Smart Micro Energy Grid - Services, Solutions, and Business Models

Daekyo Jung, Youngeun Chang, Young-Myuong Kim

***Abstract*—In this paper, we propose an integrated micro energy grid platform service, solution based on artificial intelligence regarding energy management technology.**

KT deals with micro energy business models for Energy Efficiency (GiGA energy manager), Business model for Renewable energy (GiGA Energy Gen) and Energy Trade (GiGA energy DR, EV). We show how KT applied unique services, the solution in the micro energy grid, and also provide useful information about the KT micro energy business models.

The proposed KT-MEG platform is expected to be a solution to the problem of the production– a supply-demand imbalance in energy due to the high penetration of the renewable energy together with environment-friendly energy policies.

***Keywords*—Smart Energy Service, Micro Energy grid, Energy artificial intelligence**.

I. INTRODUCTION

The Internet of Energy (IoE) technology, which combines the information and communication technology (ICT) such as big data and artificial intelligence (AI) with the energy industry, is emerging as a hot topic. Using ICT, we can construct energy grids that can reduce power consumption and store electricity using energy storage systems (ESSs). The technology is expected to bring the fourth industrial revolution in the energy market.

Against this backdrop, we propose a novel platform that aims to (1) maximize energy production, (2) minimize waste, and (3) consume energy efficiently through intelligent management of energy (MoE) by constructing an IoE based on major ICT technologies. Those are Artificial Intelligence, the Internet of Things, Cloud, Big Data, Mobile, and Security (AICBMS[1]). This approach can be a solution to resolve the problem of the production– a supply-demand imbalance in energy due to the high penetration of the renewable energy together with environment-friendly energy policies.

For efficient and integrated energy management in the future, MoE will be necessary, in which the IoE technology is further developed to encompass AI and big data technology. The MoE technology is not limited to buildings and infrastructures; it needs to be able to manage and control energy in real time through analysis and prediction using AI. We propose a platform model that can create a new market by maximizing energy management through the MoE technology.

[1] AICBMS : **AI**-**I**oT-**C**loud-BigData-**M**obile-**S**ecurity

II. SMART ENERGY SERVICE (IOE& MOE)

A. IoE (Internet of Energy)

The Internet of Things (IoT) refers to intelligent technologies and services that connect all things using sensors and the internet to communicate information between people and things and between things. Likewise, IoE is a concept in which the facilities at each of the energy production–transaction–consumption stages are connected to the internet so that information is communicated to each other. In other words, it can be considered as an IoT where the "things" are limited to energy-related facilities.

B. MoE(Management of Energy)

We define the intelligent management of energy (MoE) as "an integrated energy management platform with intelligent management concept" that collects data regarding the IoE, monitors the desired situation, and optimally controls through various analysis and predictions. This allows for transaction optimization and distributed resource management as well as the maximization above of production, minimization of waste, and efficient consumption.

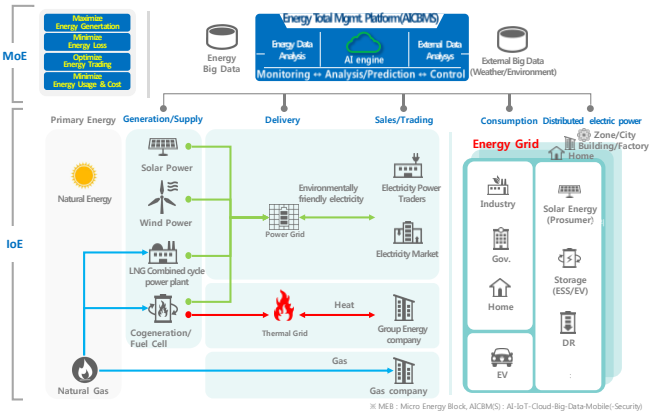


Figure 1. IoE & MoE architecture

Through the combination of IoE and MoE services, we are providing smart energy services.

In particular, in the case of distributed resources, constructing an energy grid in the form of a distributed structure around the consumer where the production such

as solar energy, ESS is directly connected to consumption such as factories, shopping centers, houses, and other facilities. The remaining or stored energy can be traded, which is called a micro energy block. To realize production–consumption–transaction simultaneously within such MEBs, the MoE, as well as the IoE, must be supported.

III. KT-MICRO ENERGY GRID & E-BRAIN

A. KT-MEG

The introduction of this MoE concept can change the conventional way of supplying and consuming energy, which depends largely on utility companies such as KEPCO(Korea Electric Power Corporation). Maximizing production efficiency and minimizing waste by balancing the demand and supply becomes feasible, which is achieved by reducing the peak demand through real-time peak management. Moreover, power generation can be controlled based on prediction, promoting energy recycling through storage. Also, it allows for real-time analysis of consumption information and optimal operation and control of the facilities to save energy, thereby enabling efficient consumption.

A representative example of MoE implementation is the KT-MEG (KT-Micro Energy Grid) platform equipped with "e-Brain," an AI engine. KT-MEG Control Center, which is in operation in Gwacheon, connects buildings including factories and apartments with facilities such as solar power plants, ESS, and EV charging infrastructure via the internet. It provides real-time remote monitoring and optimal operation and control services 24 h a day, 365 days a year, thereby creating a new energy market.

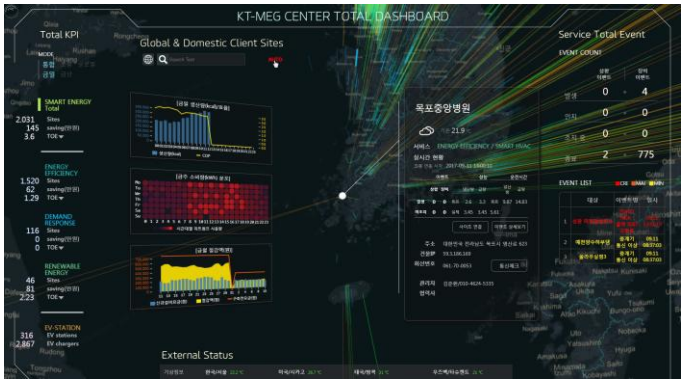


Figure 2. KT-MEG Dashboard Screen

B. e-Brain (Artificial Intelligence Engine)

The core of KT-MEG is energy analysis and prediction technology. There are unique patterns when customers consume or produce energy. KT developed an intelligent analysis engine (e-Brain) that analyzes such energy patterns like individual DNA in October 2016 and installed in KT-MEG. e-Brain automatically classifies the pattern and validates it continuously by applying big data and intelligence information (AI, machine learning) technology, thereby deriving energy DNA of individual customer and improving accuracy automatically.



Figure 3. e-Brain (Artificial Intelligence Engine Screen)

By the application of e-Brain, buildings can identify seasonal, day-by-day, and time-specific characteristics of energy consumption patterns and predict energy consumption during specific time intervals to prevent energy overuse in advance. Solar power plants analyze power generation patterns in response to changes in solar radiation and can detect problems in advance to take action if abnormalities in the production amount occur due to climate change.

Also, the KT-MEG platform uses energy IoT and cloud-based technologies for optimal operation of all smart energy services. These technologies provide real-time integrated operational management services, intelligent analytics engine based on big data, and integrated management of various customer services at an economical cost. Currently, KT-MEG Center links approximately 10,000 sites including renewable energy, energy efficiency, electric vehicle charging, and demand resources management and carries out real-time integrated control.

IV. BUSINESS MODEL FOR ENERGY EFFICIENCY

A. Energy Efficiency business (GiGA energy manager)

Recently, interest in energy-saving has been increasing. However, most companies except for the statutory diagnostic companies (high-energy-consumption group) who pay annual energy costs of more than KRW 1 billion (equivalent to the energy consumption of 2,000 TOE 2) do not know about their energy use level and improvement methods and often do not have any energy management specialist.

Based on the needs of such customers, KT launched the "GiGA energy manager" service in October 2016, which provides diverse analysis information for energy-savings by learning energy consumption patterns in buildings using an intelligent analysis engine based on big data (e-Brain).

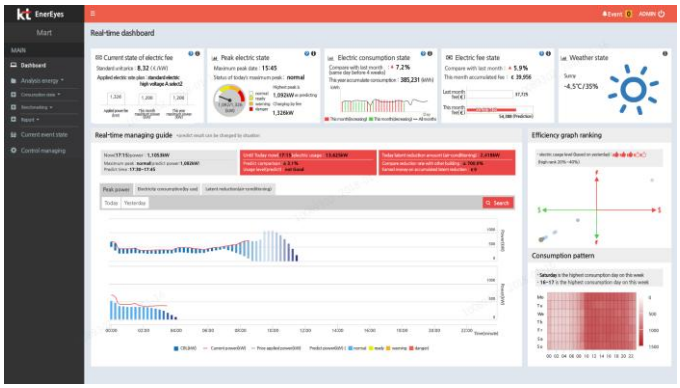


Figure 4. GiGA energy manager service screen

KT likens GiGA energy manager to an "energy health checkup." For the determination of health conditions, a medical questionnaire is completed through medical checkups and if any abnormalities are found, action needs to be taken for recovery of health or surgery is performed if necessary. As for the energy, it also needs to be easily diagnosed by anyone, and if there is an energy anomaly (waste or excessive consumption), one needs to be able to change the consumption pattern for normalization (waste minimization) or manage energy costs through facility retrofits (high-efficiency facility replacement).

GiGA energy manager brings information on power usage of building customers through KEPCO's i-Smart open API to provide analysis information according to weather changes and work patterns (work day and/or work time) and provides information such as peak forecast on the day. It allows customers to analyze the consumption patterns for the basic charge rate (peak power) and the consumption-based rates to reduce electricity bills.

Also, customers can recognize waste factors and savings factors in their daily work to efficiently operate power facilities and to determine when to replace LED/heat pumps or whether to participate in DR projects.

Electricity should be consumed at the same time when it is generated. That is, electricity that is not consumed is wasted. From this characteristic of electricity, real-time control is very important. KT plans to maximize the value of customers' energy savings by developing a service, which measures and analyzes real-time electric energy and provides real-time power management through remote control, on the platform of GiGA energy manager. It is an energy-saving service based on the MEG, which is the core of smart energy, and it will eventually contribute to the national energy savings.

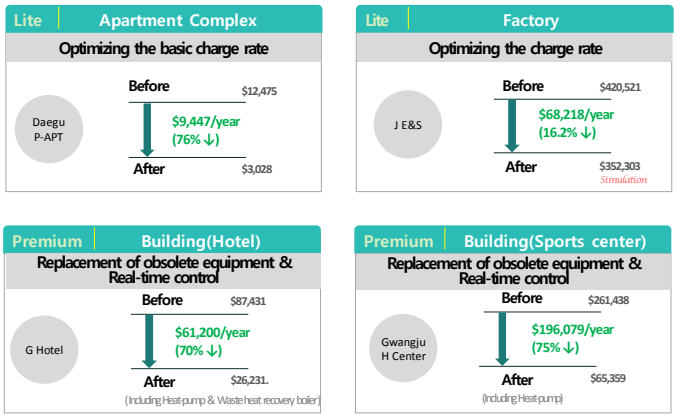


Figure 5. Benefits of GiGA energy manager service

V. BUSINESS MODEL FOR RENEWABLE ENERGY (PV, ESS)

A. Photovoltaic business (GiGA energy Gen-PV)

KT started the construction of a 7.5-MW-class Daechuck solar power plant in 2014, and now generates 33MW for solar power plants to provide 42,000MWh of environment-friendly power annually. Also, KT has been operating solar power plant with a total capacity of 1.3 MW at 16 sites using KT's telecom stations and idle sites and is continuously expanding it. In particular, operations at the Icheon Logistics Center and Hwenggye telecom station have linked solar power generation to ESS, leading the preparation for new energy markets and technology demonstrations.



Figure 6. GiGA energy Gen service screen

To increase the amount of new and renewable energy production, improving the efficiency of power generation through operation and management of existing facilities as well as facility expansion is necessary. In particular, small and medium-sized solar power plants with less than 1MW, which occupies 96% of solar power plants, are located in the blind spot of professional operation & management services, calling for immediate attention. Solutions to such issues can be resolved by integrated control and management of new and renewable power generation facilities using the IoE. If prompt on-site response based on real-time detection of system faults through remote monitoring becomes available, the optimal state of power generation facilities can be maintained, thereby contributing to the efficient operation of renewable energy power plants.

B. Energy Storage System business (GiGA energy Gen-ESS)

KT utilizes the building energy management system (BEMS) and the factory energy management system (FEMS) technology acquired through the communication network technology and the smart energy business to develop the optimal operating system (ESS-EMS) corresponding to the brains of the ESS system and completed preparations for full-scale business. The existing ESS EMS has been developed in a form suitable for the individual site and has been supplied in the form of a power management system (PMS) mainly by the inverter manufacturer. However, KT standardized the algorithms such as peak control, renewable energy stabilization, off-grid network control, and frequency adjustment, which are various functions to be performed by ESS, in library form and installed in ESS EMS.

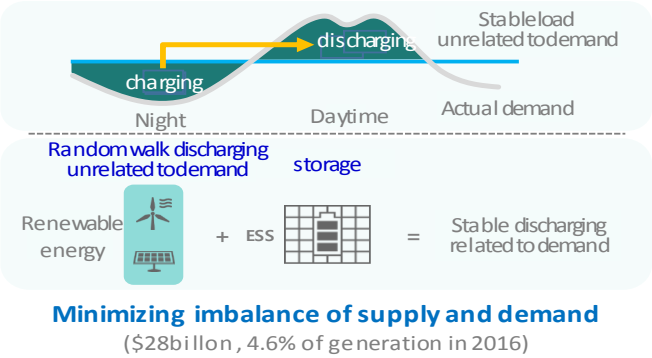


Figure 7. ESS Effectiveness

If ESS utilization is activated as shown in Figure 7, coal and gas will be able to maintain the lowest level of base power generation and spread renewable energy centered on solar power.

VI. BUSINESS MODEL FOR ENERGY TRADE (DR & EV)

A. Demand Response business (GiGA energy DR)

DR business enables Buildings, factories, and other facilities to sell electricity to KPX and to promote electricity demand resource management (DR) projects. The annual management scale is currently about 700MW. By monitoring energy use in real-time, KT is also able to advise customers when to make trades and reduce the risk of outages at times of high demand.

KT is also participating as a DR resource to spread and participate actively. When the KPX issues a DR command, it switches to an emergency generator via an uninterruptible power switch (CTTS). We applied CTTS technology to 60 sites of KT building last year and will continue to expand.

B. EV Charge business (GiGA energy charge)

In line with the expansion and expansion of electric vehicles, the electric vehicle charging infrastructure business is also underway. We installed more than 3,000 electric car charging stations around the country. KT also developed the mobile app named 'charging mate' that provides open and convenient customer services especially in payment and charging information management.

This charging service platform guides the directions to the nearest charging station, and reservations can be made to charge at the desired time.

VII. CONCLUSION

So far, we have covered the concept and examples of intelligent management of energy (MoE) that applies energy ICT technology from the perspective of "optimization of production," "minimization of waste," and "efficient consumption" for more environment-friendly energy.

For optimized energy management, energy platform technology that combines AI and big data technology is required, and we have proposed an energy integration platform structure for this.

The most important manner to prevent power waste is by balancing demand and supply through electricity trading. When prosumers participate more actively in sales of energy, prosumers with surplus resources can earn additional profits, while consumers in the grid with insufficient resources can purchase at a lower price than the market price. Also, from the standpoint of an independent grid connected to the IoE, even if the number of consumers lacking power increases, the burden of additional power generation is reduced because the issue can be resolved within the grid. In other words, eliminating the divisional loss through the transaction of the surplus resources in the zone and stable operation of the grid is possible.

The final solution is energy savings through energy efficiency, also referred to as the "fifth energy source." Energy loss can be minimized by real-time consumption management and optimal control using the IoE, together with energy diagnosis and analysis, resulting in the optimization of consumption efficiency.

Furthermore, if the open API is provided in the MoE platform to ensure open cooperation among various stakeholders, it would be easier to create new energy industries sooner, and the government could pursue its energy policy more efficiently. Energy-related equipment manufacturers would not merely manufacture and sell to facilities, but they can provide various types of supplementary services based on open platforms. Energy-related big data collected by the private and public sectors can also be interfaced with or shared, thereby making it easy to create various added values. Also, it is possible to get services provided by a platform or system in the form of vicarious management or sharing, instead of building them at a high investment cost. Also, users' needs can be satisfied with customized services through interworking with other platforms including facility management.

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Daekyo Jung received his BA and the MS degrees from the University of Seoul both in Wireless Communication and a Ph.D. degree from the Department of Future City Convergence Engineering from Sungkyunkwan University (SKKU), He is currently working as a Senior Principal Research Engineer at Korea Telecom R&D Center (2002~). He was a Visiting Scholar at University of California at San Diego (2015-2016). His research interests include IoT, Big Data, Smart grid/Microgrid and Smart cities. Dr. Jung led several projects including Detroit Guardian Building Energy Management System, U.S (2012), Korea Micro Grid Project (2012-2011), VTT Smart Eco Campus Project, Finland(2011-2013), and Smart Grid Pilot Project in Jeju, South Korea (2009-2013).

YoungEun Chang received her MBA degree from Seoul National University(2012). She has been working at KT as an ICT consultant since 2005 and is currently in charge of business strategy of KT′s smart energy business

Young-Myuong Kim received his masters of Science in Industrial Engineering and a Ph.D. in Management Engineering from KAIST. He was in charge of KT's Advanced Institute of Technology as a VP of technical strategy and management(2010~2014), and has been conducting consulting and planning for ICT convergence for both central and local governments. As an ICT technical expert, he was in charge of 'Ministry of Science, ICT and Future Planning' & 'Creative convergence CP(Creative Planner)' (2013~2015).
He is currently leading the energy business as an executive vice president of Smart Energy Business Unit.