Korea Micro Energy Grid Technology

The use case of the First-town in Sejong

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***Abstract*—This paper covers the subject on energy saving technology through the demonstration site. For developing and industrializing this technology, the four public buildings in the Sejong city's First-town were selected as the demonstration site: the office of community center, the postal office, the police station and the fire station. In the four buildings, Building Automation Systems (BASs) had been already installed but there are not in use because of systems' complexity. So, we connected BAS with BAS Gateway, and then we connected BAS Gateway with Energy Operation Center (EOC). As a result, it is possible to remotely manage buildings' energy usage at EOC, and it is expected that energy saving will be achieved by monitoring and controlling. Furthermore, we will develop energy optimization system with Building Energy Information Modeling. In this paper, the energy operation service for energy optimization is going to be introduced.**

Keywords—Smart Grid, Energy Control System (ECS); Graphic User Interface (GUI); Energy Operation Center (EOC); Building Energy Information Modeling; Energy Plus; Genetic Algorithm.

I. INTRODUCTION

According to UN report, 3E (Economy, Environment and Energy) issues come to the fore [1]. Especially, in a case of the energy, it much influences on the economy and energy so that the issue related with energy is much important. The increase of the energy demand contributes to the growth of CO_2, and it exerts a bad influence on the environment. Also, the waste of power use makes a nation's resource unnecessarily squandered, and as a result, it will diminish the economy.

For that reason, there are many countries which invest much money in the energy saving technologies, so called 'Smart Grid'. For reference, Smart Grid is a system that comprises intelligent electricity distribution devices, automated metering, and specialized computing system to enhance reliability performance system, enhance customer awareness and choice, and encourage greater efficiency of decision and of the utility provider [2].

In other words, smart grid is the technology that ICT technologies are applied in the traditional power grid. As already noted, Smart Grid is being considered prospective emerging market. According to SBI report which is famous research institute of emerging technology market, the market of smart grid will grow up 20% annually and will form 180 billion dollars in 2014 [3].

If this emerging technology is applied over a city, the city is called 'Smart Green City which is remarked over the world.' Although Smart Green City does not only include smart grid, smart grid is a key point of construction of smart green city. Like Smart Grid, in many countries such as Canada's dockside or UAE Masdar, the project of smart green city is being progressed. In a case of South Korea, Smart Green City plan is being headed by Multifunctional Administrative Construction City Agency (MACCA) in Sejong City. For that plan and smart grid application in Sejong City, MACCA contracted MOU with KT, the best ICT Company in Korea. As for demonstration, the First-town's four public buildings in Sejong are selected and the plan was taken on in the last year. In this paper, the smart grid technologies are going to be introduced through the case of demonstration site.

In second section, the technologies for energy operation service are going to be described, and then the technique will be presented for how to save energy. In final section, the expected effect will be dealt with if these technologies are applied over Sejong city.

II. THE APPLIED TECHNOLOGY FOR ENERGY OPERATION

In this section, it is going to be introduced which technologies were applied for establishing Energy Operation Service. And it is going to presented what the technologies are briefly.

A. The demonstration buildings

As the test bed, the four public buildings were chosen at the First-town: the office of community Center, the postal office, the police station and the fire station. Through the test bed, the method of energy analysis, Return of Investment and the development of smart grid will be done.

In selecting demonstration site, we visited a site, we found that in all the buildings, Building Automation Systems (BASs) were already installed, which is the building's facility management system for energy efficient. In other words, Light & Electricity, Geothermal Heat, and Air-conditioning and heating systems were separately installed at each building. But each system was not used because the buildings occupants do

not know how to operate those, and they do not have the time to operate it. To give you an opinion, it is difficult for a policeman who is busy with the public service and do not have an expert skill in BAS. So, those systems were not managed at all.

B. *Energy Control System (ECS) or BAS Gateway*

For the building's easy control and integration of BAS, Energy Control System (ECS) was developed at each building. For reference, the method of connection is different by the system. At each building, the network of the Air-conditioning and heating systems is Ethernet, that of lightening systems is RS232C, and the link type of geothermal systems is TCP/IP. So ECS plays role to unite the different systems' link and makes the users to be wirelessly access on the energy usage on anywhere and anytime through XML and network. What is more, in a case of the test bed, the data of energy usage was really huge and must be stored in a server which has large capacity so that for the transmission of data to the server, ECS was used as a transmission system (see Figure 1).

C. *Graphic User Interface (GUI)*

GUI is a type of user interface that allows users to interact with electronic devices using images rather than text commands [4]. GUI is useful because it makes a user easily to understand the computer system. For that reason, GUI was developed and applied for easy energy management. Therefore, an operator in Energy Operation Center and users can easily understand and control energy usage (see Figure 2). Before the GUI and the ECS were set up, twelve screens should be needed to monitor all systems with residing in the four public buildings. However, after the development of the GUI and ECS, only one screen is enough because the GUI screen represents all the information from the foul public buildings through ECS at one screen.

Because all of BAS systems were linked with BAS G/W, in GUI screens, the electric use in lightning, air-conditioning and geothermal are represented. And the detailed electric usage from the digital meters installed at the buildings is showed by daily, week and month, by facility and by floor.

D. *Digital Meters*

By the number of a room at each floor in the each building (refer Table 1), digital meters was set up to monitor electricity usage in detail. By doing so, the users can see how much energy is used by floor and facility. Moreover, they can easily know where energy is much consumed.

E. *Counter Sensors and Motion Sensors*

To more efficiently manage lights in buildings, counter and motion sensors was set up in the places where the rooms are often used by occupants (refer Table 1). The principle of controlling the light is as follows. When the occupant passes the door into the room, the counter sensors sense it and turn on the light. And when the people get out of the room through the door, counter sensors sense it; in the case that the occupant is in the room, the motion sensor is activated and ensure whether there are any motions; and if there are no motions, the light is be turned off. By doing so, it is expected to reduce the power consumption used for the lights.

F. *Energy Operation Center*

As represented in Fig1, all the data from the four buildings are transmitted to Energy Operation Center, and in it, an operator monitors and controls all energy uses at once. Because of that, just one operator can operate multiple buildings so that operating expenses can be largely saved. Especially, in the case of the four public buildings, building's energy management was not done at all and also it is difficult to hire an expert for it. To give you an opinion, if 15% energy is saved in the office of community center which consumes energy the most among the four buildings, the 600 dollars can be saved each month but this amount is much less than the hiring wage. For reference, the 2500 dollars are needed for hiring BAS specialist at least. Therefore, until now, energy management service is difficult to be applied in the small buildings. However, by ICT technology, each building's energy management can be syntagimatically operated so that the energy management becomes possible in small buildings. Especially because energy optimization automation system will be applied, one operator can manage many buildings. So, the more building is added, the less overall cost is, like economic effect.

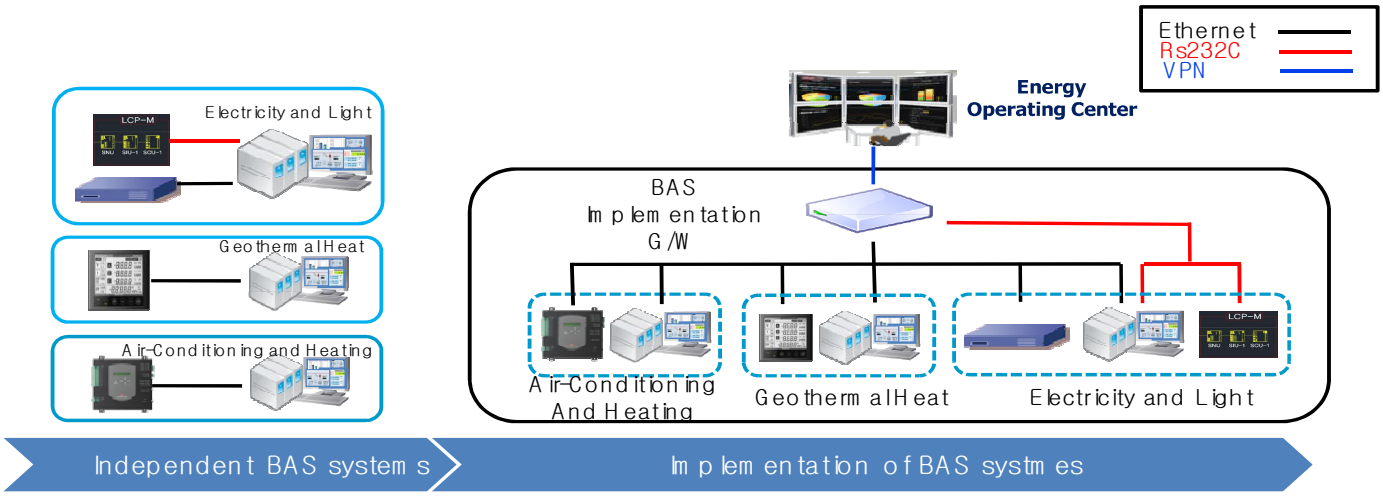

Fig 1. BAS G/W System's Concept

Fig 2. GUI screen for Sejong City's Energy Operation

TABLE I. DEVICE SETUP INFORMATION

Building	Location	Digital Meters	ECS
Office of Community Centre	B1	2	1
	B1	27	-
	F1	26	-
	F2	2	-
	F3	15	-
	F4	-	-
Postal Office	B1	15	1
	1F	2	-
	2F	2	-
Police Station	B1	14	1
	1F	2	-
	2F	2	-
Fire Station	B1	14	1
	1F	2	-
	2F	2	-
Total		127	4

Building	Location	Counter Sensor	Motion Sensor	On-off Swithch
Office of Community Centre	B1 Parking		4	1
	B1 electric& equipment Room		6	2
	F1 Reference Room	1	2	1
	F2 U-City Server Room	1	1	1
	F2 Culture Education Room	1	1	1
	F3 Toilet	2	2	2
Postal Office	1F Toilet	2	2	2
Police Office	1F Toilet	2	2	2
	2F a staff lounge	1	1	1
Total		10	21	13

III. ENERGY SAVING TECHNOLOGY

In the previous section, the base system for energy operation was introduced, which was completed in Feb.2013. Afterwards, the additional technologies for energy saving will be developed, and it is expected that 10~15% energy saving which is the objective of the project will be achieved with using all of the applied technologies. In this section, the technologies for energy saving are going to be decribed.

A. 3D Building information Modeling (BIM)

For more accurate analysis and intuitive surveillance of energy consumption, 3D Building Information Modeling (BIM) was developed (see figure 3). Because of that, the users and operators are able to analyze the energy usage, based on 3D modeling. For reference, the term of Building Information Modeling (BIM) is the technology to generate and maintain information which is produced during the whole life cycle of building from design to maintenance and is applied to various fields, e.g., energy management [5]. So, in addition to use of energy monitoring; with an algorithm and energy plus which is an environment simulation system, BIM can be utilized for energy optimization system, which is called BEIM (Building Energy Information Modeling).

Through the weather data and location information, the system is able to figure out the inner condition, and the system begin try to optimize inner environment with least energy usage.

By doing so, unnecessary energy usage can be avoided. For example, in the case of bright area, lighting may be unnecessary or a little bit intensity of illumination may be needed. In this case, through the grasp of external environment information, the system would try to former optimal environment by reducing down the intensity or turning off the lighting. By doing so, energy saving can be achieved.

B. Big Data Analytics

Because the data of energy use from the buildings are so huge, the servers which can contain it are required. So the data will be sent to Total Operation Center's server located at KT Mapo center in Seoul and the data will be analyzed. Through big data analytics, it is possible to expect how much energy will be used, and the control of energy usage will achieved. By that system, it is expected that unnecessary energy use will be reduced much. To sum up, BEIM is the technology to make energy usage efficient.

C. Genetic Algorithms

Genetic algorithm is the search method based on principle of natural selection and genetics [6]. They combine survival of the fittest among string structures with a structured yet randomized information exchange to form a search algorithm

with some of the innovative flair of human search. Since introduced by Holland, GA has been used in a scientific and economic research to find out solution [7]. So, in case of building energy operation, through GA application, GA is able to be used to find for the operation method for energy optimization, based on randomized information exchange and mutation which bear the better result than before. In fact, it is impossible to find out optimization solution; therefore, GA is continuously being run just to find the better solution than before because it was programmed to find the optimization environment which does not exist in real world.

D. Energy Saving Technology Application

In sum up, 3D BEIM measures an indoor environment condition with Energy plus simulation and determines how operate facilities such as HVAC (Heating, ventilation and air-conditioning) or lightning. In a process to find out how to operate in maximizing both the indoor condition and energy efficiency, GA is utilized. And big data analytics informs the pattern of energy usage; and if it finds the deviation that the power consumption is different from that of normal day, it begins to analyze why it is different and to adjust the energy management system or the facilities for normalizing.

E. Energy Management Service

Although the system is excellent, the system cannot help having the some problems or some lacks because there are no perfect system. Therefore, to manage the system and to perform thing that the system cannot do, a specialist is required. So, it is possible that an energy expert checks the building energy usage efficient by monitoring and directly consults it with an occupant.

For example, in the case of the demonstration site, it was figured out that geothermal facility has the problem and we consulted it with the building's occupants. And now energy experts are trying to solve the problem. Furthermore, it was identified that energy fees are charged because of wrong contract power. As a result all building owners can paid more 600 dollars per month which account for about 15%. Thus, our teams are seeking an appropriate the contract power.

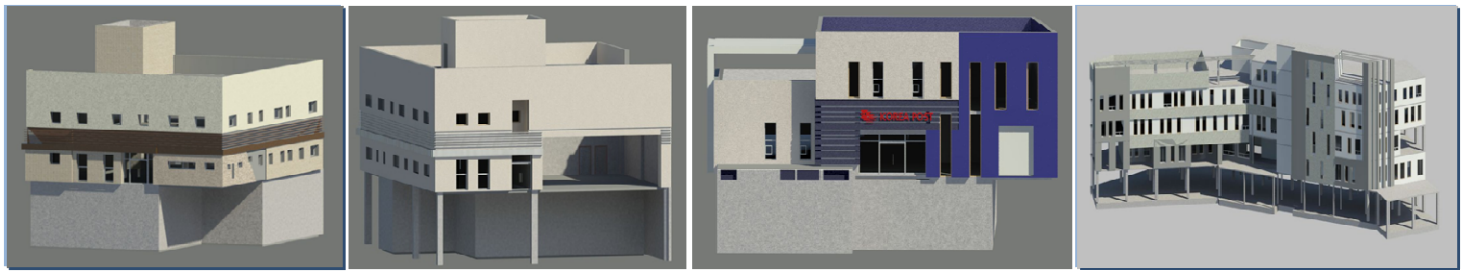

Fig 3. 3D Simulation of the pilot building (police office, fire station, postal office and office of community Centre, from left)

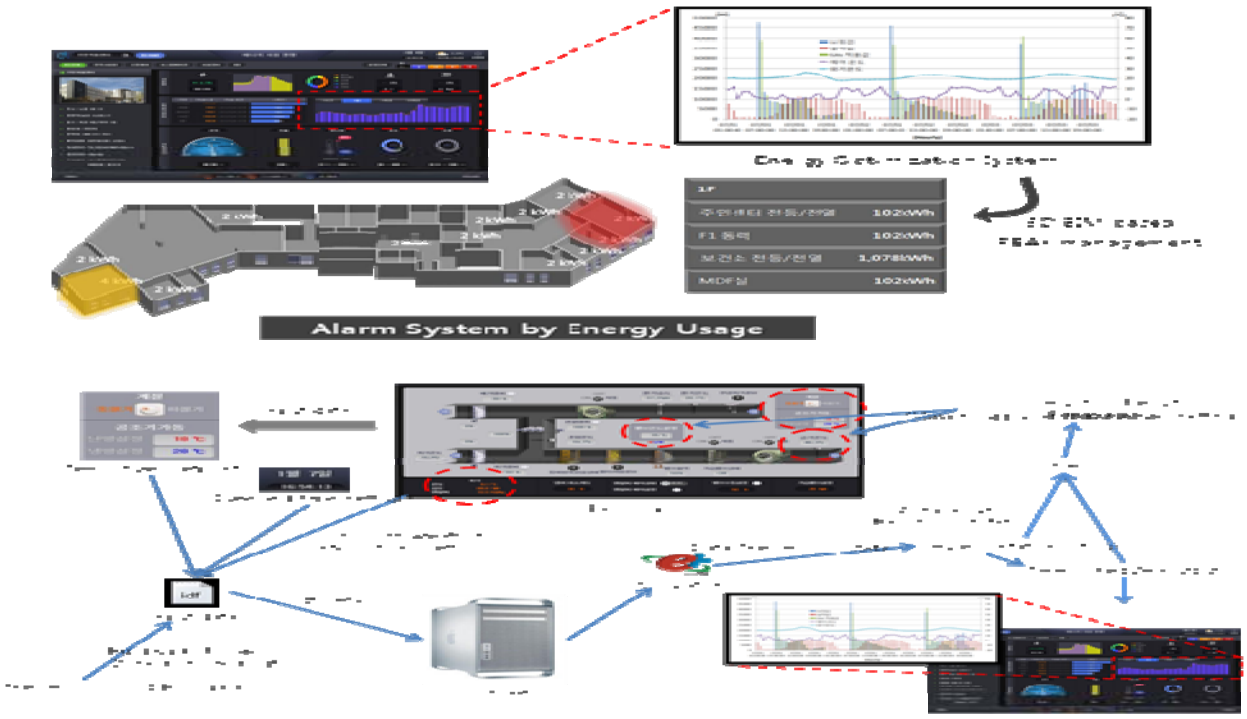

Fig 4. BEIM-based energy efficieny optimization

IV. SUMMARY

In this paper, the energy saving have been introduced. Additionally, as already noted, the energy optimization system will be developed with GA, and 10~15% energy saving will be achieved in the four public building. If the project is finished successfully, these technologies will be applied over the whole of Sejong City and all buildings in Sejong will be managable remotely and automatically. For reference, according to an economic analysis, if 10% energy saving is achieved in 500,000 home through these technologies, 40 million dollar (400,000 kWh) can be saved per year. Therefore, energy saving technologies have the positive effects not only on energy and environment but also on economy as already mentioned in 'Introduction.' Therefore, energy saving, Smart Grid, should be actively invested and be spread over, as a green technology and a technology of growth driver.

ACKNOWLEDGMENT

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