CHALLENGES FOR UTILITY WITH ENERGY PROSUMER IN KOREA

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ABSTRACT

In the meantime, KEPCO in Korea has been sold exclusively power. Therefore, it is the lack of preparation for the retail market operations with energy prosumer. KEPCO has been developed a smart grid and micro-grid technology for optimal control technology of renewable energy. In particular, KEPCO has been developed the optimum method of operating DERs (Distributed Energy Resources) by using the micro-grid technology. Micro-grids are small power supply system located on-site. Micro-grid can be thought of as a typical prosumers or considered representative of the small-scale distributed power providers as an agent.

This paper is to propose a model for small-scale electricity trading for KEPCO and energy prosumer using micro-girds that have variety micro-grid models. The model of small-scale market is important to KEPCO as well as the energy prosumer in Korea. For this reason, the aim of this study is to examine the economic benefits and social welfare in utility position and corporate profits in prosumer position respectively. This paper will provide a model that can be a win-win to utility and prosumers.

I. INTRODUCTION

In the power system, there have been enormous efforts on efficient energy management in order to resolve problems incurred from the energy and environment crises. The concept of the Smart Grid is one of the solutions to those problems. In Smart Grid systems, all the information of every grid component should be accessible and all the components composing the power grid should be controlled by two-way communication.

Besides the infrastructures and facilities, there have been other efforts on electricity pricing policies. Although Korea has not yet implemented it, Real-time pricing is one of the well-known policies for dealing with peak energy consumption. In this pricing scheme, the electricity pricing rate is available for customers one hour to one day in advance. Thus, customers can manage the usage of their electric devices in order to minimize the total electricity cost. For example, they can control the target temperatures in air conditioners or electric heating appliances, or brightness of light bulbs based on the electricity pricing rates. In addition, Demand-response (DR) incentive policy has been effectively used as a scheme for reducing peak load usage. Customers who participate in the DR events may receive benefits and incentives from power utility companies when the utilities announce the DR event. While there are various optimization strategies and polices for reducing energy consumption, they mainly focus on controlling passive components such as load control and shift but not active components such as renewable energy sources.

But the topic in this paper is the energy prosumer that can supply electricity from their distributed energy resources (DERs) or microgrid by monitoring electric pricing rather than the DR. An operator with a single generation facility such as PV or Wind may also be considered an energy prosumer. Because of its non-active response from the market signal, this paper will be referred to the microgrid only. In addition to nationwide efforts on energy management, strategies for small size power grids have been actively discussed. Microgrid is the downscaled cells of the Smart Grid. Microgrid can be operated as a dispatchable load of the conventional power system as well as an independent power system for small-scale areas. By considering DER, such as wind and solar, and energy storage system (ESS) in conjunction with scheduling and real time control, microgrid can achieve several advantages such as enhancement of local reliability, reduction of feeder losses, and increased efficiency whose main purpose is to minimize either the total electricity cost or CO2 emission from the designed microgrid. In contrast, the microgrid can supply the power as much as possible such as controllable generator to the utility power grid.

From this perspective, this paper would like to introduce the energy prosumer and retail market rules with microgrid that may be in future Korea.

II. CONCEPT OF MICROGRID FOR ENERGY PROSUMER IN KEPCO

With the rise of the concept of smart grid, micorgrid as an important component of smart grid, has played an increasingly important role such as enhance local reliability, reduce feeder losses and support local voltages in power market. Furthermore, the microgird also offers opportunities for optimizing DERs through CHP, which is currently the most important means of improving energy efficiency.

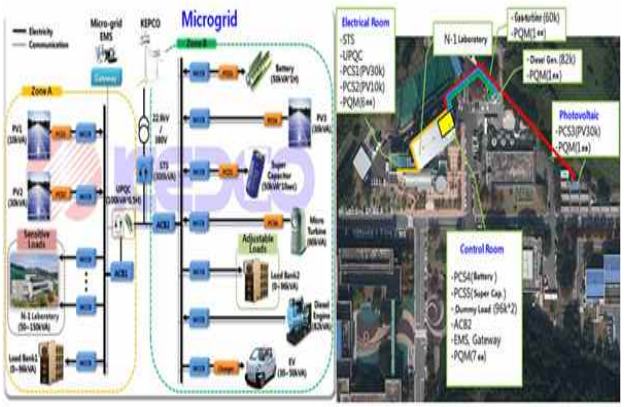

Figure 1. Microgird Demo Site of KEPCO

The microgrid usually consists of a cluster of distributed generators, energy storage systems and loads, and can operate as dispatchable generator by its energy management system (EMS).

Figure 2. Microgrid EMS

The microgrid requires the EMS, which monitors the status of the system and provides adequate control capability. The EMS was designed and developed to ensure the optimal operation of the microgrid. Supply and demand balance is automatically maintained by automatic generation control (AGC) and economic dispatch (ED) and unit commitment (UC). Therefore, the microgrid is operated such that the biggest technical and economic benefit is realized for energy prosumer or agent. In other words, the power output generated using renewable energy source such as wind power, photovoltaic power, etc. Renewable energy sources are always maintained at the maximum possible level; controllable power sources such as micro turbine, fuel cell, diesel, etc., are used to ensure the most efficient operation of the microgrid. To establish a plan for optimal power generation, EMS makes out the daily power generation plan on the everyday of load dispatch based on the load of the previous day and the forecast data of renewable energy power generation. The final set point of the individual power generator is transmitted through power control at the point of common coupling after economic dispatch is carried out for several minutes based on the start/stop plan for the everyday of load dispatch.

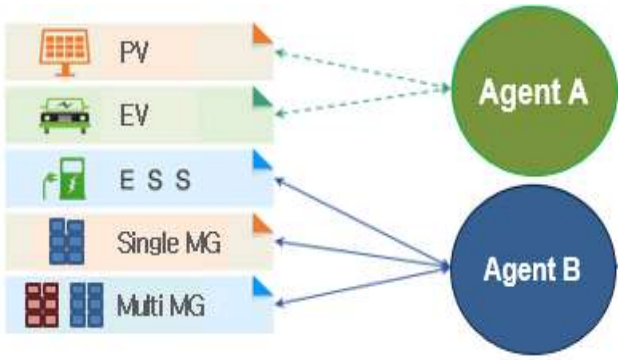

Figure 3. Concept of Agent

As mentioned in the introduction, each DER can be energy prosumer. However, it is difficult to control their active power constantly for the utility to operation. Thus the microgrid can be an agent for various DER owners. Agent of the multi microgrid like a campus is also available, not single DER.

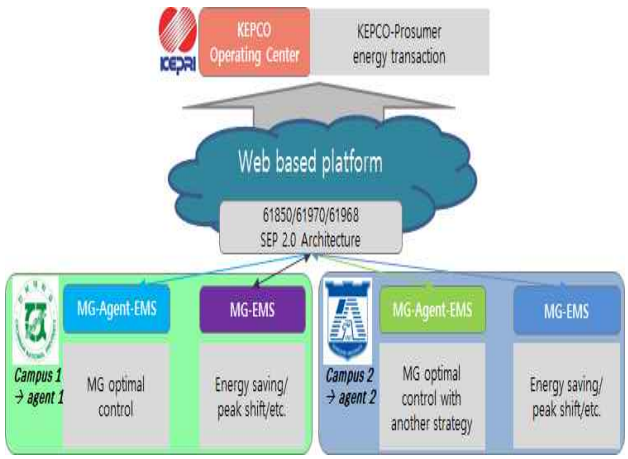

Figure 4. Utility and Prosumer Model using Campus Multi Microgrid

III. ELECTRICITY MARKET OF KOREA WITH ENERGY PROSUMER

As mentioned earlier, agents can be various entities such as private or public business operator. But, only the utility can do business with the KPX(Korea Power Exchange : ISO in Korea) to operate the electric power system safely and efficiently. In other words, the utility can cooperate with the ISO (Independent System Operator) to solve the transmission line congestion problem and voltage, reactive power supply, contingency. In this paper, the agent of energy prosumer is discussed in the utility position.

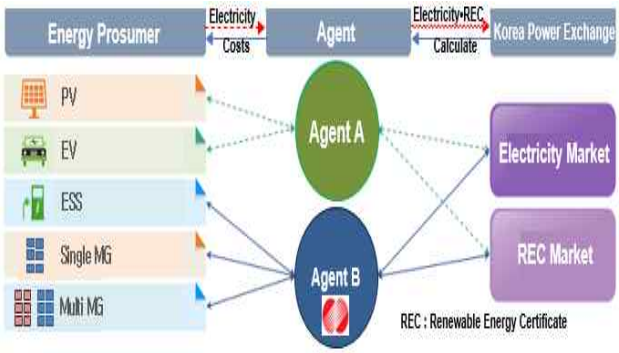

Figure 5. Overall Electricity Market Participants

At present, Korea electric power market is a CBP (Cost Based Pool), rather than a TWBP (Two Way Bidding Pool). If the generation companies submit their capacity of generators, KPX will determine the SMP (System Marginal Price) like a wholesale market. On the day, if there are the differences with day ahead plan, KPX will calculate the balance accounts for correction. Customers buy the electricity from KEPCO instead of buying the electricity directly from the market in Korea. However, the situation is expected to be much different from the current situation in Korea. Not only KEPCO but also the private company(prosumer) will be able to sell the electricity in the new laws changed. Under these circumstances, prosumer, a new participant in the market, can sell the rest of the electricity left over to either KEPCO or other customers. Also, because of the duty supply ratio of renewable energy in Korea, REC (Renewable Energy Certificate) can also be sold in wholesale market.

Figure 6. Relationship between KEPCO and Prosumer

It is strategic element whether KEPCO will passively deal with the prosumer on counter trade, whether KEPCO will be an agent for a variety of prosumer to sell its surplus electricity instead. Although detailed laws and regulations have not yet been established, it is essential that KEPCO has taken into consideration. If this agent role is allowed, KEPCO should carry out their bid and measurement on behalf of them. And then, revenue through the sale of electricity should return to each prosumer except for the commission on sales. Thus, in order to act as such agent, the agent system is required as below. The agent system checks the plan of bids and facilities status information of prosumer from microgrid EMS whether there are physical and financial problem.

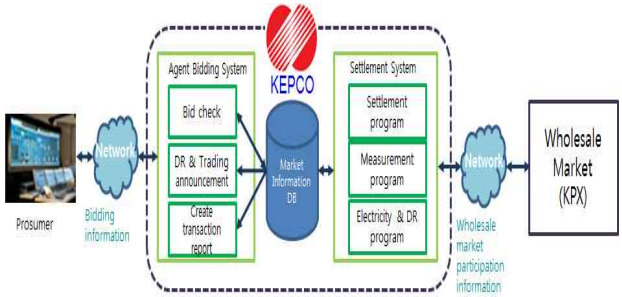

Figure 7. KEPCO Agent System

The agent system of KEPCO receives bidding information of electricity from customers (prosumers) on the day before the trading day of the electricity market. The agent system will bid on the wholesale market (KPX) for electricity and REC, DR. At this point, KEPCO, the position of the agent, aims to maximize the following function.

$$\text{Max } (P + REC + DR) - (W+C) \quad (1)$$
$$\text{s.t Local network constraints}$$

P, the price of the surplus electricity generated by prosumer, is the cost of the agent's electricity to the wholesale market. W is the cost of purchasing from wholesale market to supply electricity to customers in KEPCO. C is the cost of contract for electricity purchase by prosumer in KEPCO. In formula 1, constraint conditions, such as power flow equation and thermal capacity constraint of distribution line, etc., are added for stable operation of the local electric network in the physical position (or area) of the agent.

Object function can be thought as commission fee of KEPCO. If there are multiple agents, the formula will be more complicated. It would be a strategy for each agent to do their business.

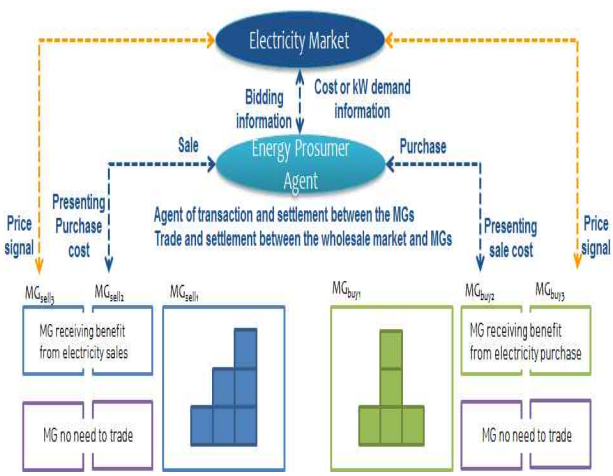

Figure 8. Role of Agent

IV. CONCLUSTION

Because the microgrid system has not only loads but DERs, it is necessary for interconnection guidelines and control coordination. Therefore, we must provide new rate system to be complicated for generation and consumption of electricity but not existing uniform rate system. In this paper, we provide the technical and financial management planning for distribution network of KEPCO as agent and utility. In the near future, the distribution network environment will have more complexity in technological and financial aspect. Without the support of utility, it will be very difficult to spread the commercial microgrid system services.

Therefore, it is important for KEPCO to get revenue as an agent. This profit can lead to delay and reduce the construction cost of transmission and distribution line. Further reliability can be achieved in electricity network operations.

This environment is not only effective in utility, but also for others. The prosumers can reduce their electricity cost by selling surplus energy. Customers can reduce their electricity fee, high block rates in Korea, by purchasing relatively cheap electricity from prosumer. Thus, social welfare can be increased by reducing the total amount of electricity energy.

Table 1. Expectation Effectiveness

Classification	Prosumer	KEPCO as Agent	Other Agents	Customers
Transaction	Sales of surplus electricity	Agent and settlement	Agent and settlement	Purchase of electricity from prosumer or agent
Effectiveness	Sales profit ↓ Reducing electricity cost	New biz. Profit ↓ Reducing transmission & distribution line construction cost	New biz. Profit	Reducing high block rates cost

To promote the green and high efficiency energy system actively, we have to prepare thoroughly in advance. This paper presents the strategic planning of KEPCO to promote the future electricity system.

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