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The Effects of Energy Cost Payment Systems on the Heating Energy Consumption of Single-Households Around University Town

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Abstract: In the present study, the effects of energy cost payment systems on the heating energy consumption of single-households around university towns were quantitatively analyzed. For the analysis, field surveys and questionnaire surveys for 287 buildings, actually measured data values for 31 households and ISO13790 based static simulation methods were utilized. According to the results of analysis, those households that were paying energy costs under the fixed charge system as energy costs were included in rents were consuming more energy compared to households that were paying energy costs under the meter-rate system by ~35%. However, even the consumers under the fixed charge system did not show any large difference from the heating energy consumption levels of general residential buildings in the same regions. That is the energy consumption did not reach the level of waste even when energy use was not limited. Meanwhile, among single-households around university towns, those households that were paying energy costs under the meter-rate system showed very low heating energy consumption levels indicating that they were enduring discomfort due to cost burdens.

Key words: Energy cost, Heating energy consumption, Single-household, University town, Korea

INTRODUCTION

Demand for rental residential spaces in university towns in South Korea is very high because of the special purpose of residence, cost benefits and densely located amenities. Rental houses in university towns as such accommodate one million single-households.

Thermal environments in living spaces vary with individuals. However, the thermal environments in livings are often determined by the residents' awareness of energy cost (Healy and Clinch, 2002) as well as the individuals' experience. In particular, low-income classes are in uncomfortable thermal environments in their living spaces due their awareness of energy costs (Hyuncheol, 2015). Some rental houses around university towns in South Korea adopt a little peculiar system in energy cost payments. Residential buildings generally adopt meter-rate systems under which households pay energy costs for the amount of energy used by them. However, some of rental houses around university towns adopt the fixed charge system under which energy costs are included in monthly rents and no separate limit is imposed on energy consumption. Energy consumption may vary in households around university towns due to cost awareness.

Heating has been reported as accounting for the largest part of energy costs in residential buildings in South Korea. Therefore, heating control is frequently adjusted according to occupants' cost awareness. In the present study, the effects of energy cost payment systems on the heating energy consumption of single-households around university towns were quantitatively analyzed. To this end, field surveys and questionnaire surveys for 287 buildings, actually measured data values for 31 households (Hyuncheol, 2015) and the heating energy use calculation method presented by ISO13790 were employed.

Survey of energy cost payment systems of single-households around university towns: In the present study, questionnaire surveys on the present situation of energy cost payment systems of rental houses around university towns were conducted with 287 buildings. In general, since land prices are very high in regions around university towns, up to the legally stipulated upper limits of the Building Coverage Ratios and Floor Area Ratios were shown to be utilized in these regions. In general, each four story building comprised 10-12 household units and the average floor area per unit was 30.71 m^2.

Table 1 showed the energy cost payment systems of the surveyed buildings and the space areas of individual

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Table 1: Energy cost payment systems of surveyed buildings and space areas

			Space areas (m^2)	
Energy payment system	N	Proportion (%)	Mean	SD
Fixed charge	69	24	27.73 (3.97)	3.97
Under the meter-rate	218	76	31.65 (2.73)	2.73
Total	287	100	30.71(3.49)	

household units. According to the survey, 218 out of the 287 buildings adopted the meter-rate system while 69 rental houses adopted the fixed charge system accounting for 24% of all buildings. In the case of units under the fixed charge system, floor areas were smaller compared to those under the meter-rate system.

MATERIALS AND METHODS

Analysis of heating energy consumption according to energy cost payment patterns: To calculate Heating Energy consumption according to energy cost payment patterns, simulations were adopted instead of end-use energy consumption data. Since, end-use data reflet the effects of not only cost payment patterns but also diverse other factors such as building insulation performance, individuals' life-styles and air conditioning systems' efficiency, the effects of individual elements cannot be derived.

Therefore, in the present study, the ISO 13790 Based Monthly Calculation Method (Hong, 2009) that is generally utilized in building energy simulations. The controlled value (e.g., U-value, building data) are extracted from data-set of previous study that conducted actual measurement in 31 households around university towns. Although, weather is another controlled variable, it is also an influence factor that has large effects on heating energy consumption. In the present study, the average weather information and insolation values provided by the Korea Meteorological Administration were utilized.

Table 2 shows the weather information and insolation values of Daegu, South Korea, which is the surveyed region. In the case of South Korea, four seasons Spring, Summer, Autumn and Winter exist and weather information shows clear seasonality. Seasons in which high heating demand occurs are Autumn and Winter generally ranging from November to March next year. To analyze the effects of energy cost payment systems, the room temperature and humidity maintained at normal times were employed. Table 3 shows data from surveys of indoor thermal environments according to energy cost patterns in 27 households around university towns which are the results of a study conducted by these researchers earlier.

Table 2: Annual weather information and insolation values of investigation cities

Variables	Jan.	Feb.	Mar.	April	Sep.	Oct.	Nov.	Dec.
GHI (Kwh m^{-2})	71	85	119	141	106	101	73	67
DHI (KWh m^{-2})	35	45	73	92	65	65	44	33
DNI (KWh m^{-2})	89	81	80	75	68	70	67	90
Temp (°C)	1.2	3.9	8.5	14.6	22.1	16.4	9.3	2.9
Humidity (%)	49	48	47	48	70	61	54	51
Wind speed (m sec^{-1})	2.4	2.5	2.7	2.6	2.1	1.9	2.0	2.3

GHI: Global Horizontal Irradiance, DHI: Diffuse Horizontal Irradiance, DNI: Direct Normal Irradiance Daegu, South Korea, Latitude: 35.88¬Longitude E 128.6¬Altitude: 57.8 m

Table 3: Indoor thermal environment according to energy payment system

	Air temperature		Humidity	
Energy payment system	Mean	SD	Mean	SD
Fixed rate	20.63	3.21	53.34	13.89
Under the meter-rate system	17.68	1.15	53.27	12.87

Data from research conducted by these research team (Hyuncheol, 2015)

RESULTS AND DICUSSION

In the present study, attempts were made to quantitatively present the effects of energy cost payment systems on heating energy consumption of households around university towns. The demand for heating energy derived through calculations is as shown in Fig. 1. Units for which energy costs were included in rents were shown to have ~35% higher heating energy demand compared to units that were paying the cost of the energy as much as they used.

These may be natural results generally predicted. However, discussion seems necessary on whether the heating energy consumption level occurring in units under the fixed charge system for energy costs is a level of waste. The heating energy demand of the rental houses the fixed charge system for energy costs was shown to be at a general level compared to the unit area standard of general residential buildings in South Korea. On the contrary, the units that were paying energy costs for the energy used by them were shown to pay heating energy costs much lower than the level of consumption by general households.

In the preceding study conducted by these researchers (Hyuncheol, 2015), low-income classes were shown to be in uncomfortable thermal environments in their residential spaces due to energy cost awareness.

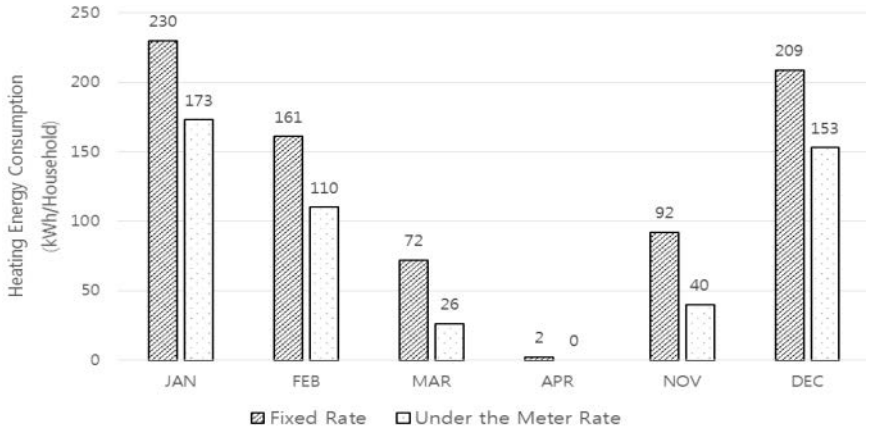

Fig. 1: Heating energy consumption of single-household around university town according to energy cost payment system

In addition, it was shown that the effects of energy cost awareness on indoor thermal environments were large in households around universities because most of the occupants were students not independent economically. There are two choice alternatives that cannot coexist; energy saving and provision of comfortable environments to households around universities.

The results of the present study indicate that in the case of single-households around university towns, energy consumption differed by up to 35% according to energy cost payment systems. Therefore, if energy saving is wanted, the installation of individual meters in household units can be made mandatory to reduce energy consumption in the housing sector. On the contrary, through ordinances in communities regarding energy costs or energy cost support projects, the choice of provision of comfortable environments to single-households around university towns that are economically neglected classes can be made.

CONCLUSION

In the present study, the effects of energy cost payment systems on the heating energy consumption of households around university towns were quantitatively presented. According to the results of the study, those units that were paying energy costs under the fixed charge system as energy costs were included in rents were consuming more energy compared to households that were paying energy costs under the meter-rate system by ~35%. However, even the consumers under the fixed charge system did not show any large difference from the heating energy consumption levels of general residential buildings in the same regions. That is, the energy consumption did not reach the level of waste even when energy use was not limited. On the contrary, in the case of single-households around university towns, those households that were paying energy costs under the meter-rate system showed very low heating energy consumption levels indicating that they were enduring discomfort to save energy because the effect of their energy cost-awareness on heating energy consumption was very large.

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