



The energy-saving effects of apartment residents' awareness and behavior

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ARTICLE INFO

Keywords:

Energy-saving effects
Residents' participation
Awareness
Behavior
Apartments in Korea

ABSTRACT

The purpose of this study is to discuss the energy-saving effects of residents' participation in apartment complexes through the imparting of relevant information and motivation. Therefore, this study compared the results of two separate surveys. Surveys developed based on the government guidelines were utilized to observe and compare residents' consciousness, knowledge and behaviors, before and after providing them with information and performing promotion activities. The major findings are as follows: First, the residents' energy-saving consciousness, knowledge, and behavior improved after they were provided with relevant information and exposed to campaigns. Second, these factors improved further if residents had been previously exposed to such information and campaigns at their apartment complexes. Third, energy-saving activities driven by residents' participation instilled a sense of pride in their apartment complex. Hence, this study's examination and discussion of the energy-saving effects of apartment complexes is expected to be utilized as a framework and guideline for the creation of effective energy-saving manuals for apartment residents.

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1. Introduction

In Korea, domestic energy consumption has increased owing to the expansion of living space and the use of large home appliances that have resulted from the increase in the GNP and improvements in the quality of life. Currently, energy consumption in Domestic is responsible for 11% of the total energy consumption in Korea (industry: 57.3%, transport 23.1%, commerce 8.5%), especially, gas and electricity consumption is occupy for more than 70% domestic energy consumption (gas: 1986: 4.9%, 2004: 51.8%, 2007: 53.9%, electricity: increased at an average annual rate of 3.7% for the 2004) [1]. Therefore, energy management in buildings, particularly apartment complexes over 50% of urban housing has become increasingly important. Various studies, such as those on the enforcement of insulation performance and the development of highly efficient energy systems, have been carried out to help save energy in buildings. The government enforced construction regulations to enhance energy efficiency and developed guidelines, including energy-saving tips, to stimulate energy saving through residents' participation and encourage such practices. The energy-saving effects of residents' participation are extremely cost-effective and such campaigns are very popular in developed countries [2,3]. Especially by providing energy information through monitoring more than 20% of identified Energy savings [4–6]

and evaluate the energy-saving potential by improving occupants' behavior in domestic life through energy-saving education [3]. Although it has been reported that the proper promotion and distribution of relevant information greatly influences energy-saving related behavior by triggering resident participation [2], there have not been any concrete studies on the effects of public relations or information provision in Korea.

Therefore, this study examines the effects of energy-saving by analyzing the changes in the awareness and behavior of apartment residents after the promotion of energy-saving activities and their proper usage and provision of relevant information. This study also aims at determining whether energy saving through resident participation contributes to the apartment community. Through these examinations, this study aims to raise awareness about the need for promoting energy-conservation and distributing relevant information, and to seek additional roles for apartment residents' in their energy-saving efforts.

2. Study methodology

This study examines how providing information to residents influences their attitude, knowledge, and behavior toward energy-saving, so that it can measure the result of energy-conversation generated by resident participation. As a primary methodology, a questionnaire survey was developed to evaluate the consciousness, knowledge, and practice, of energy conversation, all of which previous studies and papers identified as important variables toward

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Table 1
Overview of questionnaire surveys.

	First test	Second test
Date	September 13 to October 8, 2010	October 17 to October 21, 2010
Questionnaires	202 out of 220 distributed questionnaires (collection rate: 91.8%) 197 questionnaires used	78 out of 85 distributed questionnaires (collection rate: 91.7%) 70 questionnaires used

influencing energy-saving behavior; the survey was conducted on apartment residents.

The questionnaire included topics such as energy consciousness and the knowledge and practice of energy conservation. The questions on energy-saving practices were designed to assess the participants' levels by household as well as by complex. In particular, questions on energy-saving knowledge and practices were developed in a simple language on the basis of "50 Ways to Save Energy in Buildings (Domestic Division) [7]," released by the Ministry of Land, Transport and Maritime Affairs (2010). Surveys were carried out twice: as a test and re-test. The primary test examined the respondents' consciousness of energy, and their knowledge and behavior regarding energy-saving methods. After the first test, the respondents were provided with information about energy saving and encouraged to participate in energy-saving activities. About a month later, a second test was conducted where the same respondents filled out the same questionnaire. Then, the results of the two tests were compared and analyzed.

The subjects were selected from among those living in the "Best Energy-Saving Apartments," designated by the Busan Metropolitan Government and Korea Energy Management Corporation, and other apartments. The rationale behind this selection was that the energy-saving activities of the residents living in the best energy-saving apartments were regularly examined, and therefore they would presumably participate more actively in energy-saving activities.

The first test was conducted from September 13 to October 8, 2010, after revising the questionnaire through preliminary tests, and 202 out of the 220 distributed questionnaires were collected (91.8%). When submitting the survey, the respondents were provided with information on energy conservation and encouraged to inculcate energy-saving practices. The distributed information was based on the "50 Ways to Save Energy in Building (Domestic Division)," with additional data on the cost benefits from energy saving. A month after the first test, the second test was performed with the same respondents, and 78 out of the 85 distributed questionnaires were collected (91.7%). The collected data were analyzed through descriptive statistical methods and a *t*-test by utilizing PASW WIN 18.0 (Table 1).

3. Problem description

Energy-saving behavior refers to consumer' decision-making processes related to energy consumption that are practiced at home to reduce energy consumption, including the switching off of electric equipment when not in use, micro-thermal control of air conditioners, and purchase of highly energy-efficient electronic products and fuel-efficient vehicles [8].

Overseas studies on energy-saving behavior began as an attempt to understand environmental and energy-saving issues from the perspective of consumer behavior in the 1970s, earlier than those in Korea [9–13]. Initial studies, in particular, presumed that individuals have a higher awareness of environmental problems and a positive attitude toward energy-saving, and are, therefore,

motivated to perform responsible actions toward the environment when they have sufficient knowledge about it and other relevant issues; These studies also and focused on verifying the relations and correlations between awareness, attitude, and behavior. Birch and Schwaab [14] and Hsu and Roth [15] identified the statistical correlations between awareness and attitude, and Ueno et al. showed that increasing resident awareness of energy use had a major effect on consumptive behavior [2]. Peyton and Miller [16] showed that relations between attitude and consciousness, attitude and behavior differed according to relevant factors, including consciousness. The attitude-behavior study of Ajzen and Fishbein [17] adopted the concept of behavior intention and explained that intention is a critical factor determining actual behavior. Energy-saving behavior is hard to predict using a single factor such as attitude [18]. However consumer' consciousness of energy issues as an important variable has been regarded [13,19–21] insisting that it is a predictor of their energy consumption, it may be presumed that the household energy consumption of apartment residents may differ in accordance with their consciousness of energy issues.

Among studies that identified the relations between energy-saving behavior and other factors, energy-saving behavior differs according to energy-saving awareness, and the consumers' socio-economic characteristics [9–12], consumer' attitudes toward and faith in the environment might change their environmental and energy-saving behavior [8,21,22,23]. In addition, Brandon and Lewis [8] analyzed the energy-saving effects of digital information and confirmed that the accumulation of information had a substantial influence on energy-saving activities, Staats et al. [24], evaluated the positive effects of media campaigns on environmental issues like global warming. These studies suggest that knowledge improvement through accumulation and the provision of information does influence human behavior. Studies on energy-saving behavior in Korea have been carried out since the 1980s, primarily associated with environmental issues, but have yet to be rendered far more specific. A more positive attitude toward and more knowledge on energy saving led to more noticeable energy-saving behavior [25], and a higher awareness of energy saving resulted in a higher level of energy-saving behavior [16,26]. Comprehensively considering the previous studies conducted in Korea and abroad, it is expected that energy consciousness, which may be construed as an attitude toward or concern for the environment, will affect energy-saving behavior. Accordingly, education on energy and energy saving and promotion of the same should increase environmental behavior and active actions. Therefore, this study deems an environmental attitude, consciousness, and interest in energy-saving as an overall awareness and examines energy-saving behavior through energy-saving actions.

4. Overview and characteristics of subject apartment complexes and respondents


4.1. Characteristics of subject apartment complexes

Table 2 is an overview of the subject apartment complexes. Apartment complex A is an exemplary apartment that carries out the following active energy-saving promotions. It regularly detailed information on eco-friendly actions, such as reducing food waste or picking up recyclable/reusable exercise equipment (Table 3), on the public board; and presents the results to the residents through public boards, banners, and its own website, including information on the amount of reduced food waste, utility and water usage, or the awarding of the designation of "Best Energy-Saving Apartments". On the other hand, apartment complex B hardly provides information or conducts promotions (Table 4).

Table 2
Overview of subject complexes.

Item	Apartment A	Apartment B	Item	Apartment A	Apartment B
Occupation	February 2006	April 1995	Number of households	25 buildings, 26 stories, 1728 households	10 buildings, 24 stories, 1408 households
Floor area ratio	308%	391%	Building coverage	18%	22%
Heating method	Individual heating	Individual heating	Fuel	LNG	LNG
Size of apartment A	79A m ² , 79B m ² , 95 m ² , 109 m ² , 119 m ² , 135 m ² , 148 m ²		Size of apartment B	79 m ² , 105 m ² , 142 m ² , 201 m ² , 161 m ²	

Table 3
Public notices on energy saving.

Food-waste reduction public notice	Food-waste discharge amount public notice	Recyclable exercise equipment collection public notice	Paper pack separation discharge cooperation public notice	Complimentary collection of old household appliances public notice
				

4.2. Characteristics of respondents

4.2.1. Characteristics of first survey respondents

Table 5 describes the general characteristics of subject households. The women were aged 47.8 years on average (SD = 8.1), and their education level was relatively high, with a high ratio of college graduates. Among the households, 36.4% of the men were office workers and 60.8% of the women were full-time women. With regard to the family life cycle, 62.8% of them were in their adult stages. With regard to average income, 46.7% entered over 4 million won per month, showing higher earnings than the average urban household income (Second-Quarter 2010 average urban household income: 3,425,720 won, Statistic Korea). In terms of residential types, 88.1% of the respondents said that they owned their houses, and 40.1% answered that they were living in the apartment for four to six years, indicating that they were relatively used to the lifestyle in the apartment complexes.

Comparing the two subject groups the educational level of women and the family life cycle showed a statistically meaningful difference. However, other characteristics indicated no significant difference.

4.2.2. Characteristics of second survey respondents

The second survey was conducted for women who were given energy-saving information and asked to participate in energy-saving activities after submitting the first survey (Table 6). The women were 48.0 years old on average, with an equal number of 40 and 50 year olds (44.3%). The majority of the respondents were

college graduates (61.4%) and full-time women (64.1%), with no significant difference between the two subject groups.

4.3. Energy-saving consciousness

In order to examine the residents' consciousness of energy saving, questions were posed on interests, attitudes and the need, for information on energy and environmental issues (Fig. 1 and Table 7).

The pre-test indicated that the respondents' overall consciousness of energy was fairly high, with a score of 4.1(0.5) out of 5.0. In particular, they showed a keen interest in environmental issues and energy saving, and a high consciousness of the need for energy-saving practices. In addition, it turned out that they understood the information on energy saving and considered the relevant information and education helpful for carrying out energy-saving activities at home.

The analysis of the results by apartment complexes, showed no meaningful difference in environmental interests and energy attitudes between the two groups. However, with regard to the questions on consciousness of energy saving (EC8, EC9, EC10, EC12, and EC13), group A showed a higher consciousness than group B, with statistically significant differences. It may be interpreted that apartment complex A provided its residents with relevant information and actively promoted energy saving, giving the residents a higher consciousness toward energy-saving activities.

The post-test conducted after providing information and encouraging participation showed a higher consciousness in general ($M = 4.2(0.5)$, $p < 0.05$). A review of the responses to each

Table 4
Electricity and water consumption details (July 1, 2007 to June 30, 2009).

Electricity consumption			Water consumption		
Month	Usage (kW)	Charge (won)	Month	Usage (kW)	Charge (won)
July 2007 to June 2008	8,518,811	1,236,184,110	July 2007 to June 2008	392,396	324,205,680
July 2008 to June 2009	8,324,978	1,166,691,250	July 2008 to June 2009	375,710	319,785,469
Saving	193,833	69,492,860	Saving	16,686	4,420,211

won, monetary unit of Korea.

Table 5General characteristics of the subjects (first survey), *N*(%).

Item	Details	Total	Apartment A	Apartment B	χ^2
Age of women <i>M</i> = 47.8 (<i>SD</i> = 8.1)	30s	31(15.7)	20(21.1)	11(10.8)	(n.s)
	40s	76(38.6)	30(31.6)	46(45.1)	
	50s	90(45.7)	45(47.4)	45(44.2)	
	Total	197(100.0)	95(100.0)	102(100.0)	
Education level of women	College graduate or over	101(52.3)	58(62.4)	43(43.0)	7.2 df = 1 **
	High school graduate or under	92(47.7)	35(37.6)	57(57.0)	
	Total	193(100.0)	93(100.0)	100(100.0)	
Occupation of women	Housewife	110(60.8)	59(67.0)	51(54.8)	(n.s)
	Employed	71(39.2)	29(33.0)	42(45.2)	
	Total	181(100.0)	88(100.0)	93(100.0)	
Age of men	30s	16(8.1)	12(12.6)	4(3.9)	7.9 df = 3 *
	40s	61(31.0)	27(28.4)	34(33.3)	
	50s	84(42.6)	35(36.8)	19(18.0)	
	60s	36(18.3)	21(22.1)	15(14.7)	
	Total	197(100.0)	95(100.0)	102(100.0)	
Education level of men	College graduate or over	137(74.5)	72(79.1)	65(69.9)	(n.s)
	High school graduate or under	47(25.5)	19(20.9)	28(30.1)	
	Total	184(100.0)	91(100.0)	93(100.0)	
Occupation of men	White-collared	64(36.4)	26(29.5)	38(43.2)	(n.s)
	Self-employed	41(23.3)	22(23.2)	19(21.6)	
	Production worker	32(18.2)	17(17.9)	15(17.0)	
	Professional	39(22.2)	23(24.2)	16(18.2)	
	Total	176(100.0)	88(100.0)	88(100.0)	
Family life cycle	Pre-school	18(9.4)	13(13.8)	5(5.2)	12.0 df = 4 **
	Primary	25(13.1)	17(18.1)	8(8.2)	
	Secondary	28(14.7)	10(10.6)	18(18.6)	
	Adulthood	120(62.8)	54(57.4)	66(68.0)	
	Total	191(100.0)	94(100.0)	97(100.0)	
Average monthly income (10,000 won)	Under 300	42(21.5)	18(18.9)	24(20.0)	(n.s)
	300–400	42(21.5)	24(25.3)	18(18.0)	
	400–500	40(20.5)	17(17.9)	23(23.0)	
	500–700	51(26.2)	22(23.2)	29(29.0)	
	700 and over	20(10.3)	14(14.7)	6(6.0)	
	Total	195(100.0)	95(100.0)	100(100.0)	
Ownership	Own	170(88.1)	83(87.4)	87(88.8)	(n.s)
	Rent	23(11.9)	12(12.6)	11(11.2)	
	Total	193(100.0)	95(100.0)	98(100.0)	
Housing sizes	79 m ² –95 m ²	29(14.7)	10(10.5)	19(18.6)	(n.s)
	105 m ² –119 m ²	82(41.6)	31(32.6)	51(50.0)	
	135 m ² –148 m ²	86(43.7)	54(56.9)	32(31.4)	
	Total	197(100.0)	95(100.0)	102(100.0)	
Number of years of residence	Less than 2 years	23(11.7)	9(9.5)	14(13.7)	–
	2–4 years	56(28.4)	24(25.2)	32(31.4)	
	4–6 years (4 years and 7 months is the maximum period in case of apartment A)	79(40.1)	62(65.3)	18(17.6)	
	More than 6 years	38(29.8)	–	38(37.3)	
	Total	197(100.0)	95(100.0)	102(100.0)	

* $p < 0.05$.** $p < 0.01$.

question showed that the respondents demonstrated a higher interest in environmental problems and the need for energy conversation, and a higher consciousness of its promotion and education. In particular, responses to questions on the consciousness of energy-saving practices (EC5, EC10, and EC12) displayed statistically meaningful differences between the pre- and post tests. A response to a similar question (EC14) indicated that each household developed comparative perspectives on energy consumption, despite yielding no meaningful difference. These results imply that information provision and promotion did enhance residents' consciousness of energy conversation and had a particularly significant influence on their intention to practice.

4.4. Energy-saving knowledge

In order to measure the knowledge level of apartment residents on energy saving, 69 questions from 10 different categories, drawn from the "50 Ways to Save Energy in Building (Domestic Division)," were posed using a 3-point scale (Fig. 2 and Table 8).

The results indicated that the respondents have a relatively high level of knowledge about energy saving, with an overall average of 2.2(0.3). They scored over 2.0 in 58 questions (84%), which may be interpreted as known or a well known of energy conversation. Considering the attributes of the questions, the respondents had a good knowledge of 7 categories out of the 10, with the exception

Table 6
General characteristics of the subjects (second survey), *N*(%).

Item	Details	Total	Apartment A	Apartment B	χ^2
Age of women <i>M</i> = 48.0 (<i>SD</i> = 6.8)	30s	8(11.4)	7(20.0)	1(2.9)	(n.s)
	40s	31(44.3)	15(42.9)	16(45.7)	
	50s	31(44.3)	13(37.1)	18(51.4)	
	Total	70(100.0)	35(100.0)	35(100.0)	
Education level of women	College graduate or over	43(61.4)	24(68.6)	19(54.3)	(n.s)
	High school graduate or under	27(38.6)	11(31.4)	16(45.7)	
	Total	70(100.0)	35(100.0)	35(100.0)	
Occupation of women	Employed	23(35.9)	9(27.3)	14(45.2)	(n.s)
	Housewife	41(64.1)	24(72.7)	17(54.8)	
	Total	64(100.0)	33(100.0)	31(100.0)	
Family life cycle	Pre-school	3(4.3)	1(2.9)	2(5.7)	(n.s)
	Primary	13(18.6)	9(25.7)	4(11.4)	
	Secondary	11(15.7)	9(25.7)	2(5.7)	
	Adulthood	43(61.4)	16(45.7)	27(77.1)	
	Total	70(100.0)	35(100.0)	35(100.0)	

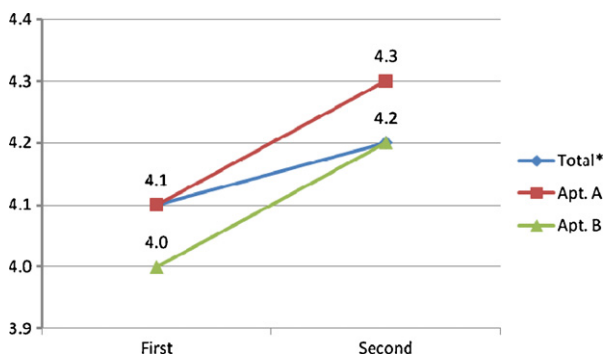


Fig. 1. Energy-saving consciousness.

of insulation, ventilation, and new renewable energy sources categories. It turned out that they are well aware of not only consumer electronics or energy-saving habits that are familiar to them, but also of heating and cooling systems. On the other hand, the 3 categories that the respondents scored low on have different characteristics from the others: they are either not commonly discussed in daily life or their technical improvement incurs a high cost.

An analyses by apartment complex, shown that the two groups have similar levels of knowledge, with A scoring 2.2(0.7) and B scoring 2.3(0.6); B demonstrated a better knowledge level on questions that revealed statistically significant differences.

The post-test revealed higher knowledge levels in most questions, and the overall average score was 2.4(0.3), which showed a statistically meaningful difference. Regarding each apartment complex, the average score meaningfully improved from the pre-test, and it may be construed that providing information and encouraging resident' participation have a positive effect on advancing the residents' knowledge on energy saving.

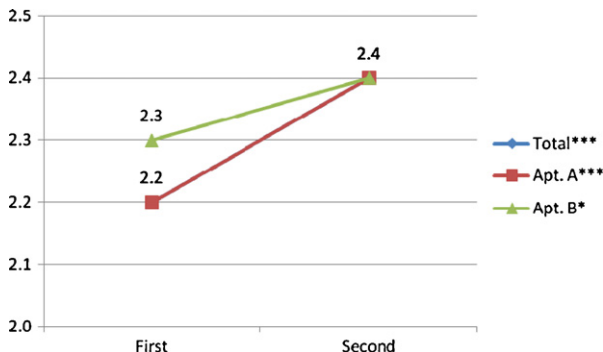


Fig. 2. Energy-saving knowledge.

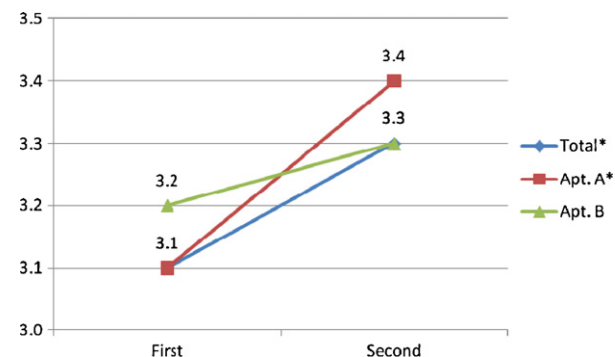


Fig. 3. Energy-saving behavior.

An analysis by apartment complex, shows that both groups scored the same, 2.4(0.3), in the post-test, with a greater improvement in the knowledge level of group A. This might imply that the residents in apartment complex A are more likely to accept information and encouragement since they have been consistently exposed to the promotion of energy saving and information provision activities by the apartment complex.

4.5. Energy-saving behavior

To examine the energy-saving practice levels of apartment residents, 61 questions from 7 out of the 10 categories suggested by the "50 Ways to Save Energy in Buildings (Domestic Division)," excluding insulation, ventilation, and new renewable energy categories that individual residents found difficult to practice, were asked, using a 5-point scale (Fig. 3).

In the pre-test, the average score for energy-saving behavior was a moderate 3.1(0.4), and the respondents scored above moderate in 40 questions (66%), which indicated that the residents' practice levels were below those of their awareness. An analysis by apartment complex, showed little difference between the two groups, with A's average being 3.1(0.5) and B's 3.2(0.4).

In the post-test, the respondents recorded better scores in most questions, with a meaningfully higher average of 3.3(0.6). With regard to each apartment complex, the average score was significantly enhanced, indicating that providing information and encouraging residents' participation have positive effects on advancing the residents' energy-saving behavior. Analyzing the test by item, showed that questions that revealed statistically significant differences were those in which the respondents scored relatively higher in the pre-test. The results show that

Table 7
Residents' consciousness of energy saving, *N*(%).

Item		Total			Apartment A <i>M</i> (<i>SD</i>)			Apartment B <i>M</i> (<i>SD</i>)			(1)	(2)
		First	Second	<i>t</i> -Test	First	Second	<i>t</i> -Test	First	Second	<i>t</i> -Test		
EC1	Energy saving influences the economic development of a nation	4.5 (0.6)	4.7 (0.6)	−2.0 *	4.5 (0.7)	4.7 (0.6)	−1.5 (n.s)	4.5 (0.6)	4.7 (0.6)	−1.4 (n.s)	−.7 (n.s)	−0.2 (n.s)
EC2	Material saving is related to energy saving	4.5 (0.6)	4.6 (0.6)	−1.0 (n.s)	4.5 (0.6)	4.6 (0.6)	−1.3 (n.s)	4.5 (0.6)	4.5 (0.6)	−0.2 (n.s)	−.6 (n.s)	0.6 (n.s)
EC3	We should recognize the seriousness of resource depletion and make efforts to prepare for it	4.5 (0.7)	4.6 (0.7)	−1.1 (n.s)	4.5 (0.6)	4.6 (0.7)	−0.6 (n.s)	4.4 (0.8)	4.5 (0.7)	−0.8 (n.s)	.8 (n.s)	0.2 (n.s)
EC4	Most of the energies we use in Korea are imported from overseas	4.1 (0.9)	4.4 (0.7)	−2.5 *	4.1 (0.8)	4.6 (0.7)	−3.3 **	4.2 (0.9)	4.3 (0.7)	−0.7 (n.s)	−.9 (n.s)	1.5 (n.s)
EC5	It is important to practice energy saving to solve the issue of energy-resource depletion	4.5 (0.7)	4.7 (0.6)	−2.0 *	4.6 (0.6)	4.8 (0.5)	−2.0 (n.s)	4.4 (0.7)	4.6 (0.7)	−1.0 (n.s)	1.4 (n.s)	1.4 (n.s)
EC6	I am interested in environmental issues	3.8 (0.9)	4.0 (0.9)	−1.8 (n.s)	3.8 (0.8)	4.1 (1.0)	−1.7 (n.s)	3.7 (0.9)	3.9 (0.9)	−0.9 (n.s)	.6 (n.s)	0.9 (n.s)
EC7	I have information and knowledge on energy saving	3.5 (0.9)	3.6 (1.0)	−0.7 (n.s)	3.5 (0.9)	3.6 (1.1)	−0.4 (n.s)	3.5 (0.9)	3.6 (0.9)	−0.8 (n.s)	.1 (n.s)	−2.2 (n.s)
EC8	If I practice energy saving, it will help reduce energy imports, even though it is only I who practices this	3.9 (0.9)	4.1 (0.8)	−1.6 (n.s)	4.1 (0.8)	4.2 (0.8)	−1.0 (n.s)	3.7 (1.0)	4.0 (0.8)	−0.5 (n.s)	2.7 **	1.3 (n.s)
EC9	If I practice energy saving, it will help solve the weather problems resulting from global warming	4.0 (0.9)	4.2 (0.7)	−1.6 (n.s)	4.2 (0.8)	4.4 (0.7)	−1.5 (n.s)	3.9 (0.9)	4.1 (0.7)	−0.9 (n.s)	2.0 *	2.1 *
EC10	Energy-saving promotion and education helps households practice energy saving at home	4.1 (0.8)	4.3 (0.7)	−2.2 *	4.2 (0.7)	4.4 (0.7)	−1.2 (n.s)	3.9 (0.8)	4.2 (0.8)	−1.9 (n.s)	3.2 **	1.2 (n.s)
EC11	I have an interest in energy-saving issues and practice energy-saving methods gathered from newspapers and TV programs	3.6 (0.8)	3.7 (0.9)	−0.6 (n.s)	3.7 (0.9)	3.9 (0.8)	−1.3 (n.s)	3.6 (0.8)	3.5 (1.0)	0.3 (n.s)	0.6 (n.s)	1.6 (n.s)
EC12	The practice of energy saving helps home economics.	4.1 (0.8)	4.4 (0.7)	−2.5 *	4.3 (0.8)	4.4 (0.6)	−1.4 (n.s)	4.0 (0.8)	4.3 (0.8)	−2.2 *	2.3 *	0.5 (n.s)
EC13	I feel the need to frequently save energy	4.2 (0.8)	4.4 (0.6)	−1.9 (n.s)	4.3 (0.7)	4.4 (0.6)	−0.3 (n.s)	4.1 (0.8)	4.5 (0.7)	−2.2 *	2.0 *	−0.6 (n.s)
EC14	I think my house consumes too much energy	3.7 (1.0)	3.4 (1.1)	−1.9 (n.s)	3.5 (0.9)	3.4 (1.1)	0.7 (n.s)	3.8 (1.0)	3.4 (1.0)	1.7 (n.s)	−1.8 (n.s)	−0.2 (n.s)
Total		4.1 (0.5)	4.2 (0.5)	−2.3 *	4.1 (0.4)	4.3 (0.4)	−1.9 (n.s)	4.0 (0.5)	4.2 (0.5)	−1.3 (n.s)	1.3 (n.s)	1.1 (n.s)

(1) First-test between apartments A and B, *t*-test, (2) second-test between apartments A and B, *t*-test.

* *p* < 0.05.

** *p* < 0.01

Table 8
Residents' energy-saving knowledge (part of the total).

Item	Total			Apartment A <i>M</i> (<i>SD</i>)			Apartment B <i>M</i> (<i>SD</i>)			<i>t</i> -Test	
	First	Second	<i>t</i> -Test	First	Second	<i>t</i> -Test	First	Second	<i>t</i> -Test	(1)	(2)
Window											
We use thick curtains during winter	2.3 (0.6)	2.6 (0.6)	−2.5 *	2.4 (0.6)	2.6 (0.7)	−1.5 (n.s)	2.3 (0.7)	2.5 (0.5)	−2.0 *	1.1 (n.s)	0.2 (n.s)
We use dual glasses or Low-E glasses	2.3 (0.6)	2.5 (0.6)	−2.3 *	2.5 (0.6)	2.5 (0.7)	−0.8 (n.s)	2.3 (0.7)	2.5 (0.6)	−2.3 *	2.2 (n.s)	0.0 (n.s)
We installed dual or triple windows	2.3 (0.6)	2.4 (0.7)	−1.4 (n.s)	2.4 (0.6)	2.5 (0.7)	−1.1 (n.s)	2.3 (0.6)	2.4 (0.7)	−0.9 (n.s)	0.7 (n.s)	0.5 (n.s)
We use window panes with good insulation performance	2.4 (0.6)	2.6 (0.5)	−3.0 **	2.4 (0.6)	2.6 (0.5)	−1.6 (n.s)	2.4 (0.6)	2.6 (0.5)	−2.3 *	0.6 (n.s)	0.0 (n.s)
We reinforce sealer sand calking in the junction of the glass and window frame	2.1 (0.7)	2.5 (0.6)	−4.2 ***	2.1 (0.7)	2.5 (0.6)	−2.7 **	2.2 (0.8)	2.6 (0.6)	−3.7 ***	−0.4 (n.s)	−0.8 (n.s)
Heating											
We use a highly efficient boiler	2.3 (0.7)	2.5 (0.7)	−1.9 (n.s)	2.2 (0.7)	2.5 (0.7)	−2.1 *	2.4 (0.6)	2.5 (0.6)	−0.7 (n.s)	−2.3 *	0.0 (n.s)
We use a boiler of adequate capacity in the area	2.2 (0.6)	2.5 (0.7)	−2.8 **	2.2 (0.6)	2.3 (0.8)	−0.9 (n.s)	2.2 (0.6)	2.6 (0.6)	−3.3 **	0.2 (n.s)	−1.4 (n.s)
We clean the boiler and heating pipes regularly	2.0 (0.7)	1.9 (0.7)	1.1 (n.s)	1.8 (0.7)	1.7 (0.7)	0.7 (n.s)	2.1 (0.7)	2.0 (0.6)	0.7 (n.s)	−2.3 *	−1.4 (n.s)
We utilize the temperature controller of the boiler very effectively	2.5 (0.6)	2.6 (0.6)	−1.1 (n.s)	2.4 (0.6)	2.6 (0.6)	−1.8 (n.s)	2.5 (0.5)	2.5 (0.7)	0.3 (n.s)	−2.0 *	0.6 (n.s)
We do not switch off the boiler unless we will be out of the house for a while	2.3 (0.7)	2.4 (0.8)	−1.1 (n.s)	2.3 (0.7)	2.5 (0.7)	−1.8 (n.s)	2.2 (0.6)	2.2 (0.8)	0.2 (n.s)	0.6 (n.s)	1.9 (n.s)

(1) First-test between apartments A and B, *t*-test, (2) second-test between apartments A and B, *t*-test.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 9
Resident' behavior toward energy saving (part of the total).

Item	Total			Apartment A <i>M</i> (<i>SD</i>)			Apartment B <i>M</i> (<i>SD</i>)			<i>t</i> -Test	
	First	Second	<i>t</i> -test	First	Second	<i>t</i> -test	First	Second	<i>t</i> -test	(1)	(2)
Refrigerator											
We leave 10% free space in the refrigerator	3.7 (1.1)	4.1 (1.2)	−2.4 *	3.4 (1.1)	4.1 (1.0)	−3.0 **	3.9 (1.0)	4.0 (1.3)	−0.5 (n.s)	−3.1 **	0.2 (n.s)
We reduce the daily opening of the refrigerator door by four times	3.1 (1.0)	3.2 (1.1)	−0.7 (n.s)	3.0 (1.1)	3.4 (1.1)	−1.8 (n.s)	3.1 (1.0)	3.0 (1.2)	−0.9 (n.s)	−1.1 (n.s)	1.5 (n.s)
We reduce the time that the refrigerator door is kept open by 10 s	3.2 (1.0)	3.4 (1.2)	−1.5 (n.s)	3.1 (1.0)	3.6 (1.2)	−2.1 *	3.2 (1.0)	3.2 (1.3)	−0.2 (n.s)	−0.5 (n.s)	1.3 (n.s)
We install the refrigerator in a well-ventilated place	3.5 (1.2)	3.9 (1.2)	−2.5 *	3.4 (1.3)	3.8 (1.3)	−1.3 (n.s)	3.5 (1.2)	4.0 (1.1)	−2.3 *	−0.5 (n.s)	−0.9 (n.s)
We regularly remove the dust on the cooling coils of the refrigerator	2.5 (1.2)	2.0 (1.2)	2.9 **	2.3 (1.3)	2.0 (1.3)	1.0 (n.s)	2.8 (1.1)	2.1 (1.1)	3.3 **	−2.8 **	−0.1 (n.s)
We adjust the temperature control of the refrigerator from Strong to Mid	3.6 (1.2)	3.8 (1.1)	−1.3 (n.s)	3.5 (1.3)	3.7 (1.3)	−0.7 (n.s)	3.7 (1.1)	3.9 (1.0)	−1.2 (n.s)	−1.2 (n.s)	−0.9 (n.s)
Air conditioner											
We reduce the air conditioner usage time by an hour a day	3.7 (1.0)	4.2 (1.0)	−3.3 **	3.8 (1.1)	4.3 (1.0)	−2.4 *	3.6 (0.9)	4.1 (1.1)	−2.3 *	1.2 (n.s)	0.9 (n.s)
We increase the air conditioner temperature setting by 1 °C	3.6 (1.0)	3.9 (1.1)	−2.1 *	3.7 (1.1)	4.1 (1.1)	−1.7 (n.s)	3.6 (1.0)	3.8 (1.1)	−1.3 (n.s)	1.0 (n.s)	1.1 (n.s)
We clean the air conditioner filter once every two weeks	2.5 (1.0)	2.5 (1.1)	0.4 (n.s)	2.6 (1.1)	2.6 (1.2)	0.1 (n.s)	2.5 (0.9)	2.4 (1.0)	0.5 (n.s)	0.4 (n.s)	0.4 (n.s)
We check the coolant of the air conditioner once a year	2.5 (1.2)	2.6 (1.3)	−0.4 (n.s)	2.5 (1.3)	2.6 (1.3)	−0.1 (n.s)	2.5 (1.0)	2.6 (1.3)	−0.5 (n.s)	0.0 (n.s)	−0.2 (n.s)
We disconnect the plug when we do not use the air conditioner	3.2 (1.4)	3.8 (1.4)	−3.4 **	3.2 (1.5)	4.1 (1.3)	−3.3 **	3.2 (1.3)	3.6 (1.5)	−1.5 (n.s)	−0.1 (n.s)	1.6 (n.s)

(1) First-test between apartments A and B, *t*-test, (2) second-test between apartments A and B, *t*-test.

* $p < 0.05$.

** $p < 0.01$.

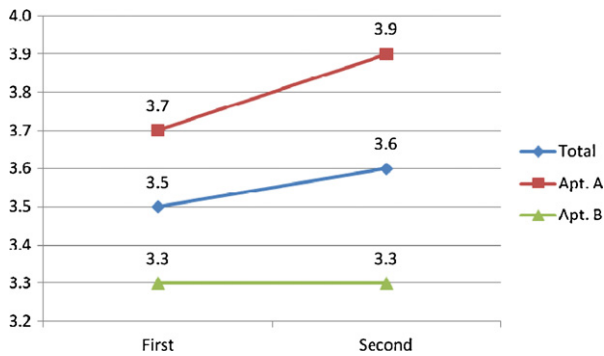


Fig. 4. Energy-saving activities of apartment complexes.

providing information or encouraging residents' participation tend to improve residents' behavior in practicing what they have already been doing, rather than what they have hardly been doing; thus, it is necessary to provide information and education more actively to make a difference in behavioral patterns.

In an analysis by apartment complex, group A showed a better level of practice and a meaningful difference between the pre- and post-tests, while B failed to show a statistically meaningful difference in the second test. It might also be interpreted, that as with the case of the knowledge level, residents in apartment complex A are more likely to accept information and encouragement since they have been consistently exposed to the promotion of energy-saving and information provision activities by the apartment complex. Therefore, it might be concluded that consistent promotion activities performed by apartment complexes do help residents inculcate energy-saving behavior (Table 9).

4.6. Attitude toward the energy-saving activities of apartment complexes

Energy-saving campaigns at apartment complex levels are made complete by the residents' behavior and participation, and the consciousness toward participation is a key predictor that can assess the community spirit of the complex. Therefore, the residents' attitudes toward practicing collective energy-saving activities at the apartment complex level were analyzed in order to examine how energy-saving practices driven by residents' participation are associated with the community spirit of the complex (Fig. 4).

The first survey disclosed a high score of 3.5(0.6) in the residents' attitude toward practicing energy-saving activities, and both groups demonstrated strong needs in the questions for EM1 and EM2. Group A showed a positive attitude toward all items, with a statistically meaningful difference from group B. It might be construed that apartment complex A has been designated the "Best Energy-Saving Apartment" owing to its energy-saving activities, and it has consistently provided relevant information to its residents so that they might develop a positive attitude toward collective energy-saving campaigns and activities in the apartment complex. Indeed, the constant effort of apartment complex A turned out to have a positive influence on its residents' energy-saving practices.

The second survey indicated a more positive overall attitude 3.6(0.7) to collective energy-saving activities, despite failing to show a statistically meaningful difference. Each apartment complex equally presented positive results, but showed no meaningful difference from the pre-test. A comparison of the pre- and post-test results by apartment complexes, revealed that group A demonstrated a more positive attitude in the post-test, while group B demonstrated no change in attitude or an even more negative attitude in the post-test, which shows that the two groups have a

Table 10
Energy-saving activities of apartment complexes M(SD).

Item	Total		Apartment A M(SD)		Apartment B M(SD)		t-Test	
	First	Second	First	Second	First	Second	(1)	(2)
EM1	3.7 (0.8)	3.8 (0.9)	3.9 (0.9)	4.0 (0.9)	3.5 (0.8)	3.5 (0.8)	2.7 *	2.2 *
EM2	4.1 (0.8)	4.2 (0.8)	4.1 (0.9)	4.3 (0.8)	4.1 (0.8)	4.1 (0.8)	0.4 (n.s)	1.6 (n.s)
EM3	3.4 (0.8)	3.5 (0.8)	3.5 (0.8)	3.8 (0.8)	3.2 (0.8)	3.2 (0.7)	2.9 *	3.4 *
EM4	3.5 (0.8)	3.6 (0.9)	3.7 (0.9)	3.9 (1.0)	3.3 (0.7)	3.4 (0.7)	3.3 *	2.2 *
EM5	3.1 (0.9)	3.1 (1.0)	3.3 (1.0)	3.4 (1.1)	2.9 (0.7)	2.8 (0.7)	2.8 *	2.8 *
EM6	3.2 (0.8)	3.2 (1.0)	3.4 (1.0)	3.7 (1.1)	3.0 (0.6)	2.7 (0.6)	3.5 *	5.0 *
EM7	3.5 (0.9)	3.6 (1.0)	3.8 (0.9)	3.8 (1.0)	3.2 (0.8)	3.4 (0.9)	5.1 *	1.9 (n.s)
Total	3.5 (0.6)	3.6 (0.7)	3.7 (0.7)	3.9 (0.8)	3.3 (0.5)	3.3 (0.4)	3.9 *	3.9 *

(1) First-test between apartments A and B, t-test, (2) second-test between apartments A and B, t-test.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

different attitude toward the practice of collective energy-saving activities. This is another indication that the residents' consistent exposure to information and promotion of energy saving does have a significant influence on their energy-saving attitude and behavior.

Moreover, in the EM4 question, group A had a relatively high score, with 3.7 and 3.9 in the pre- and post-tests, respectively, and even through the scores of group B were lower than those of A, their scores were still high 3.3 and 3.4 (pre- and post-test, respectively). Each apartment complex showed no significant difference between the pre- and post-tests, but the two groups showed statistically meaningful differences in both tests. This result indicates that apartment residents acknowledge collective activities through energy-saving activities, and consequently, feel higher sense of pride in the apartment complex to which they belong. Such a pride-building effect was significant in group A, which had extensive participation experience in the collective activities of the apartment complex. This result shows that specific theme-oriented collective activities may contribute to establishing a community in the apartment complex. Furthermore, both groups presented a high score in the EM2 question, implying that a reduction in shared bills or taxes can be a good encouragement to draw residents' toward active participation. Therefore, proactive development of education and compensation methods is required to boost residents' participation (Table 10).

5. Discussion

The following discussion pertains how promotion and information provision changed the consciousness, and knowledge, of residents about energy-saving and individual and apartment complex activities.

With regard to energy-saving consciousness, respondents had a high score of 4.1(0.5) in the pre-test, with no significant difference between the two groups, and they obtained an improved score of 4.2(0.5) in the post-test, indicating that promotion and information provision help raise consciousness about energy saving.

With regard to knowledge of energy saving, respondents scored 2.2(0.3) in the pre-test with no significant difference between the two groups, and their knowledge level improved in the post-test, with an average score of 2.4(0.3). In particular, the residents of apartment complex A, where energy-saving campaigns have been carried out regularly, showed a more significant difference, indicating that promotion and information provision help improve the knowledge of energy saving.

With regard to the practice of energy-saving behavior, respondents scored a moderate 3.1(0.4) in the pre-test, with no significant difference between the two groups, and the level increased to 3.3(0.6) in the post-test. The improvement was even greater in group A, where the residents have been exposed to regular campaigns, indicating that promotion and information provision help advance the level of the residents' energy-saving practices.

With regard to the residents' attitude toward practice of collective energy-saving activities in the apartment complexes, the average score of the pre-test was 3.4(0.6), where A presented a higher awareness score 3.7(0.7) than B 3.3(0.5). In the post-test, group A showed a more positive attitude 3.9(0.8) than group B 3.3(0.4). The result proves that consistent campaigns and information provision activities help improve the level of the residents' energy-saving practices.

6. Conclusion

This study aims to seek measures to reduce energy consumption by encouraging the participation of apartment residents' in energy-saving activities in an era where household energy consumption is

ever-increasing owing to increases in the national income level and living standards. **Broad examinations of apartment residents were conducted to determine their level of consciousness, knowledge, and behavior toward energy conservation, before and after providing them with information and performing promotion activities; the results are as follows.**

First, the residents' level of the consciousness, knowledge, and behavior toward energy-saving improved after they were provided with relevant information and exposed to campaigns; thus, energy-saving results may be expected to increase via the boosting of the residents' awareness of energy-saving and their intention.

Second, the level of the residents' consciousness, knowledge, and behavior toward energy-saving were further improved if they had previously been exposed to information and relevant campaigns provided by the apartment complex, and the result confirms that consistent campaigns conducted by each apartment complex encouraged the residents to participate in energy-saving activities.

Third, collective energy-saving activities driven by resident' participation help build the residents' pride in their apartment complexes, indicating that the collective activities of apartment complexes contribute to the establishment of a community spirit within the complex. This study has examined and discussed the energy-saving effects of apartment complexes by providing relevant information and campaigns to encourage resident' participation, and is expected to be utilized as a framework and guideline for the creation of effective energy-saving manuals for apartment residents.

Acknowledgements

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (No. 2011-0001031).

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