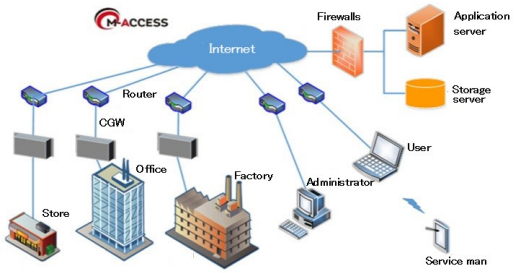
Remote Monitoring and Energy Saving of Air Conditioners
M-ACCESS Air Conditioner IoT Remote Monitoring System



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Recently, there has been a growing need to connect home appliances to the internet, and there is a similar trend in commercial air conditioners installed in office buildings. If there were a system that can monitor and control the operating status of air conditioners at remote locations, it would be possible to pre-cool and pre-warm by the air conditioners when users return from outside, also making it possible to turn off air conditioners remotely. Furthermore, the power consumption of air conditioners is said to account for 20% to 40% of the annual power consumption of buildings, and by optimally controlling air conditioners, it is possible to reduce this amount. M-ACCESS is a system that automatically controls the power consumption of air conditioners using cloud-based servers, and this system realizes energy saving without spontaneous operation by users. This system also contributes to the control of global warming through development on a global scale.

1. System overview

Figure 1 shows an overview of the entire M-ACCESS system. An application server and a storage server are built on the cloud, and the application server performs functions such as information visualization, energy saving control, and e-mail notification, while the storage server has the function of storing the operational data of the air conditioner.

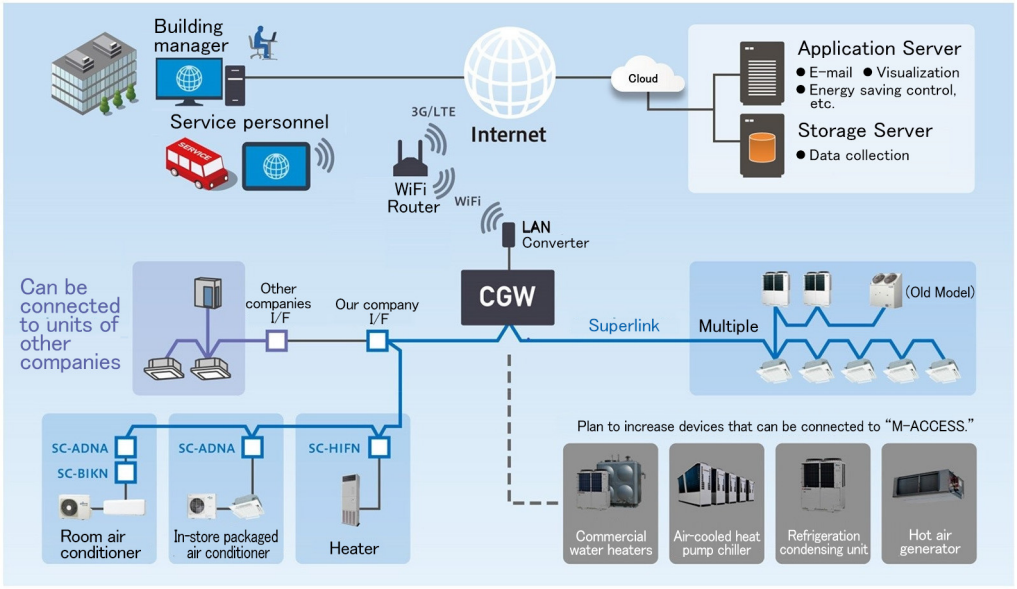

Figure 1 Overview of entire M-ACCESS system

An exclusive gateway (CGW) is also installed in the building to be monitored, and the building is connected to the internet by ethernet communication (separate wireless module). Our company's multi-package air conditioner and gateway can collect data on air conditioner operation by connecting to our exclusive communication line (Superlink communication line). Even for existing air conditioners, M-ACCESS can be installed simply by connecting this "Superlink

communication line," and the installation cost is very low.

Room air conditioners, commercial packaged air conditioners, heaters, and air conditioners of other companies can be also connected, although their functions are limited through the interface.

2. Functionality

Table 1 lists the functions of M-ACCESS. This paper introduces energy saving control and signage display, which are two characteristic functions.

Table 1 Function list of M-ACCESS

Item	Contents
Indication of operation status	Displays the operation/stop status, operation mode, air flow, set temperature, indoor temperature, and error status of each air conditioner.
Operation of the air conditioner	Change settings for operation/stop, operation mode, air flow, and set temperature of each air conditioner.
Power consumption trend display	Displays the power consumption of the air conditioner for the past 13 months in 1-minute increments.
Operation status trend display	Displays the change of set temperature, indoor temperature and outdoor temperature for the past 7 days.
Signage display	Displays the daily power consumption of air conditioners in real time using a bar graph. When energy saving control (control of annual power consumption target) is set, the degree of energy saving achieved is clearly indicated by a change in the background color.
Demand control	The operating target of the air conditioning system is set in advance, and the set temperature, air flow, and operating conditions are controlled collectively to reduce power consumption, such as peak cutting. Two control methods are available.
Energy saving control	Sets an annual power consumption target and implements automatic control of air conditioning while maintaining comfort to achieve the power consumption target.
	The outdoor air temperature is monitored, and registered air conditioners are controlled (e.g., shifting of preset temperature and reduction of air flow).
Schedule operation	The calendar is registered and the air conditioner operates according to the set schedule.
Failure detection	Detects signs of a specific fault before it becomes an abnormality, and sends information via email.
Abnormal report	Sends information via email if there is an error in the air conditioner.
Report Output	Reports total operating hours, total power consumption, temperature, top 10 operating hours, and abnormality history in PDF format.

2.1 Energy saving control (control of annual power consumption target)

M-ACCESS automatically calculates the monthly, daily, and hourly electric energy target for the user's setting for annual electric energy target, taking into account the information on the expected maximum and minimum temperature and the user's air conditioner usage. The air conditioner achieves energy savings, which the electric power consumption target is specified by M-ACCESS, by adjusting the compressor speed. However, if the M-ACCESS determines that the difference between the set temperature and the room temperature will increase due to the limited capacity, and that there is a possibility of compromising comfort, energy saving control is temporarily stopped. Thereafter, the difference between the set temperature and the room temperature is checked again every hour on the hour, and if the difference is less than a certain value, the energy saving operation is resumed. There is a difference between the target value and the actual value of the electric energy, but this difference is checked every hour, every day and every month, and the target values for the next hour, the next day, and the following month are reviewed to control the electric energy target set by the user throughout the year.

Figure 2 presents the results of energy saving control at a building in Osaka City. We measured and compared the electric energy consumption for 10 days with and without the energy saving target of 20%. The average maximum temperature and average minimum temperature during the 10-day test period were within ± 0.3°C, respectively, with and without control, therefore the test environments can be evaluated as almost the same. As a result of the test, the average daily power consumption was 400.1 kWh without control and 312.2 kWh with control. The power consumption was reduced by about 22% as seen in **Table 2**. The difference between the set temperature and the room temperature (mean deviation) was increased by about 0.28°C through the implementation of energy saving control, but none of the building residents felt uncomfortable according to our interviews.

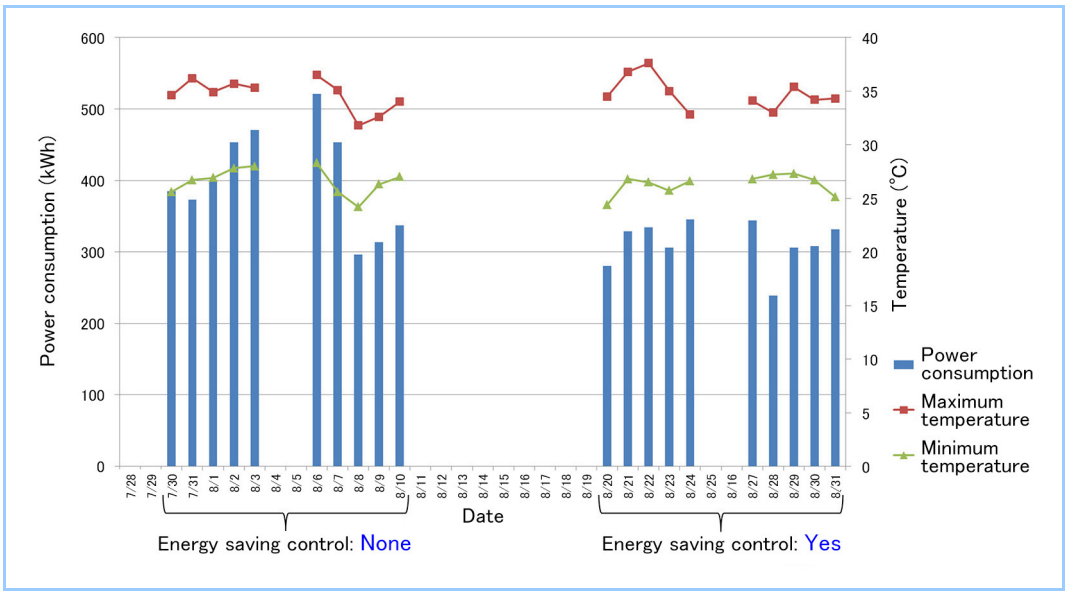

Figure 2 Energy saving effect through control of annual electric energy target

Table 2 Energy saving control results

Measurement period	Energy saving control	Average maximum air temperature	Average minimum air temperature	Thia	Ts	Mean deviation	Average power consumption	
		[°C]	[°C]	[°C]	[°C]	[°C]	[kWh/day]	
7/30 to 8/3, 8/6 to 10	None	34.7	26.6	25.8	24.9	0.86	400.1	Energy savings of about 22%
8/20 to 24, 8/27 to 31	Yes	34.8	26.3	26.6	25.5	1.14	312.2	

* Maximum and minimum temperatures are quoted from Japan Meteorological Agency data (Osaka)
Thia is the average indoor temperature during the operation of the air conditioner.
Ts is the average set temperature during operation of the air conditioner.

2.2 Signage display

Signage display is a function of visually displaying information on the air conditioner's current power consumption to the user by changing the background color of the screen. **Figure 3** illustrates how the background color of the screen changes. In the energy saving control as mentioned in paragraph 2.1, the calculated electric energy consumption target per day is compared with the actual electric energy consumption, and the background color changes from blue to red according to the ratio. Users can see the air conditioner's situation immediately on the screen, and this system is expected to enhance user awareness of energy saving.

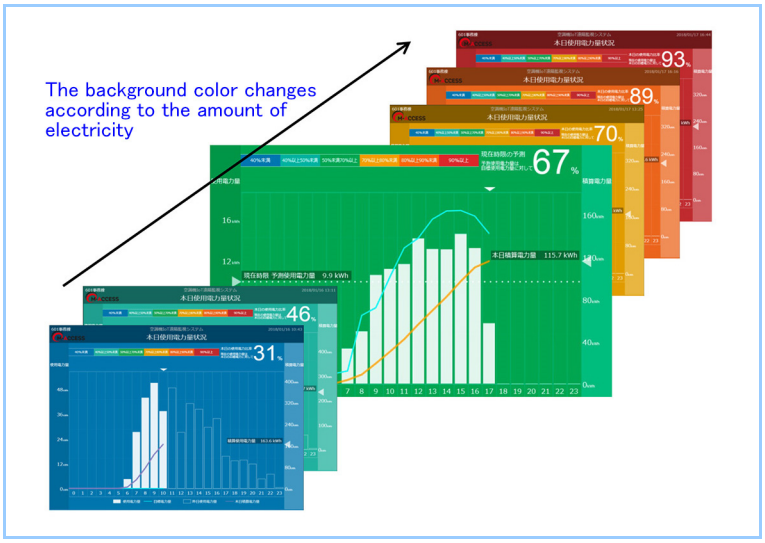

Figure 3 Signage display

3. Future Development

Effective energy use has become important worldwide, and energy saving through remote control is attracting attention, as are efforts to improve the efficiency of equipment. As mentioned at the beginning of this paper, we will further improve performance and functions, expand the range of interconnectable equipment, and develop our business overseas. We will also develop environmentally-friendly products and services on a global scale through an integrated system of cooling and heating equipment.