Development of Evaluation Techniques for Energy Saving Retrofitting of Existing Office Buildings

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1. Background and purpose of research

In order to realize decarbonization in Japan, further energy saving of not only newly built buildings but also existing buildings is indispensable. In office buildings, etc. (non-residential buildings), re-design based on the diagnosis of the current condition at the time of equipment renewal (air conditioning and lighting, etc.) to be performed every 10 to 20 years enables great energy saving effects to be obtained by reasonable additional investments (Fig.-1). However, such retrofitting (energy saving retrofitting) is not well recognized at present, and it is very seldom performed. Therefore, in this research, techniques are developed that evaluate quantitatively to what extent energy consumption can be reduced by retrofitting, for the purpose of providing guidance for retrofitting with greater effects. Here, when formulating a retrofitting plan, it is the general practice to determine whether retrofitting should be performed by simplified evaluation, and for a prospective building, to carry out detailed studies by conducting a survey, taking time. Therefore, 2 types of methods are developed: "simplified evaluation method" in which energy saving effects are roughly estimated in a simplified manner by conducting a current condition survey of about 1 hour; and "detailed evaluation method" in which energy saving effects are estimated precisely by considering the actual operating conditions of the building based on a more detailed survey. Note that both of the evaluation methods are based on the program used for determining conforming to building energy codes when constructing a new building (web program), and the settings of default values and expansion of functions are made so the program is more suitable for the evaluation of existing buildings.

2. Overview of the developed evaluation methods

(1) Simplified evaluation method

The simplified evaluation method has been designed to be a method that enables evaluation to be performed without taking time as much as possible by performing simplification shown below, based on the "model building method (for small buildings)."

- The range of entry of the building envelope and equipment specifications is limited to that of a "representative room."
- Regarding thermal insulation specifications (thermal insulation material type, thickness) and opening area specifications (performance of window frame and glass), default values are set that are used when the specifications are unknown.
- Ventilation equipment is excluded from the target of entry, and the target of entry of the hot water supply equipment is limited (only kitchen and bathroom uses in part of the building uses).

Information required for evaluation by the simplified evaluation method is shown in the table. If these 13 items can be grasped by the current condition survey, the current energy performance (BEI; a value obtained by dividing the estimated value of energy consumption of the building by the reference energy consumption specified by the national government) can be calculated. Also, by changing the value of each item, it can be grasped quantitatively to what extent the energy saving performance will be improved by retrofitting.

(2) Detailed evaluation method

The detailed evaluation method has been designed to be a method that enables energy saving performance more precisely, on the basis of the results of the current condition survey, by adding the functions shown below based on the "standard input method."
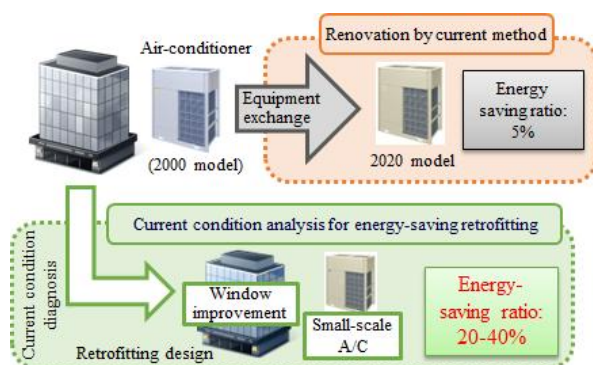

Fig.-1 Energy saving retrofitting work based on diagnosis of the current condition

Table Information required for evaluation by the simplified evaluation method

	Entry item	Current condition survey method
1	Regional category (select)	To be selected from location
2	Building use (select)	To be determined by interviewing
3	Floor area of the portion subject to calculation [m²]	To be calculated from drawings
4	Floor area of the portion subject to calculation to be air-conditioned [m²]	
5	Type of opening area/fitting (select)	To be checked visually at site (Use existing values, if unknown)
6	Type of opening area/glass (select)	
7	With or without of blind (select)	
8	Type of exterior wall/thermal insulation material (select)	
9	Type of roof/thermal insulation material (select)	
10	Type of air conditioner heat source (select)	
11	Rated capacity of air conditioner heat source (cooling, warming) [kW]	
12	Type of main lighting equipment (select)	
13	Type of main hot water supply equipment (select)	

a) Confirmation of whether thermal insulation is performed through a ceiling inspection port

b) Confirmation of the capacity of air conditioning heat source (outdoor unit) on rooftop

Fig.-2 Trial of the simplified evaluation method (scenes of the current condition survey)

- The weather conditions (temperature, solar irradiance etc.) on the construction site can be entered.
- The room use conditions of each building (usage time of each room, air conditioning period, air conditioning setting temperature, lighting usage time, occupant density) can be entered.
- The actual performance of each piece of equipment/control (energy performance curve of air conditioning heat source and energy saving effects by means of automatic control) can be entered.

Although much information is required to perform evaluation by the detailed evaluation method, such information is required definitely when designing retrofitting. By proceeding with retrofitting design while performing quantitative evaluation by this evaluation method, retrofitting proposals with greater effects can be derived.

3. Trial of evaluation
(1) Simplified evaluation method
As an example of trial, Fig.-2 shows the scenes when applying the simplified evaluation method to an office building located in Tokyo (10-story, about 900m²). The current condition survey was conducted by 4 persons, and was completed in about 1 hour. The current BEI is 1.17, and it has been found that, by renewal of the air conditioning units and lighting equipment, energy saving of about 30% can be achieved.
(2) Detailed evaluation method
As an example of trial, Fig.-3 shows the results of applying the detailed evaluation method to an office building located in the Philippines (4-story, about 7,000m²). The current condition survey was conducted by 3 persons for 2 days. Based on the results of the current condition survey, evaluation was carried out by entering the weather conditions and room use conditions of the building. It has been found that, by retrofitting the windows (introduction of vacuum glass), air conditioning (efficiency improvement, miniaturization), and lighting (introduction of high

a) Enter the actual conditions of the target building (left: weather conditions, right: room use conditions)
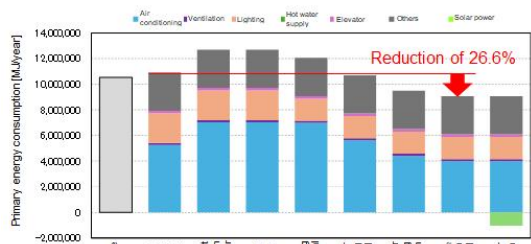
b) Study of retrofitting proposals

Fig.-3 Trial of the detailed evaluation method (studies of retrofitting proposals)

efficiency LEDs), there is an energy saving effect of 26.6% even when considering an increase in energy consumption by the introduction of ventilation fans that are not installed at present, and energy saving of 36.6% can be achieved by additionally installing solar power generation (117 kW).

4. Conclusion
For the purpose of further promotion of energy saving retrofitting of existing office buildings, etc., techniques for evaluating energy saving retrofitting effects (simplified evaluation method, detailed evaluation method) have been developed. In future, we would like to create easy-to-use interface, and at the same time to attempt to add retrofitting proposal support functions by utilizing AI.