Analysis on CO_2 Emissions Reduction Effect of Zero Energy Multi-famiy Housing to cope with UNFCCC

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Abstract

Korean government established a target to reduce greenhouse gas ("GHG") emissions to 30% by 2020 to cope with the United Nations Framework Convention on Climate Change (UNFCCC) and secure its national competitiveness, and prepared a roadmap to develop this project. Especially, the government set up the objective of Zero Energy Consumption for the newly constructed multi-family housings by 2025 to reduce CO_2 in the building sector.

This Study is aimed at the analysis of CO_2 emissions reduction effect when introducing the component technology for implementing zero-energy multi-family housing building by reflecting this trend at home and abroad. In order to do this, CE3 - Building Energy Performance Evaluation Program was adopted.

Keywords: Green Home, Empirically Demonstrated House, Passive, Renewable energy

Introduction

Global warming threatens survival of human being throughout the world in a variety of results such as drought, typhoon, flood, etc. Ironically, the acts of human being conducted for their survivals like industrial activities threaten survival of human being by emitting CO_2 that is a root cause of expediting global warming. In addition, a nation's CO_2 emissions represent the indicator to measure economy of the nation.

In the case of Korea, temperature has increased by approx. 1.7℃ for the past 96 years (1912~2008), which resulted in the loss of national land in part owing to the rise of sea level along with destruction of ecosystem. Furthermore, some advanced countries intend to use the control of GHG as a trade barrier in such a manner of banning imports from the country having high GHG emissions in the process of production.

Under the international circumstance like this, the issue of global warming became the task to be solved with top priority that cannot be delayed any longer, and Korea, therefore, prepared the plan for GHG reduction centered on Kyoto Protocol as shown in the Graph below.

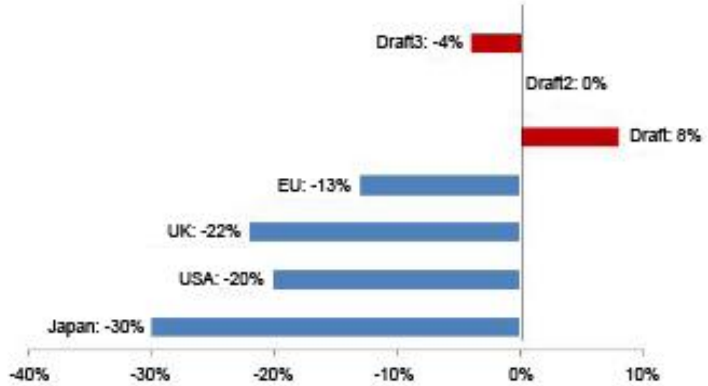

Fig. 1 Comparison of Korea's reduction target against those of the advanced countries

Korea selected the means of reduction by stages as shown in the Table 00 in order to accomplish the largest level of reduction for a developing country like 30% (4% from 2004) against BAU(Business As Usual) by 2020. Such amount of reduction is equivalent to such level of GHG being emitted from 2000cc Sonata for 49,300,000 persons (populations projected in 2020) to travel Seoul through Busan (round trip) for 24.7 times.

Table 1 Means of reducing CO_2 emissions

	Major means of reduction (Each includes policy means of the former scenario)
Draft 1	− Greening of Building/House − Reinforcing demand management such as high-efficiency facility, etc. − Changing into low carbon traffic system − Expanding the portion for new/renewable energy and nuclear sectors new & renewable − Promoting Smart Grid
Draft 2	− Removing fluoride gas that has high global warming potentials − Expanding the distribution of bio fuel − Introducing CCS in part
Draft 3	− Distributing next-generation green car (Electric vehicle, fuel cell electric car, etc.) − Expanding the distribution of high-efficiency product, electric appliances − Promoting strong demand-side management policy

Among the major means of reduction in Draft 1, the field that may most reduce GHG is the building sector. The ratio of residence to the building sector in Korea is 54% showing the highest of all, of which, the multi-family housing house occupies 53%.

That is, in order to accomplish the objective of reducing GHG emissions by 30% from BAU, it is inevitable to reduce CO_2 emissions from multi-family housing building sector. Therefore, Korean government established energy level of newly built multi-family housing houses to zero level by 2025.

This study is intended to analyze the possible reduction of CO_2 emissions from multi-family housing house using CE3 as the first step for quantifying CO_2 emissions and discuss on the method of utilizing the result of study in future.

2. Overview of Energy Performance Evaluation in Multi-family Housing

2.1 Energy Performance Evaluation Tool: CE3

In order to reduce CO_2 emissions, it is essential to forecast energy consumptions of the subject buildings. For this, this study adopted CE3 that is a tool for assessing the energy performance.

CE3 is the Web-based program aimed to assess building energy performance developed specially for domestic circumstance in consideration of EPBD (Energy Performance of Building Directives), International Standard ISO 13790, Germany's DIN V18599.

CE3 is the solution that enables to strategically analyze energy in comprehensive view of interaction of energy flow in accordance with physical or mechanical characteristic of the building on the whole, through which it is possible to suggest optimal direction by grasping the problem in energy performance sector at design stage and forecast the energy cost required for a year or CO_2 emissions.[1]

2.2 Building Energy Performance Level

In this study, energy consumption and CO_2 emissions of the building by stages from the Energy Reduction Design Standard (existing standard) to zero energy house were analyzed.

The subject fields of analysis are the buildings in general that are domestically built subject to 'Building Energy Saving Design Standard'. This standard suggests the obligation and recommendations by fields by categorizing the buildings in a certain scale into building sector, mechanical equipment sector, electrical sector, and new & renewable energy facility sector in order to improve energy efficiency and facilitate the reduction of GHG. The design standard in building sector suggests the standards of layout, plane, and lighting and ventilation plan of the building and recommends the users to observe the insulation performance of window and exterior wall. New & renewable energy facility sector was recently added since the importance of GHG reduction has emerged.

The next subject field of comparison is the case of minimizing energy consumption of the building by introducing passive component technology such as air tightness, high insulation, etc. In order to accomplish the objective established by the government by 2025, that is, Zero

[1] CE3 website: www.kihoo.co.kr

Energy Consumption of the Building, it is necessary to minimize building's energy demand through passive design, and then produce energy by introducing new & renewable energy facility. Currently, passive design standard requires the installation of Heat Recovery Ventilator with the performances of 15kWh/㎡·a for heating energy demand, 120kWh/㎡·a for primary energy demand, 0.6 times (@50Pa) for ventilation & recovery, and at least 85% for ventilation efficiency. In this study, the result of minimizing energy consumption was extracted following gradual introduction of a variety of passive component technology.

2.3 CE3 Input Data

The subject building of analysis was assumed to have dwelling exclusive area in 85m2/household comprising total 14 households for the application of multi-family housing, where two households per floor reside in 7 story building. In addition, the location of the subject building was assumed not to be influenced by the shade of the surrounding buildings when energy is produced by new & renewable energy facility.

The standard meteorological data that is one of the input values and standard operation profile in the analysis of building energy performance is the factor that may greatly influences on the result. In this study, the data of Korea Meteorological Administration clarified through TMY2 technique was adopted as standard meteorological data, while the value used when estimating energy efficiency grade of domestic building was selected for standard operation profile. When the standard meteorological data is applied, space zoning was conducted broadly into air-conditioning space (living room, room, kitchen), non-air conditioning space stair case, and elevator shaft.

Table 2 CE3 Input value by zones

Input value		Air conditioning space	Non air conditioning space
Preset temperature	Heating	20℃	-
	Cooling	26℃	-
Energy demand for hot water supply		129.84Wh/㎡	-
Lighting	Required illuminance	300lx	100lx
	Power consumption	8W/㎡ (LED Lighting)	10W/㎡

Next, the insulation performance by building zones according to the subject building of analysis was as shown in the Table 3. The values applied for performance analysis was set at the level which is being developed in Korea. Phase 1 is the case of enhancing energy performance of the window by introducing vacuum glass, Phase 2 is the case of improving the insulation performance of the wall by applying new insulating material and External Insulation Finishing System, and lastly the phase 3 is the case of installing Heat Recovery Ventilator with the heat recovery efficiency in 85% and electrically driven exterior awning system outside the window.

The value calculated through these input value is the energy demand of the subject building, and as the next stage, the scale of new & renewable energy facility being introduced to fulfill this energy demand. For the new & renewable energy source to be used, photovoltaic and solar heat were taken into account, which are the largest sources distributed in Korea. The scale of introduced system was estimated using the statistic data[2] on the productions of Korea's new & renewable energy sources.

Table 3 Energy Performance Level by Building Elements

		Exterior Wall	Roof	Window	
				K(W/m^{2}K)	SHGC
General Building[3]		0.36	0.24	3.0	0.6
Low Energy House	Phase 1	0.36	0.24	0.88	0.6
	Phase 2	0.1	0.08	0.88	0.6

[2] Korea Energy Management Corporation, 2009
- solar heat: 0.064toe/㎡·yr (745kWh/㎡·yr)
- photovoltaic: 0.292toe/kW (1,358kWh/kW·yr)

[3] The energy conservation design standards. [Annex 4] heat transfer coefficients for building elements, Chungbu area

	Phase 3	0.1	0.08	0.6	0.15~0.75

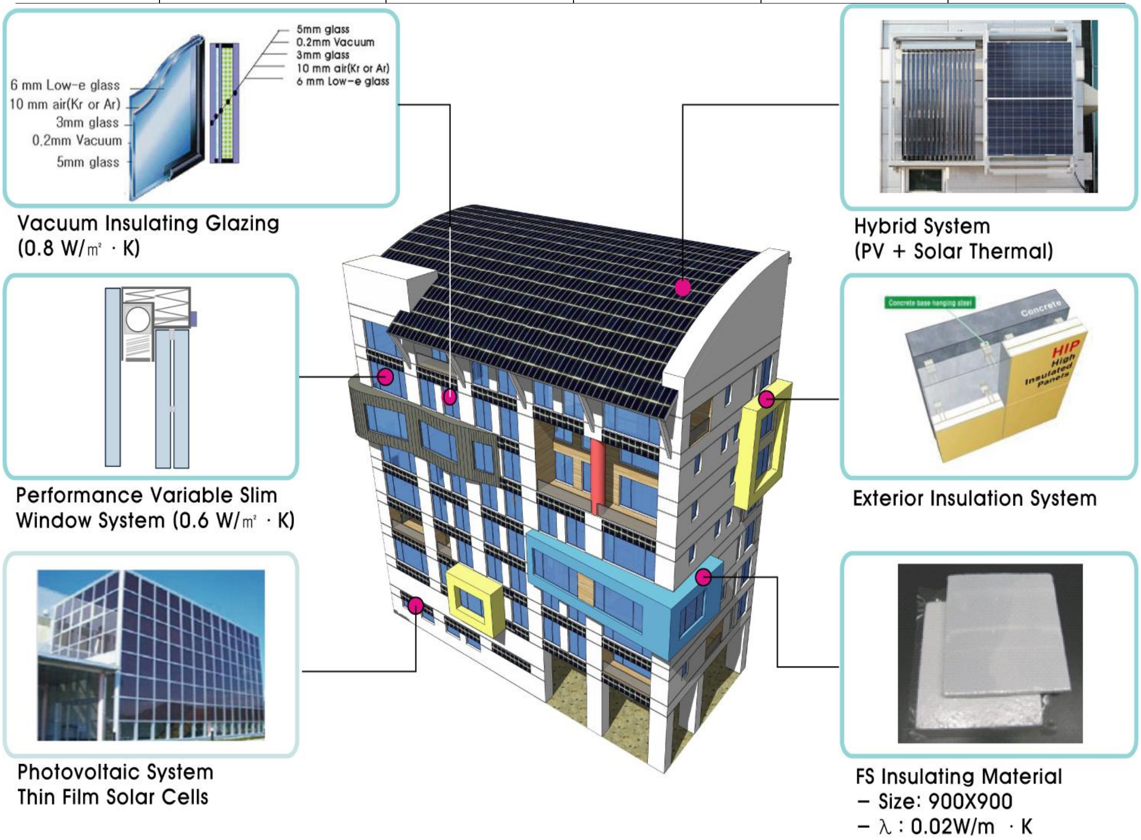

Fig. 2 Empirical Study on Application of Component Technology for the Subject Buildings

3. Results and Discussion

3.1 Energy Performance following Introduction of Component Technology

Results of energy performance evaluation by introducing building component technology by stages through CE3 were clarified as shown in the Table 4 and Figures 3 and 4 illustrate them in graph. As shown in the result, assuming that cooling/heating energy demand of multi-family housing is 100% (166.2kWh/㎡·yr) under the energy saving design standard, if passive component technology is introduced, it becomes 13.6% (22.6kWh/㎡·yr) which means cooling/heating energy demand is reduced by 86.4%. That is, with exterior insulation method and high-performance window applied, it is possible to reduce energy demand of the building by at least 80%. Especially in case of heating energy demand, it was analyzed that it reduces the demand by 90%.

According to the monthly energy demand shown in additional linear graph, in the case of the subject building of comparison, the change in the value of energy demand depending on the season is very low. This represents that the building becomes more independent from outdoor air condition as the energy performance of the building becomes higher.

Table 4 Energy Use of Subject Buildings by Stages

Unit: kWh/㎡·yr

	Standard	Subject Buildings of Comparison		
		Phase 1	Phase 2	Phase 3
Heating	126.1	90.1	18.7	12.5
Cooling	37.8	42.2	20.7	10.1
Total	163.9	132.3	39.4	22.6

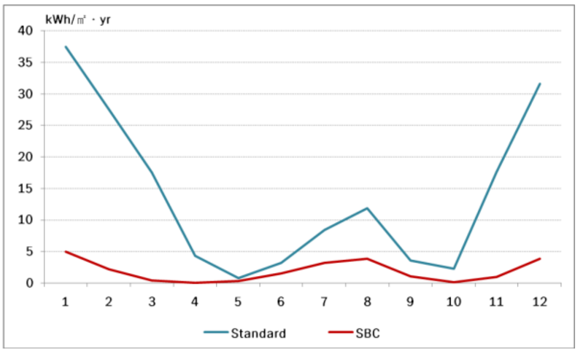

Fig.3 Yearly Cooling/Heating Energy Demand per Unit Area

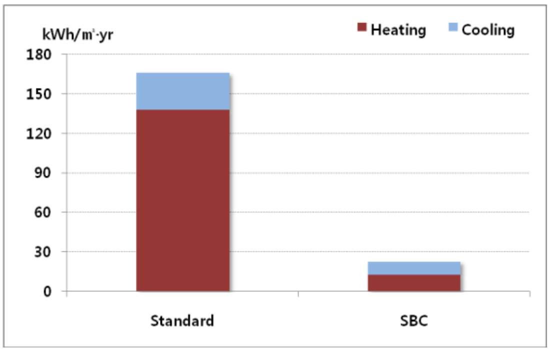

Fig.4 Yearly Cooling/Heating Energy Demand per Unit Area

Next, new & renewable energy facility introduction scale was calculated for the purpose of energy zero at the subject building of comparison. Heating can be covered by the production of hot water supply through solar heat, while cooling was assumed to utilize the power produced by photovoltaic facility. As result of calculating the scale being introduced based on the yearly energy productions by new & renewable energy sources, photovoltaic system in 9 m^2 is required to meet cooling energy demand in 10.1kWh/m^2yr, while solar heat system capable of 20 ㎡ is required to cover heating energy demand in 12.5kWh/m^2yr in order to fulfill energy zero of the building.

3.2 Analysis of CO_2 Emissions Reduction Effect

CO_2 emissions were forecast based on energy demand by the stages of introducing component technology that was already analyzed. CO_2 emissions were calculated through the application of CO_2 conversion coefficient by energy sources. In the case of thermal energy according to domestic statistic data, the consumption of 1toe results in the emission of CO_2 3.178 tons, and 0.4448 ton per MWh for electrical energy. As result of reflecting this in energy demand, if all the component technologies are introduced, CO_2 emissions is found to reach 33% of energy saving design standard. Finally energy demand becomes zero through the introduction of new & renewable energy, and therefore CO_2 emissions from the subject building reaches zero too.

Table 5 Energy Use Reduction Effect by Stages

		Standard	Subject Building of Comparison		
			Phase 1	Phase 2	Phase 3
Energy Demand	Heat (toe)	12.89	9.21	1.91	1.28
	Elec. (MWh)	44.98	50.22	24.63	12.02
CO_2 emission (tCO2)	Heat	40.97	29.27	6.08	4.06
	Elec.	20.01	22.34	10.96	5.35
	total	60.98	51.61	17.03	9.41

4. Conclusions

Energy demand of the building was analyzed to be reduced by 86.4% through the introduction of passive component technology (high level of insulation, high-performance window, etc.) of the building. In addition, the additional introduction of new & renewable energy facility enables to accomplish zero energy demand from the subject building.

CO_2 emissions of the subject building of analysis can be reduced by 85% when passive component technology is introduced, and the energy demand reaches zero when new & renewable energy facility is applied.

In the following studies, the implementation of zero energy in the multi-family housing house including the feasibility analysis of component technology and the area of new & renewable energy facility to be secured for installation, etc. should be considered.

Acknowledgments

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