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A study on the proposes of energy analysis indicator by the window elements of office buildings in Korea

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ABSTRACT

Recently, the window area ratio of buildings has increased but the thermal insulation performance of windows is lower than the wall. Therefore, many studies have been carried out to reduce this heat loss. The Republic of Korea policies and guidelines for windows do not consider the optical and design elements of windows because it is more important to the insulation performance of windows. This paper proposes the supplement point of the Korea's policies and guidelines regarding windows through a comparison of Korea's policies and guidelines for windows, checks the variation of the energy consumption of buildings through the variation of the window elements, and proposes an energy analysis indicator for the Republic of Korea's situation. This study confirmed that the variation of the window elements affect to energy consumption by previous studies to consider in window design according to the policies and guidelines. The window elements were divided into performance elements of the windows and architectural/equipment plan element. By analyzing the energy consumption by changing the element, this study confirmed the variation of energy consumption by using the COMFEN4.0 simulation tool. This paper proposes an actual energy analysis indicator in the Republic of Korea.

1. Introduction

The world regulates carbon dioxide emissions to help solve the energy crisis. Accordingly, the Republic of Korean government announced 'A low-carbon, green growth' aim to be 7th in the word in 2020 and 5th in the world by 2050 [1]. The government proposes a detailed policy: 'Building Energy Conservation Design Standard' about 'Energy-efficient Buildings' among the many policies for energy saving in the architectural field. This policy is applied to new buildings and requires existing buildings to submit a building energy-saving plan [2]. The government has made significant efforts for building energy-saving. The WWR (window-wall ratio) is increasing because the curtain-wall method is fashionable for reasons of view and age-flow [3]. Generally, an increased WWR results show an increased heat loss of buildings because the window has higher heat loss than the wall. The policy limits the thermal insulation performance to a limited WWR and proposes standards in policies and guidelines of window design of the Republic of Korea. On the other hand, the optical performance and orientation was not considered in detail.

A previous study examined the window element for decreasing the energy consumption of buildings by evaluating the energy consumption of buildings. Lin considered various elements (inter-heat, skin insulation, efficiency of boiler, etc.) when examining the building energy and studied the WWR and type of windows affecting the building energy consumption [4]. Yu used eQUEST, and examined the low-energy envelope design on a hot summer and cold winter zone in China. This study examined the effects of selected elements, such as WWR, type of window and shading, on energy consumption, and confirmed the electricity consumption of heating and cooling according to the variations of these elements [5]. Grynning confirmed the heat loss factor in buildings to predict the energy consumption of buildings because the performance of windows and the elements of the architecture have a complex relationship. A previous study examined the heat loss of windows using three methods to calculate the heat loss of office buildings [6]. These studies predicted the energy consumption of buildings and confirmed the window element as a way of reducing the energy consumption.

Many studies have confirmed the effects of the energy consumption of buildings by the variation of windows. Nielsen reported

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a diagram of the different performance of windows by *U*-Value and *G*-Value (Total solar energy transmittance) [7]. Ochoa considered the element of windows for energy consumption and optical comfort. In particular, this study proposed the result that considers the side of energy consumption and optical comfort regarding the WWR. They confirmed that the WWR has a significant effect on energy consumption and optical comfort [8]. Persson confirmed the changes in energy consumption according to the WWR, orientation and glazing type in a low energy house [9]. Oral compared many types of windows to identify a suitable window in terms of building heating [10]. Karlsson proposed a simple model to confirm the energy consumption by a variation of the window elements. The energy of windows was calculated in terms of building energy consumption by solar radiation gain and heat loss [11]. Therefore, many studies have performed quantitative analyses of the variation of energy consumption according to the variation of the window elements.

Energy consumption analysis of various windows, and a study on the local and actual situations are being carried out to consider their effect on buildings according to climate or region. Urbikain examined a window energy rating system from Spain. A Window Energy Rating System (WERS) provides a simple, approximate method to compare the energy performance of various windows as well as determine the different potential savings for a range of weather conditions. The Window Energy Rating System was proposed for residential buildings in Basque Country, which is expressed in kW h/(m^2 year), two method for the calculation. This considers the solar gain that is essential from a building-heating standpoint. Different windows can be compared and their relative heating energy savings for a reference building can be estimated using a simple equation [12]. Tian simulated a Typical office building in Hong Kong using WERS. A generalized WERS that considers all the primary influence factors was presented for a more realistic energy evaluation of typical office buildings. An application example showed that the algebraic WERS derived from the simulation results can be used easily for the optimal design of windows in buildings similar to a typical building [13]. Jaber examined thermal and economic windows design in three climate zones and proposed a thermal model and economic model from the results of zones by the WWR and type of window [14]. Su confirmed the effect on the environmental performance optimization of the WWR for different window types in the hot summer and cold winter zone in China in terms of the LCA (Life Cycle Assessment). This study can be a more accurate LCA prediction to consider the window element (WWR, orientation, glazing type) on LCA analysis in China [15]. Lee using building simulation modeling, evaluated a range of window properties, such as the *U*-Value, solar heat gain coefficient (SHGC), and visible transmittance (VT), with different window wall ratios (WWR) and orientations in five typical Asian climates: Manila, Taipei, Shanghai, Seoul and Sapporo [16]. Through these studies, they provided the energy consumption analysis of the window elements according to the actual climate and region.

Yasar used an energy simulation software to determine the effects, including the building energy consumption and economy, of different types of glazed units (solar control, heat conservation and solar control, and heat conservation glazed units) used in high-rise residential buildings located in the moderate-humid climate regions in Turkey [17]. Bojic examined the energy performance of multiple windows in a residential high-rise building in the hot and humid climate of Hong Kong [18]. Hassouneh examined the variations of the type of glazing using eight types of glazing (clear glass, types A–G) to determine the most appropriate in each direction. In addition, the orientation of the window is changeable in the four main directions (N, S, E, and W). The area of glazing was also varied in a different orientation to determine the effects of the window area on the thermal balance of the building. The results showed that if energy efficient windows are used, the flexibility of choosing the glazed area and orientation increases [19]. As above, studies of actual buildings with specific examples have been carried out.

In a Korean study, Park examined the energy use impacts of the SHGCs of windows in a detached house. This study confirmed the following result. The energy consumption of a building is decreases with decreasing *U*-Value of a window but the energy consumption variation by SHGC was different. This study revealed a problem of the policies of energy saving based on the *U*-Value in the Republic of Korea [20]. Another study proposed a typical WWR of Korean houses, and confirmed that the variation in energy consumption by the variation in the *U*-Value is larger than that caused by a variation in the SHGC [21]. In Korea, it is difficult to predict the energy consumption because the studies are limited to the thermal insulation performance and do not consider the optical performance. Yong-Sang, Yoon examined the Optimal Window Applications According to the Window Ratio (WWR) and SHGC in Office Buildings. In this study, a building energy simulation was conducted, and the influence on the energy performance was analyzed according to the WWR, Visible light Transmittance (VT), Solar Heat Gain Coefficient (SHGC) and *U*-Value. When the heat load and radiation were considered, the window area ratio was found to increase and the increase in energy consumption was not proportional. In the same WWR, much larger cooling energy consumption than heating was confirmed from the effects of the variation of SHGC. In a low SHGC, it was confirmed that the energy consumption is smaller at the maximum WWR than minimum WWR. This study proposed that the optical performance element and suitable WWR considered before the window design [22].

From the result, a study of the effect of the window element for the energy consumption of a building is being carried out but the government and guidelines proposed only a thermal insulation standard and did not consider complex elements. This study confirmed that the government and guidelines need to consider complex window elements because they have a complex effect on the energy consumption of buildings. Therefore, actual applications by policies and guidelines will decrease the energy consumption of buildings with a raised WWR.

In this study, the window elements were considered in window design through a comparison of the policies and guidelines for windows in other countries. From the results, the complement points of policies and guidelines in Korea were proposed. This study confirmed the effects of the window elements on the energy consumption. An energy analysis indicator according to the window elements in an actual environment in Korea is proposed.

In this study, the scope of the study is as follows: the policies and guidelines regarding windows in Korea and other countries were compared; the data was divided into the performance element of the windows and the architectural/equipment plan element. An energy analysis indicator was also proposed for the Republic of Korea.

In this study, the method in the study was as follows: the policies and guidelines for windows in Korea and other countries were compared; an energy simulation on applying a complex performance element of the window and architectural/equipment plan element was performed; and effects on the energy consumption of a building was confirmed by analyzing the heating and cooling energy consumption.

To propose the energy analysis indicator for the Republic of Korea situation, this study analyzed the energy consumption of buildings by the variation of the window element that considered to the policies, institution and guideline. This study proposed an energy analysis indicator.