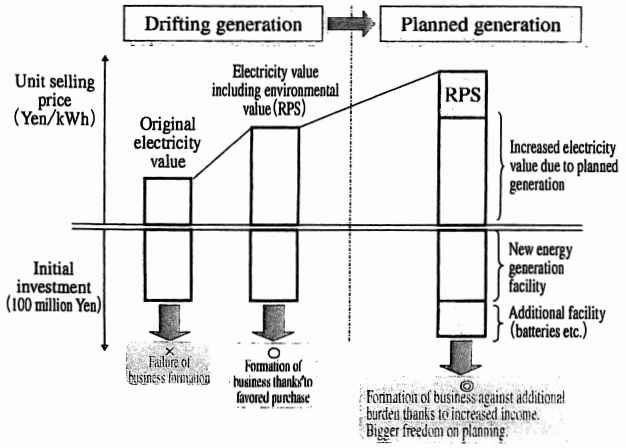

Fig. 1 Enhancement of business with planned power generation

to consume the locally produced energy in the same local area. It is a concept set forth for the purpose of enhancing the introduction of new energy these days, but, in actual cases, the new energy is 'locally produced', but not 'locally consumed'. For example, the power generated by newly constructed wind power generating plants is combined with the electricity generated in the thermal and nuclear power plants through the transmission lines and then delivered to a number of unspecified consumers. Thus, locally produced power is not consumed in the same local area. The second point to popularize new energy is to realize actual 'local consumption', in other words, to find the best use of the locally produced electricity for local purposes.

New energy electric power has less stable output than that generated from fossil fuel, and therefore some mechanism is needed to stabilize such uncertainty. However, if the problem is just thrown to the suppliers, this system would be economically deadlocked. To avoid this unfavorable situation, the consumers' creative activity and cooperation is needed.

With regard to this issue, there are two major directions. One is to select the demand side that is the supplier's side in favor of the new energy. For instance, it may be possible to supply low-quality electricity to some loads that can accept such quality. The electric power for road heating does not require costly adjustment of quality. On the contrary, it may be good idea to offer well-arranged, high-quality electricity to specific customers who require such quality at a higher price. The unit price of electricity varies depending on the size of demand and the load factor, but it is a quick route for grasping possibility of business to approach the consumers who can accept a deal as favorable as possible for the new energy power generators.

Another direction is to make the consumers use the new energy in relation to the amount generated amount. It is not possible to completely control the demand in relation to the output of new energy power generation, but if the consumer has distributed power sources, it may be possible for the consumer to control the receiving power in accordance with the output of the new energy power. To accomplish this kind of 'local production for local consumption', the consumers' acknowledgment of the new energy is initially inevitable, because this system requires considerable close relation between the new energy generators and the consumers. To realize the term 'local consumption' is equal to enhancing consumers' awareness of the new energy.

4. Direction of New Energy Supply System

There are two directions of the new energy supply system to develop under the conditions discussed above. One is the planned power generation type independent power producers (IPP), and the other, the microgrid system.

4.1. IPP (planned power generation type) The planned power generation type IPP means the system in which a power plant generates its power for certain 30-min intervals which has been agreed upon previously. If the amount of power to be generated is known, the power generator can expand its clients to the PPSs and effect wholesale power exchange in addition to electric power companies, and it can sell its electric power at higher prices. Of course, in this case it is difficult to realize this idea depending only on the new energy power, which is occasionally affected by the natural environment. Here it becomes necessary to coordinate operation with storage batteries and distributed power sources.

With regard to the wood-type biomass power generation, the amount of generated power depends on the quality (heat quantity) and amount (amount of incineration), and as the fluctuation of quality is very small, it is quite easy to control the power generation under the plan by adjusting the amount. On the other hand, some problems exist in the power sources that are significantly affected by natural environment such as wind power generators and photovoltaic power generators.

If nothing is measured, it is necessary to prepare at least the same size of storage batteries or distributed power sources as the new energy power generation stations for prior offering or promising certain power generation in coordination with storage batteries and distributed power sources. However, storage batteries and distributed power sources are expensive, and such a big investment may not be acceptable in an actual business operation. Now, the best expected idea is a forecast system of the electric power generation by use of the weather forecast information. By use of the weather information, the amount of power generation can be

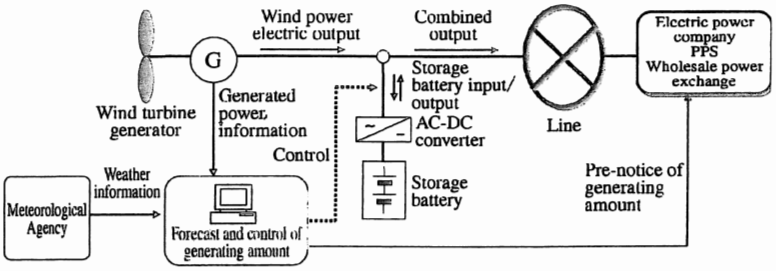

Fig. 2 Planned generation type IPP (Wind power generation)

forecast, and accordingly the adjustment of the power generation can be done with minimum units of storage batteries and distributed power generators (Fig. 2). Of course some allowance should be given, but, nonetheless, the facility efficiency will be improved compared with not acting, even though an additional investment for storage batteries and distributed power generators will be ncessary to compensate the allowance. This idea has not come into effect yet, but it is a business model expected in the near future.

4.2. Microgrid The microgrid system is an energy system with high independence, that is, the 'local production for local consumption' system networking plural power sources and consumers within a limited area. The Hachinohe City's microgrid system maintains the balance of demand of electric power and its quality, and all the electric demand is satisfied with the new energy power generation as well as within each network. The microgrid system can be the ultimate new energy supply system that can maximize the utilization factor of the new energy as stated above.

However, there are two issues to be solved for commercialization of the microgrid system. One is the cost for controlling the self-dependence level and demand–supply balance in addition to the cost of new energy itself. From the viewpoint of selling electricity, the generated electricity can be sold directly to the consumers, which brings the selling price equal to the retail price, and this is a more favorable condition than IPP. But on the other hand, if the controlling cost becomes high, this system cannot be operable as a business. This is now in the stage of demonstration, and for the future a general-use-type and cost-effective control system is anticipated.

Another issue is the business size. To be successful in business, a larger size is more competitive. For instance, taking wind power generation as an example, a wind farm with some 1000 kW class generators is superior to a small generator with respect to unit price of electric power. Enlarging the size requires more demand in proportion to the size, which will adversely affect the business performance because of the increased cost for installation of private lines, etc.

Finally, the microgrid system is suitable for an area where electricity consumers are concentrated near to the location of the new energy power plant and where the demand is rather large. Local industrial complexes may be probable candidates. In the future, it is expected that new energy microgrid systems will be established for large-scale demand in an industrial complex.

5. Conclusion

To popularize the new energy steadily, as discussed here, it is necessary to make business possibile and free market entry compatible. After the enforcement of the Kyoto protocol, new energy is expected to become much more popular, and the market is wide open thanks to deregulation. These situations serve to spur the popularization of new energy. The utilization of the new energy supply systems discussed here has still certain issues to be solved, but some of them are already in the demonstration stage and just at the point of actual application. It is expected that with such follow-up new energy will continue to be popularized at an even larger scale than at the introductory stage.

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