A STANDARD REMODELING SYSTEM FOR EXISTING HOUSING UNITS INTEGRATED WITH THE ENERGY PRODUCTION MODULE USING ALGAE ACTIVATION

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Abstract- This research proposes an optimal energy remodeling improvement plan which can be applied to existing apartment houses by simulating the energy performance and reclassifying the technology elements applied to existing passive houses and energy saving building in domestic and foreign cases. The Korea diffusion ratio of house has exceeded 100% in 2008 by the National Statistical Office. Korean construction systems including housing have been transformed from quantitative to qualitative. The construction trend is focusing existing buildings through reconstruction and remodeling rather than new construction due to the physical limitations: limited land use, decreased demand, changes in the economic structure, changes in the resident's mind, etc. In addition, most of the domestic energy housing systems (Zero energy house, Bio-housing, Green building, Passive house, etc.) and related researches have done only for new construction. In this situation, the purpose of this research is to analyze the situation in Korea objectively and to study the suitable method applicable to the existing building and house and to suggest a direction through the research result.

Index terms- Algae Energy, Algae Façade, System of energy production housing, existing housing and buildings, changes in elevation, Applicable platform for existing housing, Apartment

I. INTRODUCTION

The total consumption of households in Korea accounts for more than 10.5% of total domestic energy consumption. Therefore, energy saving efforts has been variously researched and developed in the residential area.
As part of energy saving efforts, it is also important to reduce energy consumption of existing buildings and to use them efficiently. Government also was enacted the "Greenhouse Gas Emission Trading Act" on January 1, 2015 to reduce greenhouse gas emissions, purchase emission credits, and established a green building certification system (G-SEED) for buildings that contributed to energy conservation and environmental pollution reduction based on certification standards.

Also, the government aims to provide Million of Green Homes by serve some of the installation fee when installing new and renewable energy facilities in homes until 2020. And recently, Korea's diffusion ratio of house exceeded 103 percent, among which apartment houses occupy about 75 percent. In addition, Korea regulations about the performance of housing energy have been gradually strengthened.

In the case, constructed houses in the 1970s (1.04W/m2K), there are four times the difference, constructed houses in the 1980s (0.58W/m2K), there are twice the difference. But today Korean researches of energy housing system are focused only new building and construction. Therefore, this research aimed to analyze the Korean housing situation and to propose the applicable technologies and simulation result data for existing buildings.

II. RESERCH METHOD AND SCOPE

The purpose of this research is analysis the change of energy performance according to the change of elevation shape by the remodeling of apartment house using simulation. For this research, this research reviewed basic method and advanced research by case studies on energy performance remodeling of national and international buildings. And this research reorganized factor of Zero Energy House System, which was limited to new and single houses, to be applicable to the existing apartment and suggested a system that can improve the energy performance on existing apartment.
Through this process, this research simulated the energy performance by 3D modeling representative form of apartment unit in the 1970s and 1990s for comparative evaluation of reorganized factors and suggested system. Also this research compared the energy performance before and after the remodeling of the existing apartment by the simulation using the REVIT Energy analysis program, OPEN STUDIO, ENERGY PLUS and the heating and cooling load using the ECOTECT. And I finally aim to propose a best solution and method of remodeling by comparison of the result values.

In addition, this research planed about the application of algae energy system and algae façade system. Now, previous studies and case studies about algae are analyzed and thermal data is earned necessary to simulation by The University of North Carolina's Algae research. So this research will analyzes the performance improvement and the energy production through the application of Algae Energy System, Algae Façade System.

III. PRELIMINARY RESEARCH

1) Analysis of Basic Statistics

Prior to the study, most of the energy efficient residential systems (Zero Energy House System, Passive House System, Green House System) serve to newly constructed and single- family houses. On the contrary, the current Korea housing situation shows that new construction is steadily decreasing.

Year	Number of Apartments	Increase /Decrease	Number of Single houses	Increase /Decrease
1975	89,248		4,381,772	
1980	373,710	+284,462	4,652,127	+270,355
1985	821,606	+447,896	4,719,464	+67,337
1990	1,628,117	+806,511	4,726,933	+7,469
1995	3,454,508	+1,826,391	4,337,105	-389,828
2000	5,231,319	+1,776,811	4,069,463	-267,642
2005	6,626,957	+1,395,638	3,984,954	-84,509
2010	8,185,063	+1,558,106	3,797,112	-187,842

Table 1: Increase / Decrease in Number of Single-family houses and apartments by year

The number of apartments still shows a steadily increase, but the number of single-family houses is on the decline. Also, Domestic Housing new construction is decreasing. Domestic housing construction has exploded in the 1970s and has experienced rapid quantitative growth until the 1990s. However, it started to decline gradually in the 2000s, and now is sharply decreasing.

2) Study of Previous Research

The current trend of domestic research on apartment remodeling can be seen before and after the change of the characteristics of apartment remodeling to the improvement of energy performance. Studies of the apartment remodeling before the change of the energy performance improvement are mainly focused on the status, situation of remodeling and policy improvement for aged apartment. Jeong-yoon Bae (2004) researched to the status of remodeling of apartment and institutional improvement policy, and Eun-soon Kim (2010) researched on growth plans and improvement prospects.

After the change, many studies focused on the remodeling plans for improving the energy performance of existing houses such as green remodeling. The Ministry of Land (2013) proposed a remodeling plan for revitalizing the energy performance of existing buildings.

IV. REORGANIZATION AND SIMULATION

1) Reorganization of Factor

First step of Experimental is reorganization to applied factors of Smart Energy House by previous and case studies. And applied factors are divided into the passive technology group, active technology group and renewable energy technology group. And these classified factors are re-organized with applicable to existing housing, apartment housing. Divided factors are as shown in the following Table 2.

Group Name	Factor Name	c1	c2	c3	c4	c5
Passive Technology Group	Location of Southern	●	●	●	●	●
	Rectangular Shape	●		●	●	●
	Shading Device	●	●	●	●	●
	Skylight					●
	Green Wall & Roof	●	●	●	●	●
	High Insulation	●	●	●	●	●
	High Efficiency Window	●	●	●	●	●
	High Airtightness	●	●	●	●	●
	Thermal Mass			●		
	Natural Ventilation	●	●	●	●	●
	Daylight Duct System	●				
	Rainwater Recycling			●	●	
Active Technology Group	High Efficiency LED	●	●	●	●	●
	High Efficiency Boiler	●			●	
	Interruption of Power	●	●	●		
	Heat Recovery Ventilator	●	●	●	●	●
Renewable Energy Technology Group	Solar Energy Generation	●	●	●		
	Solar Heat Energy System	●	●	●	●	●
	Wind Energy System			●	●	
	Geothermal Energy System	●	●	●	●	●

Table 2: Divided Factors by Previous Studies and Case Studies

As a result re-organized factors are as follows: Shading Device, Green Wall & Roof, High Insulation, High Airtightness, High Efficiency Window, Natural Ventilation, Solar Energy Generation, Wind Energy System. These factors have commonly features like easy to apply, fewer limit of apply and high efficiency energy saving.

2) Type of Apartment House

Look at the standards for remodeling in Korea, remodeling is extend a building within 3/10 of the private housing area of each household when 15 years have passed after obtaining approval for use. Therefore, the type analysis of this paper targets are focused on apartment houses built by Korea National Housing Corporation from 1990s to 2000s, which has been over 15 years old. The 1980s and 1990s are period of quantitative growth centering on apartment complexes in Korea. Also after 1993, when the Construction of 2 million Houses Plan was completed, the apartment complex business and plan continually focused on large-scale residential development projects in the surrounding areas of the metropolitan area. Therefore, the apartment complexes that were supplied at the time still occupy a large proportion and need to be analyzed as an object of immediate remodeling. But, the type analysis focuses on apartment complexes built by Korea National Housing Corporation.

	Region	Name of Apartment Complex	Area(m²)	Year Completed	Number of household
1	Panam-dong, Daejeon	Jugong-2	64-105	1990.01	1130
		Jugong-1	63-105	1990.03	1016
		Jugong-5	50-78	1992.08	1436
2	Haan-dong, Gyunggi	Jugong-10	60-105	1990.03	2032
		Jugong-6	52-71	1990.03	1260
		Jugong-7	63-105	1990.03	1342
		Jugong-8	63-105	1990.03	1680
		Jugong-5	63-105	1990.05	2176
		Jugong-11	52-69	1990.06	1080
		Jugong-9	63-105	1990.09	1818
		Jugong-12	59-104	1990.11	2392
3	Munheung-dong, Gwangju	Woosan-2	63-82	1990.06	1138
4	Sunbu-dong, Gyunggi	Jugong-11	49-58	1990.08	1190
		Jugong-15	49-68	1993.04	1210
⋮	⋮	⋮	⋮	⋮	⋮
88	Gyo-dong, Gangwon	Gyodong Jugong-1	65-110	1999.12	1019
89	Damgam-dong, Busan	Baeyang Purenchae	68-101	2000.02	1116
90	Busan-dong, Gyunggi	Unam Jugong-1	61-105	2000.03	1755
		Unam Jugong-2	102-102	2000.11	1036
		Unam Jugong-3	62-108	2000.05	1651
91	Gojan-dong, Gyunggi	Neobill-6	92-103	2000.05	1043
92	Jungbu-dong, Yangsan	Yangsan Jugong	52-77	2000.06	1248
93	Sinlim-dong, Seoul	Samsungsan Jugong-3	75-146	2000.08	1482
94	Dukjung-dong, Gyunggi	Bongwoo Jugong-5	69-82	2000.08	1732
95	Goam-domg, Gyunggi	Juwon Jugong-2	70-84	2000.11	1935

Table 3: 1990s Projects by Korea Housing Corporation

3) Simulation

3D Models are constructed by reflecting the thermal data and representative plan type in the process of typification. They are commonly set south, corridor apartment, RC + wall structure, 210mm of floor slab, 150mm outside and intergenerational wall.

In this paper, this research classified the apartment houses of 1990s-2000s into area and plan types, and then constructed to 3D modeling for simulation. After reflecting common data to the five types, this research tested performance and effect of energy saving technology factors applicable to the existing apartment houses and analyzed increasing and decreasing of energy usage by REVIT, and will more test on light, heat and energy performance by ECOTECT and ENERGY PLUS.

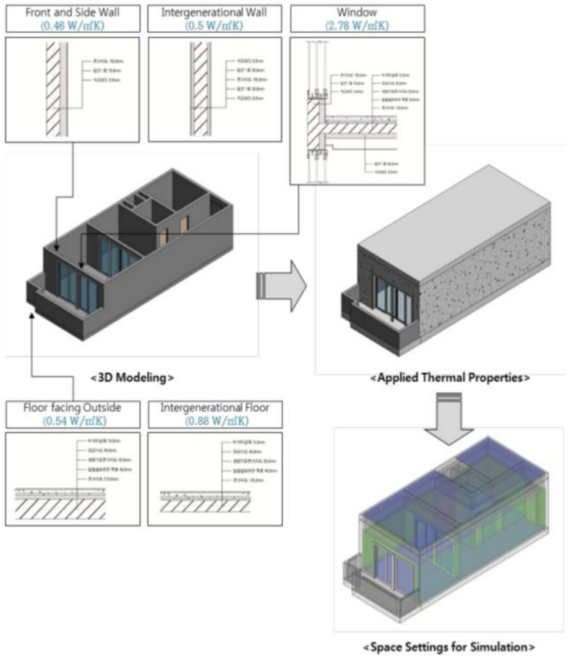


Figure 1: Process of Simulation on REVIT

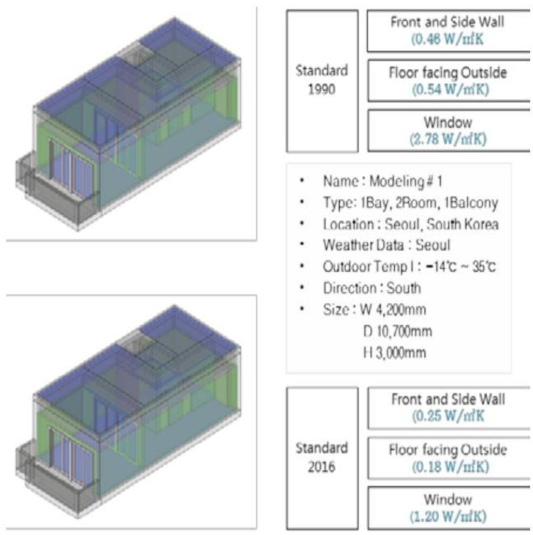


Figure 2: Compare of Energy Performance to 1990 and 2016

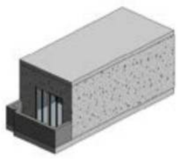
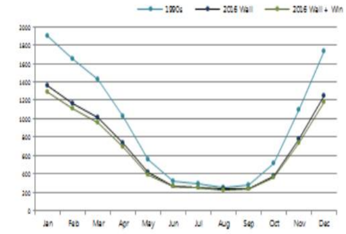
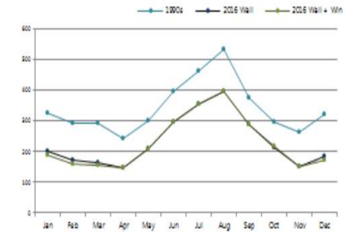
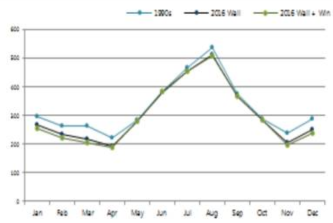
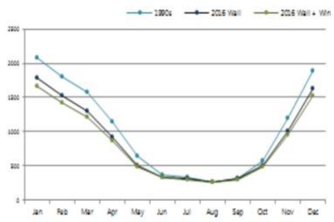
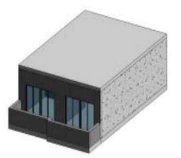
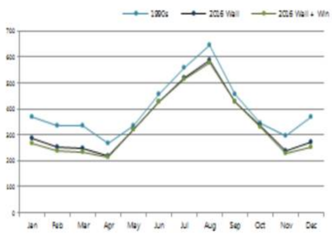
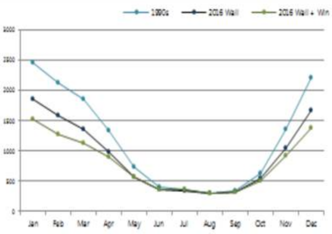
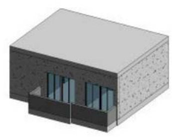
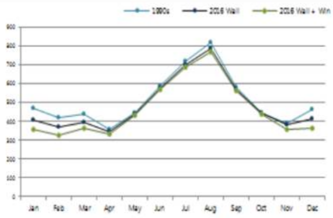
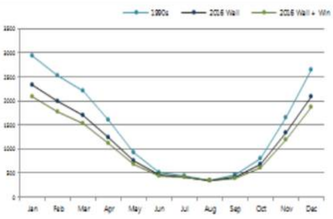
3D Model#1 (1Bay, 2Room, 1Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m²K Floor : 0.54 W/m²K Intergeneration Floor (Roof) : 0.75 W/m²K Win : 2.85 W/m²K	Wall : 0.25W/m²K Floor : 0.18 W/m²K Intergeneration Floor (Roof) : 0.48 W/m²K Win : 1.45 W/m²K
Consumption (elec)	120 kWh/m²/y	90 kWh/m²/y
Consumption (fuel)	1,172 MJ/m²/y	922 MJ/m²/y
Consumption (Total)	1,606 MJ/m²/y	1,248 MJ/m²/y

Table 4: Result Data of Energy Performance Simulation

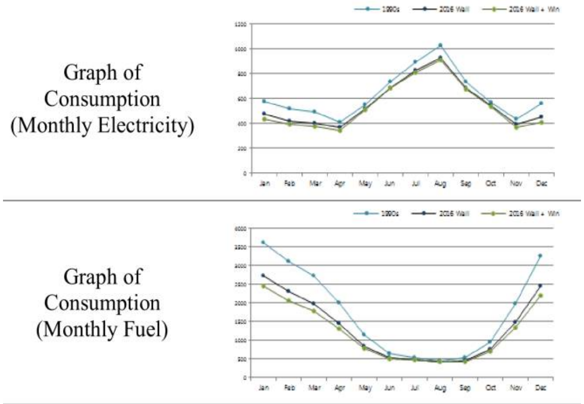
Graph of Consumption (Monthly Electricity)	
Graph of Consumption (Monthly Fuel)	

3D Model #2 (2Bay, 2Room, 2Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m²K Floor : 0.54 W/m²K Intergeneration Floor (Roof) : 0.75 W/m²K Win : 2.85 W/m²K	Wall : 0.25W/m²K Floor : 0.18 W/m²K Intergeneration Floor (Roof) : 0.48 W/m²K Win : 1.45 W/m²K
Consumption (elec)	105 kWh/m²/y	92 kWh/m²/y
Consumption (fuel)	1,184 MJ/m²/y	909 MJ/m²/y
Consumption (Total)	1,563 MJ/m²/y	1,240 MJ/m²/y
Graph of Consumption (Monthly Electricity)		
Graph of Consumption (Monthly Fuel)		

3D Model #3 (2Bay, 3Room, 2Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m²K Floor : 0.54 W/m²K Intergeneration Floor (Roof) : 0.75 W/m²K Win : 2.85 W/m²K	Wall : 0.25W/m²K Floor : 0.18 W/m²K Intergeneration Floor (Roof) : 0.48 W/m²K Win : 1.45 W/m²K
Consumption (elec)	106 kWh/m²/y	91 kWh/m²/y
Consumption (fuel)	1,132 MJ/m²/y	821 MJ/m²/y
Consumption (Total)	1,515 MJ/m²/y	1,149 MJ/m²/y
Graph of Consumption (Monthly Electricity)		
Graph of Consumption (Monthly Fuel)		

3D Model #4 (3Bay, 3Room, 2Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m²K Floor : 0.54 W/m²K Intergeneration Floor (Roof) : 0.75 W/m²K Win : 2.85 W/m²K	Wall : 0.25W/m²K Floor : 0.18 W/m²K Intergeneration Floor (Roof) : 0.48 W/m²K Win : 1.45 W/m²K
Consumption (elec)	107 kWh/m²/y	97 kWh/m²/y
Consumption (fuel)	1,070 MJ/m²/y	782 MJ/m²/y
Consumption (Total)	1,454 MJ/m²/y	1,131 MJ/m²/y
Graph of Consumption (Monthly Electricity)		
Graph of Consumption (Monthly Fuel)		

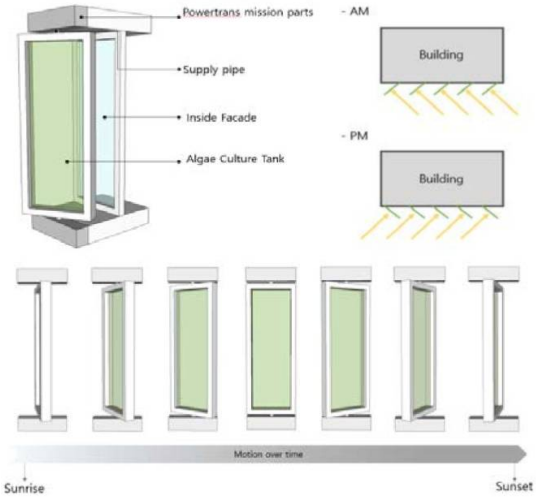
3D Model #5 (3Bay, 3Room, 3Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m²K Floor : 0.54 W/m²K Intergeneration Floor (Roof) : 0.75 W/m²K Win : 2.85 W/m²K	Wall : 0.25W/m²K Floor : 0.18 W/m²K Intergeneration Floor (Roof) : 0.48 W/m²K Win : 1.45 W/m²K
Consumption (elec)	100 kWh/m²/y	91 kWh/m²/y
Consumption (fuel)	1,003 MJ/m²/y	731 MJ/m²/y
Consumption (Total)	1,362 MJ/m²/y	1,059 MJ/m²/y



4) Application of Algae Technology

this research will analyzes the performance improvement and the energy production due to the application of the new renewable energy (Algae energy, in this study) among the applicable remodeling technologies that have already been reorganized.

Figure 4: Images and Principle of Algae Façade



And, with conducting the energy simulation, thermal data are essential. Especially, the research of the thermal performance of the algae façade was almost hard to find because they are not commercialized. The University of North Carolina in the U.S.A recorded thermal energy distribution grasped using infrared camera by producing mock-up for algae façade. In the result of this research, algae façade was shown to have same energy efficiency as Low-e Coated IGU (Insulated Glass Unit). This research will simulates using this thermal energy data.

CONCLUSION

In this study, this research reclassified and reorganized the applicable factors into the existing apartment houses, due to some limitations of existing Energy House System such as low applicability with existing houses and high-rise houses. And this research analyzed the types of apartment houses in the 1990s-2000s that need be remodeled immediately. Through this, constructed 3D modeling and simulated energy performance, energy effectiveness of each changes (change of thermal standard, heat insulation property of wall and floor).

And, this research analyzed the change of electricity and fuel consumption according to the change of insulation standard. As a result of the above simulation, it is confirmed that electricity is saved 4,330.7 kWh per year, fuel is saved 17,160 kWh per year, total of 21,490 kWh per year. It is expected that energy savings will also increase when the area is increased because simulation unit is smaller area in houses unit. And this research will do additional simulation and test the performance improvement and the energy production due to the application of the Algae energy system or Algae façade.

Finally, this research has expected that this study may serve as fundamental findings of new trials for energy housing systems and suggest new methods applicable to the existing housings and buildings.

ACKNOWLEDGMENTS

This research was majorly supported by a grant (G01201406010105) from International Standard Technology Enhancement Program (Project No. 10049462) funded by Korean Agency for Technology and Standards under Ministry of Trade, Industry and Energy of Korean Government.

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